Process oriented Human Resource Information Systems
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Supporting a process orientation in Human Resources through Information Systems

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Friedrich Röhrs
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Dekan:	Prof. Dr. Cornelius König
Erstberichterstatter:	Prof. Dr. Stefan Strohmeier
Zweitberichterstatter:	Prof. Dr. Peter Loos

Abstract

This thesis proposes a design for an information system that combines the functionalities required by human resource (HR) activities and a framework that allows their execution based on augmented business process models, a process oriented human resource information system (proHRIS).

During the gain in popularity of business process management and its spread in the last decades, the fundamental ideas of process orientation have spread to many different areas. From the development of information systems, to the management of organizational knowledge, more and more areas explicitly are based around the operational business processes of the organization. While the idea of process orientation has found resonance in specific parts of human resource management (HRM), no holistic process oriented HRM has emerged. To support the establishment of such an approach, this thesis proposes the design of an information system that allows a process oriented execution of typical HR activities. The design is kept on a relatively high abstraction level to discuss the components required for the process oriented execution of all of HRM core functions: staffing, appraisal, development, and compensation. To offer more concrete insight, exemplary, more detailed, use cases are developed.

The feasability of the proposed design of a process oriented human resource information system (proHRIS) is demonstrated and the design is evaluated through the construction of a prototype which is used in a specific use case and the assessment of the elicited requirements of the system.

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List of Acronyms

API Application Programming Interface

BPM Business Process Management

BPMN Business Process Model and Notation

BPMS Business Process Management (System or Suite)

BPMTool Business Process Modeling Tool

BPR Business Process Reengineering

DBMS Database Management System

DSR Design Science Research

EIS Enterprise Information System

EPC Event based Process Chain

ERP Enterprise Resource Planning (System)

ESS Executive Support System

ETL Extraction, Transformation, and Loading

GUI Graphical User Interface

HR Human Resource(s)

HREPC Human Resource Event based Process Chain

HRIS Human Resource Information System

HRM Human Resource Management

IS Information System

KM Knowledge Management

MOF Meta-Object Facility

MSS Management Support System

NFR Non-Functional Requirements

PAIS Process Aware Information System

PMS Performance Management System

PPMS Process Performance Management System

proHRIS Process oriented Human Resource Information System

proHRM Process oriented Human Resource Management

RM Repository Management

TPS Transaction Processing System

UML Unified Modeling Language

WfM Workflow Management

WfMS Workflow Management System

XML EXtensible Markup Language

1 Introduction

1.1 Problem description

The idea of thinking of organizations as collections of business processes has a tradition in the scientific literature reaching back to at least the beginning of the last century (Nordsieck, 1934 as cited by Becker & Kahn, 2012; Nordsieck, 1972). However, only due to the increasing economic pressure and changes in economic structure, from a purely producing industry to a stronger service industry, the idea of focusing, organizing, and managing organizations around business processes has gained significant popularity in practice (see figure 1 and, for example, McCormack, 2001; Jeston & Nelis, 2006a, p. 4 ff.).

In the advent of process orientation as a focus for organizations the idea of thinking in processes was mainly found in reorganization initiatives and as support for implementing enterprise wide information systems (e.g. Davenport, 1993; Davenport & Short, 1990; Gaitanides, Scholz, & Vrohlings, 1994; Hammer, 1990, 1997; Scheer, 1990).

With time these ideas have matured into specific process oriented management approaches (e.g. Neubauer, 2009) and have resulted in specific information systems that support the management, analysis, and enactment of operational business processes (e.g. van der Aalst, 2009a).

This has lead to a stronger understanding of process orientation across all members of the organization. In turn a broad understanding and acceptance of process oriented thinking has lead to an adoption of process oriented approaches in more and more organizational areas (e.g. J. Fischer, 1996; Maier & Remus, 2002; Krauß & Mohr, 2004; Kohlbacher, 2010; Brocke & Sonnenberg, 2014). Such a broad adoption of process oriented approach further supports a holistic process orientation of the organization itself, which is why a broad understanding of process orientation in the organization and a focus on operational business process in all areas of the organization are seen as an important factor for business process (management) maturity (e.g. Willaert, Bergh, Willems, & Deschoolmeester, 2007, p. 9; McCormack et al., 2009, p. 794; Röglinger, Pöppelbuß, & Becker, 2012, p. 335).

Human resource management (HRM) can be seen as one of those additional areas in which the idea of process orientation has taken root. Classically HRM aims at supplying the right employee for the right task at the right time. It includes all activities relevant for that goal and the overall management of the employees such as the recruiting of employees, developing existing employees to better fit their assigned tasks or to prepare them for future positions in their career. Furthermore, HRM activities include handling regular appraisals of employees to measure their faculties to perform their duties, and managing the compensation of employees.

In a context such as HRM a business process orientation can take two specific forms. In the first form the general existing ideas, management, and optimization methods for handling operational business processes are applied to the context of HRM: Operational processes in the

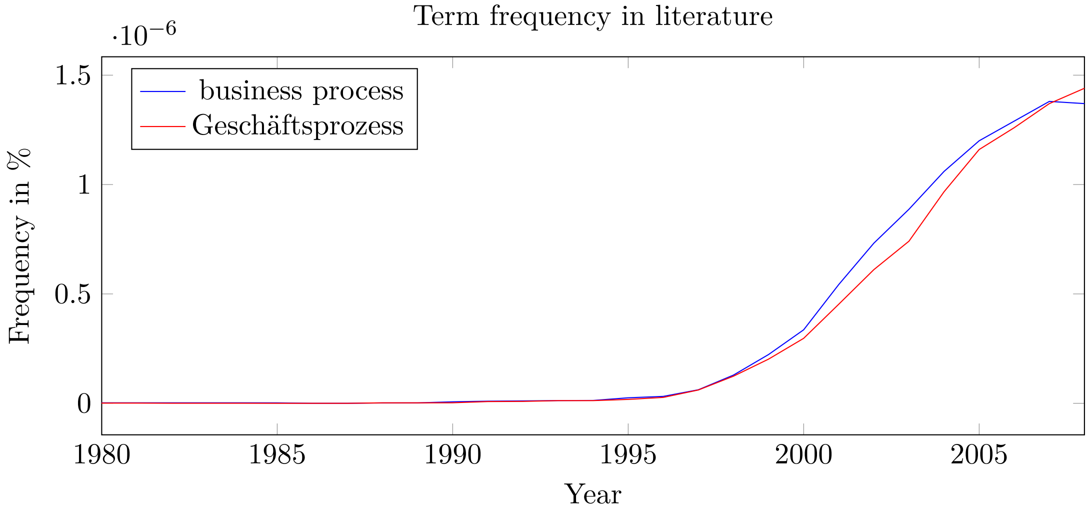


Figure 1: Popularity of the terms "business process" and "Geschäftsprozess" in the English and German literature.
The analysis is based on the Google ngram viewer. It represents about 4% of the published literature and thus is without claim of comprehensiveness. Still, it offers the possibility to identify general trends (for more in depth explanation see also Michel et al., 2011)

area are identified, explicitly modeled, and used as a basis for the optimization initiatives (e.g. Gontard, 2006; c.f. Cakar, Bititci, & MacBryde, 2003). In recruiting, for example, this means to model and document the actually performed recruiting process: from the first identification of missing human resources by the line manager, to the publication of a job posting on external and internal channels, to finally the on-boarding of the new employee.

To achieve this form of process orientation, methods and tools developed for the management of the core operational business processes can be applied in the new context. Modeling tools are used to document human resource (HR) processes, simulation tools and analysis tools are used to analyze potential bottlenecks in the recruiting process and process enactment systems are used to orchestrate the repeated enactment of these HR processes. The classical human resource information systems (HRIS) are still used in each of the individual steps without much change.

The second form of process orientation does not primarily focus on the HR processes, but instead keeps the focus on the core operational business processes. It can be seen as integrating additional points of view in the already existing array of views on the operational business process. For the example of recruiting this might still involve a redesign of the recruiting processes but with the goal of integrating recruiting activities with the existing management activities relating to the operational business processes. These processes should not only be analyzed based on their structural weaknesses, but also on personnel related weaknesses which can result in specific requirements for new employees.

Such an approach, while ensuring a tight integration between HRM activities and the support of the core operational business processes of the organization, can not be directly supported by existing methods and tools already developed. Classical recruiting systems have no concept of gathering requirements from business processes or managing the on-boarding of new employees into specific operational business processes. The classical HRIS are built around a mainly structural understanding of the organization that abstracts away the concrete flow of activities represented through business processes. Existing process aware information systems on the other hand predominantly have no concept of the specific HR activities that are of relevance. While modeling and analysis tools allow the modeling of specific operational business processes and thorough analyses of possible process weaknesses they can not necessarily provide the user with a job posting for a specific process. Enactment systems might understand how to forward specific work folders to specified users, but have no notion of how to automate the payroll based on the activities performed by its users.

A holistic process oriented view of an organization requires a process orientation of HRM in both forms discussed above. All key processes in the organization, included the HR processes, should be explicitly documented, measured, and managed. The management should take into account as many facets of the process as possible (e.g. McCormack, 2001, p. 58; McCormack et al., 2009, p. 794 ff.; Rosemann & vom Brocke, 2010, p. 112 ff.). This includes HR aspects, especially since they are directly related to the employees actually performing the processes (this includes a cultural aspect; cf. J. V. vom Brocke & Sinnl, 2011).

Currently, however, the majority of organizations do not exhibit an HRM that includes both forms of process orientation. A survey conducted by the institute for general management and organization, Graz University of Technology, in summer 2008, for example, found that more than half of the interviewed firms did not have a reward systems that was build around, or emphasized the needs of the business processes of their organization (Kohlbacher, 2011).

A stronger holistic process orientation in HRM is hindered by three aspects: (1) missing methods (2) missing notations, and (3) missing information systems.

(1) A holistic process orientation in HRM requires new methods that are based around and focus on the actual operational processes in the organization instead of following a structural primacy. An example of such an approach is the development of new methods for vocational training that is based around the operational processes (e.g., M. Fischer, 2005)

(2) The use of specific process oriented methods necessitates that a general notation exists that can capture the information from the business process domain, as well as from the HR domain. While there are many general purpose business process modeling languages, such as event based process chain (EPC), business process model and notation (BPMN), petri-nets, or the unified modeling language (UML), they have insufficient support for allowing the execution of human resource activities based on business process models created by the use of these languages. A domain specific modeling language, that includes process information as well as HR information and, therefore, can be used as the basis of a process oriented HRM is missing (some approaches can be found, e.g., Remus, 2002; see also section 2.4.2).

(3) To tie the notations and methods together, support their usage, and allow the enactment of created process models, HRIS are needed that understand the concepts of operational business processes and can support the practical application of the process oriented HR methods. They should serve as a bridge between the management of the business processes

and the management of the human resources.

1.2 Goal of the thesis

Given the problem described above the goal of this thesis is to propose a design for an information system that supports a process oriented approach to HRM. It should serve to bridge the gap between managing operational business process and managing the human resources: a process oriented human resource information system (proHRIS).

This thesis follows a design-oriented approach to information system (IS) research. In concordance the main object of research in this thesis are IS. Design-oriented IS research aims at developing and providing instructions for action that allow the design and operation of IS, based on a "to-be" conception while taking into account given restrictions and limitations (Österle et al., 2011, p. 8).

To better delimit the goal of this thesis in this context and to show how it how this thesis contributes to design-oriented IS research, the research goal and the artifacts produced to achieve it are positioned in the design science research (DSR) knowledge contribution framework proposed by Gregor and Hevner (2013). This framework aims at helping to understand and position the contributions of a research project by specifying the possible types of knowledge created and allowing a classification based on problem maturity and solution maturity.

The framework differentiates between two types of knowledge that can be contributed: descriptive knowledge and prescriptive knowledge. Contributions to descriptive knowledge can be made in form of, f.ex., observations, measurements, or classifications of phenomena. Additionally, contributions can take the form of the development of theories, the discovery of natural laws or patters, as well as the identification of regularities. Contributions to prescriptive knowledge take the form of definitions of constructs, creation of models, development of methods, construction of instantiations or synthesis of existing elements to overall design theories.

Research contributions are further categorized by the problem context in which the projects are embedded as well existing artifacts which can be used as a basis for new developments. These two dimensions are observed based on their maturity, which in the knowledge contribution framework, can be described on a scale from low to high. The resulting 2×2 matrix possible categories of contributions and the positioning of this thesis are shown in figure 2.

The maturity of the problem context is represented on the x-axis and the maturity of the existing artifacts used as a potential starting point are shown on the y-axis (cf. Gregor & Hevner, 2013, p. 345). The framework differentiates between four general types of projects: routine design, improvement, exaptation, and invention. The "routine design" category encompasses projects that apply existing solutions to a well defined problem context. Both the problem context's and the solution context's maturity are high. Such projects often do not contribute any new knowledge.

The "improvement" category includes research project that develop new solutions for known problems. In such areas the problem context itself is well understood (high maturity) but existing solutions are nonexistent or sub-optimal (solution maturity low). Such projects generally provide prescriptive knowledge at least in forms of instantiations.

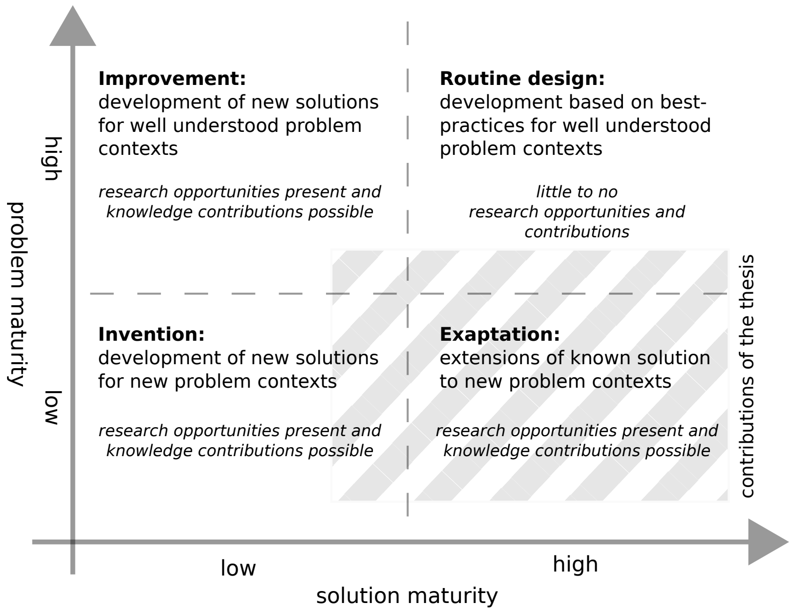


Figure 2: Positioning of the research in the DSR knowledge contribution framework (based on Gregor & Hevner, 2013, p. 345).

Projects in the category "exaptation" deal with existing solutions and try to apply them to a different domain then the one they are typically employed in. Here existing (high maturity) artifacts are applied to a new problem domain (low maturity). This can result in prescriptive knowledge as well as descriptive knowledge, through a better understanding of the artifacts in use.

The "invention" category groups research projects that target a currently not fully understood problem context (low problem maturity) where no existing solution artifacts are available (low solution maturity). Here a recognized problem may not necessarily exist and the value of the solution may remain unclear. Part of the contribution to knowledge is that of first conceptualizations of the problem context and solution artifacts.

This thesis can be assigned to the exaptation category. A process oriented approach to HRM as the problem context is to be positioned at the lower end of the maturity spectrum. While individual approaches exist that target specific sub areas of HRM no overall and comprehensive approach to process oriented HRM has been developed. The existing artifacts on which the proposed design in this thesis is based originate from the context of process oriented information systems and human resource information systems. The maturity of the artifacts in those contexts used as potential starting points can be positioned on the middle to high end of the y-axis. So the research project document in this thesis uses existing (mature) solution artifacts in a novel context.

This thesis therefore aims at making contributions in form of descriptive as well as prescriptive knowledge. The main goal of the thesis is to describe the design of a proHRIS. For this the different relevant constructs relating to a proHRIS are defined. Additionally, different models to describe the proHRIS are created. These models show the different components of the proHRIS as well as how they interact. For the design of the system possible methods of performing a process oriented HRM are presented as well as methods for the functionality of the proHRIS

knowledge type	contributions
prescriptive knowledge	
constructs	The thesis provides definition of relevant constructs in the context of process orientation of HRM and proHRIS, i.e., elaboration of the components of proHRIS, description of relevant actors, definition of employee, qualification, goal, position assignment concepts, etc.
models	The thesis presents diagrammatic models of the components to be used in a proHRIS that show the individual components as well as their possible interactions. An exemplary modeling notation for the representation of problems in the HRM domain under a specific process oriented point of view is described. Furthermore, more general requirements of modeling notations that combine business process management (BPM) aspects with HRM aspects are presented.
methods	The thesis discusses general process oriented approaches to the core HRM activities. The application of existing methods from the BPM domain through a proHRIS for the support these activities is elaborated upon.
instantiations	The thesis shows a specific instantiation based on a subset of the components of the designed proHRIS. In a similar fashion the presented modeling notation represents a possible instantiation of the notation to be used for working with a proHRIS.
descriptive knowledge	
classification	The thesis elaborates on a possible positioning of proHRIS in the context of IS in general as well as in the context of specifically process oriented IS. Furthermore, a possible categorization of different types of proHRIS is discussed.

Table 1: Knowledge contributions presented in this thesis (cf. Gregor & Hevner, 2013).

described. To evaluate the proposed design an instantiation of a subset of the features belonging to the proHRIS is created. An overview of the knowledge contributions aimed for in this thesis is given in table 1.

1.3 Methodology and structure of the thesis

This thesis follows a pragmatic research approach, i.e., the creation of an artifact that solves a specific problem. The approach used is based on the “design science” approach as popularized by Peffers, Tuunanen, Rothenberger, and Chatterjee (2007) as well as the ideal-typical research process described in Österle et al. (2011).

The steps of the process are outline in figure 3.

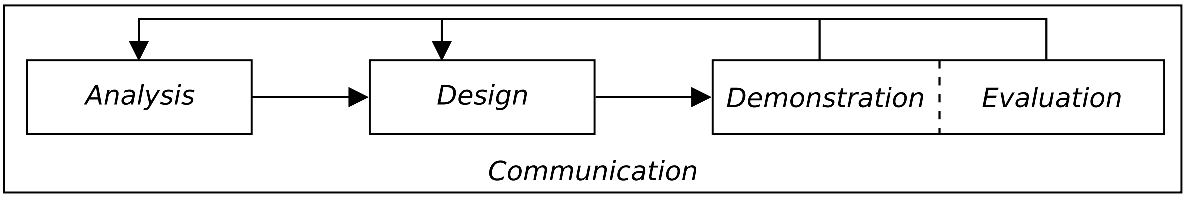


Figure 3: General research process used in this thesis.

Analysis Design oriented research aims at solving specific problems, or classes of problems. The source of these problems can come from the practitioners community as well as scientific community. An important first step in any research project is a clear identification of the problem and its components. A state of the art can show existing research regarding the problem and possible solutions. This also helps in explaining the motivation for the research, as well as the value of the proposed solution.

Design The actual design of the artifact that solves the specific problem identified in the analysis step can take the form of, e.g., models (modeling techniques or models instances), guidelines, prototypes, or ready-to-run IT systems designed for commercial use. An important aspect of the design is a clear and plausible justification for each component of the artifact as well as a delimitation from existing solutions for the given problem.

Demonstration and Evaluation To show and judge the success of the artifact in solving the described problem generally two possibilities coexist, one or more demonstrations of the solution for specific problem instances and/or a quantitative and qualitative evaluation of the solution with regard to the criteria defined in the analysis phase. The demonstration involves the application of the solution in experimentation, simulations, case studies, or other appropriate activities. In case of more abstract solutions, or solutions with a wide scope the creation of prototypes is an established method of demonstrating the feasibility and get a concrete object to get a firmer grasps on the potential advantages and problems (cf. Wilde & Hess, 2007, p. 282).

Another possibility to judge the success of an artifact is that of evaluating the created solution. The evaluation of the solution and the overall research process is a crucial part of research and many methods of evaluation exist depending on the type of the created artifact (cf. Hevner, March, Park, & Ram, 2004, p. 86) and used research methods. Conceptually, such evaluation could include any appropriate empirical evidence or logical proof. When evaluating a designed artifact or performed demonstration, the researcher can decide whether to iterate back to the analysis task or the design task to try to improve the effectiveness of the artifact or to improve the analysis of the problem. Another possibility is to communicate the current results and leave further improvement to subsequent projects. Whether further iteration are possible, depends on the nature of the research project at hand.

Communication A wide spread dissemination of research results is aimed at in any form of research. Possible ways of spreading the results include scientific articles, practitioners articles, conference contributions, lectures, dissertations, textbooks, open source software,

> creation of enterprises, implementations of research results in public or private enterprises, etc. The communication of research results and the research method also serves the purpose of allowing external evaluation of the results as well as the employed research methods. This can occur in form of the peer review of journal or conference submissions, the examination of theses, or the discussion after lectures or conference presentations. The communication is not a final part of the research process but can occur after any of the steps of the process itself, i.e., researchers can present the analysis results and gather feedback through peer review before starting with the design of an actual artifact.

The research project presented in this thesis follows the structure of the general process outlined above. The thesis itself can be considered as a step for the dissemination of the results of the research and a possibility for feedback from the community. The structure of this thesis, therefore, focuses on the steps analysis through evaluation.

As such, after this introductory chapter (chapter 1), the general concept of a process oriented human resource management (proHRM) is developed in chapter 2. The reflections recorded there can be considered as part of the analysis phase, as they help to delimit the object which the to be designed information system should support. The delimitation of this new problem context is achieved through the presentation of concept of HRM (section 2.2) that is complemented by a delimitation of the concept of process orientation (section 2.3). Based on the discussion of both of these concepts a delimitation of the specific understanding of proHRM used in this thesis is presented (section 2.4).

A second step in the analysis is the discussion of existing solution artifacts that are to be used as a basis for the design of the new solution (chapter 3): HRIS and process oriented IS. Each of these offer solutions for the two problem contexts which make up proHRM. In a first step therefore HRIS are delimited (section 3.3) and then the specific properties that result from a support of process orientation in IS are described (section 3.4).

Chapter 4 represents the core of this thesis. Here the actual proposed design of a proHRIS is presented. The description of the individual components and their interrelationship is split into three parts. In a first step the requirements stemming from the problem context and also shown through the existing solution artifacts are elicited (section 4.2) and a fundamental understanding of a proHRIS is defined. Based on this understanding and the requirements the proHRIS is presented by first giving an overview of the components and actors involved with the system and then describing each component as well as the interactions between components in greater detail (section 4.3). In a final step the bridge between a proHRIS and proHRM is further expanded by discussing the core activities of a proHRM and linking them to the specific components that support them and the overall business process life cycle (section 4.4).

The next step of the general research methodology, the demonstration and evaluation, is represented in chapter 5. Here the created prototypical implementation of a proHRIS for the area of staff assignment is described. For this the general requirements discussed previously are refined for the specific topic (section 5.2.1). Then a modeling notation for the use in the implementation is described (section 5.2.2) and finally the concrete implementation of the prototype is presented (section 5.2.3).

The prototype is then appraised through the discussion of an explicit use case, that demon-

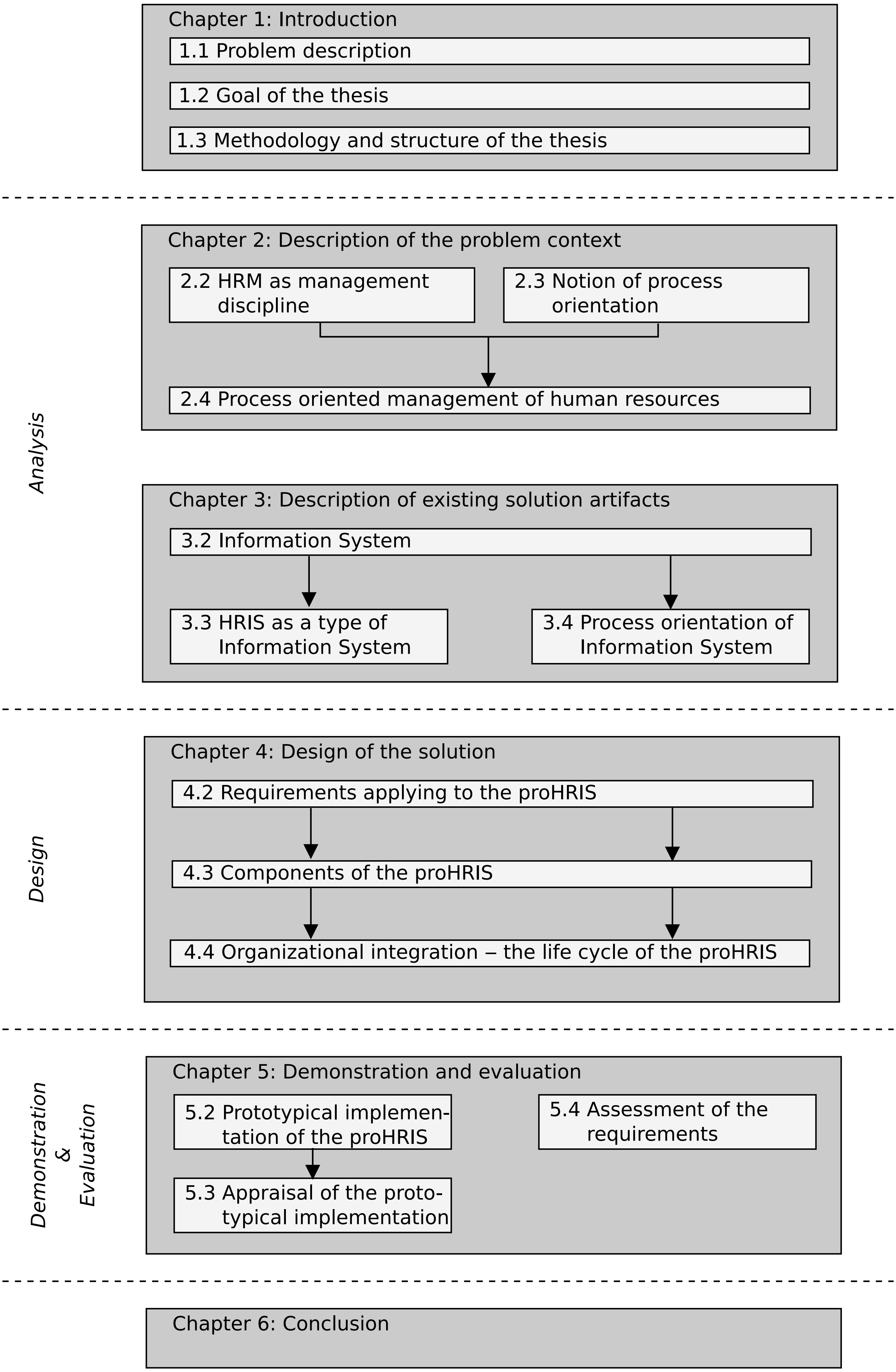


Figure 4: Structure of the thesis.

strates the working of the system as well as a discussion of the lessons that could be learned from the implementation itself (section 5.3). The evaluation is concluded with an assessment of the set requirements and a discussion of how the systems fulfills them (section 5.4). The thesis concludes with a summary of research as well as a discussion of further research possibilities (chapter 6).

A visual overview of the structure of the thesis and the relationship between the chapters, the sections, and the research methodology is given in figure 4.

2 Description of the problem context – process oriented human resource management

2.1 Approach of this chapter

The research opportunity seized in this thesis is that of applying and adapting existing solutions to a new problem context. For this, in a first step, the new problem context has to be defined. The problem context of this thesis is that of proHRM. And the developed solution is that of a proHRIS to support the activities of proHRM. While proHRM constitutes a new field, it naturally can be approached from the field of classical HRM. In combination with the notion of (business) processes and the orientation of managerial activities in organizations around operational business processes, HRM can serve as a basis for a first tentative definition of proHRM.

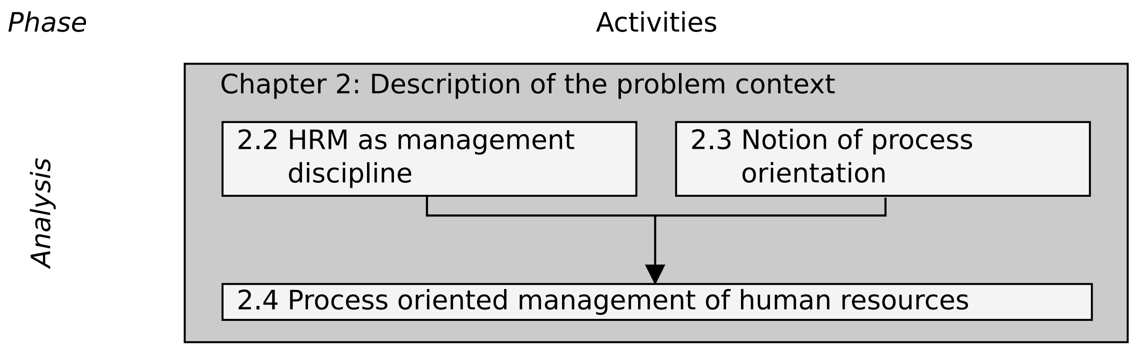


Figure 5: Approach chosen to describe the problem context.

This chapter therefore introduces HRM as a management discipline (section 2.2) and describes the concept of process orientation in organizations (section 2.3). Specifically BPM as the core management discipline of business processes is introduced and business process modeling as the natural language for explicitly representing business processes is described. However, an indepth analysis of the reasons for a process orientation in organizations is not elaborated in detail. Process orientation is taken as a given, i.e. a new phenomenon that HRM has to adapt to. Based on this foundation a first definition of the new field of proHRM (section 2.4) is given (see figure 5).

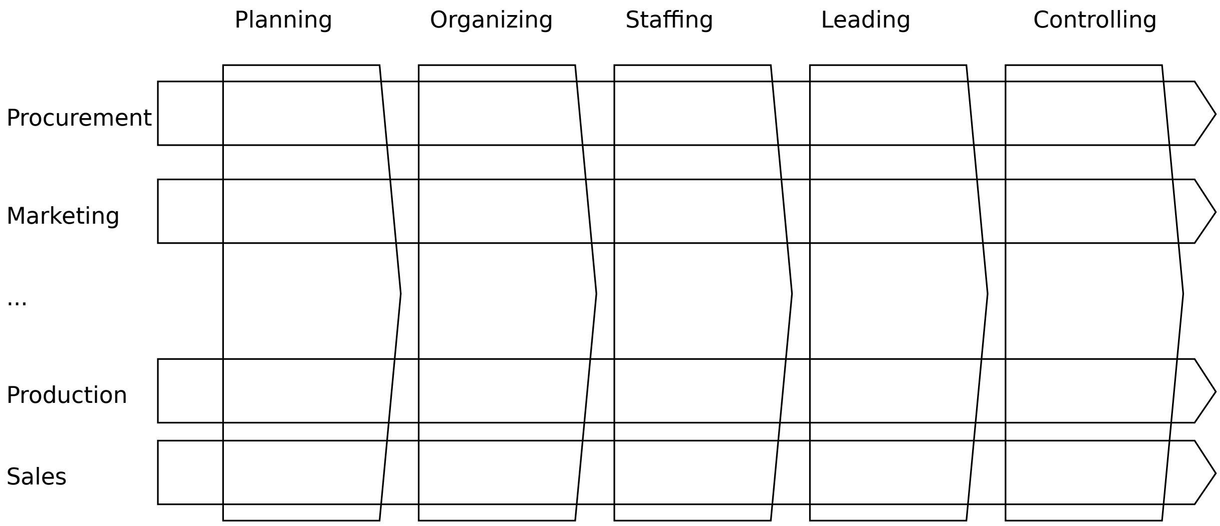


Figure 6: Management functions in relation to the core functions of an organization.

2.2 Human resource management as a management discipline

2.2.1 Definition of Human Resource Management

As HRM can be seen as part of the management function (in a broader understanding) as well as management of the human resources (in a narrower understanding), a short discussion of the terms “management” and “human resources” is appropriate before a definition of the term HRM is presented.

The term management (in a functional conception; cf. Staehle, Conrad, & Sydow, 1999, p. 80; Buck et al., 2014, p. 25; Steinmann & Schreyögg, 2000, p. 6) refers to the goal oriented design and control of complex sociotechnical systems, especially organizations. These activities are set apart from those of the actual working of the system. There are two understandings of the term management which delimits the activities that fall under the concept: a broad understanding and a narrow understanding. In the broad understanding the management activities are classically characterized as planning, organizing, staffing, leading and controlling (Steinmann & Schreyögg, 2000, p. 8). The operational activities are grouped by the department that executes them: procurement, production, marketing, sales, etc. Management activities target the operational activities and cannot exist without them (see figure 6). In a narrow understanding management refers only to the planning and controlling of any operational activity (Steinmann & Schreyögg, 2000, p. 7).

The term human resource can describe both the workforce in an organization and the department charged with administrative duties such as payroll and benefits (Gilley, Gilley, Quatro, & Dixon, 2009, p. xv). When referring to the workforce, human resources are the “entirety of the performance potential available to the organization through its employees”(Bartscher, Kleinhenz, & Werding, 2009). The term human resources is used to put a focus on the value of employees being more than simply production or cost factors (Büdenbender & Strutz, 2011, p. 135;Lengnick-Hall & Lengnick-Hall, 1988, p. 453). Employees are seen as creating value for the organization and can directly lead to a competitive advantage. In contrast, the term personnel has a stronger notation of employees as cost factor (cf. the human capital theory; e.g., in Sweetland, 1996).

Against the background of the management functions, the term “Human Resource Management” as a combination of “management” and “human resources”, leads to understanding HRM as part of the management process, i.e., the staffing function (Bratton & Gold, 2000, p. 11). Its purpose is to fill the structure created in the organizing function with employees able to fulfill the planned tasks. The usage of the term human resources implies a more strategic view, human resources being understood as an investment instead of just a cost factor that should be reduced whenever possible.

Definition 1. Human resource management (HRM) comprises the entirety of activities performed to support the optimal execution of the core processes with regard to human resources.

This is a very broad definition that understands HRM as a generic term (Storey, 2007, p. 6), but is sufficient for the purpose of this thesis with the concept being further elaborated on in the following sections and chapter 4. A single more precise definition is hard to find in the scientific literature, because of the broad use of the term “human resource management” (e.g., Boxall & Purcell, 2000; Wächter, 2013). The central elements of HRM, the employees or the personnel of an organization are complex entities that are subjects to multiple scientific disciplines (business administration, psychology, jurisprudence, industrial engineering, etc.). This has resulted in a very wide range of possible definitions for and different conceptions of HRM. The understanding of HRM in this thesis is also referred to as the managerial understanding of HRM. For a discussion of other possible perspectives (economic perspective, politic perspective, etc..) or other categorization approaches see, e.g.,Ortlieb (2010, p. 9),Armstrong (2006, ch. 1),Stock-Homburg and Stock (2008, ,pp. 6-15),Scholz (2004, p. 430) and the literature given there.

2.2.2 Description of Human Resource Management goals

While the main goal of HRM is to ensure the successful fulfillment of an organization’s strategy, it makes sense to further distinguish that goal as the later development of a supporting IS should also support these goals. Following Stock-Homburg and Stock (2008, p. 11) three main aspects can be identified:

- administration
- value-added
- competitive advantage

From an administrative viewpoint the goals of HRM certainly include the execution of administrative tasks such as documenting personnel movements, administrating leave requests, handling payroll, etc. These goals have a more operative meaning in that they do not directly create an added value for the organization, but are nonetheless necessary for its operation. While the recent HR literature tries to focus more on other goals of HRM (see below), the correct fulfillment of the administrative task are still an integral goal of each HR department.

Taking a more managerial view one of the core goals of HRM certainly is to create a genuine value-added for the organization. This includes goals such as development of leadership, increasing the satisfaction of employees with their work, or optimize the long term employee retention as well as manage knowledge in organization (Longenecker & Fink, 2013, p. 30).

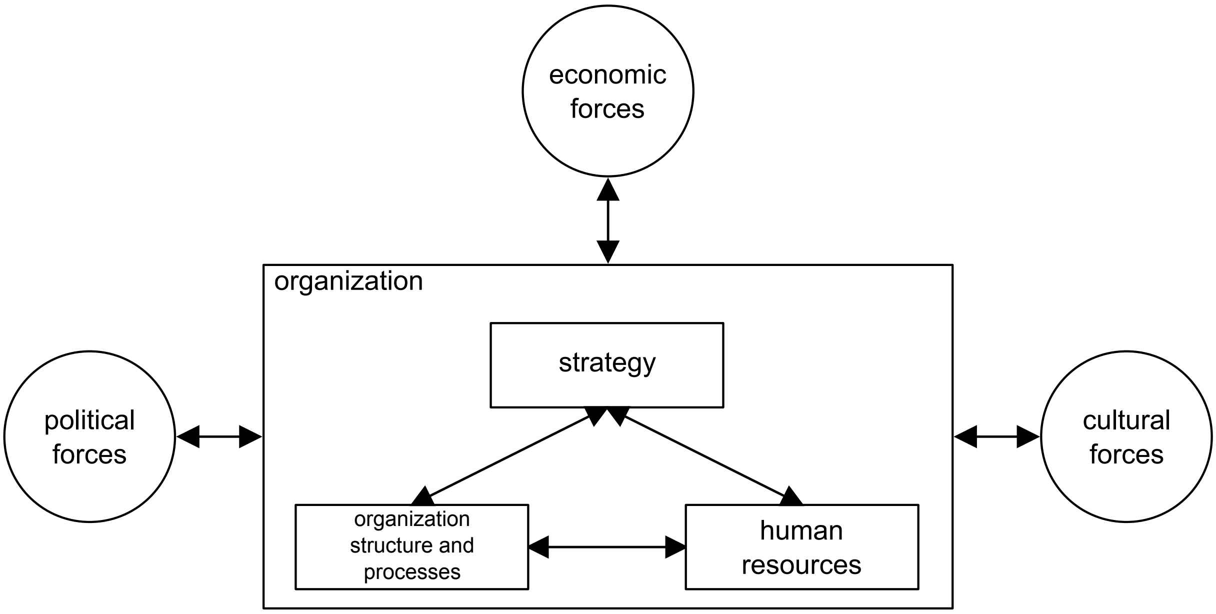


Figure 7: Core elements of an organization (based on Tichy et al., 1982, p. 48).

A third type of goal relates to gaining a competitive advantage for an organization. An important keyword in the discussion of HRM as a factor of competitive advantage is the "fit" (for an in depth discussion of the concept see Boon, 2008 and section 2.4.1). The basic premise is that organizations adopting a specific strategy require different HR practices than organizations adopting alternative strategies (see Delery, 1998; Delery & Doty, 1996, as well as the sources given there). While there are many dimensions to the fit HRM tries to achieve, three main types of fit can be identified: the "vertical fit" between an organization's strategy and human resource practices, the "horizontal fit" between the organizational structure and human resources and the "external fit" between an organization and its competitive sector (Boxall & Purcell, 2000, p. 187). The achievement of an optimal fit is, therefore, one of the long term goals of HRM as only through that fit a real advantage can be created. This can include taking into account more strategic aspects in personnel planning or personnel development, to ensure that employees have the qualifications needed for an organization to prevail long-term in a market (external fit). Other goals might be the matching (or even creation) of career plans to include available positions in the organization and long-term management of how which employees to selected for specific paths (horizontal fit). The relationship between HRM and other parts of the organization are shown in figure 7.

2.2.3 Presentation of the human resource cycle as framework for human resource management functions

The specific activities that comprise HRM differ from organization to organization. However, four generic functions of HRM can be identified (Tichy et al., 1982, p. 50): staffing, appraisal, development and compensation. Following a process view these can be seen as functions that represent sequential managerial tasks. Figure 8 shows the functions in relation to each other and a central element, the performance of the employees. In the following paragraphs a short description of each function is given. It should be noted, however, that each activity performed in one of these functions can relate to or even (depending on the broadness of its understanding) include activities described here under a different heading.

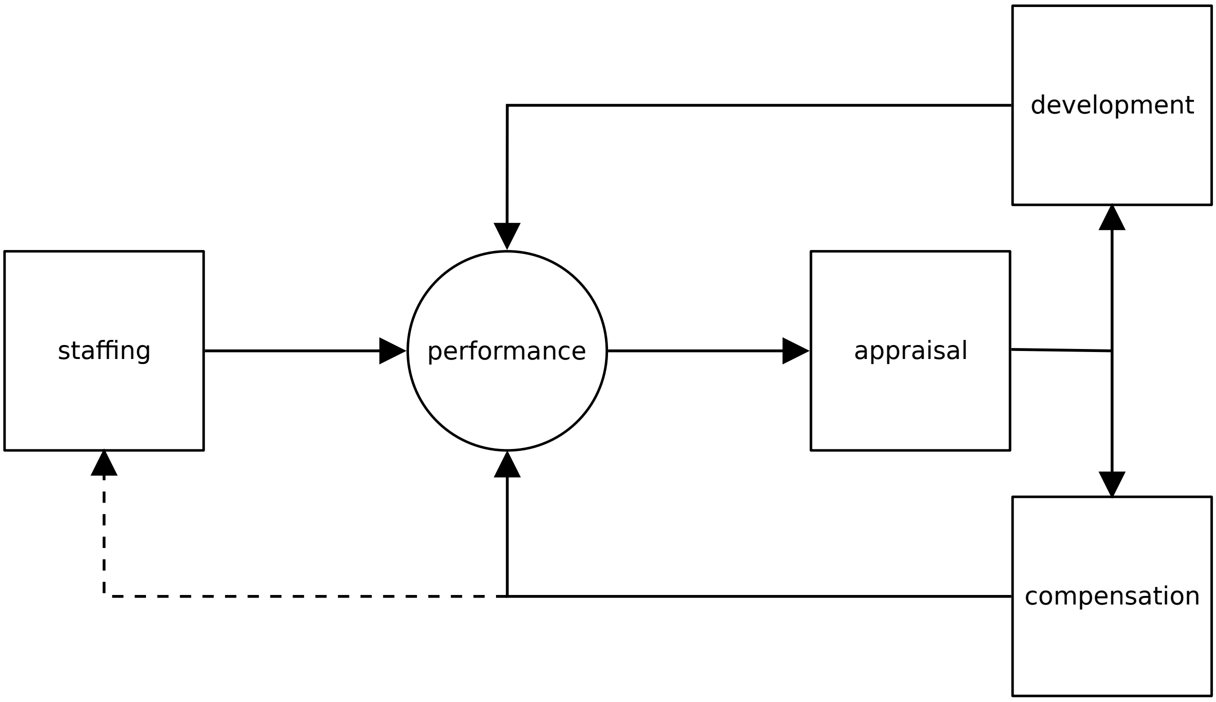


Figure 8: Human resource cycle (based on Tichy et al., 1982, p. 50).

The *staffing* function includes all activities related to the movement of people inside and from outside of the organization. It includes recruitment activities as well as personnel placement and personnel retention. It is often described as matching available human resources to jobs in the organization (Caruth, Caruth, & Pane, 2009, p. 1). However, depending on the cultural setting (see figure 7) it can also mean finding a position for employees fitting the organization (Sekiguchi, 2004, p. 190). In its broadest understanding staffing can also include activities that would normally be summarized in the concept of appraisal. To be able to judge whether an employee fits to a position or a task that match must be appraised. Activities in staffing range from very operational tasks such as creating job posting over strategic tasks such as designing and implementing a recruitment strategy for a new locality to planning activities such as analyzing the activities and positions in a process to define the requirements for personnel.

The performance of employees in the organization and, therefore, the organization itself is – as mentioned above – a result of this assignment, the rewards process and the development process. The rewards and development processes, however, are mostly based on the results of the appraisal of the employees' performance. The *appraisal* function groups the activities responsible for that appraisal. This includes activities from the day-to-day control systems, to strategic decisions about which appraisal results should be valued. The process of appraising employees and making sure this appraisal is fair (M. S. Taylor, Tracy, Renard, Harrison, & Carroll, 1995) and goal oriented is often also conceptualized under the term performance management (Fletcher, 2001).

Performance management in its broad definition, however, also includes task attributed here to the development or compensation function (Armstrong, 2000, p. 15 ff.).

The *development* function contains activities that are designed to ensure that employees have the proper qualifications for the task they are to carry out. Activities range from on-the-job training activities to strategic general development guidelines. Another term often referred to in this context is knowledge management. Knowledge management sees the knowledge in an organization as a resource and aims at managing its creation, acquisition, organization distribution and application (cf. Hislop, 2013; Ruggles, 1998).

The *compensation* function includes activities that deal with rewarding employees. Possible rewards are not limited to pay in its various forms but include, besides others, praise or promotions as well (cf. Baker, Jensen, & Murphy, 1988; Rynes, Gerhart, & Minette, 2004). The compensation function includes activities from the wage and salary administration to linking the reward system to the organization's long-term business strategy.

2.3 Notion of process orientation in an organizational setting

2.3.1 Definition of (business) process orientation

From a linguistic point of view the term "process orientation" can be seen as a combination of the terms "process" and "orientation". In common parlance a process is "a series of actions or steps taken in order to achieve a particular end"(*Process [Def. 1]*, n.d.).

Besides other meanings, the verb "to orient" refers to "tailoring or adapting (something) to specified circumstances"(*To orient [Def. 2]*, n.d.). At the same time "orientation" can also refer to the state of being oriented ("Orientation [Def. 1b]", 1996) or "the relative position or direction of something"(*Orientation [Def. 1.1]*, n.d.). In combination with the term process, "process orientation" can have two meanings: first the adaptation of something to processes. Process orientation can, therefore, be understood as the extent to which something is adapted or tailored to processes. Second "process orientation" can be understood as the direction or positioning of something towards processes.

In the context of business administration, the term "process" is generally used as short for business process. There are a multitude of definitions of the term "business process" in the scientific and practitioners literature (for a discussion of the different definitions and problems in defining the term see, for example, Melao & Pidd, 2000;Lindsay, Downs, & Lunn, 2003). For this thesis the following definition (based on Weske, 2012, p. 5;Dumas, La Rosa, Mendling, & Reijers, 2013, p. 5) is sufficient.

Definition 2. A business process is a collection of inter-related activities inside a single organization that are performed in coordination inside an organizational and technical environment to realize a business goal. The activities are executed by information systems or staff members. In their sum business processes implement the business purpose of an organization.

This definition is a bit more lax than the very strict definitions that define only end-to-end business processes from external customer to external customer as complete business processes. All processes inside an organization are seen as business processes, as long as they realize a business goal. In practice there can be processes in organizations that do not fulfill any real goals. These processes are seen as redundant or unnecessary and removed in optimization attempts.

In common parlance and scientific literature business processes can be seen on two different levels: type and instance. The two concepts are borrowed from computer science where type (or class) and instance are used in programming. Types represent abstract definitions of objects, while instances represent specific realizations of those definitions. On a type level business processes are concepts of how activities are performed in the organization. They are modeled, documented, analyzed and optimized. Each business process type can have multiple business process instances. A business process instance represents the specific execution of activities belonging to the business process. While it is not possible to directly observe the duration of activities in business processes on a type level, the duration of activities in specific business process instances can directly be observed.

Business processes can also be categorized by their degree of structure or predictability (see Georgakopoulos, Hornick, & Sheth, 1995, p. 124ff.; Oberweis, 1996, p. 14 ff.; van der Aalst, Stoffele, & Wamelink, 2003, p. 310; Dumas et al., 2013, p. 107ff) ranging from unframed processes over ad hoc framed, loosely framed to tightly framed processes. Processes are characterized as unframed if there is no explicit process model representing them. Ad hoc framed processes are defined before their enactment, but are only performed a few times before being changed or discarded. These could, for example, be processes in projects, that are only executed once for the project. A process can be said to be loosely framed, if there is a prior process definition that documents the standard process flow but specific enactments of the process are allowed to deviate from this definition within a certain range. An example of this are general administrative processes which normally follow predefined steps but can be deviated from when necessary as long as social or organizational rules are followed. In contrast, a tightly framed process consistently follows a prior definition of the process.

In the context of business administration the term “process orientation” in fact refers to “business process orientation”. Based on the generic definition of process orientation above it encompasses two things: first a change of how an organization is perceived (orientation as direction) and second a change in actions relating to the organization (orientation as adaptation).

By adopting a process oriented view of an organization the most prominent components of an organization become its business processes (Rummler & Brache, 2013). Such a view can be used as a base for all activities related to the organization (Gaitanides & Ackermann, 2004) resulting in a process oriented interaction with the organization.

Process orientation in the context of business administration (and this thesis) is defined as follows.

Definition 3. Process orientation is adapting one’s actions based on a perception of the organization that focuses on its business processes.

Therefore, something is process oriented when its actions are based on and aligned to the business processes in an organization (cf. McCormack, 2001; Willaert et al., 2007).

One example of this is organizational design. When using this process oriented view in designing (or redesigning) an organization the result is a process oriented organization. In such an organization the organization's core components are seen as business processes and these business processes are the basis for its formal structure and for strategic planning activities (Kohlbacher & Gruenwald, 2011). Such a process oriented organization is also referred to as "horizontal organization", "process-centered organization", "process enterprise", "process-focused organization","process approach" or "process organization" (see Kohlbacher, 2010, p. 135 and the provided literature there).

From a historical point of view the idea of a process oriented view of the organization gained popularity in the latter half of the 20th century. While the idea that an organization consisted of structures as well as processes was nothing new, generally the structure of organizations was used as basis for any management practices and dominated the processes (Gaitanides & Ackermann, 2004, p. 5). This dominance of the structure over processes was broken when different management approaches that focused on business processes gained popularity (e.g., Armistead & Rowland, 2007; Hammer, 2010). The understanding of process orientation in that context fits into the more general definition given above: "Process centering, more than anything else, means that people [...] in the company recognize and focus on their processes" (Hammer, 1997, p. 9).

Davenport and Short (1990) even articulate that process orientation actually refers to the management of said organization and how much it thinks in processes and not functions. As business processes are at the core of a process orientation the following sections briefly explain management approaches that focus on them and the idea of process modeling to explicitly describe them.

The reasons for an organization to adopt a process orientation or a process oriented organizational design are manifold. However, most organizations choose a process oriented approach in the hope of increase organizational performance. Studies find significant associations with a strong process orientation in organizations and their performance (e.g., Kohlbacher, 2013; Lavassani, Movahedi, & Kumar, 2010; McCormack, 2001; Škrinjar, Vukšić, & Štemberger, 2010).

In a survey published in 2013 the relationship between dimensions of process orientation in an organization (organizational structure, the application of continuous process improvement methods, organizational culture, etc.) and different aspects of an organizations performance where analyzed (Kohlbacher). The results (see table 2) show that, for example, the quality of a product is improved through the usage of stringent process performance measurement. Interestingly the broadest influence is the establishment of a process oriented culture in the organization. The dimension captures the organization wide understanding and adoption of process orientation as a way of understanding the organization. It is measured through items such as process workers' knowledge about process design, inter-departmental teamwork, customer-focused attitude of employees, use of process language, etc. (see Kohlbacher, 2013, p. 251).

2.3.2 Definition of business process management

Business process management is a management approach that focuses on business processes as the core part of an organization. For this thesis the following definition is authoritative (see also Dumas et al., 2013; Hill, Sinur, Flint, & Melenovsky, 2006; van der Aalst, ter Hofstede, & Weske, 2003).

dimension of process orientation	ret. on sales	ret. on assets	prod. quality	cust. satisf.	delivery speed	time to market speed	delivery relia-bility
performance measurement	-	-	▲	-	-	-	-
organizational culture	▲	-	-	▲	▲	-	▲
organizational structure	-	-	-	-	-	▲	-
continuous improvement	-	▲	-	-	-	-	-

Table 2: Effects of process orientation on an organizations performance (based on Kohlbacher, 2013, p. 255).
▲ denotes a positive influence

Definition 4. Business process management (BPM) is a process oriented management discipline. It comprises designing and analyzing, implementing, enacting, and evaluating of operational business processes using a specific body of methods, techniques and tools.

This definition limits BPM to operational business processes (van der Aalst, ter Hofstede, & Weske, 2003). This refers to the targeted time frame and focus of the business process. Operational business process generally have a short time frame and represent day-to-day activities of an organization. The longer the targeted time frame and the wider the focus of business processes is (from operational via tactical to strategic) the harder and less useful an explicit representation of the business process becomes. Without explicit representation, however, processes can not efficiently be enacted and analyzed using software tools (see also section 2.3.3). There is a trade off between the amount of work that is needed to make a process explicit and the use that is gotten out of this explicit representation. Generally speaking the more structured a process is and the more it is repeated in the day to day activities of the organization, the more use an explicit representation of the process can provide (there are different opinions on this, e.g., Hammer, 2010, p. 11, who is of the opinion that even low-volume, creative processes should be explicitly defined, since any explicit process definition is better than no process definition).

The different actions named in the definition also stand for different phases in the life cycle of business processes and can be seen in a temporal relation. There are many views on the life cycle of business processes which also appear under different terms: "business process management life cycle" (Dumas et al., 2013; Lodhi, Köppen, & Saake, 2011; Weske, 2012), "process management life cycle" (zur Muehlen & Rosemann, 2004) or "process improvement life cycle" (Hill et al., 2006). The following description is based on the above definition and the life cycles phases described by Weske (2012) and van der Aalst, ter Hofstede, and Weske (2003). While the naming conventions and specific number of phases differ from author to author the phases described below generally all are executed in the given order and contain the same steps.

The life cycle of a business process can be split into 4 phases: the design and analysis of the business process, the implementation of the business process, the enactment of the business process, and the evaluation of the business process (see figure 9).

The "design and analysis" phase is concerned with creating explicit models of business processes. Those are either based on the implicitly existing models in the head of the employees performing it ("as-is" modeling, or process discovery) or represent business processes as they should be ("to-be" modeling, when this step is the result of an evaluation of the process itself) (Dumas et al., 2013). Some sources, therefore, split this phase into multiple sub elements to emphasis the distinction between as-is-modeling and to-be-modeling. This step is generally combined with an analysis of the model, which can also provide feedback to or entice a remodeling of the processes.

The analysis can be split into two parts. One is the analysis of the process model, focusing on finding problems with the model itself. The analysis of the process model generally consists of the validation and verification of the model and is further elaborated on in section 2.3.3 (see also Mendling, 2009). The other part consist of an analysis of the business process itself. Here the identification of issues with the process is the focus: for example, the localization of root causes for process inefficiencies (Conger, 2010). The question answered by the analysis, therefore, is "Why does a process perform (as poorly) as he performs", while the to-be-modeling itself answer the question of how a process should be structured to perform better.

The implementation phase represents the realization of the modeled business process. This includes the definition of all organizational rules and regulations as well as possible information systems design, configuration and initial operation. Whether there is an organizational or informational implementation of the process depends on the given circumstances in the organization. It might be that the whole process is realized through a software system without human interaction, in which case the organizational aspects remain minimal (van der Aalst, 2009a).

The enactment of business processes comprises all steps necessary to support the execution of the modeled business processes (be it either the virtual execution through software systems, the actual performing of the process through humans, or a combination of both). This includes the day to day management of the business process, the reaction to imminent problems during its execution and is mainly focused on specific process instances. In a (at least partial) informational implementation of a business process, workflow management system (WfMS) can warn managers if specific process instances remain in the same state to long or exceptions occur. During the monitoring of the process additional data can be collected via information systems or manually from managers, or employees. During the enactment this data is, however, mostly looked at on an instance to instance basis. The question answered during this phase is "Are there any problems with specific instances of the business process?".

In the evaluation phase the recorded data is then further aggregated and analyzed. Techniques adapted from classical data mining are used in an "process oriented" way, i.e., process mining (van der Aalst, 2011). The question answered in this phase is "How does the process perform?". Results of such an analysis can in turn help find problems with current process implementations which can either be worked on or lead to a redesign of the business processes bringing the process back to the design and analysis phase of its life cycle.

Based on this understanding of BPM and the business process life cycle it is now possible to differentiate BPM from earlier concepts such as workflow management (WfM) and business pro-

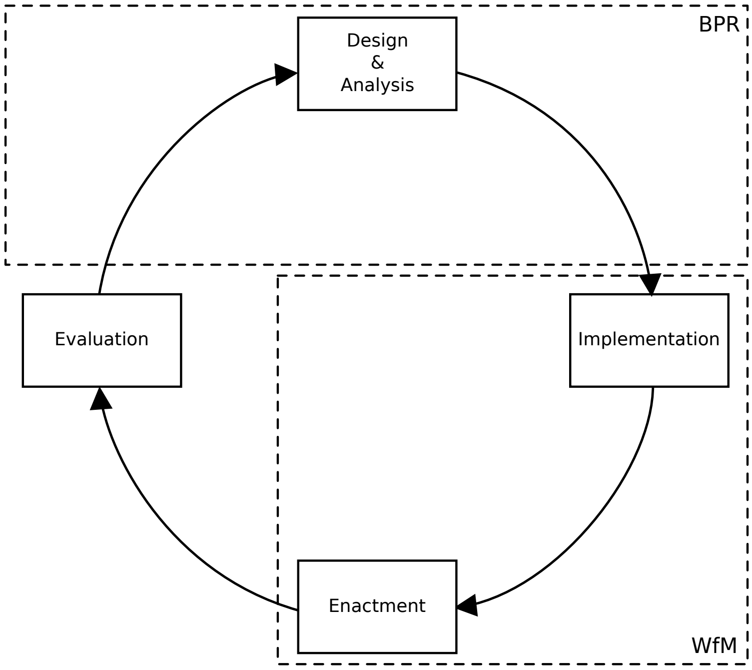


Figure 9: Business process life cycle (based on Dumas et al., 2013; Weske, 2012).

cess reengineering (BPR).BPR is a management paradigm that advertised a complete redesign of business processes (often times though of as a one-time project; Davenport & Short, 1990), starting with completely throwing out existing processes and beginning from scratch. Appropriately the seminal work describing this paradigm called for "obliterating" existing processes (Hammer, 1990; Hammer & Champy, 2001).BPM takes a more pragmatic approach to process redesign, enhancing them in an iterative fashion making them incrementally better, as well as encompassing the other phases (enactment, controlling and evaluation) of the life cycle (Dumas et al., 2013). As such BPR can be seen as the actions in the business process life cycle being performed in the "design and analysis" phase (cf. Ko, Lee, & Wah Lee, 2009, p. 748).

WfM focuses on the design and enactment of business processes with the help of specific systems. The focus is on the enactment and controlling of business processes through the use of workflow management systems (Workflow Management Coalition, 1999). The design of business processes is insofar relevant as it is necessary for a representation of the business process in the workflow management system.BPM expands on this focus by also analyzing enacted processes and finding way to redesign these processes to perform optimally.WfM can be seen as the enactment (and controlling) phase of processes in the business process life cycle.

For a more in depth discussion of other management disciplines and their relationship to BPM see the textbook from Dumas et al. (2013) and the literature given there (p. 31).

Organizations striving for a process orientation and following BPM associate certain benefits with such an adaptation. Generally three main benefits from a process orientation can be identified in the literature (Willaert et al., 2007, p. 2): cost reduction, agility increase, and customer satisfaction increase. Having an explicit representation, clear goals and optimization tools for business processes allow organizations to reduce their inefficiencies reducing the costs of processes. Having an overview of the processes in organizational units, their specific tasks and being able to standardize those processes allow organizations to react faster to external or internal contextual changes (Zairi Mohamed, 1997). Through it all the optimization of processes regarding the speed and quality has a positive impact on the satisfaction of the customers. An extensive and detailed overview of the effects of process orientation is also presented in the literature review by Kohlbacher (2010).

2.3.3 Definition of business process modeling

Business process models are an integral part of BPM, the business process life cycle, or even any process oriented interaction with an organization. They allow for an explicit representation of the business processes that constitute an organization from a process oriented perspective. The understanding of a model in this thesis follows a design-oriented approach that can be said to be generally accepted in the information systems research community (see Thomas, 2005, p. 25). Based on the definition of a business process the following definition of a business process model is authoritative.

Definition 5. A business process model is a goal oriented abstraction of a business process. This abstraction is often represented in a graphical way.

This definition specifies business process models as abstractions of business processes, more specifically business processes on a type level (see section 2.3.1). While it is generally true, that models do not represent specific instances of business processes, it is possible to represent a specific process instance in a graphical way that uses most of the same visual representations. One possible way is the "token concept" (based on the basic concepts of petri-nets; e.g., Murata, 1989; Dijkman, Dumas, & Ouyang, 2008). Other possibilities include the augmentation of the model with data from a specific instance (Bobrik, Reichert, & Bauer, 2007, p. 90).

The definition includes the orientation of the model towards a goal. This is because there can be many models for the same business process. Each model shows different concepts and relations of the real business process based on the intended use for its creation.

The process of creating a business process model is called business process modeling. To be able to create an abstraction of a business process, the modeler has to follow some kind of method. Since the created model should be goal oriented, the intended use of the model has to be clear in the beginning. While a modeling method describes how the business process should be abstracted, the modeler also requires a notation that defines the abstract rules of how the specific parts of the model can be connected between each other or the specific visual representation of elements of the model. For most intended uses a business process model is created using a modeling tool, that supports the modeler in creating the visual representation following a given notation. Normally this is a software, but can also just be a sheet of paper and a pen if the visual representation is created by hand. The different aspects of business process modeling are summarized in definition 6.

Definition 6. Business process modeling is the act of creating a business process model in a specific notation for a specific purpose, following a specific method and using a specific tool.

In the following paragraphs the individual elements of the definition are elaborated upon.

In many phases of the business process life cycle the main *purpose* of process models is to increase human understanding and support the communication between involved actors (B. Curtis, Kellner, & Over, 1992, p.76). The management of business processes is not done by one single actor, but by many members of an organization (at minimum 2 types of actors can be identified: modelers and domain experts; see Hofer, 2011). Each of these actors can have a different background and perspective on the business process. As such, business process models can help bridge the conceptual gap between each of the actors understanding of the business process.

There can, however, be a plethora of additional usages which range from process documentation, over process simulations to certifications for quality management. Following Rosemann, Schwegmann, and Delfmann the intended uses can be grouped into the categories "organizational management" and "application system development" (2005). A short excerpt from the most popular intended uses is given in the following section (see also Allweyer, 2005; Termer, Nissen, & Wessels, 2012).

Organizational management: In the context of organizational management process models can be used as process documentations. In a way similar to other organizational documentations such a job descriptions or organigrams depicting the organizational hierarchies, business process models contain information about which organizational unit executes which tasks in a process. Often additional information like who is responsible for the correct execution is added to the process model to make escalation procedures clear.

As described in the process life cycle process models can also be used as a starting point for process reengineering projects.

Application system development: In application system development business process models can be used in a multitude of ways. The functionality of enterprise resource planning (ERP) systems is often documented in form of reference processes. A possible point of reference for the selection of an ERP system can, therefore, be the comparison process models for typical processes in the organization with the reference process models of the system provider.

Similar to the selection of a fitting ERP system. Process models can also be used in the requirements gathering for specific software systems. In such a case the process models need to include specific elements describing the needed data structures, potential run-time requirements, security restrictions or other data related to the development of a software system.

The given examples of intended uses do not try to be complete and should only be seen as an example of the diverse areas in which business process modeling is used. For a further elaboration of possible uses see section 2.4.2 and the discussion in the literature (see, for example Aguilar-Savén, 2004; Rosemann et al., 2005).

Business process modeling is performed by following a specific *modeling method*. In the context of information system research a modeling method classically consists of two parts (see figure 10):

a description of one or more notations to use for a model and a description of the design procedure, that describes the essential steps to create the model (Braun, Esswein, Gehlert, Stark, & Weller, 2007, p. 5).

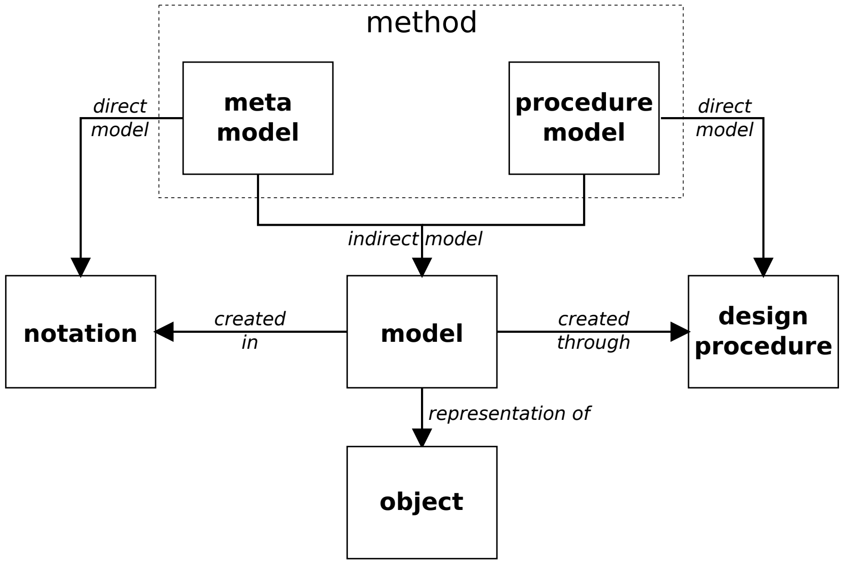


Figure 10: Relation between a model and the surrounding concepts (based on Braun et al., 2007).

Typically, the steps outlined in the modeling method are supported by one or more *modeling tools*. The term modeling tool as used in this thesis refers to software that supports a modeler in creating a business process model based on a specific notation. One advantage of using software tools for creating business process models, is that these models can later be reused in other software system that use the information available in the system (e.g.,WfMS). A distinction between general modeling tools and specific modeling tools can be made. General modeling tools supply generic shapes and visual elements that can be arranged to resemble the visual representation of a business process model in a specific notation. However, the logic that is represented in business process models is not available to the software tool itself and the model created in such a way, while visually fitting the notation, can not be used by other software systems to work with or on the given process model without additional parsing and converting of the model. Furthermore, the modeling tool is not aware of what type of concept a displayed shape represents, only its visual characteristics. Specific modeling tools, however, represent the business process model in such a way internally that the software is aware of the different elements and can perform notation specific analyses such as, for example, checking for syntactical correctness (see the paragraph about notation), finding deadlocks in process models or minimizing redundancy in the process. In this thesis “modeling tool” will always refer to a specific modeling tool unless otherwise stated.

Business process models, for any purpose, are created (either manually or with the support of a tool) in a specific *modeling notation*. There are a plethora of business process modeling notations used throughout the scientific community and even more by practitioners (for a comparison see, for example, Recker, Indulska, Rosemann, & Green, 2009). Every notation, however, consists of two aspects. A conceptual aspect and a visual aspect. The visual aspect is sometimes also referred to as specific syntax and the conceptual aspect differentiated to an abstract syntax and semantics (Frank & van Laak, 2003, p. 20). The conceptual aspect defines what concepts are used in the modeling notation. In a business process modeling notation this generally includes functions, events, organizational units, as well as decisions, logical and temporal relations, responsibilities, etc. It further more regulates how these concepts can be related to each other. The definition of the syntax(es) is often achieved by the means of meta-models (Becker, Mathas, & Winkelmann, 2009, p. 96). They define the concepts and rules after which a model has to be constructed (abstract syntax) as well as the meaning and possible relations of the concepts itself (semantics) as well as the rules of how to visually represent the elements (specific syntax).

The visual aspect defines how each concept is visually represented. While a modeling notation can have multiple ways to visually represents concepts (visual aspect, specific syntax), it can only have one meta-model (conceptual aspect) to stay the same notation (cf. Seel & Vanderhaeghen, 2005, p. 123). Table 3 shows a meta-model for the EPC concept function and some of its visual representations found in the literature and well known modeling tools.

The exact type of concepts that are included in a business process modeling notation depends on the intended use for the model (Rosemann et al., 2005, p.49). The literature, however, agrees on a set of areas from which most business process modeling notations borrow their concepts. This is also referred to as perspectives on business processes and follows the argumentation that since business process models are just abstractions of real business processes they do not capture the whole of the process but represent it from a specific perspective (for an overview of perspectives in different modeling notations see (B. Curtis et al., 1992, p. 78; Gadatsch, 2010, pp. 67-70). Since modeling notations try to cover a wide spectrum of possible intended uses, they often provide concepts from many of the well known perspectives. It should be noted, however, that there is no need to display all available elements in a specific model instance. To reduce complexity and improve the understandability of models it is often suggested creating specific model instances for relevant aspects of the actual business process (Gadatsch, 2010, p. 67). The most common perspectives are listed in the following (cf. B. Curtis et al., 1992, p.77;Giaglis, 2001, p.212;Scheer, 2002, p. 36).

functional: The functional perspective represents *what* process steps (functions, activities, etc.) are being performed.

organizational: The organizational perspective shows where process steps are performed and *who* performs them. It links the process to the physical and organizational structure of the organization.

informational: The informational perspective (also referred to as data perspective or input-output perspective) shows the informational resources consumed, produced or manipulated by the process. This includes information contained in physical objects (such as messages), as well as their electronic counterpart. Often the change to a specific world-state is represented in process models as events which can also be seen as informational objects either triggering the process or being created by it.

control: The control perspective describes when process steps are performed. It shows in what

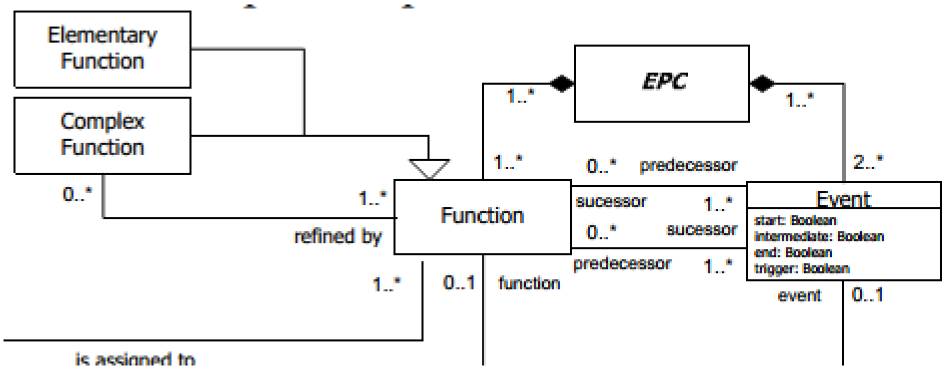
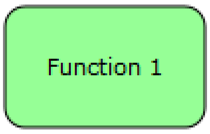
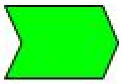
Type	Visualization
meta-model	
representation 1	
representation 2	
representation 3	
representation 4	

Table 3: Different visual representations for functions in the EPC (see also List & Korherr, 2006 for the meta model).

general temporal-relation different process steps are to each other. This perspective also exposes the logical structures (such as loops) in the process flow. It, therefore, also show *how* a process is performed.

2.4 Process oriented management of human resources

2.4.1 Motivation for a process orientation of human resource management

2.4.1.1 Discussion of sources for the need of a process orientation of human resource management

First indications of a process orientation in specific HR activities and HRM in general have been reported in the scientific literature, as well as in practitioners' reports (see the next section). The shift to a process orientation in HRM is, in fact, a natural development of HRM given the context of HRM as part of the overall managerial function and a general popularity of business process orientation in organizations. Two main sources for reasons for a stronger process orientation can be identified. The motivation can come from the area of HRM as well as from the area of BPM.

From a BPM point of view, a stronger process orientation of HR related activities is sensible as they add to a holistic management of the business processes. Typically, human resources are seen as a specific type of resource needed for the enactment of the business process (cf. zur Muehlen, 1999, Jung, 2007, p. 31 ff.). As such the explicit consideration of human resources allows for a more complete representation of the business process in form of a model and therefore a better management of the business process itself. This is represented in business process (management) maturity models through the growing inclusion of additional aspects of processes with higher maturity levels (cf. Röglinger et al., 2012; e.g., Rosemann & vom Brocke, 2010, p. 110 ff.).

From a HRM point of view, the motivation for a stronger process orientation can be found in the concept of the fit. As mentioned in section 2.2 the fit of HRM with other parts of the organization, as well as the fit of HR activities with each other plays an important role in the achievement of the goals of HRM. The concept of fit and the argumentation for a stronger process orientation following from its application to HRM in the context of a process oriented organization is elaborated upon in the following sections.

2.4.1.2 Description of the concept of fit in human resource management

Following Nadler and Tushman the fit (or congruence) can be defined as "the degree to which the needs, demands, goals, objectives, and/or structure of one component are consistent with the needs, demands, goals, objectives, and/or structure of another component" (1980, p. 45). The concept is generally used to explain the difference in performance of organizations (Wright & Snell, 1998).

For a more specific understanding of fit, the context in which the concept is used needs to be taken into account. The concept itself is common to many models that try to explain the performance of organizations. At least three approaches using the concept of fit can be differentiated in structural contingency research (Drazin & Van den Ven, 1985): the selection, interactions, and systems approaches (a further list of possible approaches can be found in Boon, 2008, p. 11 ff.).

Selection approach In selection approaches fit is assumed to be a premise underlying the congruence propositions between organizational context, structure, and process (Drazin & Van den Ven, 1985, p. 516). From a natural selection perspective in a long term view the fit is seen as a result of the process of adaptation of organizations that ensure that only the organizations with the best performance survive. From a managerial selection point of view the fit is the results from the choices made by managers to adapt the organization to the existing and changing contingencies the organization is facing.

Interaction approach Another possible interpretation of fit is that it represents the result of the interaction between the structure of an organization and its context and has an impact on its performance. A typical example is the relationship between environmental heterogeneity and structural complexity of the organization. A specific grade of heterogeneity with a specific amount of complexity in the organizational structure result in a specific performance of the organization (Drazin & Van den Ven, 1985, p. 518). The focus of research using such an approach does not necessarily lie with understanding the fit between structure and environment but explaining variations of performance or different organizational structures.

Systems approach Following a systems approach fit can be understood as a feasible set alternative designs, that are internally consistent and of equally effective with regard to a specific configuration of contingencies the organization faces (Drazin & Van den Ven, 1985, p. 515, 520). The systems approach maintains that an organizational designer has two basic tasks: (1) to select patterns of structure and process that best matches the contingencies (i.e., external factors) the firm is facing and (2) to ensure that these patterns of structures and processes are internally consistent. The reasoning for inclusion of the aspect of internal consistency results from the fact that multiple contingencies can require conflicting changes in organizational structure or process. So trade-off decisions have to be made to ensure a high performance of the organization (Drazin & Van den Ven, 1985, p. 521)

This thesis follows a systems approach understanding of the concept of fit. In the context of HRM, the concept of fit can be applied to multiple components. First on an organizational level the HR structures and processes are part of the pattern of structure and process of an organization that make up its design and that should be effective in relation to the contingencies the organization faces. The HR structures and processes, therefore, have to be specific to the external context of the organization.

Second, still on the organizational level, the HR structures and processes have to be consistent with the other parts of the organization. This includes the structural components, i.e., departments, but also the processes existing in other areas of the organization, e.g., the overall sales process. This is generally achieved by following the guidelines set forth by upper management, as they try to achieve this organization internal fit of the different components of the organization.

However, following the overall notion of a system, as consisting of individual components which themselves can be understood as systems, the concept of fit can also be regarded from a purely HR context. In this the component HR is seen as the system that has to react to contingencies, which now stem from the different aspects of the overall organization. This is equivalent to the internal consistence of the overall organization. From a point of view of HR these are contingencies that HR structures and processes need to take into account. Furthermore, the HR design must itself be internally consistent, i.e., the individual activities and structures have to work towards a common goal. The HR external contingencies can be contradictory and must be solved accepting trade-offs.

These different kinds of fit are often also referred to internal and external fit or horizontal and vertical fit. Internal or horizontal fit referring to consistency of the HR activities and structures with each other and external or vertical fit relating to the degree of consistency between HR and the overall organization (vertical fit relates especially to the fit between HR and the organization's strategy).

2.4.1.3 Discussion of fit as reason for the process orientation of human resource management

In this framework the fit offers a good explanation for the need of HRM to adopt a fully process oriented approach. The premise for these considerations is that a process orientation is one aspect that contributes to a better external fit for the organization. The current external contingencies can be faced more appropriately through a process oriented approach then others. This then has implications for the consistency of the structures and processes in the organization itself.

If the core activities of the organization, the value drivers, are viewed as interrelated and belonging to a coherent process, this has implications for the way how these activities are managed. In practice this has resulted a new type of management approaches (BPM). However, it can lead to an inconsistency between the parts of the organization that exhibit this focus on the business processes and the parts of the organization that still follow a purely functional primacy. This inconsistency results in challenges that have to be faced by the organization, e.g., reward systems based on the functional model are no longer viable in a strongly process oriented organization (e.g., Armistead, 1996, p. 49), vocational education paths no longer match the requirements of organizations (e.g., Bennett, 2002; Kremer, 2009), criteria for effectiveness and capabilities needed by employees change (e.g., Sparrow, 1998, p. 87).

A process orientation of HRM itself will help to deal with the created inconsistencies. This process orientation should encompass or at least impact all areas of HRM as otherwise the inconsistencies between HRM and other parts of the organization are simply replaced by inconsistencies between different parts of HRM.

Up to now the concept of fit has been discussed mostly from a static point of view. However, organizations operate in dynamic environments. Changes to the contingencies occur and organizations have to adapt to these changes, resulting in changes in their business and HR strategy. For HRM this highlights the need of flexibility as it will impact the effectiveness of the organizational (and HR) system (e.g., Wright & Snell, 1998, p. 757;Boxall, Purcell, & Wright, 2007, p. 58 ff.).

One of the fundamental advantages claimed by process orientation proponents is that a process orientation increases the flexibility of organizations, allowing them quicker reactions to changes in their adaptation to new or changed contingencies. For HRM this results in a gap between the speed of overall management being able to adapt to a changing context and that of classical HRM. Without operating itself on a process oriented premise HRM activities and structures will not be able to keep up with the changing organization around them, resulting in internal inconsistency of the organization. A specific example of this is that with processes being the first to adapt to changes in the organization,HR activities either have to generate the job descriptions directly from the processes or take the processes as basis for their task in order to not work on outdated information (Kohlbacher, 2010, p. 275).

The required consistency of organizational components can also be observed from a BPM point of view. The literature on BPM emphasizes the need for an integration of HR aspects in the implementation process of BPM initiatives (Hung, 2006; Ohtonen & Lainema, 2011; Trkman, 2010). On a practical level Kugeler and Vieting, for example, report that the early-on inclusion of HR experts could have saved a lot of time and effort in an BPM project (2000). Since the evaluation of positions in the given organization was partly based on special keywords in the position description (i.e."coordinating" being valuated higher than "supporting") all function names had to be rechecked taking this into account, before trying to automatically generate position descriptions based on process models (Kugeler & Vieting, 2000, p. 265). Next to their importance in the introduction of BPM,HR aspects are also important for the enactment of BPM. For example, measuring the performance of business processes implies evaluating and rewarding employees based on indicators that directly contribute the given process (Willaert et al., 2007, p. 4).

Since BPM strives to continually improvement business processes the integration of human resources as an additional parameter in this optimization process is also advantageous. As seen in the next section (section 2.4.2) process improvement methods already try to integrate more and more additional information about the resources needed for the execution of processes into the improvement process (e.g., Cabanillas, Resinas, & Ruiz-Cortés, 2011; J. vom Brocke, Recker, & Mendling, 2010; zur Muehlen, 1999). Information about the human resources, their capabilities, and their limitations as well as ways to affect those offer new dimensions for the improvement of business processes.

However, without a consistent and integrated approach in the form of proHRM the fit of HRM,BPM and the other internal components of the organization can not be achieved.

2.4.2 Review of existing attempts of process orientation in human resource management

2.4.2.1 Description of the review framework

The idea of a more process oriented approach to HRM is not completely new. Starting with the rise of the lean management movement and the general spread of the idea of process orientation effects and implications on HRM where also researched (e.g., Scheer, 1996, p. 31). To get an overview over existing attempts of a process orientation in HRM, a literature review was conducted. For this review research literature as well as practitioners literature was collected. The general properties of the identified literature and the used review framework are discussed in this section.

The literature itself was identified through an in depths literature search. This included a keyword search in popular scientific databases (such as "Science Direct","Academic Search","Google Scholar"), as well as forward and backward reference searches. After filtering duplicates and not topic specific literature 102 sources where considered for the review. An extensive list of the sources and their characteristics (see below) is given in appendix B.

The following sections discuss the identified attempts based on the main context to which it can be attributed with regard to the HR function that is to be supported. As such the context to which the attempts are assigned are "staffing", "appraisal", "development", and "compensation". If no specific HR function could be identified, or the attempts span multiple functions, the attempt is assigned to the "general" category. While the main structure of the review revolves around these categories, other characteristics of the attempts have been identified. These characteristics constitute a framework into which the identified attempts can be sorted. An overview of these characteristics is given in table 4. The identified features are: the source of the attempt, the understanding of process orientation followed in the attempt, the context in which the attempt was performed, the research approach used, whether the attempt was the primary focus of research, and the results of the attempt.

feature	manifestations			
source	BPM literature (61)	HRM literature (33)		practice (8)
understanding of process orientation	integrated (5)			
	internal (8)			external (89)
HR function	general (49)			
	staffing (25)	appraisal (10)	development (23)	compensation (6)
approach	design (56)	behavioral (25)		other(18)
focus	HR specific (74)			other (28)
result	method (33)	model (22)	tool (8)	discussion (38)

Table 4: Forms of process orientation attempts found in the literature.
The number in parentheses represents the number of sources that can be assigned to each category (see also appendix B).

The source of the attempt is important because it allows to judge the quality and maturity of the presented attempt. Furthermore, it gives context from which the attempt can be evaluated. Two research areas from which literature about process orientation in HRM stems can be identified:*BPM* and HRM. Additionally, there are *practitioners* reports that supply additional results in form of use cases, software documentation, or success stories. Practitioners reports can not directly be related to a BPM or HRM literature as they are not necessarily performed from a purely HR or process management point of view, but are often part of an organizational project that include multiple shareholders.

The source of the attempt has an influence on which HR function is considered in that attempt. The origin of the literature also correlates with the results insofar as practitioners reports either include specific tools that have been developed (e.g., Etz-Stuttgart, n.d.; Haak & Eekhoff, 2004) or empirical/anecdotal results and discussions based on those (e.g., Jereb, Kuchem, & Sohn, 2009; Sandau, 2011). Literature from scientific sources more often results in proposed methods or developed models.

The literature from the HRM field tries to grasp the concept of process orientation and understand its implications on classical HRM. The general effect is seen as positive, with process orientation representing a possibility for HRM. There are, however, also different opinions seeing a degradation in the quality of HRM work with increased process orientation (e.g., Turner, Huemann, & Keegan, 2007; Willmott, 1994).

Research originating in the BPM field also ventures more and more into the context of HRM. One example is WfMS and the research done to find optimal assignment of resources to the modeled workflow (e.g., zur Muehlen, 2004a). The more detailed and realistic the workflow models created become, the more they reach into the area of staffing and even personnel development.

Another relevant aspect for the analysis of the literature is that of the understanding of process orientation underlying the attempt of process orientation. There are two different understandings of process orientation of HRM in the literature: *internal* and *external*. An *internal* understanding of process orientation sees the HRM department itself as consisting of processes which can be documented, measured, optimized, and managed. From this point of view the methods and tools used to fulfill the goals of HRM do not need to be changed, but the importance of modeling and optimizing internal processes is emphasized. The literature following an *external* understanding of process orientation is emphasizing the focus on operational business processes in the overall organization. From this point of view a continuance of HR practices with the classical tools and methods diminishes the fit between HRM and the rest of the organization, as a discrepancy is introduced between the process based organization and the classical HRM activities which still focus on a structural representation of the organization which is not the primary item of organization. There a new type of methods and tools need to be developed that perform HR activities based on the actual operational processes instead of outdated structural representations. Of course these two views are not exclusive. Authors can emphasis the need of new methods and tools that focus more on the processes in the organization while still advocating for an optimization of the HR processes in which these methods are to be used. In fact, for a holistic process orientation both aspects are required.

Existing attempts at delimiting process orientation in HRM can stem from a *behavioral* school of thought or follow a *design* approach. *Behavioral* research looks at existing process oriented organizations, either on an individual level (i.e., a single organization) or on an aggregated level (i.e., a collection of multiple organizations) and tries identify key aspects of how HRM is designed in these organizations. Problematic with such results, however, is that they do not represent the archetypal proHRM but the then current state in a changing organization. One of the characteristics of switching to a process oriented understanding of an organization, is that this switch is not instantaneous throughout the organization. *Design* research attempts often create models, or tools representing a process oriented approach to HRM. They are often very specific in scope (e.g., a method for the process oriented elicitation of qualification requirements) and, therefore, only represent a part of a proHRM.

The attempts of process orientation can also be classified based on their focus. Either the research is mainly about another topic but residual results concern a process orientation in HRM or the research is directly related to process orientation in HRM. The residual results are often found in research articles that come from a BPM research area.

The research can also be differentiated by the result it produces. This depends of course of the research method chosen in each publication. Possible manifestations are: *method*, *discussion*, *model* (extension), (software) *tool*. Some publications present specific *methods* of performing parts of HRM with a focus on process orientation. Other work includes mostly *discussion* of empirical data collected, either in a quantitative or qualitative form. Other publication target the creation of *models*. They include extensions to existing business process modeling language or specialized modeling language to represent (in a process oriented form) HR relevant information. These models are often presented with an associated method. In rare cases the method and models are also implemented in actual software *tools* that can support the execution of the methods.

The review shows that while there are different attempts of a stronger process orientation in parts of HRM on a more detailed basis and for HRM in general on a very general basis, there are no attempts to holistically describe a proHRM, especially with regard to the specific activities involved. Furthermore, there is no existing system that supports a such a process oriented approach to HRM.

The next sections discuss the attempts which were identified in more detail, grouped by the context to which they can be assigned.

2.4.2.2 General attempts of process orientation in HRM

Attempts of process orientation in HRM that target the whole HRM and not specific functions and that take an external view of process orientation are not described in great detail in the literature. Several authors have presented elaborated methods and ideas on how the business process orientation of HRM can be achieved but those imply an internal understanding of process orientation (Böttcher, 2002; Cakar & Bititci, 2002; Cakar et al., 2003; Gontard, 2006; Schönenberg, 2010).

Research into an external process orientation of HRM from the HRM field early on discussed what characterizes process orientation in organizations (e.g., Drumm, 1995) and what this would mean for HRM. Later research reported on the need for and made observations about the effects the process orientation of an organization has on its HRM (Kabst, Larsen, & Bramming, 1996; Potoczek, 2011; Wickramasinghe, 2012; Zucchi & Edwards, 1999, 2000) in real organizations.

From the BPM field consideration of a process orientation in HRM are limited to relatively short statements. An example for this are the observations of Hammer regarding the maturity of process orientation in organizations. He states that in a truly process oriented organization “hiring, development, reward, and recognition systems reinforce the importance of intra- and inter-enterprise collaboration, personal learning, and organizational change” (2007, p. 5). How the different systems have to be designed to reinforce those aspects is not elaborated on however. Other research focuses on what relevant HR activities have to be executed for the successful realization of BPM initiatives (e.g., Jeston & Nelis, 2006b, p. 170 ff.; Scheff, 1994, p. 58ff.) noting also potential problems HRM could pose for a success realization and how to deal with those. Additionally, process oriented HR systems are identified as important for the maturity of the process orientation in an organization (Kohlbacher & Gruenwald, 2011, p. 275).

2.4.2.3 Attempts in the context of staffing

Staffing is one of the topics that quickly received attention after the popularization of process orientation. There are existing attempts from the HRM area as well as BPM area.

From a BPM point of view this is due to the fact that employees are limited resources similar to other limited resources such as machines, or materials. Process redesign initiatives, or process execution methods need to take this into account. Most attempts to somehow manage the selection of personnel from the BPM area, therefore, stem from the research in workflow management systems (zur Muehlen, 2004a). Here the main question to which researchers try to find answers is how to find the best fitting employee for the execution of a task in a process instance. Results of research in this context can be split into three categories: process models allowing the explicit representation and management of (human) resources (e.g., Etoundi, Ndjodo, Monessa, & Zobo, 2006; Koschmider, Yingbo, & Schuster, 2012; Ouyang, Wynn, Fidge, ter Hofstede, & Kuhr, 2010; Stroppi, Chiotti, & Villarreal, 2012), assignment methods (or rules) of tasks to resources (e.g., Cabanillas et al., 2011; Ly, Rinderle, Dadam, & Reichert, 2006; Rinderle-ma & van der Aalst, 2007), and concrete software artifacts supporting that assignment. The assignment criteria do not focus only on available time of the employee, or even qualifications, but try include additional social aspects such as relationships between employees performing tasks together (e.g., Shen, Tzeng, & Liu, 2003).

The personnel assignment problem is also examined in the more management oriented BPM literature, where analysis methods for business processes are devised that include qualifications (e.g., Leyking & Angeli, 2008) and allow the reorganization of business processes taking the qualifications of the employees into account. It is relevant to note that there is an overlap between the assignment of staff and the appraisal of the performance. The measured performance of employees of course plays a role in further assignment to process tasks (e.g., Huang, Lu, & Duan, 2012).

The existing attempts from the BPM literature show that there is a need for a process oriented staffing. However, most approaches in the BPM literature take a shorter view of the assignment problem, creating staffing schedules for a short time frame.

Literature from the HRM area is more focused on long term staff assignment in processes. The first step for this is to define the personnel requirements. These can be extracted from business processes (e.g., Hüsselmann, 2006; Landgraf & Lenhardt, 2013; Muche, 2002), which is something that is regularly done in practice (e.g., H. Gutmann, 2011; Junge & Kretschel, 2008). Most modeling tools also have the feature to generate personnel requirements or at least positions descriptions for modeled processes (e.g., Junginger, Kühn, Strobl, & Karagiannis, 2000; Sandau, 2011).

Research into process orientation in the context of staffing, therefore, mainly comes from the workflow management research area (e.g., Heravizadeh, Mendling, & Rosemann, 2009), with newer attempts stemming from HRM literature.

2.4.2.4 Attempts in the context of appraisal

Attempts of process orientation or research on effects of such attempts in personnel appraisal mostly come from the BPM field and consist of residual results especially of research regarding performance management of business processes.

For example, Cardoso, Almeida, Guizzardi, and Guizzardi (2009) use the concept of goal oriented business process modeling and try to link business process models and goal models together to allow for a more direct analysis of how the processes affect the goals (Cardoso, Sérgio Dos Santos, Almeida, Guizzardi, & Guizzardi, 2010). A more formal discussion of the possible connection between business processes and goals is done by Soffer and Wand (2005)

The idea of modeling (strategic) goals in business process models is also explored by Hartmann and Wolf (2012) with the goal of identifying which specific parts of business processes are affected by changed in the strategy (another example of such an approach is explored and extended in Neiger & Churilov, 2004; Neiger, Churilov, & Flitman, 2009).

More specific results directly relevant to personnel appraisal can be found in the development of the ADJUST performance measurement toolset (Glykas, 2011a). The toolset provides interfaces to three kinds of management tool categories: process management tools, HRM tools, workflow management tools. Specifically the ADJUST tool incorporates an interface to the HRM Software in the form of Performance Management Software (Glykas, 2011a, p. 19-21). The toolset allows the capture and synchronization of employee performance measures from business processes or workflow executions. Such a setup allows for a process oriented gathering of appraisal relevant data. While authors discuss how performance measures can be modeled in business processes (Korherr & List, 2007a, 2007b) and how process oriented performance measurement systems (general systems not HR specific systems) can be designed (Beretta, 2002), specific research looking at how personnel appraisal can be designed in a more process oriented way was not found.HRM literature focuses on an internal understanding of process orientation and discusses how personnel appraisal processes can be designed and optimized (e.g., Busch, 2007).

2.4.2.5 Attempts in the context of development

From all HRM functions, personnel development has been the most extensively adapted towards a focus on processes. Attempts have come from the BPM field, as well as the HRM field resulting in a broad range of methods, tools and models.

From the HRM field, the concept of knowledge management (KM) has gained in popularity around the same time as process orientation (Wiig, 1997). This has resulted in research focusing on a process oriented way of performing KM (e.g., Kalpic & Bernus, 2006; Maier & Remus, 2002). Process oriented KM understands the connection between knowledge and processes in two ways: processes as knowledge and knowledge in processes. Since business process represent the way businesses fulfill their goals, they in themselves represent essential knowledge for an organization and therefore have to be documented and their content imparted to employees. At the same time knowledge is also needed as well as generated during the execution of business processes through employees. Process oriented KM tries to capture these inter-dependencies and manage the knowledge accordingly.

In general education there have been many attempts at creating and measuring the impact of (work) process aware training activities. For example, Koch and Meerten discusses the conceptual argumentation for process aware training activities. They see a paradigmatic shift with regard to professional education based on the requirements towards education in a process oriented world. The classical notion of a profession has changed because of the popularity of process orientation. The goal of the development of employees lies in providing the employees with the ability to execute the tasks belonging to a specific business process. The business process itself can be optimizing and that optimization is again seen as process, which is executed by employees. In the best case the optimization process is even initiated by employees of the process to be optimized. The competitiveness of an organization depends more and more on the success of those optimizations. Therefore, one important change is that the qualifications are not only determined by the business processes, but tend to evolve constantly. Koch and Meerten use the construction process for a car as an example: if instead of welding parts together they are now glued, that qualification becomes part of the needed qualifications for a position involved in that process. The needed qualifications for an employee are not mainly defined by his or her profession anymore, but by the processes (2003, p. 43).

This new dominance of business processes in professional education (and therefore in personnel development) leads to important changes. In a pilot scheme with multiple organizations Krauß and Mohr identify some of them (2004):

- process orientation has to be a key qualification for every employee
- employees will need a baseline qualification to be usable in any part of the process
- training activities (be they on or off the job) need to be tightly integrated with real business processes
- the responsibility of training and development assignment changes towards middle management

The idea of process optimization requires information about which processes have problems, which processes should be outsourced, which better kept in-house. While effective (process oriented) performance management systems can provide such information, the creation and upkeep of such systems are complex and not appropriate for all processes. Therefore, that information has to come from employees. To be able to asses such problems, employees have to have a basic understanding of process orientation and possible problems in processes or how to solve them. The idea of teaching employees process orientation to implement process orientation and doing this by teaching them in their processes seems generally supported by the BPM literature (e.g., Pritchard & Armistead, 1999, p. 21).

Since qualification requirements change more quickly, every employee needs to have the baseline qualifications to be able to be introduced along the process and acquire relevant technical qualifications. While previously there was still a discussion whether work rotation, stays abroad or work sessions where part of personnel development, most expert then stressed the importance of such training activities to acquire the necessary skills.

The kind of specific technical qualifications combined with more general qualifications and the knowledge about process orientation that are required in a process oriented organization are subsumed under the term "work process knowledge" (M. Fischer, 2005). The idea of integrating training activities more closely with specific real world processes is simply an extension of the process orientation employees have to show in organizations to training activities. However, it is important to also supply students with conceptual and theoretical knowledge that goes beyond the simple sequence of tasks and how to execute them. Otherwise, there is no real understanding of the whole business process and its implications (Tramm, 2009, p. 99).

The parties involved in the development of employees changes substantially in that the line manager are more strongly involved in suggesting training activities or informing employees of their performance deficits. This seems natural since the line managers generally have a broader spectrum of responsibility towards the business process they are involved in (Zucchi & Edwards, 2000, p. 217f.).

From an empirical standpoint a study with more than 200 companies has show a positive effect on the return of training activities of their process orientation (A. Maurer & Rauner, 2011). More generally there have been many attempts at designing process oriented qualification strategies internally to organizations, as well as in the public education system.

From the BPM literature personnel development is seen in the light of resource management. As personnel is seen as one of the limited resources needed for the execution of business processes, the need to find (or create) a fitting resource for each task is the main objective. There have been attempts to show how the requirements for training activities can, therefore, be extracted from business process models (Binner, 2003) or the relevant organizational knowledge can be expressed in them (Leyking & Angeli, 2008; Loos, Leyking, & Chikova, 2007). Another approach in the management of knowledge or the just-in-time qualification of employees lies in supplying context relevant information to employees during the execution of business processes (Böhm & Härtwig, 2005).

From a technical point of view several projects and organizations have developed software applications that are meant to support process oriented training activities (Etz-Stuttgart, n.d.; Fuchs-Kittowski, Manski, Faust, Prehn, & Schwenzien, 2003; Fuchs-Kittowski & Walter, 2002; Haak & Eekhoff, 2004; Kraemer, Grohmann, Milius, & Zimmermann, 2007). The support of these tools ranges from additional model elements for required qualifications for specific tasks to integrated learning environments that structure the training around business processes.

2.4.2.6 Attempts in the context of compensation

While literature in the field of BPM generally agrees, that remuneration structures have to be integrated into the process oriented design of the organization (Rosemann & vom Brocke, 2010, p. 116), there is not much literature on how this can be achieved.

One possible way is discussed by Hüsselmann (2006) in the context of process orientation in the public sector. He discusses what requirements exists in regard to the modeling of business process models, so that these models can then be used to define the compensation groups (or grades) of specific positions in the organization.

In the private sector, where compensation is not as much standardized the needed qualifications (represented in the compensation by the compensation group an employee is assigned to) are not the only criteria which makes up an employee's possible remuneration. Additionally, the performance of the employee can also play a role in his or her compensation. In a study carried out at the beginning of the century Zucchi and Edwards found that the change to a process oriented view in organizations generally lead to the redesign of the reward system, making it more performance based (2000, p. 219). In the same line a survey in 2011 identified an impact of business process orientation on "people management" especially in the form of a switch to more performance oriented compensation (Bronzo et al., 2013, p. 304, 306). The idea of linking process performance to employee compensation is a natural transfer of a structural method for compensation to a process oriented method. The main idea is to show the employee how his or her actions affect the overall process, thus allowing him a more process oriented view of his or her work. The creation of compensation (and performance management) systems that are process oriented are, therefore, also often seen as key parts in the transformation into a process oriented organization (e.g., Lockamy & McCormack, 2004; McCormack et al., 2009).

2.4.3 Development of the concept of process oriented Human Resource Management

2.4.3.1 Definition of term process oriented human resource management

Based on the discussion of process orientation, classical HRM, and a review of existing attempts of process orientation in HRM a concept of a process oriented human resource management (proHRM) can now be outlined. Using the definition of process orientation from section 2.3.1 and the definition of HRM from section 2.2.1 a proposal for the definition of proHRM can be developed.

As seen in definition 3 process orientation is the adaptation of one's actions based on a new perception of the organization as a collection of processes. This means that a proHRM is different from a classical HRM in that its actions are based on different concepts. Classical HRM manages the human resources of an organization in regard to the fulfillment of the organization's strategy (see definition 1). While this definition does not include or preclude a focus on the business process in practice there is such a (at least partial) preclusion. The classical approach of HRM is based on a structural view of an organization. Classically HRM focuses on positions, organizational units and departments. The organization is perceived as a structure of different units that each execute a specific function. A process oriented HRM on the other hand focuses on the business processes that exist in an organization. That also means that methods used in the achievements of its goals are based on the business processes and not positions, organizational units, or functions. One of the core elements of classical HRM is the job description, in proHRM the core element is the business process. These considerations are reflected in the following proposed definition (definition 7).

Definition 7. Process oriented human resource management (proHRM) includes all business processes that plan, organize, lead, or control the human resources needed for the effective and efficient execution of the processes in an organization. These HR processes use the concept of business processes as basis for their activities.

The proposed definition includes an external and internal understanding of process orientation (see section 2.4.2) in that the activities that comprise HRM are seen as business processes, as well as the elements around which these processes are oriented, are themselves business processes. This is insofar consistent as HRM is also responsible for the management of the personnel that actually performs HRM activities.

2.4.3.2 Description of the general characteristics of process oriented human resource management

As elaborated above, proHRM differs from classical HRM in that it sees the organization as a bundle of business processes instead of a fixed structure. The resulting changes can be seen on a

characteristic	classical HRM	process oriented HRM
core element	job description (organizational position)	business process
responsibilities	central HR department	individual managers
design choice	centralization vs. decentralization	process standardization vs. diversity

Table 5: Characteristics of proHRM in comparison to classical HRM (based on Hammer & Stanton, 1999).

general level for all HRM activities and in a more detailed fashion for each HR function. In this section the changes are discussed on a general level, while the changes for specific HR functions are discussed in the next sections. The general changes relate to the core element, the division of responsibilities and the general design choice of HRM. They are sketched in the following (see table 5).

Orientation on the business processes Classical HRM focuses on organizational functions and positions which often leads to a neglect of the organization's business processes and their structure. While an organization's functions and the positions existing in it ultimately are derived from its processes (Gaitanides, 2012, p. 26 ff.) there is a temporal gap between process changes and structural changes. Furthermore, there are additional problems with the use of positions as basis for organizational or human resource work (e.g., Reiß, 1984). For example, the amount of time a position needs for each of its day-to-day activities does not necessary reflect the importance of those activities for the business processes a position is involved in. While this becomes clear when focusing the individual tasks in the business processes, looking only at the positions, the amount of time that is invested in a task may mislead its importance. That is why classical HRM has a tendency to neglect the original business processes. On the other hand proHRM tries to bridge this gap by focusing directly on business processes, instead of positions or specific organizational functions. Such an orientation results in changes of all areas of HRM. Recent studies have proposed, for example, that unique positions are not necessary anymore but instead groups of employees work on business processes together. In that case job descriptions become team descriptions that describe what the tasks of the team executing the work are.

Process specific solutions The solutions created by proHRM are process type specific. As was seen in the literature review, personnel aspects can not be handled on a general basis anymore, but need to be adapted on a per process basis. One example of this has been seen in section 2.4.2.5 where training activities are adapted to specific business processes. While there are best-practice reference processes that describe the execution of generic activities, these are adapted from organization to organization to match the specific circumstances present. The same applies to HR solutions: each business process potentially needs a specific way of selecting employees, choose their training activities, or manage their compensation. Each business process can include different qualification requirements, e.g., order fulfillment processes can have a different structure between business units: one focusing on response time, the other flexibility depending on customer requirements. This does not mean, that proHRM prevents a standardization of the business processes. Whether processes should be standardized, needs to be decided on a case to case basis. The advantage of having standardized processes includes having a unified workflow (identical tools, methods, documentations, and training activities), providing a one-face-to-the-customer experience, and the ability to quickly react to changes in demand by switching employees between those standardized processes (Hammer & Stanton, 1999, p. 114 f.). In such a case, however, HR aspects still need to be designed fitting that specific process type.

Decentralization of responsibilities The mentioned specificity of solutions in regard to processes can only be achieved by a decentralization of the responsibilities. One aspect observed in process oriented organizations is that the general management (or the so called "process owner" if management structures have also been oriented around processes) has more responsibilities (Hammer & Stanton, 1999, p. 3). He or she is responsible for many of the HR activities, such as recommending qualifications, classically attributed to the HR department (Krauß & Mohr, 2004, p. 8).

The changes sketched here have an effect on all areas of proHRM. The following sections show how this shift of focus can impact the different HR functions: staffing, appraisal, development, and compensation.

2.4.3.3 Description of process oriented staffing

Staffing is one of the most important HRM activities in any organization. In an ideal-typical fashion this includes three essential steps: employee planning, recruiting and selection, and assigning employees to specific positions or tasks (cf. Beardwell, Holden, & Claydon, 2004, p. 111 ff.; Armstrong, 2006, p. 359 ff.).

In a process oriented execution of these activities the planning consists of analyzing the business processes and identifying the duties and the required skills of each task in the process. With an estimation of the future volume of process instances, the qualitative and quantitative requirements can be anticipated. Based on this different assignment possibilities can be identified to fulfill these requirements (this is also referred to as scenario planning; see Armstrong, 2006, p. 372 f.). This activity could also be postponed until the end of the recruitment and selection. However, this would greatly reduce the available information for the search for employees, as different assignment choices could result in different quantitative or qualitative gaps.

The assignment of employees to process activities, follows the process redesign idea, where different sources can be the reason for decisions of the process modeler (e.g., best practices in Dumas, van der Aalst, & ter Hofstede, 2005, p. 217 ff.). The planning phase ends with a tentative best option for the assignment of employees. This option can then be used to identify the quantitative and qualitative gap of human resources for the given process and to create one or more job descriptions/job postings to fill the gap. After qualified applicants have been attracted, a decision is made between them. The recruitment and selection activities are also optional if no quantitative or qualitative gap is identified. With the quantitative and qualitative gap closed, the final personnel assignment can take place. Finally, the assignment is documented

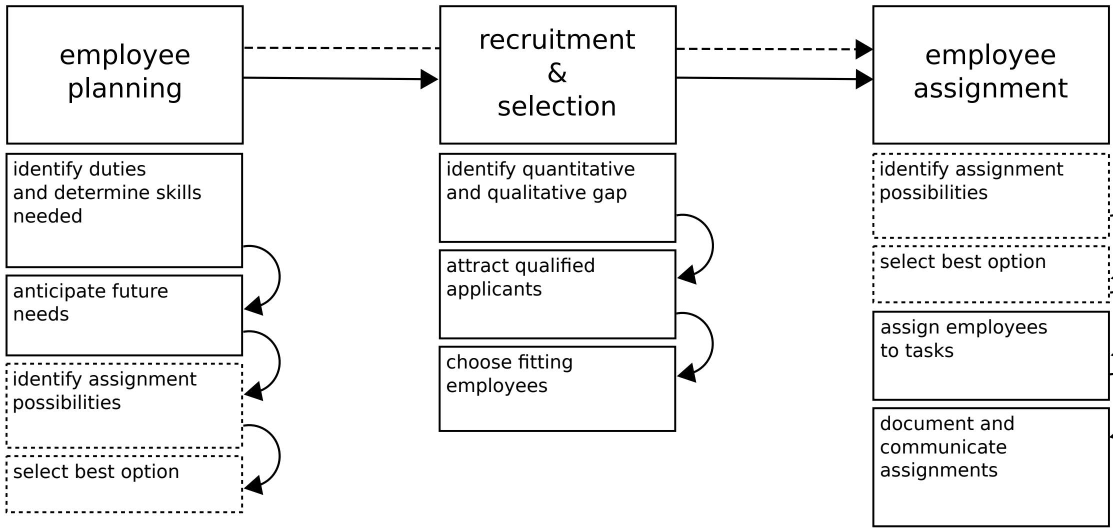


Figure 11: Process oriented staffing activities (based on Beardwell et al., 2004, p. 157 ff.; Armstrong, 2006, p. 370; Caruth et al., 2009, p. 9; Potoczek, 2011, p. 43).

and the assignments communicated to the involved parties (see figure 11).

The steps which are primarily based on information gathered from business process and are affecting the process directly are planning and employee assignment. A proHRIS can, therefore, be centrally involved these activities. Recruiting and selection are performed based on the information gathered during the planning phase and do not primarily rely on working with the operational business process.

When working directly with business processes, the concept of a job description or fixed organizational position can be questioned. Originally the idea of positions and position types helped reduce the complexity of the staffing problem by grouping multiple activities into one job (cf. Bratton and Gold 2000, p. 199). In classical HRM the job description, therefore, rightly is one of the central elements around which the activities are focused (see also section 2.4.3.2). However, as organizations focus more specifically on their processes and give more importance to the operational processes than the organizational structure, positions and, therefore, job descriptions become another informational object that needs to be maintained. Each time processes or employee assignments within a process change the job definitions need to be updated. Depending on the context, contractual obligations are modeled very specifically to job descriptions hindering a process oriented deployment of employees. Often the additional effort of updating job descriptions is not performed regularly leading to outdated job descriptions that then have to be painstakingly updated during the recruitment process (or any development activities, e.g. Bahl, Koch, Meerten, & Zinke, 2005, p. 29; cf. Reiß, 1984).

As a result many proponents of a fully process orientated organization advocate the notion of "process teams" (e.g., Armistead, 1996, p. 51; Kugeler & Vieting, 2000, p. 223; Hammer & Champy, 2001, p. 69 ff.). A group of employees performing the whole process in coordination. The hoped for advantage is that, the process team, now being grouped together in the same organizational unit can be more effective than when each process performer belongs to a different organizational unit. In the end what sort of organizational model is chosen depends on the overall organization structure as well as the type of business process and the specific organizational setting. For this thesis it will be assumed employees are directly assigned to tasks in business processes, without the intermediary of positions, as this offers more flexibility in the assignment as well as the recruitment and selection of employees.

2.4.3.4 Description of process oriented appraisal

The appraisal of employees is one of the corner stones of HRM and appraisal systems some of the most widely used types of HRIS (cf. Ball, 2001, p. 685). Appraisals are the basis for many types compensation schemes (e.g., Ulmer, 2009, p. 27 ff.) as well as one of the primary information provider for decisions about personnel development (e.g., Beardwell et al., 2004, p. 376; see also section 2.2.3). Consistently appraisals are also at the core of the more modern concept of performance management. Following Armstrong (2009, p. 9) performance management is understood here as "a systematic process for improving organizational performance by developing the performance of individuals and teams" (see also e.g. Bratton & Gold, 2000, p. 214; Ferreira & Otley, 2009). While performance management in its broader understanding includes activities such as the compensation of employees and their development, this section focuses purely on the activities relating to the measurement of the performance of employees.

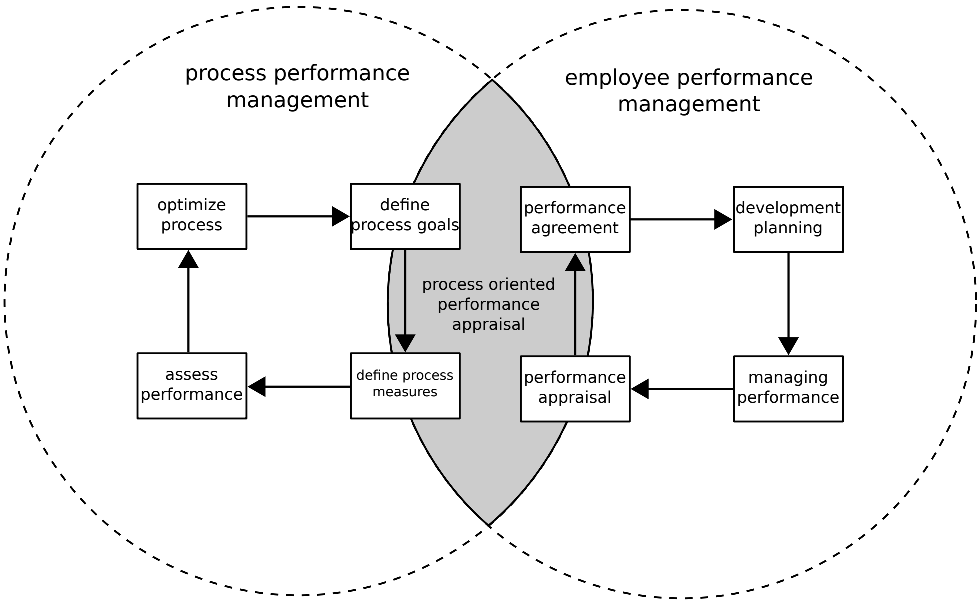


Figure 12: Visualization of process oriented performance appraisal as the intersection of process performance management and classical (employee) performance management (based on Armstrong, 2000, p. 14 ff.; Heckl & Moormann, 2010; Dumas et al., 2013, p. 213 ff.).

From a BPM perspective performance management does not relate to the measurement and management of the performance of individual employees or teams, but to the performance of business processes. It is considered an integral part of the business process life cycle (referred to as evaluation, see section 2.3.2). Different methods and tools, such as the balanced scorecard (e.g., Kaplan & Norton, 1992, 1993) or self-assessment, have been developed and with the rise in popularity of BPM specific business process performance management systems have been envisioned (e.g., Heckl & Moormann, 2010; Kueng, 2000).

Still, the management and measurement of performance from a HRM point of view and from a BPM point of view have many commonalities and connections and as such a combination of both areas can serve as a basis for a description of a process oriented appraisal (see figure 12).

While the strategy of performance management and the specific methods used for the appraisal are organization specific, the general (employee) performance management process can be described as containing the steps: performance agreement, development planning, management of the performance, and appraisal of the performance (Armstrong, 2009, p. 62 ff.; Beardwell et al., 2004, p. 524 ff.). These steps are also considered following each other chronologically, for example, in a yearly cycle with the performance agreement at the beginning of the year and appraisals at the end (cf. Caruth et al., 2009, p. 256). The two most important steps that also can be strongly related to operational business process are the performance agreement and the performance appraisal.

The performance agreement is the result of the performance planning and records what performance goals are targeted and how the appraisal will be performed. It is an agreement between the appraiser, i.e., the employee performing the appraisal, and the appraisee, i.e., the person being appraised. Often such agreements also include development plans with qualifications to work towards until the performance appraisal. The performance appraisal itself often has the form of a rating, that is carried out by the appraiser during or after a formal meeting. It normally results in a document that contains different items and ratings regarding those items, which indicate the quality of the performance of the employee regarding the given criteria.

Which measures are actually evaluated, which scale is used to rate the performance in those areas, or even the concrete method of appraisal (360-degree feedback, behaviorally anchored rating scales, management by objectives, assessment centers, etc.; e.g., Caruth et al., 2009, p. 233 ff.; Shaout & Yousif, 2014) is something that is decided on an organization to organization basis and part of the overall performance management strategy.

Even if no definitive list of items in an appraisal document can be given here, some general aspects that the literature suggest about the content and method of appraisal and how a process oriented performance appraisal should be performed can be discussed.

Appraisals need to not only be objectively fair, but also be perceived as being fair. Organizational researchers have gathered a strong body of evidence that suggest that employees care about the fairness of appraisals, compensation and staffing (e.g., Folger & Cropanzano, 1998, p. 108 ff.; Armstrong, 2009, p. 73). One aspect which can increase the perceived fairness of appraisals is that of using "fair" criteria. This includes, for example, an agreement between employee and supervisor about the employees job duties (Folger & Cropanzano, 1998, p. 121). The usage of business process models as basis for the job description (see also previous section), makes it very clear to both parties what the job duties of the employee are. All tasks assigned to the employee are his or her responsibility. It also ensures that all factors used to evaluate an employee relate to the job that is appraised and not the person (cf. Caruth et al., 2009, p. 248 f.). Another possibility to increase the acceptance of appraisals is to allow the participation of employees in setting criteria for the evaluation, or having them understand the reasoning behind the criteria (e.g., Cawley, Keeping, & Levy, 1998; Kueng, 2000, p. 82). Here a process oriented approach can offer support, by directly linking performance measures to specific process tasks

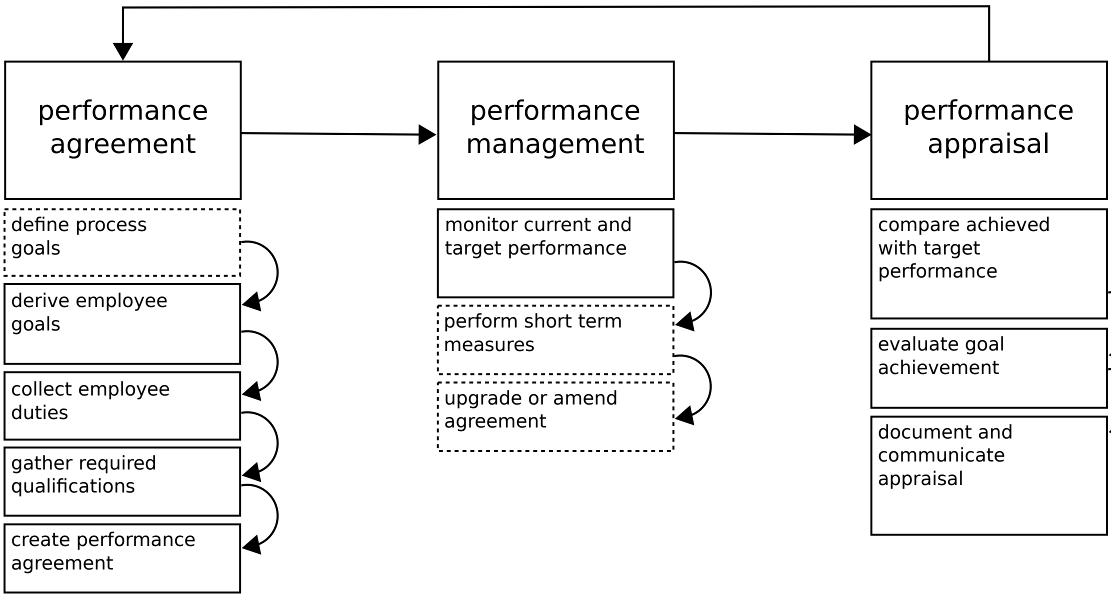


Figure 13: Process oriented appraisal activities (based on Armstrong, 2000; Kueng, 2000; Krause, 2003; Busch, 2007; Armstrong, 2009, esp. p. 183 ff.; Heckl & Moormann, 2010, p. 126 ff.).

and goals. This makes it clear for the employee why he or she is being appraised for a specific task and what impact this has on the whole process. This also makes sense from a process oriented perspective. Often times the process performers are the one most knowledgeable in the part of the process they perform. Including them in the definition of performance measures can make uncovering critical bottlenecks, that need to be monitored, easier.

Linked with the perceived fairness of the appraisal system is also the possibility to provide goals to employees. While not every performance management method includes such a possibility, research has shown that specific goals lead to more positive employee reactions (e.g., Folger & Cropanzano, 1998, p. 122; Armstrong, 2009, p. 97 ff.; Gruman & Saks, 2011, p. 128). However, it is also important that it is transparent for both the appraisee and the appraiser how those goals contribute to overall organizational performance (e.g., Armstrong, 2000, p. 34 f.). This can be achieved in a process oriented setting by modeling process goals, process performance measures, etc. in process models and linking them between each other and organizational goals. As one central concept in the design of business processes is the goal of the process, who should be linked to organizational goals (see section 2.3.3; cf. Kueng & Kawalek, 1997; Neiger & Churilov, 2004; Korherr & List, 2007a), performance measures and more specific goals can be derived from process goals. This ensures that all goals have a transparent relationship to overall organizational goals. It also supports a stronger process oriented view of the organization by the employees (e.g., McCormack, 2001; H. a. Reijers, 2006) as the performance of individual employees is directly linked to the performance of business processes and the overall organization (e.g., Rummler & Brache, 2013, p. 64 ff.).

Based on the previous discussion the general process related appraisal steps can be described as follows (see figure 13). Leading up to the performance agreement the process goals have to be defined. If that has not been done in a prior iteration it should be done as first step. Based on those organizational and process goals the goals of specific employees can be derived. This can be achieved in multiple ways. One possibility being the manual creation of goals and linking them to employees and process goals. Another possibility would be a more objective approach defining only general rules by which employee specific goals should be created based on goals on a process or task level. Together with the collected duties and required qualifications the goals make up a huge part of the process specific part of the performance agreement.

During the year performance data of the process is monitored and employee target performance compared to actual performance (e.g., Fay & Nardoni, 2011, p. 452). In case of discrepancies short term measures can be enacted, either by initiating staffing or development activities. It is also possible that performance agreements of employee are upgraded or amended in this step with relation to the business process model and/or the current performance data.

The regular performance appraisal consist of the comparison of the aggregated performance data with the goals and performance targets set in the performance agreement. The results of that comparison are then documented and can be used in compensation schemes, as a basis for the identification of development paths, and as baseline for new performance agreements.

2.4.3.5 Description of process oriented development

The development of the human resources is important for organizations in so far, that their competitiveness more and more stems from the quality of their employees (cf. Chambers, Foulon, Handfield-Jones, Hankin, & Michaels, 1998; Beardwell et al., 2004, p. 269; Drumm, 2008, p. 333 ff.). This is represented well in the critical success factors as collected by Solga, Ryschka, and Mattenklott (2011, p. 28 f.):

- ▷ Development goals and contents should be oriented along the organization's strategy.
- ▷ Development activities should be linked with each other and with the HR functions along the organization's strategic goals.
- ▷ Through the establishment of a "learning culture" a framework for the long term development of strategically relevant qualifications should be created.
- ▷ The transfer of knowledge and application of new skills in daily activities should be required, supported, and rewarded.
- ▷ Organizational design decisions should support the development of qualifications by employees.
- ▷ Development activities should be evaluated.

These factors (cf. Baruch & Peiperl, 2000, p. 360 ff.) heavily influence how a process oriented application of employee development should be understood. While a very broad range of activities can be subsumed under the heading employee development or human resource development (cf. Swanson, 1995; Swanson & Holton III, 2008), here development will be understood as a term for the classical concept of "training and development", "a process of systematically developing work-related knowledge and expertise in people for the purpose of improving performance" (Swanson & Holton III, 2008, p. 204). In a training and development understanding training focuses on the short term, targeting new employees or employees with new responsibilities or activities, while development is more geared towards the long term with targeting the development of knowledge and expertise beyond their current activity assignments (e.g., Winterton, 2007, p. 328 ff.). The term development in this thesis encompasses both the short and the long term view. This fits with the development function of the human resource cycle discussed in section 2.2.3, however, it precludes some activities that are more strategically oriented. This limitation, however, is acceptable as the focus of this discussion is on the more operative activities that can directly relate to operational business processes.

Following this distinction and the success factors outlined above the need for development stems from three primary sources: the organization, the process and the employee himself (see figure 14). The organizational context provides the overall goals which employee development should support, as well as more broad human resource strategies that involve employee development and to which it has to adhere (cf. Drumm, 2008, p. 335 f.). The operational processes define qualification requirements, responsibilities, and specific performance goals derived from the overall organizational goals (see also section 4.3.3.3) from which the concrete development needs can be derived. Finally, the employee himself provides the potential that is to be developed as well a personal career plan they wish to fulfill (cf. Klug, 2011, p. 35). In this context career planning offers the requirements for the long term development activities by highlighting the deficit between the employees qualifications and potential future requirements, while performance appraisals supply the short term training goals by focusing on the discrepancy between currently required qualifications, the performance, and the employees current profile.

A process oriented approach to development should include a process orientation in career planning as well as performance appraisal (cf. the change in development portrayed in Pritchard & Armistead, 1999). A process oriented approach to appraisals has already been outlined in the previous section (section 4.3.3.3). In summary the appraisal focuses on the goals and targets of the operational business processes the employee is involved in instead of goals derived from functional assignments. In practice the specific goals of an employee do not have to substantially differ. The change lies in the way the goals are derived. The idea is that through the focus of operational business process and process goals the goals derived for individual employees are transparently and explicitly related to business process and, therefore, organizational success.

Careers ("the pattern of work related experiences that span the course of a person's life"; Greenhaus, Callanan, & Godshalk, 2009, p. 10) themselves are specific to an individual's point of view and do not directly relate to one single organization. From an organizational standpoint, however, careers are insofar relevant as they relate to employee retention and succession management as a part of the staffing function. The management of an employee's career possibilities by an organization is influence by a broad range of factors: the reward strategy of the organization, the appraisal processes, the culture and values of employees and the organization, training and development opportunities, promotion opportunities, etc. (Bolton & Gold, 1994, p. 8). Four general approaches can be identified in relation to the management of employees careers (or the management of successions; cf. Bolton & Gold, 1994, p. 11). These range from very basic approaches that can be characterized as reactive management to the long term development of each individual employee. The simplest approach is to fill vacancies when they become vacant. There is no forward planning at all. More active are single step planning approaches in which

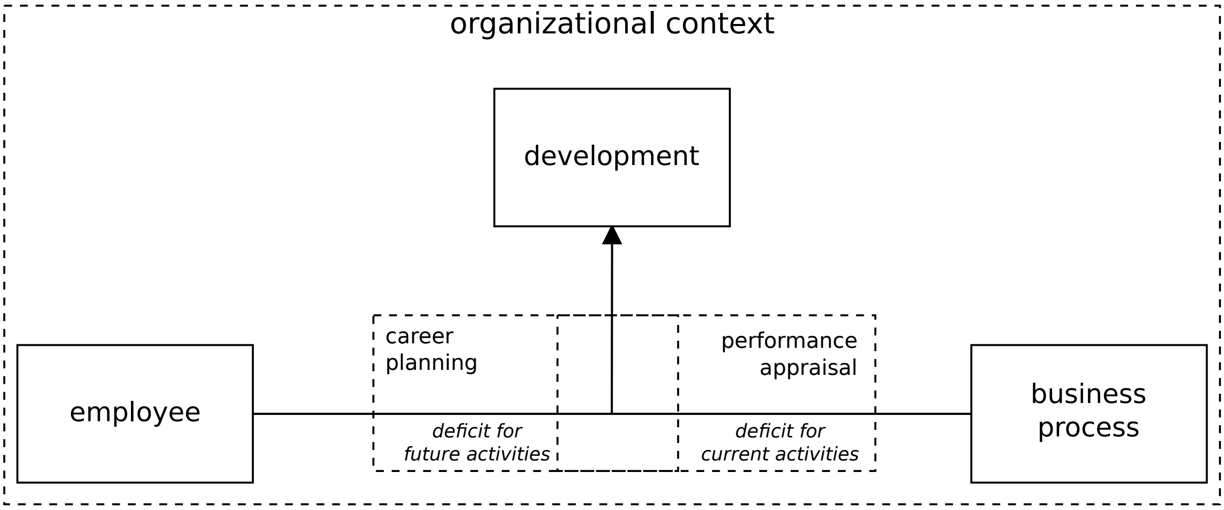


Figure 14: Sources for development needs of employees (based on P. J. Taylor et al., 1998; Scholz, 2000, p. 506; Drumm, 2008, p. 339; Klug, 2011, p. 35).

successors for positions are identified from the organizational layer below. Another approach incorporates the single step planning with specific fast tracking of certain employees that have a high potential. The other end of the spectrum concentrates on each individual employee and how they can achieve their potential resulting in vacancies with many requirements (cf. Baruch & Peiperl, 2000, p. 358 ff.).

Focusing on operational business processes and process oriented development, career planning provides business processes for which a process performer should be potentially considered. As noted before a process orientation in organizations generally leads to a blurring of fixed positions and rigid career paths (see section 2.4.3). This impact is notable in vocational training (e.g., Bahl, Koch, Meerten, and Zinke 2004; Bahl et al. 2005; Koch 2012; Koch and Meerten 2003) but affects organizational training and development as well. Employees need to be trained in the specific processes they will be performing and not fixed job profiles that might not match the day to day activities anymore.

Based on the short discussion of a process oriented approach to career planning and performance appraisal a process oriented development can now be outlined. Figure 15 shows the development activities as they relate to an operational business process and the possible support that can be provided by a proHRIS.

The general steps for the development of employees with regard to an operational business process consist of the employee planning (as seen in section 4.3.3.2), the actual employee development, and the performance appraisal (see also section 4.3.3.3). The first step in identifying the requirements for the development of employees is the collection of development needs (cf. Armstrong, 2006, p. 571; Drumm, 2008, p. 342 ff.; Klug, 2011, p. 49 ff.). This is done during employee planning (see section 4.3.3.2; especially figure 11; cf. Drumm, 2005, p. 232) where duties and requirements of employees assigned to specific tasks are identified. During employee planning different scenarios of employee to task assignments are created resulting in different development needs for the planned employees. These represent one part of the needs stemming from the operational business processes. Additionally, development needs resulting from the performance appraisal of the employees factor into these needs. From the employees side his

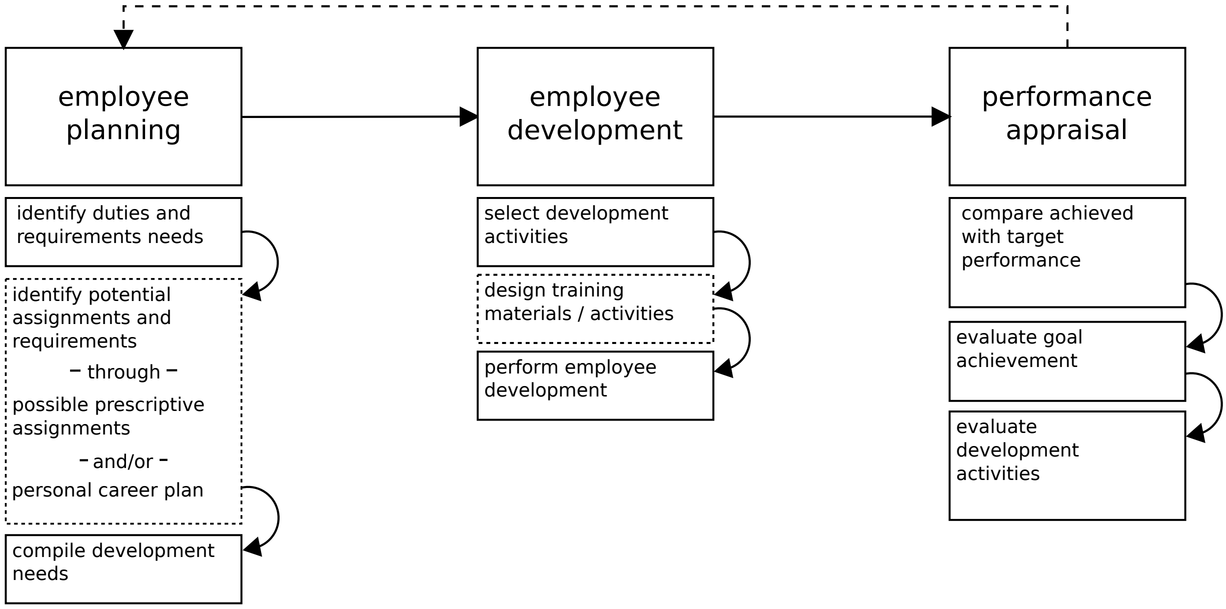


Figure 15: Process oriented development activities (based on Scholz, 2000, p. 508; Müller et al., 2005; Armstrong, 2006, p. 571 ff.; Drumm, 2008, p. 339; Leyking & Angeli, 2008, p. 41; Noe, 2010, p. 7; Solga et al., 2011, p. 23 ff.).

or her career plans are taken into account and in combination with the process based needs result in the development needs. While shown in a linear relationship in the figure, the reference between the single steps is more circular as they require coordination between the process owner and the (potential) process performers.

Once the development needs have been finalized, fitting development activities have to be selected. There is a broad range of possible development activities and techniques that can be used for the development of employees. A possible classification is shown by Demmerle, Schmidt, Hess, Solga, and Ryschka (2011) and consists of simulation techniques, feedback techniques, behavioral modeling training techniques, cognitive techniques, presentation techniques, moderation techniques, casework techniques, and systemic techniques (cf. Armstrong, 2006, p. 579 ff.). Simulation based development activities are, e.g., role-playing, case studies, or business simulations. Here employees are placed in a simulated environment to test, train, and perfect behaviors without having to fear real implications in case of problems (e.g., Ben-Zvi & Carton, 2007; Ruben, 1999). Behavioral modeling training methods at their core consist of the trained employees observing a "model person" performing the activities with the desired behavior. Based on this, learning goals are derived and then trained employees perform the activities themselves, e.g., in the context of a business simulation, and receive feedback about their success. Most "on-the-job" training, such as job familiarization, can be seen as such training methods. The employees observe coworkers performing the activities and emulates them receiving direct feedback (cf. Scholz, 2000, p. 511). Another example are casework techniques in which to be trained employees analyze real work challenges they encounter during their day-to-day activities and develop solution approaches with the help of a coach or expert.

Independent on the technique used for a process oriented approach it is important to integrate the operational processes in the development techniques. In the named examples this can be achieved by, e.g., using process models in the simulation or even simulate business processes on a case to case basis. In casework techniques the focus on the operational processes is inherent through the usage of real world challenges which result from the enactment of the business process and problems in achieving set process targets or goals. Another possibility is the inclusion of reference processes which can serve as guidelines or discussion basis for the analysis of concrete operational processes. Even in a more classical teaching setting (clear "off-the-job" training such as external certifications etc.), processes can be used as the basis for the development of the curriculum, as it is already proposed in vocational education literature (e.g., A. Maurer & Rauner, 2011; Spöttl & Schulte, 2012), or imported into e-Learning systems (e.g., Kraemer et al., 2007).

This direct reference to operational business processes can also result in changes to the prescriptive processes, so that they include "on-the-job" learning opportunities for the process performers. For example, assigning two employees to an activity resulting in an overabundance of capacity, but allowing one employee without the required qualifications to learn from his or her colleague during the enactment of the process.

The last activities of the process oriented development are performed during performance appraisal of the employees. Additionally, to aspects discussed in section 4.3.3.3, the appraisal of employees can relate to development goals of employees. This can serve as basis for an updated employee planning in which the employee fulfills the qualification requirements or can even have an impact on the employees wage (depending on the reward strategy). The appraisal can also relate to the development activities themselves. If they are intended as a method to increase the performance or reduce problems originating from employee behavior or qualification discrepancies there has to be a way to measure their success (cf. Solga, 2011). One possible way is to take into account performance appraisals of the employees after they have completed the development activities (see also the success factors listed at the beginning of this section).

2.4.3.6 Description of process oriented compensation

The monetary compensation an employee receives for his or her work is a key part in the employee to organization relationship. The monetary compensation can itself be seen as being part of a broader reward system, which is often seen as one of the most challenging HRM systems (Bratton & Gold, 2000, p. 238).

The literature generally agrees that reward systems aim at the following goals (Armstrong, 2006, p. 624 f.; Drumm, 2008, p. 488; Holtbrügge, 2010, p. 179 ff.):

- ▷ Employees are to be fairly compensated for the work they have performed and will perform for the organization (fair pay is often included in laws and regulations). Reward systems should operate fairly and transparently. They should apply equitably to all employees and function consistently.
- ▷ The rewards should incentivise the employees to perform work in the future to the full extend of their possibilities. They should motivate people and educate them in what is important to the organization, so that organizational and employee goals align.
- ▷ The employees should be induced to not switch to other (competing) organizations through

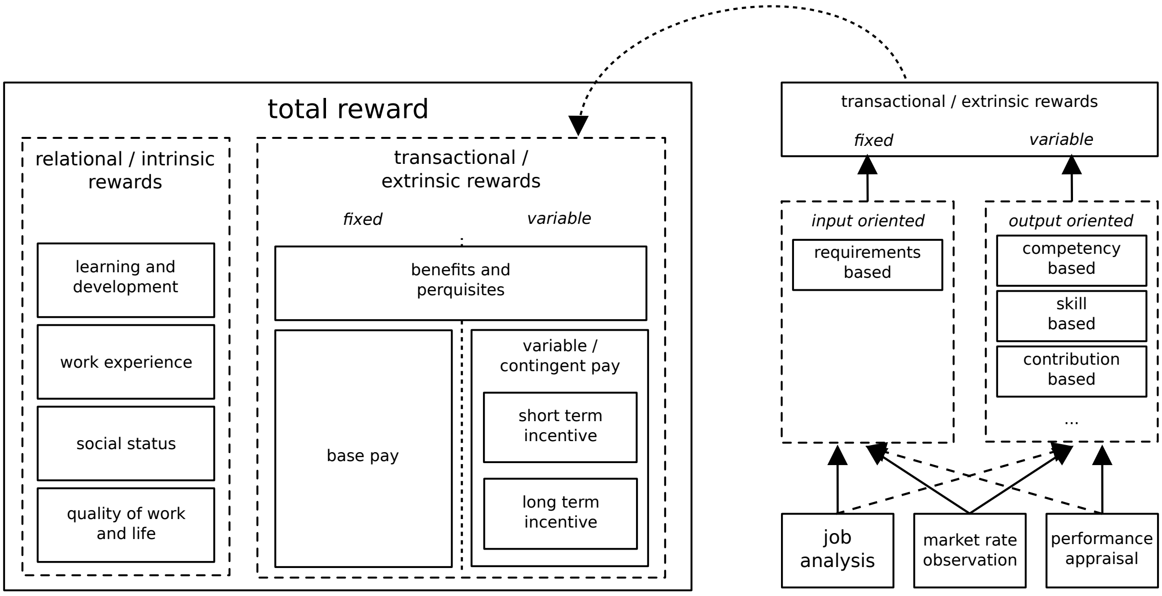


Figure 16: Components of employee rewards and typical sources of determination (based on Armstrong, 2006, p. 631 ff.; Oechsler, 2006, p. 391; Ridder, 2015, p. 235; Festing et al., 2012, p. 141; Manas & Graham, 2003, p. 2; J. Gutmann & Bolder, 2012, p. 35).

their rewards. At the same time high quality potential employees should be incentivise to join the organization.

The rewards an employee receives from the organization can be broken down into different components. Figure 16 shows an overview of the different components grouped by the motivation they provide (following the total rewards approach, cf. Manas & Graham, 2003). Intrinsic rewards which stem from the relation between the organization and the employee include examples such as the quality of work and life of the employee, the social status he or she attains through employment at the organization, the learning and development opportunities his or her job provides, etc. These can not be directly measured in monetary value but still motivate the employee to offer his or her services to the organization. The other components of the total reward the employee receives can be subsumed under the term extrinsic or transactional rewards. These tangible rewards are the direct result of transactions between the employee and the organization. Tangible rewards include the base pay an employee receives, be it in form of an hourly wage or base salary. They also include a variable portion that can be either in form of short term incentives, such as bonuses, or in form of long term incentives, e.g., stock options. These incentives aim at motivating the employee to be more invested in the success of the organization. Furthermore, tangible rewards are also benefits such as health care plans, retirement and saving plans, or paid time off. Also included under this heading are perquisites such as company cars, memberships, subsidized housing, etc. (e.g., Armstrong, 2006, p. 729). It is also possible that these benefits or perquisites are included as a variable component similar to the variable pay. An example would be special parking places for high performing employees (cf. Fay & Nardoni, 2011, p. 459). There is also a social aspect to the pay employee receives, which is not represented in figure 16. As the social aspect is not specific to a process oriented compensation it is not discussed further here (most prominent example is increase of pay with increase of employee age; cf. Wöhe, 2002, p. 223; Drumm, 2008, p. 486, p. 503 ff.).

The determining sources of the extrinsic rewards can be divided into two types: input oriented and output oriented. Input oriented sources normally make up the fixed portion of the extrinsic rewards. These are mainly the requirements posed by the job that the employee performs and are independent of his or her performance or qualifications. Differentiation in the base pay is then realized through different scales and pay structures (cf. Armstrong, p. 689 ff.). For determining the variable portion of employee rewards organizations mainly rely on output related sources. For example, on the performance or attributes of specific employees (or groups of employees, cf. Baker et al., 1988, p. 606; Manas & Graham, 2003, p. 25 f.; Armstrong, 2006, p. 724 f.). A sample of common sources for contingent pay are: competencies, skills, contributions, or simple performance (cf. Varma, Budhwar, & DeNisi, 2008, p. 67 ff.).

- ▷ In performance related pay schemes the compensation increases in relation to the achievement of previously agreed upon results (cf. Storey & Sisson, 2005; Armstrong & Murlis, 2004, p. 288). This increase is either permanent, or in form of cash bonuses which have to be re-earned.
- ▷ Competency based pay schemes focus on rewards in reference to the level of competency an employee demonstrates in carrying out his role.
- ▷ Skill based pay schemes focus on the specific skill employees exhibit, independent on whether they use them or not. This is a difference to competency based schemes in which shown competency in performed tasks is rewarded, while in skill based schemes the available skill (or knowledge) is rewarded independent on how often it is really used in practice.
- ▷ Contribution related pay schemes can be seen as a combination of competency and performance related pay schemes. Employees are rewarded for the outcome as well as how competent they achieved this outcome (e.g., Armstrong & Murlis, 2004, p. 292 ff.).

All presented pay schemes are based on three main sources of information. Those are the job analysis, the performance appraisal and a market analysis (cf. Fay & Nardoni, 2011, p. 457 ff.; Ulmer, 2009, p. 39 ff.;).

The job analysis can be understood as the process of collecting, analyzing and organizing information about jobs (Armstrong & Murlis, 2004, p. 103; cf. Caruth et al. 2009, p. 96 ff.). Part of the job analysis is the job evaluation. The job evaluation defines "the relative worth or size of jobs within an organization in order to establish internal relativities" (Armstrong & Murlis, 2004, p. 112). It can be used to design and define the different pay grades and structures used in an organization for the differentiation of base pay. There are different methods to allow for a qualitative and quantitative evaluation and ordering of jobs (cf. REFA - Verband Für Arbeitsstudien Und Betriebsorganisation e. V., 1987; Drumm, 2008, p. 126) sometimes also categorized into analytical and non-analytical (summary) methods (cf. Armstrong, 2006, p. 660 ff.).

The appraisal of employees aims at measuring the performance of employees with respect to their tasks, previously set goals, and existing measures (see also section 4.3.3.3). As mentioned in the previous section the performance agreement and the result of the appraisal can be used as a basis for the different contingent pay schemes.

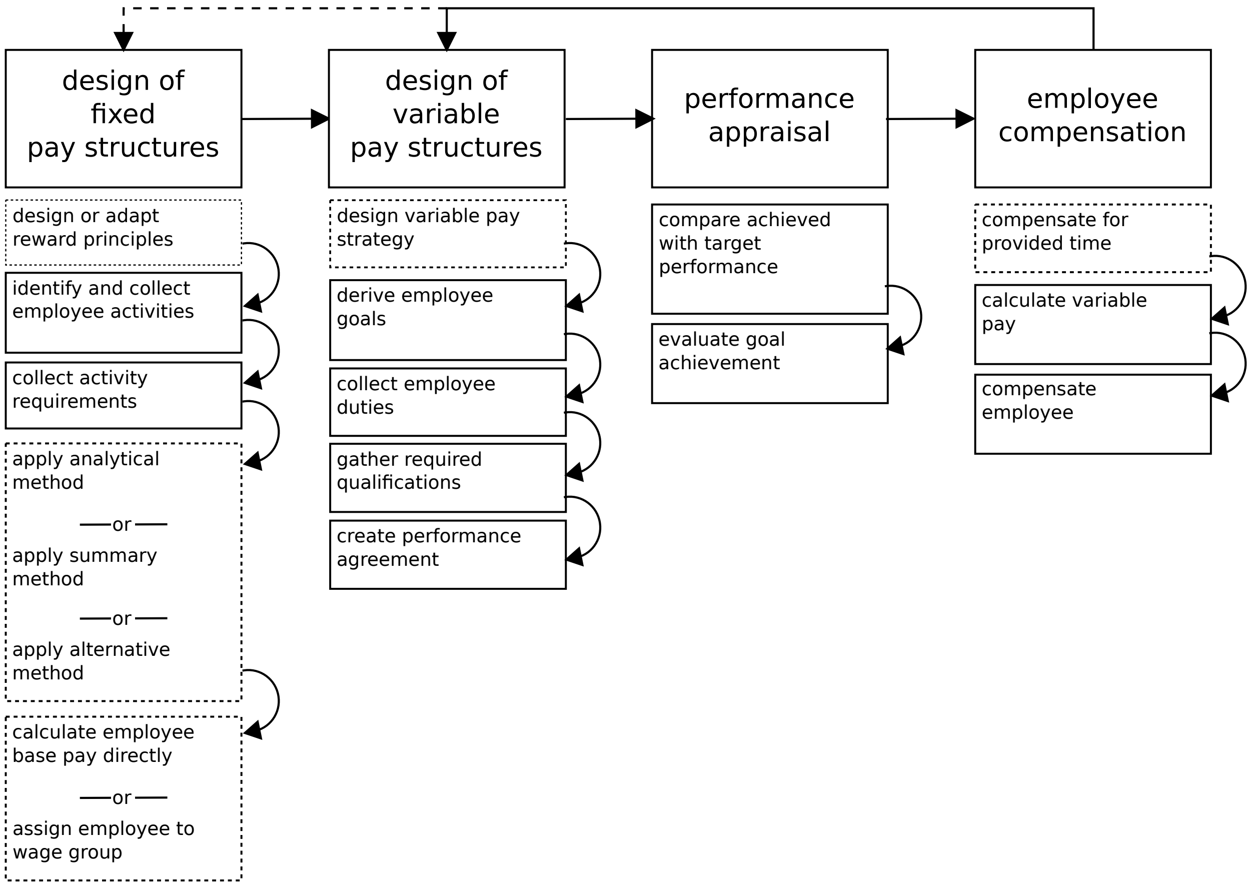


Figure 17: Process oriented compensation activities (based on Armstrong & Murlis, 2004, p. 212; Armstrong, 2006, p. 660 ff.; Holtbrügge, 2010, p. 179).

The third main source of information is a market analysis. As organizations do not exist in a vacuum, they need to take into account their competitors when designing pay schemes. This source of information is not specific to fixed pay components or variable pay components but influences the design of both. Be it in one or the other organizations have to be aware how their offers compare to those of their competitors. Depending on the importance organizations put in seeming more appealing to potential employees than their competitors the impact of a market analysis on the reward system can be strong.

Viewed from a process orientation standpoint information from operational business process should be included in both components of the extrinsic rewards. As noted in section 2.4.1 a focus on business process can increase the flexibility of reward structures and increase the fairness, flexibility and transparency of the reward system in accordance with its aims. While proponents of process orientation highlight the growing importance of variable and especially performance related pay (e.g., Hammer & Champy, 2001, p. 78; Zucchi & Edwards, 2000, p. 219 ff.), considerations regarding the process orientation of performance appraisals have already been made in the previous section, the following will therefore focus on the fixed components of the reward system.

Figure 17 shows the process oriented compensations activities. The activities are grouped into the phases: design of fixed pay structures, the design of variable pay structures, the performance appraisal, and the actual employee compensation. Each of the steps can be seen to be executed

method of quantification \ method of qualification	**non-analytical** evaluation as a whole	**analytical** evaluation based on individual requirements and calculation of overall score
ordering the individual items are ordered based on given priorities	**ranking** comparision as a whole and ordering based on priority	**factor ranking** comparision of individual requirements ordering based on weighted rank of the requirements
grouping the individual items are assigned to specific groups	**classification** the overall requirements are assigned to specific classes based on guidelines	**point rating** the individual requirements are rated based on a weighted schema and summed

Figure 18: Sample of classical job evaluation methods (based on Oechsler, 2006, p. 335; Wöhe, 2002, p. 229; Scholz, 2000, p. 735; Armstrong & Murlis, 2004, p. 113).

in chronological order. With relation to the business process life cycle the two design tasks have to be completed during the design and analysis and the implementation phase of the business process. The performance appraisal and employee compensation happen during the enactment phase or (depending on the duration of the cycle) within the evaluation phase.

The design of fixed pay structures includes the design of the overall reward principles if those have not yet been decided upon. Here management has to decide on the criteria for the compensation differentiation (work requirements, performance, qualifications, social aspects, etc.; e.g., Holtbrügge, 2010, p. 179). A decision also needs to be reached on the number of grades or bands used for classification of employees, or whether those are to be used at all. Furthermore, the question if and how employees are to be grouped into jobs and/or job families needs to be answered. It should also be decided what kind of employee evaluation method should be used to assign employees to a pay grade: be it analytical methods, summary methods, or some other alternative method (for an overview see Armstrong, Cummins, Hastings, & Wood, 2005, p. 129 ff.; Bullinger, 1995, p. 193 ff.). The term employee evaluation method is used here instead of job evaluation, because the evaluation does not relate to any idea of a "job" but takes into account activity and process requirements directly. Once such a decision has been made, relevant information can be gathered from the process and the method applied. Based on the given results the pay of the employee can then be calculated directly, or the employee can be assigned to a given wage group.

As mentioned before, classical job evaluation methods can be differentiated by the method of qualification of the job, i.e., how to evaluate the job, and the method of quantification, i.e., how to value the result of the evaluation with respect to other jobs. The evaluation can be either analytical, taking into account the different individual factors that make up the requirements of the job, or non-analytical, in which case the job is evaluated as a whole. To quantify the jobs two possibilities exist. The jobs are either brought into an order, or gathered in different groups in which all jobs assumed to have the same value. This differentiation and the four possible evaluation methods resulting from it is shown in figure 18.

To perform the design of fixed pay structures based on the operational business processes a solution is to adapt the classical evaluation methods to be more strongly based on business processes. That means that instead of a job or position evaluated the evaluation takes place at a lower level, i.e., the process or even activity level. The possible usage of these classical methods in the context of operational business processes is elaborated on in the following paragraphs.

Ranking The ranking method is a non-analytical method that can be used to create a clear ordering of the jobs being evaluated. It is a very primitive form of evaluation that does not take into account any specifics about the job being evaluated but evaluates them as a whole. The jobs value for the organization is then compared directly to those of other jobs and the jobs brought in a specific ordering (e.g., Armstrong and Murlis 2004, p. 120).

Directly transferred to business process this would mean that the evaluation and ordering is applied to processes instead of jobs or positions. Each business process that is enacted in the organization would be evaluated as a whole and its importance or value to the organization used for the ordering. The same method could be applied to activities within a specific business process. The activities of the process could be compared to each other and brought in an order of importance. This could, for example, lead to activities only performed during some process execution in a low number of cases be ordered behind the core activities necessary for every enactment of the process. For an employee the process he or she performs or the activities he or she performs would decisive.

Factor ranking The method of factor ranking is more involved method of ordering jobs. Each individual requirement of a job is compared to those in other jobs and an order of the requirements created. This is often performed by grouping requirements by a specific scheme (e.g., mental requirements, physical requirements, responsibilities, work conditions; see Oechsler, 2006, p. 406) and ordering the requirements for each job in the given groups. The order of the jobs is then decided as an average of the order of the different requirements.

In a similar way to jobs, processes and activities can be evaluated in such a manner. The specific scheme can be incorporated in the modeling language and business process models augmented with the required information. The evaluation of processes could be directly derived from the requirements of the different activities contained in the process. Again, for an employee the process he or she enacts or the activities he or she performs would be decisive.

Classification The classification method is a non-analytical method in which each job is evaluated according to a specific schema and its characteristics and then assigned to a specific job group. The scheme can be based on exemplary job difficulties make up a template of jobs in a specific group. Each individual job is then matched to the best fitting template and assigned to its group. While detailed description of the job is necessary for the comparison of the job with a template, the individual characteristics are not compared but the job as a whole is matched.

It is imaginable to classify processes similarly to jobs in the classification method. In fact such classifications of processes are already done regularly be it either by topic for the simple management of these processes or by other criteria (e.g., Silvestro, Fitzgerald, Johnston, & Voss, 1992; Tumay, 1996; Thome, Hennig, & Ollmert, 2000; Rohloff, 2002; Moness, 2010, p. 26 ff.). This classification could be supported by process mining techniques that would match specific patterns in business process models and create classes accordingly (e.g., Grigori et al., 2004; van der Aalst, 2011). Activities themselves could be similarly classified. The employees wage group would again be decided based on the process or activities he or she enacts.

Point rating The point rating method evaluates the job based on the individual characteristics of that job similar to the factor ranking method. However, the individual factors are not ranked with regard to each other. Instead, each requirement is scored on a given scale. The overall score of the job is then the weighted sum of the score of the individual characteristics. This can be considered a grouping method as multiple jobs can in the end have the same score and, therefore, be in the same group. In practice specific ranges of values often make up specific pay grades.

As for the factor ranking method an application of the point rating method to processes and activities is possible. Here, each activity could be assigned a score based on the value of specific characteristics of that activity. The score for the overall business process could be a weighted sum of the individual activities of the process. The processes could then be grouped into different classes. Employees could be evaluated based on the process they are assigned to, or could be scored similarly as processes based on a weighted sum of the individual activities they perform.

As was shown in the previous paragraphs most of the classical evaluation method can be adapted to a process oriented focus. Additionally, modern evaluation methods could be used (e.g., White & Druker, 2000, p. 86 ff.; Oechsler, 2006, p. 410 ff.), however, fitting methods should include business process based information (an example for the public sector is discussed in Hüsselmann, 2006).

Another relevant question with regard to the adaptation of classical methods is whether to base the valuation of the employee on the process he or she is involved in, or the activities he or she performs. The valuation based on processes has the advantage of being simpler to manage. Using, for example, the classification method each business process represents a wage group in which an employee can be put. Such an assignment works well if one employee is enacting a single business process and each employee enacting that process has to perform the same tasks. In an organization following a team oriented approach to process enactment where process teams exist that enact the processes this is the case (e.g., Armistead, 1996, p. 51; Hammer & Champy, 2001, p. 69 ff.).

However, if a business process is performed by many employees whose tasks do not overlap and employees are assigned to multiple processes such a simple process to wage group assignment does not work out well. In such a case it makes more sense to base the wage on the characteristics of the individual activities performed by the employees.

The choice how to calculate base pay for employee is, in the end, one that is made by the organization, based on criteria such as the complexity of the processes, the detail in which they are modeled, the input from employees and the influence of the markets competitors. The base pay scheme is never designed based only on one of the factors (e.g., Beardwell et al., 2004, p. 534).

The design of the variable pay structures is similar to what was already discussed in the previous section (section 2.4.3.4). If no overall variable pay strategy has been selected, such a

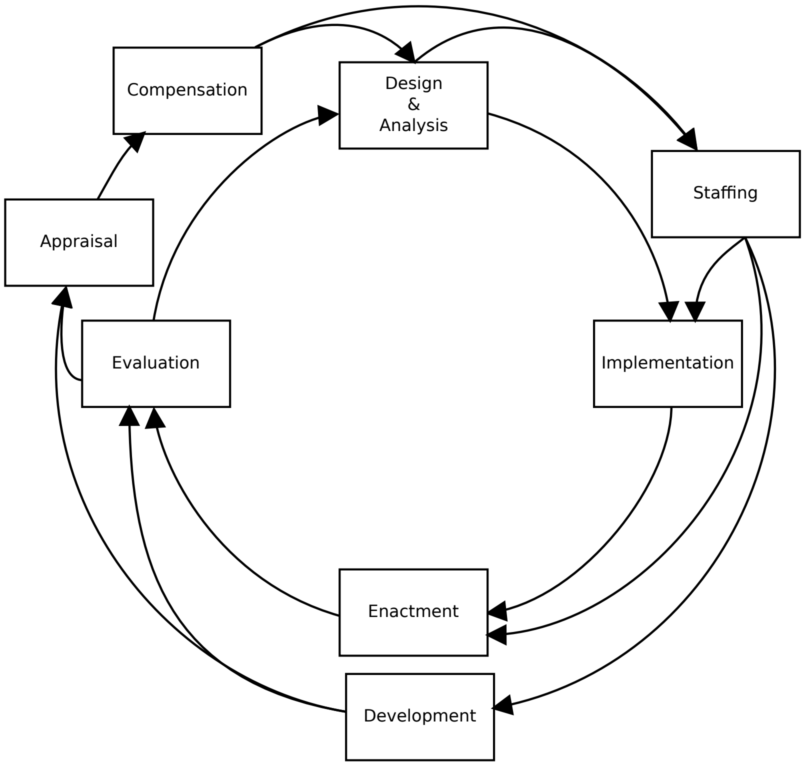


Figure 19: Process oriented human resource cycle (based on the business process life cycle and the human resource cycle).

selection has to take place before anything else. Here the criteria for the evaluation and the effects goal achievements or the not achievement of goals have on the variable pay of an employee have to be defined.

From a compensation point of view the results of the performance appraisal, the performance agreement and the variable pay strategy can be used to calculate the variable pay of the employee and finally compensate him.

2.4.3.7 Overview of the process oriented HRM life cycle

Integrating the different process oriented versions of the classical HRM functions with the business process life cycle (see figure 9) a proHRM cycle can developed (see figure 19). Each phase of the BPM cycle (displayed in the inner circle) is interlinked with the relevant HR activities. Together they represent all activities relevant for the process oriented management of business processes as well as the employees needed for their enactment.

The design and analysis phase can be seen as the starting point of the cycle. Based on the created process models the staffing activities can be performed. The resulting assignment of employees to activities serves as input for the implementation phase as well as for the enactment phase and the development activities.

The staffing phase takes into account the results of the design and analysis phase and the results of the compensation the HR aspects that have to be taken into account are the assignments of employees to tasks. This step normally done in the implementation phase with a classical HRM, is integrated with the design and analysis of business process models. Due to the higher information quantity needed for a direct assignment of employees, business process models have to be more detailed. The models must contain information such as the needed qualifications for a process, the planned amount of time that will be required for the execution of a task. The location at which this task will be executed. This additional information makes business process models harder to create and maintain. But overall the amount of work required stays the same. If the information is not gathered in the design and analysis phase, it has to be gathered during the implementation where the classical assignment of employees would take place. Furthermore, the additional available information in business process models allows for more in depth analysis of potential business process weaknesses which are no feasible with the information normally available. The result of the design and analysis phase is a business process model of the to-be business process, as well as an assignment of employees and/or employee requirements.

In the development phase this information is used to selected which employees should receive what training activities to qualify them for the tasks of the process they are assigned to. Next to directly required qualifications for the specific tasks the employee executes, additional methods can be used to predict which possible further requirements an employee could be faced later on. Career management is changed in that it does not look at different positions that the employee can switch to, but different processes the employee could be involved in, or processes in which the employee could take over more responsibilities. Even succession planning can use the information resulting from the design and analysis phase, i.e., which employee is assigned to which process or task to identify possible vacancies in the future that would negatively impact the business process.

During the implementation phase, possible vacancies need to be filled, compensation schemes adapted to the designed (or redesigned) business process. Furthermore, possible goals for employees are derived from the goals of modeled business process and communicated to the employees executing the business process.

In the standard BPM life cycle the enactment phase includes the monitoring and operative management of the enacted business process. From a HR point of view this means reacting to possible short term changes in the available employees for a business process, either by adapting the staffing schedule or trying to compensate in some other way for vacancies. If employees are directly assigned to activities in the process, the reaction can be a lot more fine tuned than in a classical HRM approach. There a replacement for a specific position has to be found, or a position changed to include additional responsibilities. In proHRM, since the activities and requirements for these activities are explicitly modeled, it is possible to find replacements for each specific task that the missing employee was assigned to. Making the locating of fitting employees easier.

The Evaluation phase contains HR specific activities, too. Additionally, to the business process in itself that is evaluated, the evaluation is extended to the employees working on the business process. This appraisal of the employees is based on the goals set during the implementation phase and takes into account the appraisal of the employees as well as the data about process instances gathered during the enactment phase.

In the compensation phase employees are remunerated based on the strategy set (or adapted) in the implementation phase. Due to the remuneration being linked to the business process performance either through profit participation or process oriented appraisal, employees are certain to view the success of the process as the primary goal. The problem of possible long standing business unit goals and policies preventing a successful business process enactment is mostly prevented.

The process oriented human resource cycle shows how, in an ideal-typical way,HR activities can be integrated into the business process life cycle. In practice, however, the different phases of the life cycle are not as clearly defined. The most obvious example of this is that there is not one single compensation phase of the employees after the evaluation of the business process. Furthermore, employees are generally compensated on a monthly basis and not in a piece-by-piece fashion and employees possibly are not only assigned to a single business process. In practice, it is more likely that employees will have a process independent part to their compensation as well as a process dependent part, which can take the form of bonus payouts depending on the evaluation results of the process and the appraisal of the individual employees.

2.4.3.8 Challenges of a process oriented human resource management

Additionally, to the typical challenges, every HR initiative faces, the challenges in implementing and enacting a process oriented HRM are similar to the general challenges faced in the execution of process orientation initiatives of organizations: the human barriers, the mismatch or lack of IT applications, and the absence of fitting tools or methods (Hill et al., 2006).

Human barriers

Human barriers can hinder any organizational change. In process orientation this is, however, especially true, since process orientation is based on the perception of the organization. Process orientation, be it in a process oriented organization or a process oriented HRM, requires a change in the mindset of the employees (Willaert et al., 2007, p. 5). The two main components of the human barriers are inertia and vested interests. Inertia relates to the unwillingness to change current practices, be it from HR practitioners, or department specific employees. Employees can have worked with specific tools or methods for decades and not want to learn a new way of performing their task. Possibly also because in the short term they have to relearn something which they already had mastered. The second component is vested interest. In organizational change this relates to department heads, who will lose control over part of their domain, since functional departments have to give up oversight in relation to new cross functional, process oriented departments. For a process oriented HRM, this relates to mainly two actors: the HR professional and the individual managers.HR professionals give up part of their responsibility, since the individual managers take up more of the responsibilities (in regard to HR activities) towards their direct subordinates. The role of the HR professional changes from actually being responsible for certain tasks to a support position in which he or she supports the individual manager in performing theses tasks (Hall, 2008, p. 90f.).

To overcome these human barriers it seems essential to integrate the affected organizational members in the change process and not neglect their training (in this proHRM is not different from other process orientation initiatives, see also Ohtonen & Lainema, 2011).

Information systems

The rise of process orientation has lead to a multitude of IT applications that focus on business processes or are at least aware of processes. These are subsumed under the category of process aware information systems (e.g., Dumas et al., 2005; van der Aalst, 2009a). They range from ERP systems to WfMS. There are generally two types of process aware information systems. Those that create and optimize the processes and those that execute the processes. They either base their flow on given business processes, while not allowing for changes in the structure and makeup of the business process, or they allow for the modeling and analysis of business process, while having no facility for the execution of business processes.HRIS generally fall in the first category. Even in ERP Systems the HR functionalities are provided and guided by specified business processes, but the specific functions relate to structural aspects. Since the rise of process orientation and advances in process orientation in parts of HRM (knowledge management, education and training, see section 2.4.2) specific HRIS have started to focus more strongly on the process as the object on which the activities are performed.

Tools and methods

The tools and methods used in proHRM are what mostly makes up the difference between classical HRM its process oriented counterpart in the day to day activities. To be able to support a HRM that focuses on the processes of an organization instead of its structure the tools and methods used to accomplish its tasks have to focus on the processes as well. For example, the fixed job descriptions used in classical HRM represent barrier to a process orientation which assumes flexible structures (Potoczek, 2011, p. 43).

2.5 Preliminary Conclusion

This chapter introduced and delimited the new problem context relevant for this thesis: proHRM. In the knowledge contribution framework this contribution can be classified as a contribution to prescriptive knowledge. The concept of proHRM is introduced and possible effects to existing methods HR methods are shown based on the previous analysis.

For this, in a first step, the concept of HRM was introduced (see section 2.2). In its sum HRM aims at providing the human resources to support the optimal execution of an organization's required activities. This goal translates to each area of HRM (staffing, appraisal, compensation and development; see section 2.2.2). Historically HRM has changed from the management of simple administrative tasks such as payroll and accounting to become an integral part of an organization's strategic planning and management.

In a second step the notion of process orientation was refined and the different existing understandings elaborated upon (see section 2.3). A special focus was put on BPM a management discipline that deals with the design, analysis, implementation, enactment, and evaluation of business processes in organizations. The field of business process modeling was also introduced as business process models can be considered a core part of any in depth process orientation initiative.

In section 2.4 the concept of proHRM was then introduced as a synthesis of classical HRM with the idea of process orientation. In its role as core part of an organization HRM strives for a fit between itself, the organization and the organizational strategy. The need for a process orientation in HRM can therefore be explained through this pursuit when concept of process orientation is adopted in an organization. Additional reasons for a process orientation in HRM include the positive effects for the general BPM which can become more holistic, when taking into account the employees as more than mere resources (see section 2.4.1). This need and the advantages of a process oriented HRM have been identified in the literature before and different attempts have been made towards a process orientation in HRM or at least a process orientation in specific areas of HRM (see section 2.4.2). These attempts have been more or less successful and more or less complete. For example, much work has been done towards a process oriented knowledge management in the area of personnel development, while a process oriented compensation has had much less attention in the literature. Attempts at developing or outlining a process oriented HRM on an aggregate level mostly remain on the level of defining requirements in the specific areas.

Based on the existing attempts as well as the foundations laid in the sections regarding process orientation and HRM a definition of a proHRM was then developed. A HR augmented business process life cycle was finally introduced which showed the relationship between the areas of HRM and the life cycle of a business process in a process oriented setting.

Finally, challenges in the introduction of a proHRM were identified. Next to the classical human barriers to change the main challenges for a proHRM are the need for fitting information systems as well as the required methods and tools.

3 Description of existing solution artifacts – human resource information system and process oriented information system

3.1 Approach of this chapter

The research opportunity seized in this thesis is that of applying and adapting existing solutions to a new problem context. For this the new problem context was defined in the previous chapter as a first step. The general idea for the solution to use in this new context is to be derived from existing solution artifacts for contexts similar to the new context. The stroven for solution is that of a proHRIS for the support of proHRM. Existing solutions relevant for this can be found in the field of BPM, relevant for the management of business processes, and that of classical HRM, relevant for the management of human resources. The solutions used in these contexts are HRIS and process oriented IS respectively. This chapter therefore introduces these existing solution artifacts for the support of HRM and BPM. A general overview of the approach is given in figure 20.

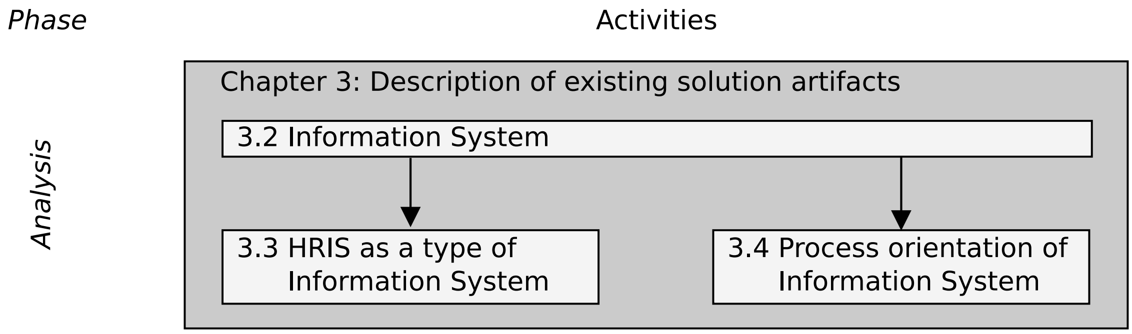


Figure 20: Steps performed to describe existing solution artifacts.

Based on a general discussion of the term information system in the context of organizations (see section 3.2), HRIS are introduced as a specific kind or business information systems (see section 3.3). Similarly the different possible types of support IS can offer with regard to a process orientation are discussed in section 3.4.

3.2 Information System

Following the argumentation of Teubner (1999, p. 17) information is understood as explicit knowledge that is provided or used by humans. The explicitness requires information to be or be able to be made available independently of humans. For use in business administration this restriction is certainly useful, since tacit knowledge, i.e. knowledge that is difficult to be verbalized, can not be easily shared among members of organizations. Another aspect that separates information from other forms of explicit knowledge representations, such as data, is its purpose (G. Curtis & Cobham, 2008, p. 3). In the context of businesses, the purpose for which information is used, is the fulfillment of organizational goals or tasks. Therefore, information is defined as follows (definition 8).

Definition 8. Information is explicit knowledge that humans use or provide for the completion of their operational tasks.

It is important to note that this thesis assumes the context of an organization for the understanding of the terms information and, therefore, information system. The operational tasks are to be seen in a business context, relating to a business purpose. This is insofar relevant as it precludes the use of the term information system for privately used soft- and hardware systems that are not used in a business context.

The scientific committee business and information systems engineering in the association of management scholars ("Wissenschaftliche Kommission Wirtschaftsinformatik [WKWI] im VHB") provides a general definition of an information system (a selection of further definitions is provided in Ferstl & Sinz, 2008, p. 9f.). They define information systems as "socio-technical systems that are comprised of human and technical components (subsystems). They support the collection, structuring, supply, communication, and usage of data, information and knowledge as well as their transformation." (1994, p. 1).

The definition is based on the understanding of a system as a "collection of interrelated parts that taken together form a whole such that: the collection has some purpose and a change in any of the parts leads to or results from a change in some other part(s)" (G. Curtis & Cobham, 2008, p. 14). These parts themselves can be seen as systems allowing for a hierarchical structure of a system consisting of multiple subsystems. In the case of the above definition the information systems consist of human and technical parts that can be seen as subsystems of the information system. The purpose of the systems, following a definition of G. Curtis and Cobham (2008, p. 15 f.), follows from the definition of the term information (see def. 8): the completion of the operational task.

A narrower but often (Gabriel, 2013) used understanding of the term information system is that of an application or software system "to capture, transmit, store, retrieve, manipulate, or display information" (e.g., van der Aalst, 2011, p. 4). At a first glance the difference between the two understanding consists mainly of the importance attributed to the human or social part of the system. These different viewpoints could then be explained by the context in which the information systems is considered. If an information system is regarded with a focus on its software components without their relation towards a specific hardware setup or the systems relation to a specific organization it is equivalent to a software system. If, however, the focus is on the implementation in a specific organizational setting and the interrelations between sociological and technological parts are of interest the information systems constitutes more then just the software, the hardware of the system, or a combination of both.

The inclusion of the social aspect has much wider implications however. While application systems or software systems can be analyzed and designed by themselves, information systems

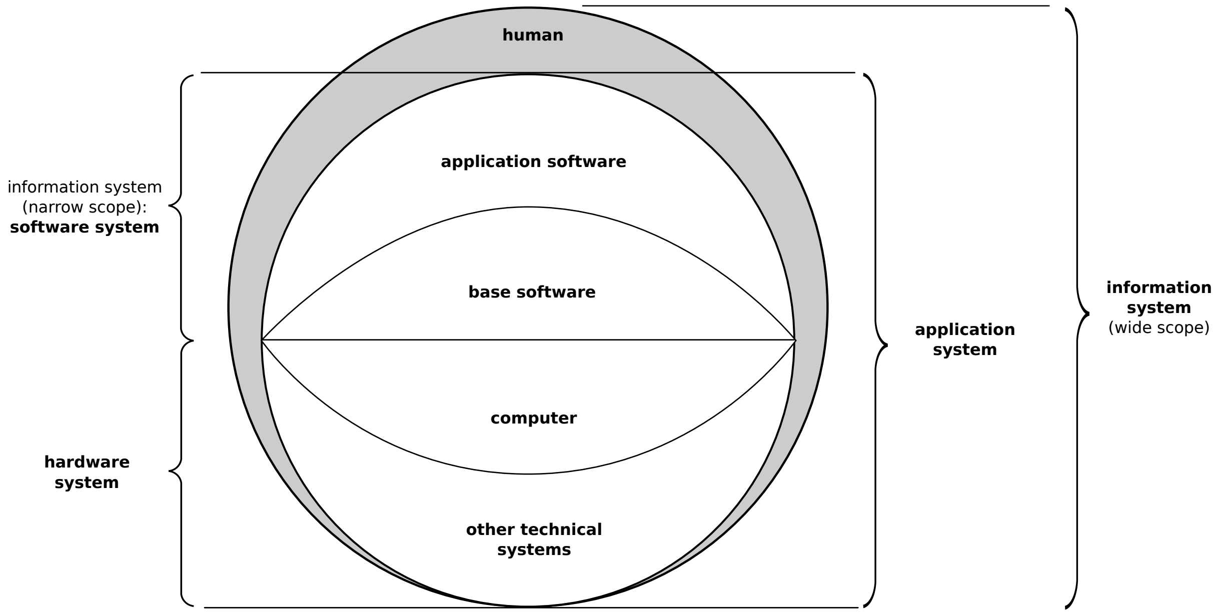


Figure 21: Shell model of an information system shows the different layers as well as the respective terms used in this work (based on Teubner, 1999, p. 26; Hesse et al., 1994, p. 43).

always relate to a specific individual organizational context. An information system, therefore, constitutes a much broader design object then an application system. The development of an information system requires specialized knowledge in information technology as well as organizational management, personnel development and business process management.

The relationship between the different terms and understandings is displayed in figure 21.

Based on the above definition of the scientific committee of business and information systems engineering and integrating the specific definition of information, the term information system is defined as follows for this thesis (def. 9):

Definition 9. An information system is a socio-technical system that is comprised of human and technical components. It supports the collection, structuring, supply, communication, and use of information.

This definition also fits with the notion of an information system as a special type of work system. A work system is a system "in which human participants and/or machines perform work (processes and activities) using information, technology, and other resources to produce specific products and/or services for specific internal or external customers" (Alter, 2008, p. 451). An information system can, therefore, be seen as a special kind of work system whose products and/or services are centered around information.

Following the work of Teubner (1999) the different components of the information system can be further specified. The technical components represent an application system. The application system in itself consist of a physical part (a hardware system) as well as virtual part (a software system). The hardware system itself is comprised of the computer as well as other technical systems used. The software system includes the base software used to run the computer as well as specific application software. While this separation makes sense from a conceptual point of view in scientific practice the focus of application system development shifts towards the software system or even the application software itself, as long as no customized hardware is needed. The model presented in figure 21 also shows the main points of interaction between each component. The application software mostly only interacts with the base software and through it with the hardware system. The human component on the other hand can interact directly with most of the other components of the system.

It is important to note, that while the terms information system, application system, and so on are used in a singular manner, each system can be composed of multiple subsystems (G. Curtis and Cobham 2008, p. 18; Teubner, 1999, p. 10). Most information systems consist of multiple human actors as well as multiple application systems that work together. Application systems themselves can consist of multiple hardware systems on which one or more software systems are running.

In this thesis the main object of interest is the software system. Before an integration in a specific organizational context can be devised the internal working of the system, especially the core logic must be defined. Therefore, the main focus in the description of an information system will be on the software system aspects. Additional technological aspects as well as sociological aspects will be touched upon where necessary. However, the organizational context plays an important role even for the design of the software system, as requirements and relevant actors of the system, that is to be used in an organizational context, have to be defined. As such a tentative definition of the problem context for which the system is designed, as done in the last chapter, is a sensible task.

3.3 Human resource information system as a type of information system

3.3.1 Description of categorization possibilities of information systems

In a business context different types of information systems can be identified by characteristics relating to the organization in which they are used. As shown in figure 22 one characteristic by which the systems can be categorized is the business function that they are used in (Laudon & Laudon, 2005). The typical functions include sales and marketing, production, finance and controlling, as well as HRM.

Following Laudon and Laudon (2005, p. 84 ff.) systems can, furthermore, be differentiated by the organizational level in which they are used. Systems can be used on an operative level in the supporting of day-to-day activities, as well for managerial tasks or even to support executives on a strategic level.

Systems can be designed to support one specific business function or one specific organizational level or be designed to offer their support across organizational boundaries. The second type of information systems are also called integrated information systems. The idea of integration is a very extensive topic in information system research (for a more in depth discussion see, for example, Mertens, 2013). In short integration means the “restoration of a whole” (Mertens, 2013, p. 13). In the context of information systems that integration is between the different relevant components of the system as well as the tasks to be achieved with the system. Since information systems consist of multiple different subsystems, the integration of these system is

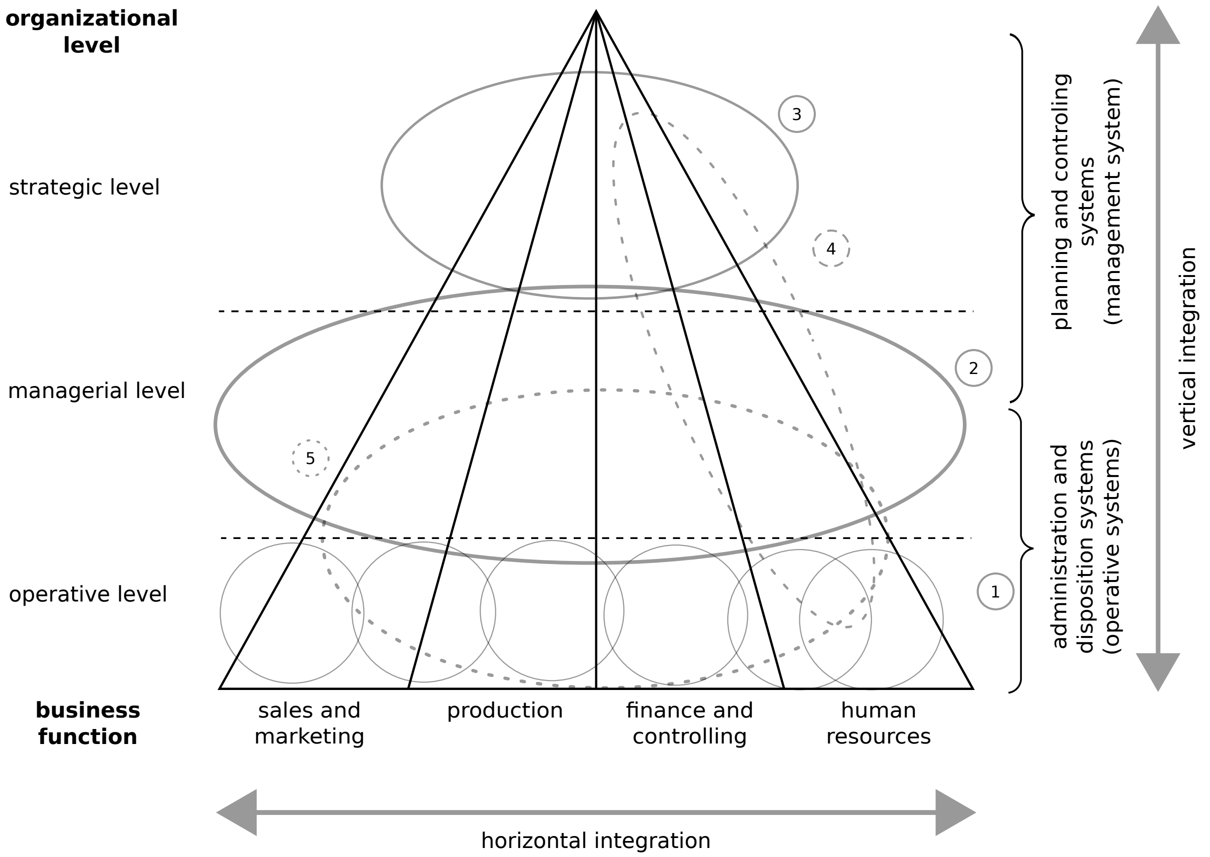


Figure 22: Categorization and types of information systems (based on Laudon & Laudon, 2005, p. 81 ff.; Scheer, 1997, p. 5; G. Curtis & Cobham, 2008, p. 26 f.).
The different types include, for example: 1. transaction processing system (TPS), 2. management support system (MSS), 3. executive support system (ESS), 4. business function specific systems such as human resource information system (HRIS), 5. enterprise resource planning (ERP) systems.

always an important factor during the implementation of an information system. Displayed here are only the two directions the integration can take place in: horizontal and vertical integration (see fig. 22).

Horizontally integrated information systems are characterized by the fact that they offer support in more than one business function across the value-chain of the organization. Vertical integration implies the support of tasks across different organizational levels (Mertens, 2001b, p. 244), especially the data provisioning of planning and control systems through the operative systems (Mertens, 2013, p. 18). Mertens (2013, p. 14) defines the main objects of integration as follows.

Data Data integration concerns itself with the logical connection of existing data structures and data representations. This is achieved either through the creation of a singular data basis, or the design of fitting transformation processes to transform data from one back-end to another (Heine, 1999, chapter 3.3). In the case of a vertical integration, i.e. data warehouses being supplied with information from operative systems, this is part of the extraction, transformation, and loading (ETL) process (Vassiliadis & Simitsis, 2009).

Function The integration of functions relates to the coordination of functions on an organizational level. Equalizing and standardizing similar tasks across organizational boundaries and defining who (human, computer, or both) is to execute a specific task.

Application While the function integration is more subject and content oriented, the application integration (or program integration) has a more technical focus. It concerns the integration of different software applications into a single information system. Relevant for this integration is the survey of existing application programming interfaces (APIs) for communication between the different software application. Since many software systems start to contain their own database systems internally the application integration becomes more and more important as a simple data integration is not sufficient anymore (e.g., Irani, Themistocleous, & Love, 2003).

Process The integration of information systems along organizational processes plays a big part in the horizontal integration of information systems. The business processes that are supported through the information system can be aligned to one another with the help of organizational changes but also through the information system itself (Vogler, 2006). In a sense the process integration described here supports a process orientation (see section 2.3.1) from an information systems point of view; it then corresponds to the implementation step (see figure 9 in section 2.3.2).

Method The goal of integrating methods, is to make sure that different methods used in the organization are suited to each other. It can be problematic and costly if sales forecast methods and methods to define safety stocks are not correctly aligned. Method engineering is a research field that focuses on software development methods, their specification, comparison, integration, and adaptation (Brinkkemper, 1996). The field of application is, however, not limited to the method analysis in the context of software development. It can be generally be transfer to (business administrative) non mathematical or heuristic methods and allows their integration as well (Stadlbauer, 2003, p. 41)

From these different objects of integration, from a narrower understanding of information systems, especially data and application integration are important, since different software modules have to fit together and work on the same data basis. In a broader understanding the focus is extended to the coordination of functions, processes, and used methods during the conception and implementation of information system (the general topic of integration is often also referred to as enterprise application integration, see Wong, 2009).

Additionally to the subsuming of systems under the different organizational levels, it is also possible to categorize the systems by the type of tasks supported (or automated) by them. This results in two broad categories of systems: administrative and disposition systems (or operative systems, e.g., Scheer, 1997, p. 5 or for a further categorization of the operative systems Mertens et al., 2012, p. 5 f.) as well planning and controlling systems (or management systems, e.g., Stahlknecht & Hasenkamp, 2002; Chamoni & Gluchowski, 2006, p. 10 ff.). Operative systems are mainly used on the operative level of the organization and by lower management. They support routine activities that are necessary for the daily operation of the organization. This can include administrative systems such as systems for the communication with suppliers but also disposition systems that allow for short term resource assignment (Laudon & Laudon, 2005, p. 85).

Management systems support members of the organization on a higher organizational level. The tasks are less structured and entail the planning on case by case basis or the control of discrepancies between plans and as is results (Fink, Schneidereit, & Voß, 2005, p. 209 f.).

Typical system categories and their placement in regard to the different dimensions have be outlined in figure 22: transaction processing systems (1) are systems that process simple day-to-day inputs. Examples would be goods receiving systems or payroll systems. Management support systems (2) are located on the managerial level of the organization. They provide support in making decisions by supplying the user with aggregated information from the operative systems and external sources. The information gathered is not limited to one business function but includes all relevant organizational units. Executive support systems (3) cover the highest organizational level and support executives in strategic decision making. The differentiation between support on the different upper organizational level is strongly academic. Another approach is to subsume the systems under the type of decision support system as a system type that helps users make decisions by providing analytic tools and models as well as user friendly interfaces (Laudon & Laudon, 2005, p. 504 f.). The higher the organizational level that is to be supported the more unstructured the problems faced generally get. One very broadly used type of information system are enterprise resource planning systems (4). The main focus of ERP systems is on an integration aspect (Mertens, 2001a). ERP systems span a wide range of business functions and offer support for most operative functions. Simple report generation and controlling can also be supported through the systems making them span multiple organizational levels.

While ERP systems span the different business functions across mostly one organizational level, there are many system types that can be attributed to one business function but offer functionalities across multiple organizational levels. One example of such a type of system would be customer relationship management systems. These can be attributes to the sales and marketing business function and seek to provide information on existing customers to employees, help identify new markets and create new employees, manage relationships with related organizations, or provide services to customers to improve their satisfaction with the organization (G. Curtis & Cobham, 2008, p. 251 f.). Another such type of system are human resource information systems (5). They try to provide support for functions across all organizational levels for the human resource business function. HRIS are explained in detail in the following section.

3.3.2 Definition of Human resource information system

As introduced in the previous chapter HRIS can be seen as the category of information systems specifically tailored to support the human resource business function of an organization. Matching the general notion of information systems, Mülder (2000) thus describes HRIS as "allowing the capture, storage, processing, transfer and output of information that is necessary for the support of administrative human resource activities and planning purposes".

The above definition fits the general notion of information systems, in supporting the work with information, and includes human resource activities on all organizational levels (see fig-

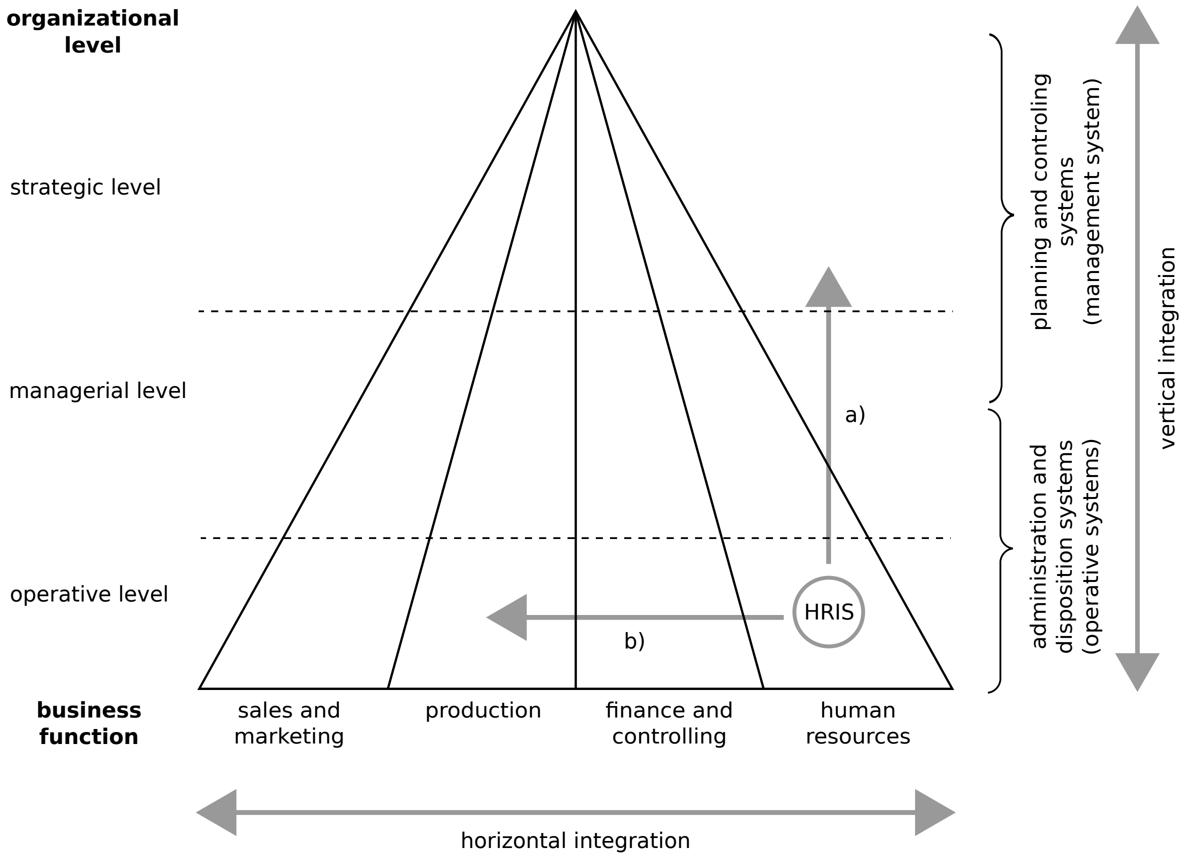


Figure 23: Expansion of HRIS supported areas from historical systems to current systems.

ure 22). Historically, however, the term HRIS was used for systems providing support on the lower organizational levels. Many HRIS , since their advent in the 1960s, focused on administrative tasks (see for example Bassett, Campbell, & Liccardi, 2003; McLeod & DeSanctis, 1995, p. 14; Mülder, 2000, S98; Broderick & Boudreau, 1992, p. 8; Ngai & Wat, 2006, p. 305).

Since then HRIS have started to support more and more managerial tasks (e.g., Hendrickson, 2003, p. 382; Hannon, Jelf, & Brandes, 1996, p. 262; Strohmeier & Kabst, 2007, p. 38; Broderick & Boudreau, 1992, p. 8; Hussain, Wallace, & Cornelius, 2007, p. 80). Currently the category of HRIS includes systems supporting operational tasks through to systems supporting strategic decision making or a combination of both (see figure 23 a).

At the same time HRIS now support a wider variety of stakeholders. While classical HRIS mainly worked in conjunction with HR professionals current HRIS have a multitude of stakeholders. In addition to HR professionals, they support (line) managers in functional areas and the employees themselves (self service; e.g., Broderick & Boudreau, 1992, p. 8; Gueutal & Falbe, 2005, p. 195 ff.). Due to this increase in stakeholders HRIS display characteristics of integrated information systems, spanning across organizational boundaries. In fact due to the provision of employee self services, that offer support to every employee of an organization and managerial self services that offer support in employee related managerial tasks to (line) managers, HRIS can be said to span all organizational units. This of course leads to the need of integrating HRIS with a multitude of different functional IS. For example, an HRIS might provide support to the leave-request process in production involving both an employee and his or her line manager. To fully support the process it should be integrated with the production planning system to allow for production planning taking into account possibly missing personnel capacity or notify the manager of possible production plan restriction in regard to the request (see figure 23 b).

Following Zuboffs (1985, p. 9) argumentation IS can automate, i.e. replace manual tasks, and inform, i.e. supply new information to humans. These two types of support are also referred under different terms such as, e.g., "administrative" and "analytical" support (Ball, 2001, p. 679) or "strategic " and "non-strategic" usage (Hussain et al., 2007, p. 76). Classical HRIS certainly focused on the former, automating the payroll processes and shift scheduling. As collated by Ball in his survey around the turn of the century, most HRIS use aims at "easing the administrative burden of record keeping and pay administration" (2001, p. 679). Current HRIS however, while still automating many HR tasks, also focus on supplying information to HR (or line) managers in support of their tasks. As reported by recent studies and surveys (Harris & Spencer, 2016; HR Technology Advisors, 2014; Hussain et al., 2007; Strohmeier & Kabst, 2007; Visier, 2014) many organizations are aware of the potential of HRIS support for analytical and planning tasks and most already routinely use HRIS for those tasks, or plan to increase their maturity in these areas in the short term. HRIS increase the continuity with which managers receive information and they support the comprehension of the data by providing analysis functions. They thus allow for a greater control of the relevant processes. Therefore, "current HRIS are best understood as configurations of different interacting systems that aim at the generation and delivery of HR functionality in order to automate and informate HRM"(Strohmeier & Kabst, 2007, p.31).

Based on the discussion above the following definition is authoritative for HRIS in this thesis.

Definition 10. a human resource information system (HRIS) is an information systems that supports the collection, structuring, supply, communication, and use of information with the goal of automating HR tasks and informing in relation to HR decisions.

3.4 Process orientation of information systems

3.4.1 Description of process orientation as a characteristic of information systems

Based on the discussion of process orientation in section 2.3 an initial delimitation of process oriented information systems can be given as information systems that adapt their actions based on the business processes of organizations (see esp. definition 3; cf. Mutschler, Bumiller, & Reichert, 2006, p. 436). The goal of an information system is the collection, management and use of information in the fulfillment of operational tasks. Analogous to the central nervous system an information system can be seen as the central nervous system of an organizational entity (Amberg, 1999, p. 42 ff.) as it is used for control of any activity. With process orientation as the primary design criteria for such a system the supported activities are seen in the broader context of the business processes they are involved in. This orientation in respect to the business processes can, however, take many forms. In the following, therefore, a number of characteristics are presented that can be used to better describe a process orientation of IS.

Structuredness or predictability of supported business processes As seen in section 2.3.1 the structuredness of processes ranges from unframed to tightly framed processes. An unframed process is one for which there is no explicit process definition. While a tightly framed process is always enacted within the boundaries of its definition. The structuredness of the process impacts its predictability. From the point of view of a supporting IS in tightly framed processes the next activities or possible outcomes can be predicted with a high confidence. With unframed processes it is very difficult to predict which actions will be enacted next or which outcome is more probable. Another important aspect is that ad hoc framed processes often are not executed in a regular fashion. This means the adaptation of IS for a specific unframed or ad hoc framed process often is not economically sensible unless a very high value can be attributed to the support. IS therefore tend to either offer very generic support functions, that can be used by a very broad range of unframed or ad hoc framed processes, or mostly focus on stronger framed processes (cf. Huth & Nastansky, 2000; Lillrank, 2003; Dumas et al., 2005, p. 13 ff.).

Types of interactions in the business process Another important characteristic by which the process orientation of IS can be differentiated is the interaction support they provide to the actors involved in the enactment of the business process. Systems can be more human centric or more application centric (Georgakopoulos et al., 1995, p. 128 f.). On one end of the spectrum human centric systems mainly control and coordinate the interaction between different human actors while on the other end application centric systems mainly focus on the integration and communication of different specialized applications.

The types of interaction differentiated here are human to human interactions, human to application interactions and application to application interactions. There is a correlation between the type of actors involved in a process and its structuredness. Knowledge intensive business processes, i.e., processes from which value is mostly created through the fulfillment of the knowledge requirements of the participants (Gronau & Weber, 2004, p. 164), tend to be unframed and very human centered, while repeatable processes tend to be tightly framed and automated, thus requiring little to no human interaction (see figure 24).

This results in different requirements for information systems supporting these classes of processes. Application to application interaction requires a higher understanding of the process and data structures involved in the business process. To be able to forward the right information from one application to the next, the supporting IS needs to "understand" the structure of the process as well as the structure of the data provided by the sender application and the expected structure of the data required by the receiving application. In unframed or ad hoc framed processes such detailed information might not be available. With human to human interaction, however, the information system often does not need specific knowledge about the process structure or the type of information exchanged by human actors. The decision to whom to forward the information is made by the humans involved.

Phase of the business process life cycle The support provided by IS in regard to a business process can happen at different times during the life cycle of the business process. The phases differentiated here are design and analysis, implementation, enactment and evaluation. Design and analysis refers to the design of business processes and the analysis and optimization of those processes. In the implementation phase the business process

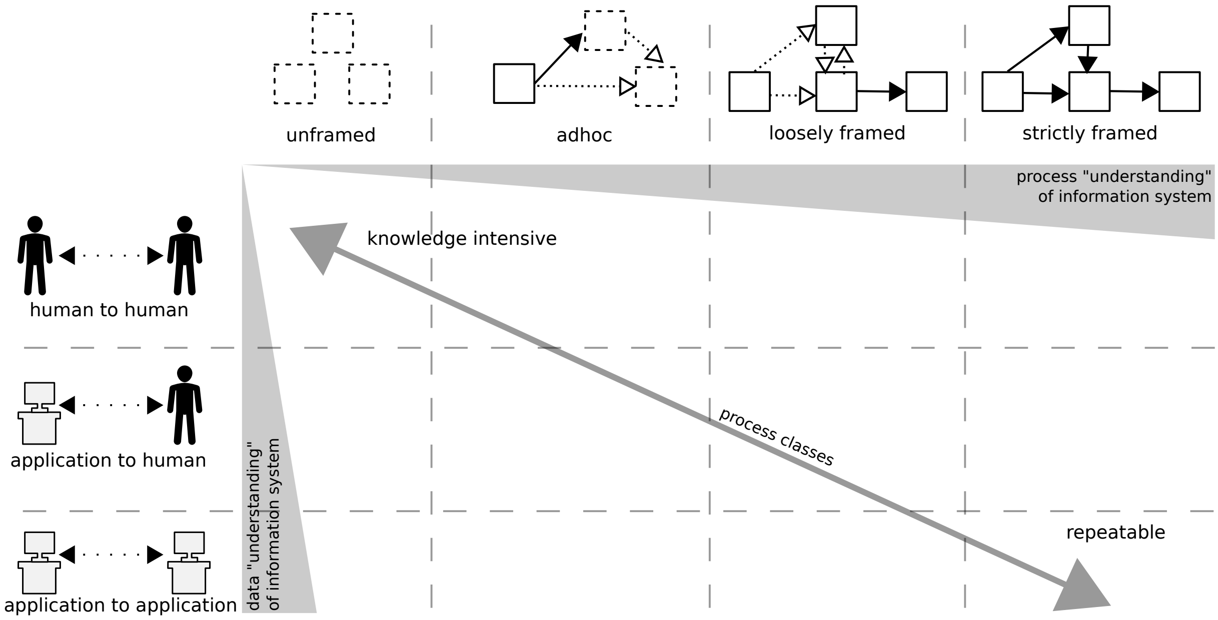


Figure 24: Classification of processes based on their structuredness and involved actors and the effect on the supporting information systems (based on van der Aalst, 2013, p. 5). The more tightly framed a process is the greater the possible understanding of the process by the information system. The more the interactions are purely application to application based, the greater the possibility and need for supporting information systems to understand the data structures. Most processes can be found around the diagonal.

are organizationally and technically implemented. In the enactment phase the business processes are enacted through humans and technical systems. The evaluation phase refers to the evaluation of enacted processes with regard to their performance and possible weaknesses of the business processes. This evaluation might lead to a new process design in the design and analysis phase (for a detailed discussion of the phases see section 2.3.2).

In the context of business process orientation information systems can be distinguished by which phases of the life cycle are most supported by them. An information system can support the design or the analysis of business processes, it can support the organizational or technical implementation of processes by, for example, converting more abstract business process models into code and thus creating application tailored specifically for the process. A huge part of the support can of course be provided during the enactment of the process. Additionally an information system can specifically support the evaluation of enacted processes. This is, for example, the case if the systems allows the comparison of the enacted process with previously defined process models on which the process is based. Especially in loosely framed processes where changes from the defined process are to be expected such an evaluation can result in relevant information.

Managerial and operational support The support given by the information system can either focus on managerial activities, on the operational activities, or support the whole range of activities. Such a distinction is closely related to the life cycle phases of a business process as design and analysis, implementation and evaluation can be seen as mainly managerial level activities while the enactment is mainly composed of operational level activities. However, this distinction is not always clear. It is also possible for information systems to support managerial level activities (such as the assignment of employees to tasks, or the ad hoc planning of alternative tasks) during the enactment phase.

The conceptual separation into a managerial and an operational level allows to distinguish further parts of an information system based on that separation (see Amberg, 1999, p. 43).

- Activities can be split into those activities actually related to the enactment of the business process (operational level), as well as the activities relevant for the management of the business processes (managerial level). The focus of the activities on the managerial level are the business processes consisting of the activities on the operational level. They comprise the activities performed in preparation of the enactment as well as those for directing and controlling the enactment itself.
- Performers, i.e., the actors performing the tasks (be they human or machine), can be differentiated between those that perform the actual processes (operational level) and those that perform tasks to manage the processes (managerial level).
- Information required for the performance of the tasks can be categorized in the same way. As information required for the management of business processes (managerial level), as well information required for the enactment of the business process (operational level)

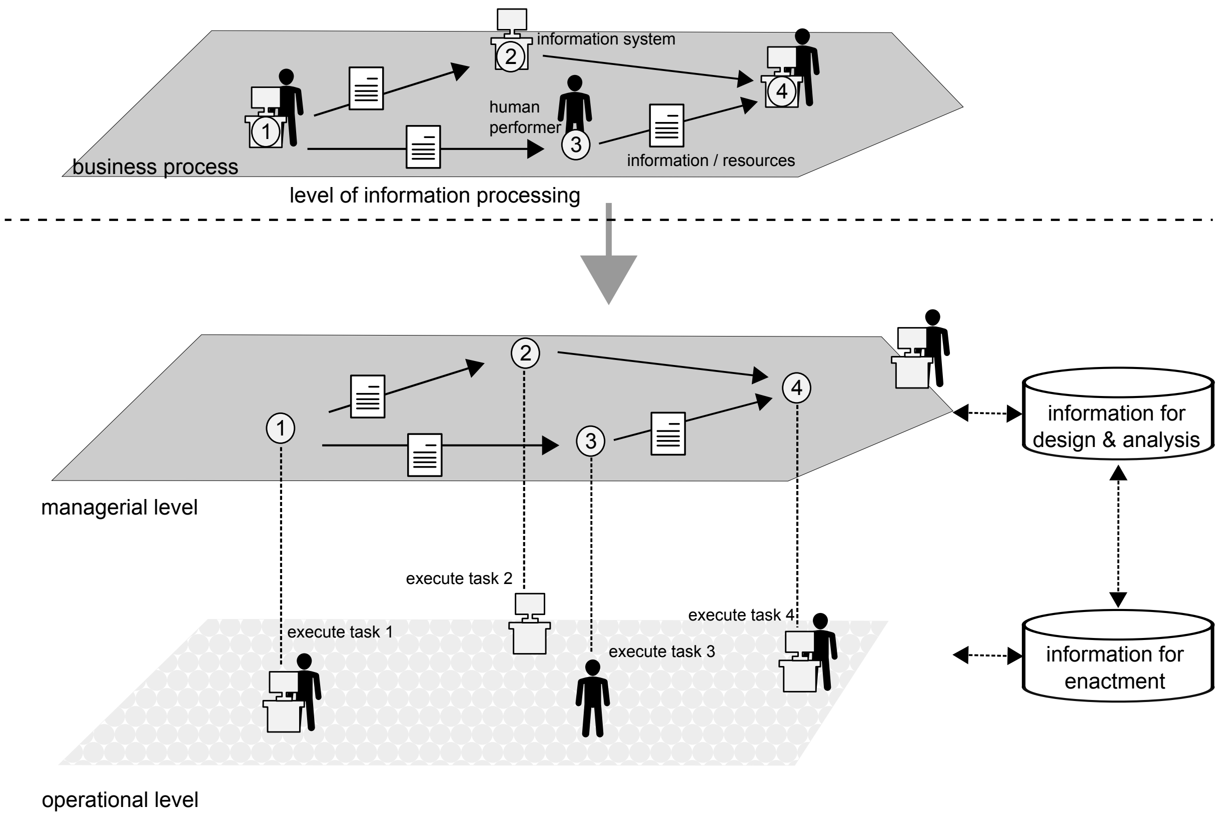


Figure 25: Differentiation between managerial and operational activities in the context of process oriented information systems (based on Amberg, 1999, p. 42).

Figure 25 shows the relationship between these levels and the information required by the activities in each as well as their relationships. On the operational level a process oriented IS can support the execution of the business process by offering "the right task, at the right point in time, to the right persons along with the information needed to perform these tasks" (Dadam, Reichert, and Kuhn 2000, p. 36; see also Mutschler et al., 2006, p. 436; Lind, 2005, p. 8). The process orientation implies that the tasks supplied fit the currently enacted business process and do not simply represent generic features of a software system unrelated to the current process.

On a managerial level process orientation of IS relates to the ability of IS to support the management of business processes, i.e. primarily the design, analysis and evaluation of the abstract processes. As the management of business process heavily relies on the concept of business process models, this includes support in the creation, analysis and optimization of these models (e.g., Giaglis, 2001). On a managerial level, therefore, process types are most relevant, while on the operational level the focus especially lies on process instances (see section 2.3.1).

Hard coded and generic process support Information systems can also be distinguished by the way in which they are oriented toward existing processes. The process orientation of a system can be something fundamentally attributed to the design of that system. While this seems similar to the life cycle phases of business processes, it is important to note that one characteristics focuses on life cycle of the processes, while the other focuses on the life cycle of the information system. There are two ways such an adaptation of the system can be achieved: the systems adaptation can occur during the run-time of the system or system can be adapted during its build-time.

The concepts of build-time and run-time are often referred to in the literature (zur Muehlen, 1999, p. 137; Amberg, 1999, p. 43; Weber, Reichert, Rinderle-Ma, & Wild, 2009, p. 119; Workflow Management Coalition, 1999, p. 24 & 43). Build-time refers to the time span before the actual enactment of the business processes while run-time especially refers to the time span during which the enactment of the process takes place (e.g., Reichert & Weber, 2012, p. 30ff). They closely match the idea of managerial and operational levels, with build-time generally relates to the managerial level and run-time to the operational level.

The design of information systems normally occurs during the implementation phase of the life cycle of business processes. At that point the business process has been designed and is implemented through organizational and technical measures. One of those measures is to either conceive new information systems to support the process, or to adapt existing information systems to provide the required support. Assuming the design of a new information system, the system can either be designed in such a way that it supports the process as it is current defined, or the system can be designed in such a way that it can support any process that is defined in a specific way. In the first case further change in the process during the systems run-time is then not possible. With the second type of adaptation the system can readily accept process changes during its run-time by changing the definition of process deposited in it.

The general idea of decoupling the process logic from the application logic is not new (e.g., van der Aalst, 2009a, p. 2224; Dumas et al., 2005, p. 8). Initially monolithic, software systems started to share generalized (and functionally specialized) components for different parts of the system (see figure 26).

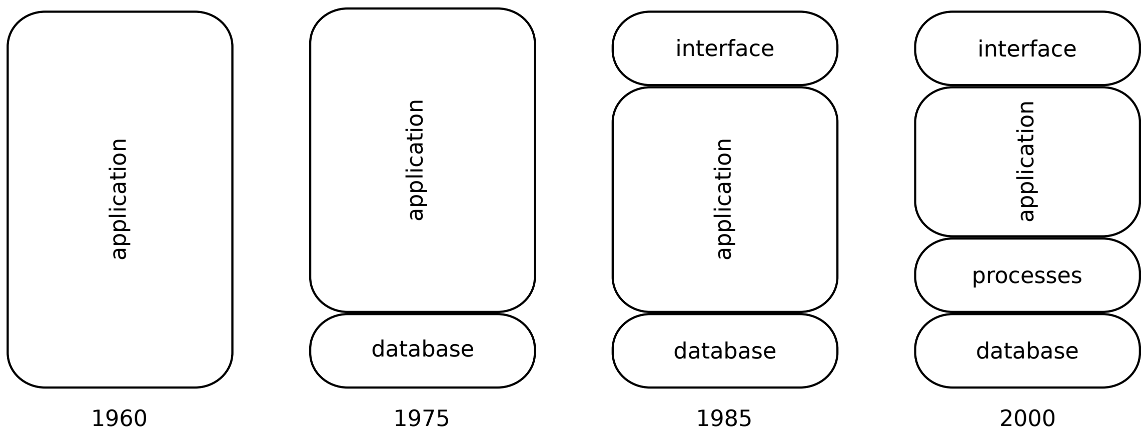


Figure 26: Trend of externalization of generic features using more generalized components (based on van der Aalst, 1998, p. 23; van der Aalst, 2012, p. 4; Chang, 2006, p. 56).

During the first introduction of information technology in organizations, every part of the software system was specifically designed and programmed for each individual system. However, many pieces of one software system could be reused other systems. Generic data management components could be designed and used in different systems, as each system had the same requirements in regard to data management. In this way the management of the data for a software system was outsourced to database management systems (DBMS). These specialized subsystems where more refined and more error resistant due to the fact that much more development time and effort went into them than on the data management functionality of monolithic systems (Helland, 2009, p.715f.). The same applied to the interface of the software. Generic functionality (buttons, windows, forms, etc.) could be externalized into own components. Specialized frameworks and tools for the design of the user interface then assumed the task of displaying information to the user. In the same way the process logic can be decoupled from the application logic. This allowed for specialized process enactment subsystems in the software system. An example of this are the workflow engines in most ERP systems that decouple process and application logic (see also section 3.4.3).

While such a generic process support seems superior to a hard coded process support, it requires an overhead in the system to manage the definitions of processes, parse the definitions, and handle changes in the definitions during run-time. Such a system also requires very detailed process definitions that include a lot of technical information which increases the effort of creating such definitions. This results in a trade-of, as hard coded process logic can be easier to implement, but increases the effort during later changes in the process, while a generic process support, requires a greater amount of work in a first implementation but can the be more easily adapted to process changes. In the case of support for unframed or very loosely framed processes systems do not need to be adapted during the run-time of the system. As their support is designed in such a way, that the responsibility to adaptation to changes in the process falls mainly to the human users. This is, for example, the case in groupware systems that focus on facilitating the interaction between different human agents.

Inter- and intra-organizational support Another relevant distinguishing characteristic is the scope of the information system supporting the business process. Three values are distinguished in this thesis: departmental, inter-departmental or intra-organizational, and inter-organizational. While the support of processes through information systems initially focused on intra-organizational settings, i.e. the support of processes involving people and applications inside on organization (or even within one organizational unit) the support is more and more expanded beyond organizational boundaries (Irani et al., 2003; Malhotra, Gosain, & El Sawy, 2005; Shaw, Holland, Kawalek, Snowdon, & Warboys, 2007, p. 94; van der Aalst, 2009b, p. 6). As business processes can span multiple organizational units, information systems that have a broader scope are better suited to support these processes (e.g., Davenport, 1993, p. 37 ff.). This is also highlighted by the extension of business process modeling languages specifically addressing intra-organizational representation of business processes (e.g., Seel & Vanderhaeghen, 2005; Decker & Puhlmann, 2007; OMG, 2011, p. 111 ff.). The design and following implementation of inter-organizational systems faces additional challenges. Among others aspects the organizational integration, the technical integration (between organization internal information systems and inter-organizational systems), and standardization between organizations need to be addressed (e.g., Lu, Huang, & Heng, 2006).

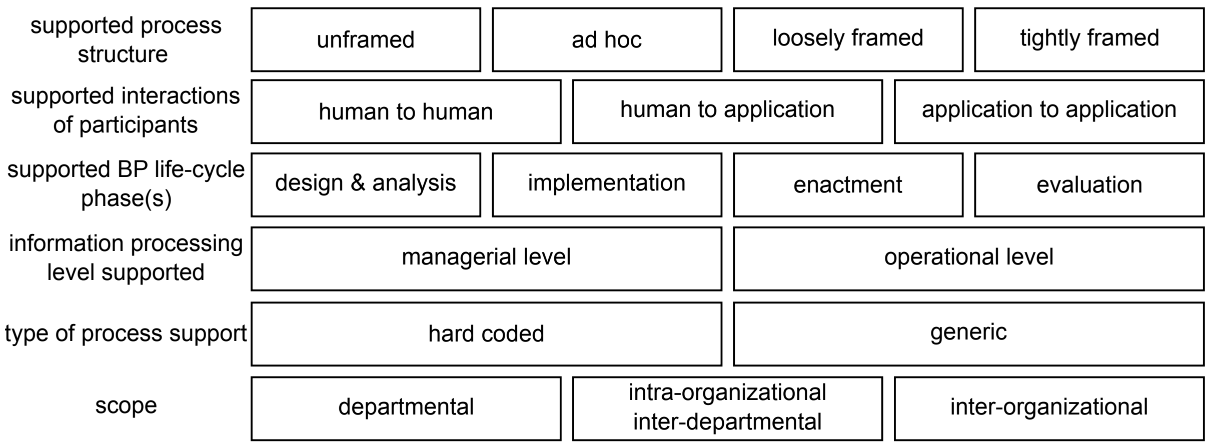


Figure 27: Relevant characteristics for the comparison of the process orientation of information systems (based on Amberg, 1999, p. 55; Becker et al., 2002, p. 45; Dumas et al., 2005, p. 11ff.; Shaw et al., 2007, p. 100ff.; van der Aalst, 2009b, p. 3 ff.; Dumas et al., 2013, p. 306 ff.).

An overview of the characteristics and their values is given in figure 27. The presented characteristics show the broad range of aspects that have to be considered when discussing the process orientation of information systems. They can also serve as a framework to better differentiate commonly used terms (see section 3.4.3). In the following they will be used to allow for a more specific delimitation of the term “process oriented information system” as this thesis puts a specific focus on the concept.

While the provision and management of information for the support of the communication between actors in unframed or ad hoc framed processes is sensible, it is not in line with central understanding of process orientation in an organizational setting (see section 2.3.1). This thesis, therefore, focuses on systems that support loosely or tightly framed processes. An additional focus is set with regard to the type of support. While a hard coded process flow in the source code of an application can be said to make the application process oriented. A generic process support allows for much greater adaptability of the IS towards the respective processes and changes in those processes. An increased flexibility in information systems is also the current trend in research of process orientation of information systems. Therefore, the term process oriented information system is used for those systems in which the technical components allow for a generic process support, i.e. the technical components can “understand” process models supplied to them and support the enactment or management of those processes. Based on those restrictions an authoritative definition for the term “process oriented information system” can be stipulated (see definition 11).

Definition 11. A process oriented information system is an information system which technical components support the management and/or enactment of business processes based on an explicit representation of those processes.

Finally based on the identified aspects in the discussion above and derived definition, a general structure of process oriented information systems can be devised. This structure is shown in figure 28 and includes the relevant subsystems, the performers as well as information sources relevant for the systems and/or performers.

Following the idea of a system comprised of individual entities (see section 3.2) the general structure of a process oriented information system is described by the subsystems that comprise it. The relevant systems: are design system, a management system and an enactment system. Following the conceptual distinction between a managerial level and an operational level the three systems can be assigned to one or more levels. The design systems focus is on designing and analyzing business processes. The focus, therefore, lies on the business process types and not business process instances and can be located on the managerial level. The data used and created in this step can be considered as belonging to the managerial as well as the operational level as, for example, in a visual model based system the created business process type models can be instantiated for their enactment. The focus of the enactment system lies on enacting concrete instances of the previously designed business processes. For this it interacts with other external systems, such as client applications or legacy systems, or, in case there is not one single enactment system responsible for the whole business process, with other either subordinated enactment systems or enactment systems on an equal level (such as systems in another organization). To supply external systems and/or human performers with the required information the enactment system needs instance specific process data. Furthermore the system collects information about the performed instances of the business processes and the results of that enactment (kept as run-time data, sometimes also referred to as event logs). Such information is useful in a multitude

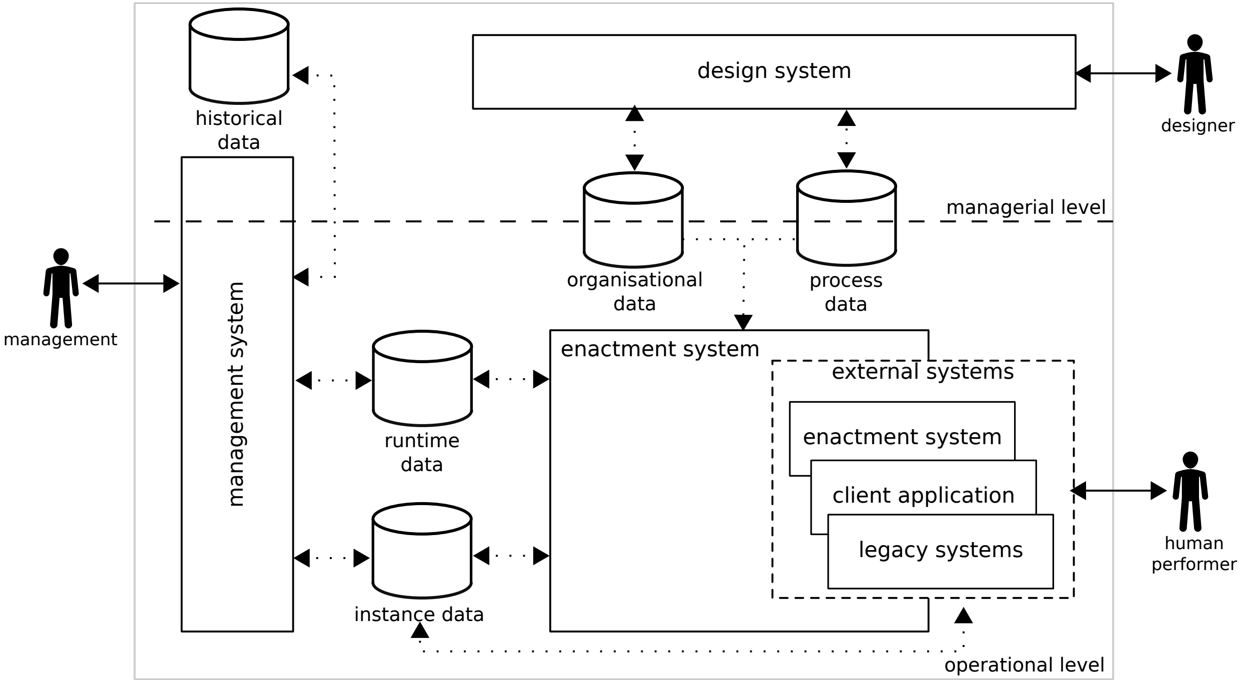


Figure 28: Idealized structure of a process oriented information system (based on van der Aalst, 2009a, p. 18; Amberg, 1999, p. 44; Workflow Management Coalition, 2001, p. 23; van der Aalst et al., 2010, p. 316; Dumas et al., 2013, p. 299).

of ways and can be accessed by the enactment system itself, as well as a management system.

For example, in the case of an automatic assignment of employees to process instances there exists a multitude of assignment algorithms that try on-the-fly optimization of the human performer to task assignment (e.g., zur Muehlen, 2004a, p. 278 ff.; Weske, 2012, p. 104 ff.). There are, of course, simple assignment strategies that do not require run-time data. For example, the round-robin assignment strategy simply assigns each new to be performed tasks to the next (free) human performer. More advanced strategies, however, require access to instance, run-time, and organizational data (e.g., Kumar, van der Aalst, Verbeek, Ave, & Hill, 2001). For example, it is possible that in a customer support center all request of customers are routed (if possible) to the employee that has already had contact with the customer before (Becker, von Uthmann, zur Mühlen, & Rosemann, 1999, p. 4). For this the system needs information about past process instances with the same customer to identify possible human performers to assign the task to.

The management subsystem operates on the operational as well as on the managerial level. On the operational level it monitors the current process instances and allows managers to check on the current progress of process instances or overwrite decisions made automatically by the system (see also zur Muehlen, 2004b, p. 175 ff.). On a managerial level, the information gathered through the execution of process instances can be archived and further analyzed to extract relevant information from the data (for an in depth introduction to process mining see van der Aalst, 2011, p. 191 ff.). It is possible, for example, to monitor assignment rules of performers to processes to react to possible organizational changes (e.g., Rinderle-ma & van der Aalst, 2007). The information generated by the management subsystem can also be used by the design system during the design and analyze of the business process types. This circular relationship of the different subsystems fits into the business process life cycle (see section 2.3.2). The design and analysis phase is supported by the design subsystem, the implementation and enactment phase is supported by the enactment subsystem and the evaluation phase is supported by the management subsystem.

While such a strict distinction between phase, time spans, and systems makes sense on a conceptual level to gain a better understanding of the individual elements, in practice it falls short. The idea of adaptive systems, for example, merges the change of process models, on which the enactment system bases, with the actual enactment. I.e., the human performers can themselves define exceptions to the defined process and change the process type while a process instance is being enacted (e.g., Weber et al., 2009, p. 194 f.). This places activities that are normally attributed to the build time during the run time of the system. Depending on the complexity of the optimization and amount of control the enactment system achieves it might require more information, for example, of historical process data.

3.4.2 Description of challenges in the process orientation of information systems

The general difficulty for the process orientation of information systems lies in the incorporation of both conceptual levels (operational and managerial) and the synthesis of the separation of build and run-time activities (flexibility). In their study Mutschler et al. (2006) identify five main challenges (see also Mutschler, Reichert, & Bumiller, 2008):

- ▷ With organizations trying to adapt to changing market conditions and the growing importance of change and variability in processes business processes tend to change over time. The rate of change of business processes is seen as increasing instead of slowing down. These quickly changing processes need to be supported by the information systems. This requires of the systems to be quickly adaptable to the changes in and new business process (e.g., Buchwald, Bauer, & Reichert, 2012; Dehnert & van der Aalst, 2004).
- ▷ Many (during design-time process oriented) information systems have a hard coded process logic. Once defined during the design phase the logic is hard-coded into the application software. This results in a considerable effort required in adapting the system to changed or new business processes. With the further increase in the rate of change in business processes and the increasing variability of processes systems need a stronger focus on application and process logic separation.
- ▷ The use of off-the-shelf standard software increases this problem. While standard software offers a broad range of functionality it needs to be customized before it can be used in a specific organization. However, this customization is often very complex and requires huge efforts from the part of the customizing organization. Insufficient customization possibilities result in an ineffective adaptation to process changes (e.g., Mutschler et al., 2008, p. 281).
- ▷ Often there is inadequate support for the required functionality. This problem also depends on the use of off-the-shelf standard software. As these systems have to provide features for a wide range of organizations from a wide range of areas. This results in functionality in the

software that is not necessarily needed during the execution of the current process and, therefore, does not add any value for the using organization. Other times applications offer more functionality than is needed for the execution of the process in the specific organization or context. AT the same time, some required features are not provided by the software at all resulting in the need for manually performed task without direct support of IS.

- ▷ Ideally the enactment subsystem and the management subsystem can rely on run-time data and historical data, for example, in form of transaction logs. However, in practice there is a discrepancy between the amount and structure of the data generated that differs from system to system (e.g., Pérez-Castillo et al., 2011; or more in general Grigori et al., 2004). This adds an additional layer of complexity and, therefore, increases the effort it takes to analyze historical process data and extract information for run-time data. This of course impedes the optimization of business process based on the gathered data and prevents, for example, on-the-fly optimization of the assignment of performers.

Additional challenges lie in the security implications of process oriented information systems. This is especially relevant for flexible systems that allow a change of the process flow during the enactment of the business process. Three concepts are generally regarded as relevant for information systems (specifically for process oriented systems, e.g., Herrmann & Herrmann, 2006, p. 310 ff.; Leitner, 2011, p. 687 or in general, e.g., Whitman & Mattord, 2012, p. 11ff.): confidentiality, integrity and availability. For process oriented information systems confidentiality implies that constraints have to be in place which ensure that information should only be accessible to authorized users of the system. The distributed nature of the system, and the inclusion of external enactment systems or legacy systems complicate this goal. Integrity relates to data as well as the process itself. Integrity of a process means that certain action should be executed only after another action has finished if that is so specified in the process model. Integrity of data means that unauthorized change of data needs to be prevented. The concept of availability refers to the access to processes or data without interference for authorized users. Again the distributed nature of the system can make this challenging, as each system could have their own security measures in place.

3.4.3 Identification of different types of information systems in the context of process orientation

Only systems exhibiting specific characteristics (compiled in section 3.4.1) fit the definition of a process oriented information system authoritative for this thesis. However, many other types of information systems are referred to as being "process oriented". This is so even if they have a hard coded process logic, or do not "understand" explicitly represented models of business processes. A short overview of often named system types and their given definition is given in table 6. In the following relevant types of information system are shortly presented and the expression of the characteristics for the given system type elaborated. Through this it should be possible to better delimit the understanding of a process oriented information system used in this thesis.

Concept / Term Author(s)	Definition / Delimitation
process aware information system (PAIS)	
Dumas et al. (2005, p. 7)	a software system that manages and executes operational processes involving people, applications, and/or information sources on the basis of process models.
workflow management system (WfMS)	
Workflow Management Coalition (1999, p. 9)	A system that defines, creates and manages the execution of workflows through the use of software, running on one or more workflow engines, which is able to interpret the process definition, interact with workflow participants and, where required, invoke the use of IT tools and applications.
business process management system/ suite (BPMS)	
Hill et al. (2006, p. 8)	A business process management system (BPMS) is a set of integrated technologies that enables process stakeholders and users to go quickly around the process revision cycle.
Gartner Inc. (2016)	BPMS are the leading application infrastructures to support BPM projects and programs. A BPMS supports the entire process improvement life cycle — from process discovery, definition and design to implementation, monitoring and analysis, and through ongoing optimization.
H. a. Reijers (2006, p. 360)	A BPMS is typically described as a piece of generic software that supports activities such as the modeling, analysis and enactment of business processes.
Chang (2006, p. 50)	BPMS is a new class of software that allows organizations to devise process-centric information technology solutions. Process-centric means BPMS solutions are able to integrate people, systems, and data.
Karagiannis (1995, p. 10)	Information systems dealing with the definition, administration, customization and evaluation of tasks evolving from business processes as well as from organizational structures are called Business Process Management Systems (BPMS).
van der Aalst, ter Hofstede, and Weske (2003, p. 1)	a generic software system that is driven by explicit process designs to enact and manage operational business processes
Poelmans, Reijers, and Recker (2013, p. 295)	A business process management system (BPMS) is generic software that supports the modeling, analysis and enactment of business processes.
enterprise information system (EIS)	
Tabatabaie, Paige, and Kimble (2011, p. 423)	An Enterprise Information System is a software system[1] that integrates the business processes of organization(s) to improve their functioning.

Table 6: Examples of definitions of classes of information systems in the context of process oriented information system.
[1]The authors use software systems in the understanding of information system in this thesis, i.e. a system composed of technical and human parts.

Enterprise information system (EIS)

The Enterprise information system (EIS) can be seen as an umbrella term for nearly all information systems used in an organization. It generally encompasses all systems that support coordinating the actions in an organization (e.g., Davenport, 1998; Taxén, 2012). Therefore, nearly all information systems being used in an organization fall under that heading. However, the term EIS is mostly used for organization spanning systems, which, therefore, reach across organizational levels and departments (Brown & Vessey, 2003, p. 65). A more restrictive definition proposed by Tabatabaie et al. (see table 6) focuses on use of EIS for the integration of business processes (including across organizational boundaries). This is where EIS and the concept of process orientation also primarily touch. As discussed before an important step in the life cycle of business process is their implementation. This includes the organizational as well as the technical implementation. During the technical implementation the used enterprise systems need to be adapted to support changes in processes. EIS are also used during the design and analysis phase as they can supply required information to involved actors. As the term is used for such a broad range of systems it is impossible to attribute values to the characteristics developed previously. It can be noted that the category of process oriented information system is a sub category of enterprise information system. One difference, however, is that EIS are generally seen as at least inter-departmental systems. This is not necessarily required for process oriented information systems as processes can also only span single departments or the systems support managerial activities regarding inter-departmental processes inside a single department.

Business process modeling tool (BPMTool)

While technically not an information system, but (following the schema described in section 3.2) application software, business process modeling tools (BPMTools) play a central role in process oriented information systems and the process orientation of an organization in general. The applications are either used in standalone fashion, or included as components in more complex information systems. Figure 29 shows related concepts and systems to BPMTools from a practitioner's view. Core features of the tools are the modeling of different aspects of the business process in a notation understandable by involved users. In such they are more specialized than simple graphics tools which can be used to visually display models, but don't have an "understanding" of the created model. Many BPMTools also allow the modeling of organizational structures and other organizational aspects (see also the research area of enterprise modeling; e.g., Fox & Gruninger, 1998; Frank, 2002). The simulation of modeled processes is another feature that is often directly provided by BPMTools or specialized simulation tools (for a list of other common features see also Nüttgens, 2002; Recker, 2012, p. 218).

As process oriented information systems depend on explicitly described business processes, the use of standalone BPMTools or modeling components in more complex systems is required. Because of this, BPMTools are, therefore, mostly used in the design and analysis phase of the business process. Normally modeling functionality is not used during the enactment phase of the business process. However, if the systems allows for on the fly changes to the process during its enactment, such changes can be created through a model based interface (e.g., Reichert & Weber, 2012, p. 153 ff.). Which types of processes can be supported by BPMTools mainly depends on the modeling notation used. They are mostly used for processes which structure can be explicitly represented. Some modeling methods, however, also offer notations that do not focus on the structure of the process (for example, the collaboration diagram in the BPMN or the possibility to model ad hoc sub processes in process diagrams, see Object Management

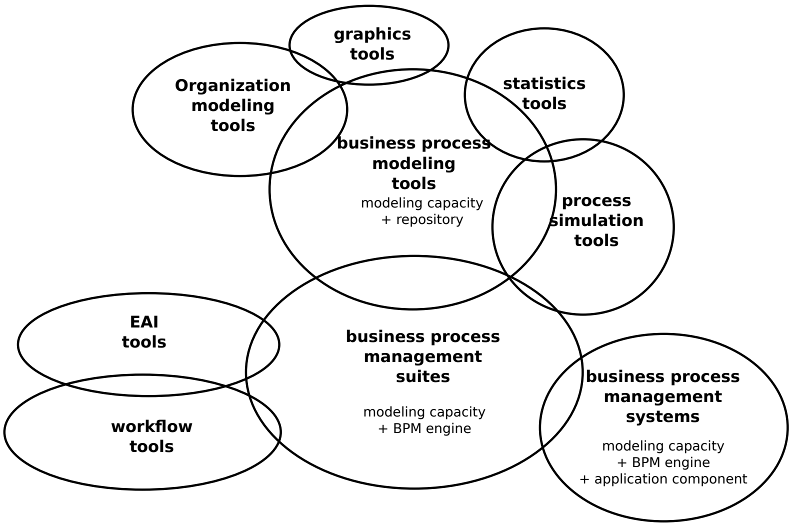


Figure 29: Types of software tools used by business practitioners (modified from Harmon & Wolf, 2014, p. 50).
Note that the terms used here are taken from the survey conducted by Harmon and Wolf. They do not necessarily exactly correspond to the terms used in the thesis.

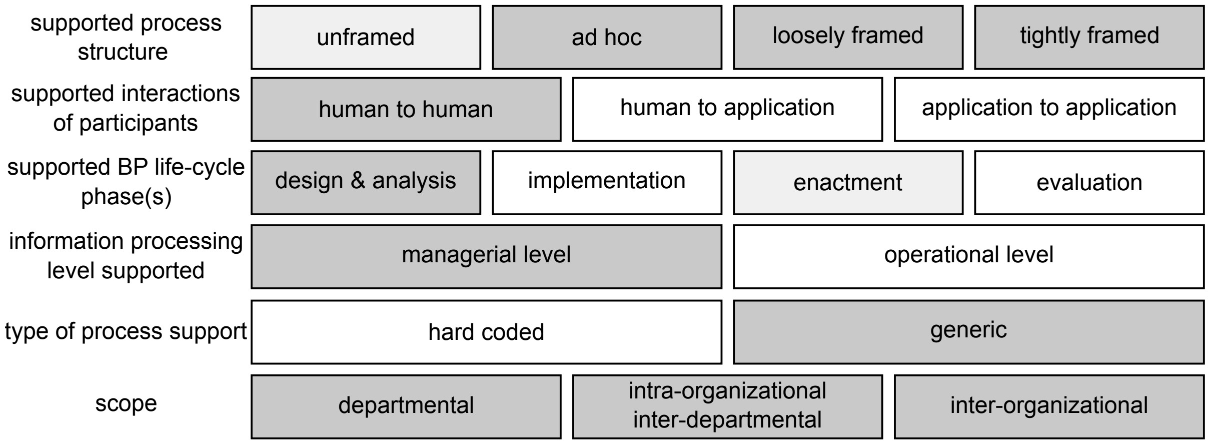


Figure 30: Expression of the characteristics in BPMTools.

Group, 2011, p. 109 ff., 175 ff.). BPMTools do not directly interact with other information systems involved in the enactment of the process. They do, however, offer the possibility for multiple human actors to work on creating process models (e.g., Renger, Kolfschoten, & de Vreede, 2008; Rittgen, 2008, 2009). BPMTools can support local and even remote collaboration (through messaging of participants and communication features, e.g., Mendling, Recker, & Wolf, 2012). Figure 30 gives an overview of the expression of the characteristics as elaborated here.

Workflow management system (WfMS)

WfMS have a long history of supporting organizations in automating their operational processes. A WfMS consists of components to store process definitions, to interpret them, and to create as well as to manage workflow instances as they are executed. Furthermore, components exists to manage the interaction with workflow participants and applications (Workflow Management Coalition, 1999, p. 9). Workflows are basically processes whose control logic lies within the control of an information system, i.e. the WfMS (cf. Rosemann and zur Muehlen 1998,

p. 103; Workflow Management Coalition, 1999, p. 8; Chang, 2006, p. 131 ff.). There are two typical categories of workflow support used in organizations (van der Aalst, 2004, p. 7):

Standalone WfMS pure WfMS are standalone software (and hardware) systems that provide the features attributed to workflow systems. This type of standalone system is functional without any additional functional application software (cf. zur Muehlen & Allen, 2000, p. 49).

Embedded WfMS workflow management components can also be embedded into other, more complex, systems. The provided application logic is then already present in the same system and is coordinated by the workflow component. According to zur Muehlen (2004b, p. 116 f.) while in the later part of the last century standalone (pure)WfMS where popular many workflow vendors then shifted to provide building blocks that could be included in "workflow-enabled " systems.

As WfMS are meant to automate the execution of processes, they mainly support tightly framed processes. Without a tightly framed process as a basis there can be no process definition that the system can interpret to create and management workflow instances. As the goal is to automate the process as much as possible, an WfMS mostly supports application to application interactions. It also supports assigning workflow tasks to specific human actors (Becker et al., 2002, p. 43 f.; van der Aalst & van Hee, 2002, p. 77 ff.). In workflow terminology both are named "workflow participant" (Workflow Management Coalition, 1999, p. 18).

The WfMS is mainly used during the enactment phase of a business process. The enactment is supported on the operational level, by assigning the relevant resources to their respective tasks. Support on the managerial level is given in form management interfaces that allow workflow administrators to reassign work to different participants or monitor the overall performance of the workflow engine (zur Muehlen, 2004b, p. 169, 175 ff.; Chang, 2006, p. 143; van der Aalst and van Hee 2002, p. 157 ff.). The evaluation phase of the business process life cycle is also partially supported by WfMS in form of the workflow log (or audit trail, see in detail zur Muehlen, 2004b, p. 181 ff.).

Whether the WfMS is embedded in another system or a standalone solution is provided, the type of process support can be categorized as generic, as this flexibility lies at the core of WfMS (cf. van der Aalst & van Hee, 2002, p. 145).

As WfMS focus on the enactment of workflows, they are not limited to departmental or organizational boundaries from a technical point of view. However, organizational obstacles will have to be overcome to integrate the different systems used by different organizations (cf. van der Aalst, 1999b; Becker et al., 2002, p. 46; zur Muehlen, 2004b, p. 133 ff.). The expression of the characteristics is aggregated in figure 31.

Business process management system (BPMS)

The differentiation between business process management suites and BPMS is not very distinct in the literature. The term suite is mostly used in practice and refers to a set of tools that support all stages of the process life cycle (cf. Hill et al., 2006, p. 8; ABPMP, 2009, p. 176 ff.). As such business process management systems are part of business process management suites. In the following discussion focuses on business process management system as the other

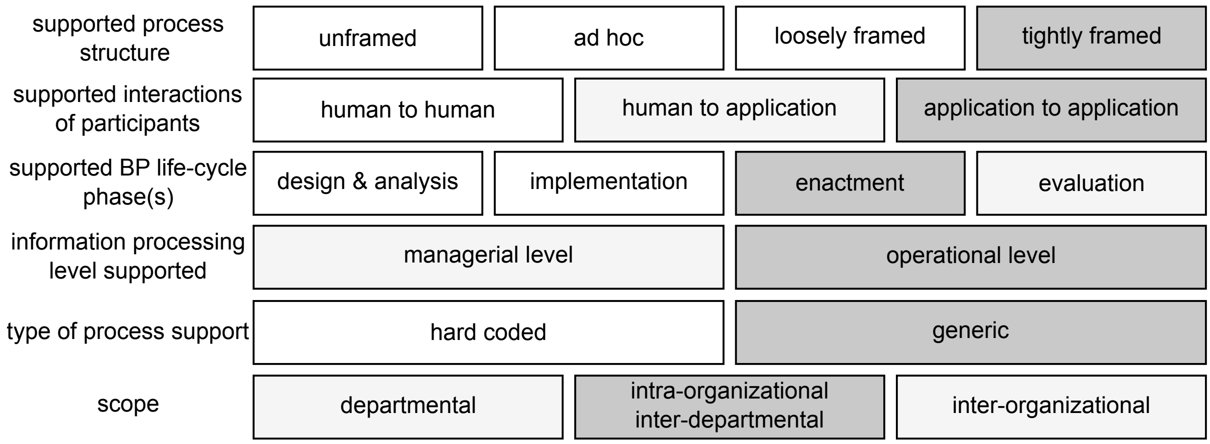


Figure 31: Expression of the characteristics in WfMS.

software tools have a broad overlap with business process modeling tools (cf. Harmon & Wolf, 2014, p. 51).

Similar to WfMS, BPMS support the automated execution of the business processes. They are typically described as software systems that support activities such as modeling, analysis, and enactment of business processes (H. a. Reijers, 2006, p. 390). While exact definition varies regarding the activities that are supported (e.g., Smith & Fingar, 2003, appendix B; Karagiannis, 1995; Grigori et al., 2004; Chang, 2006, p. 37 ff.; Sinur & Bell, 2003; Dumas et al., 2013, p. 298) there is a consensus that much of the functionality attributed to BPMS has been historically attributed to WfMS and therefore BPMS can be seen as a second generation of WfMS (e.g., van der Aalst, ter Hofstede, & Weske, 2003, p. 4 f.; Dumas et al., 2013, p. 14; Chang, 2006, p. 153 ff.). BPMS are cited to have build-time and run-time diagnostic capabilities, wider capabilities than WfMS regarding enterprise application integration and business-to-business integration. The workflow capabilities of BPMS are expected to cover a broader spectrum of work support than the previous WfMS (H. A. Reijers & Heusinkveld, 2004, p. 129 f.), i.e., supporting a broader range of possible interactions as well as more phases of the business process life cycle. Furthermore BPMS are considered to be more able to handle on-the-fly process definition changes (e.g., Dadam, Reichert, Rinderle, & Atkinson, 2005, p. 6). Due to the addition capabilities they are also more suited to an inter-organizational scope. A summary of the expression of the characteristics is given in figure 32.

Process aware information system (PAIS)

The term process aware information system (PAIS) is another umbrella term that subsumes many different types of information systems (e.g., Poelmans et al., 2013, p. 295), although it is primarily used in the research community. The general definition is that of “a software system that manages and executes operational processes involving people, applications, and/or information sources on the basis of process models” (Dumas et al., 2005, p. 7). The core of a PAIS is built on top of a workflow (or similar) component (cf. Dumas et al., 2005, p. 5; Weske, 2012, p. 50 ff.). On this basis the PAIS provides functionality for the modeling, enactment, and monitoring of processes. During run-time analysis PAIS can provide status information about running processes or give diagnostic information (Weber et al., 2009, p. 116). Regarding the

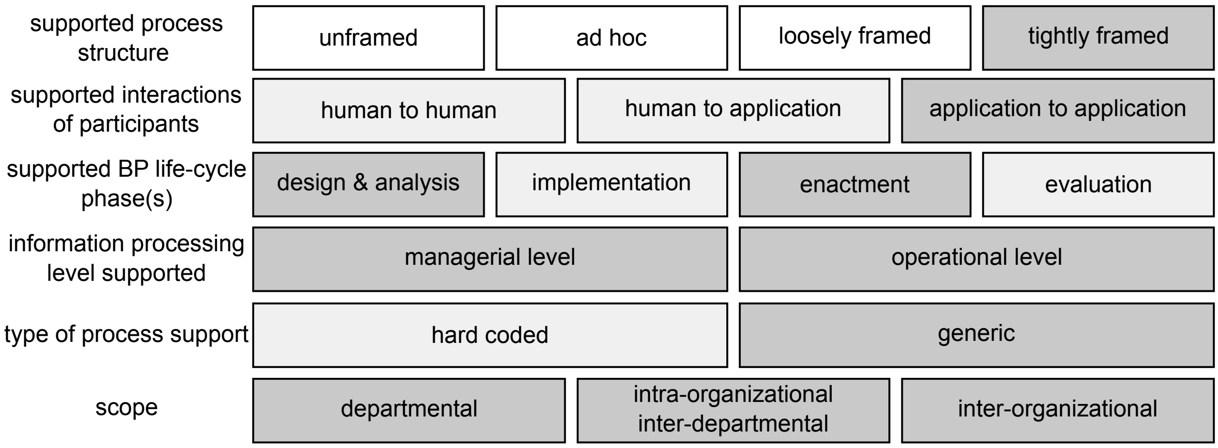


Figure 32: Expression of the characteristics in BPMS.

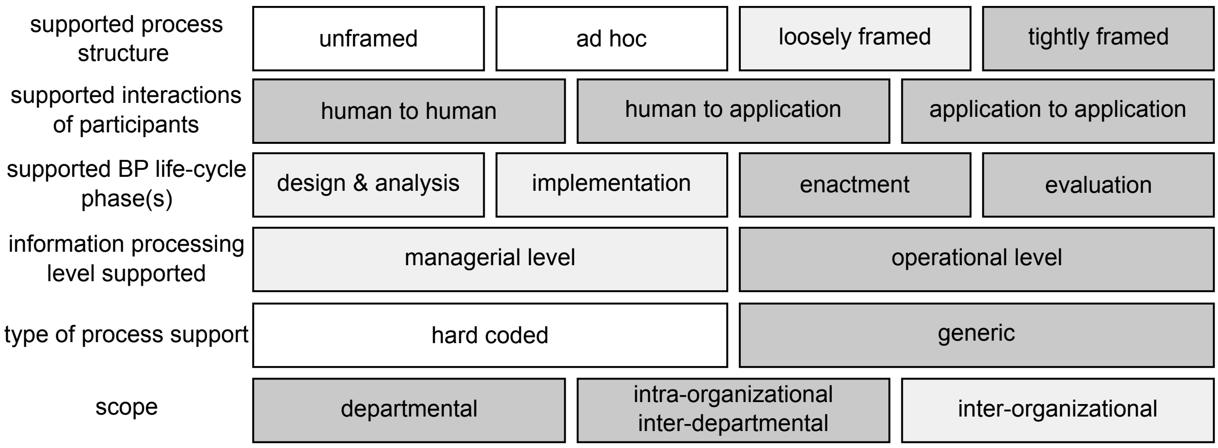


Figure 33: Expression of the characteristics in PAIS.

characteristics the focus of PAIS lies on tightly framed processes, or at least processes that can be explicitly defined, for example, through business process models. The process support can be categorized as generic as it is fully based on a provided business process definition. A PAIS can support business processes on a managerial as well as an operational level, as it supports most steps of the BP life cycle. There is no clear limitation as to the supported interactions. The scope of support is also not limited, PAIS can support departmental processes as well as inter-organizational processes (with the same challenges already mentioned during the discussion of WfMS). Figure 33 shows the expression of the characteristics relevant for PAIS.

In summary it is possible to conclude that in a very general sense the terms “process aware information system”, “process oriented information system”, “business process management system”, and “business process management suite” can be seen as covering nearly the same concept. However, for the purpose of this thesis they contain certain specific differences. While all systems general try to cover the BP life cycle, BPMS do not focus on the implementation and evaluation phases. The focus of PAIS lies in the enactment and evaluation of business processes. This could, however, be attributed to the origin of PAIS being the research community for WfMS, as well as that WfMS are often taken as an example PAIS from which the discussion about PAIS is performed. All terms stress the importance of a generic process support implying tightly framed processes, which can be traced to their origins in WfMS. One important difference, however, lies in the information processing level that is supported. Most system types support both the managerial and operational level, while the definition of PAIS explicitly implies a support of both levels. An information system that does not in itself enact the business process is not a process aware information system. Such a limitation is not placed on the type of process oriented information system for this thesis. BPMTool that support the design of human centric business processes and with the resulting data help in the organizational implementation of the process in a department are still a process oriented information systems. Therefore, in accordance with Mutschler et al. (2006, p. 440), altogether “process awareness” can be considered as a special subset of “process oriented”.

3.5 Preliminary Conclusion

In this chapter two existing solution artifacts for the problem context of process orientation and HRM were introduced: HRIS as a specific category of IS that supports the management of the human resources and process oriented IS as information systems that exhibit certain characteristics and support the management and/or enactment of operational business processes, based on explicit business process models. The specific classification of different IS in the context of process orientation is a contribution of this thesis that constitute descriptive knowledge in the knowledge contribution framework. The developed categorization framework itself is in novel in the presented form and could be used to classify further systems.

In the context of organizations IS are generally used to support the operational task that arise during the achievement of the organizations goals (section 3.2). One way of classifying IS in this context is by which business function this support is mostly geared toward. HRIS can be seen a subcategory of IS specifically supporting the operational tasks in the human resources context (section 3.3).

Another way to look at IS is by focusing on if and by what degree they offer support for the management and enactment of business processes (section 3.4). When discussing the process orientation of IS different characteristics can be regarded. These characteristics include how structured the supported process is, which interactions are supported, which phase of the life cycle in a business process is supported, etc.

With the introduction of these two aspects of IS that allow a more refined analysis of existing solutions and the delimitation of the new problem context of proHRM in the previous chapter, a solution for this new problem context based on the existing solutions can now be designed. For the support of proHRM an IS that supports HR activities based on a process oriented information base, a proHRIS is needed.

4 Design of the solution – the process oriented human resource information system

4.1 Approach of this chapter

The design of the proHRIS, as performed in this thesis, consists of three main parts. First the requirements of the systems are elicited on a fitting abstraction level (section 4.2). In a next step, the system resulting from a design fulfilling these requirements is described component by component (section 4.3). Finally, an integration of the system in the organizational context is discussed (section 4.4).

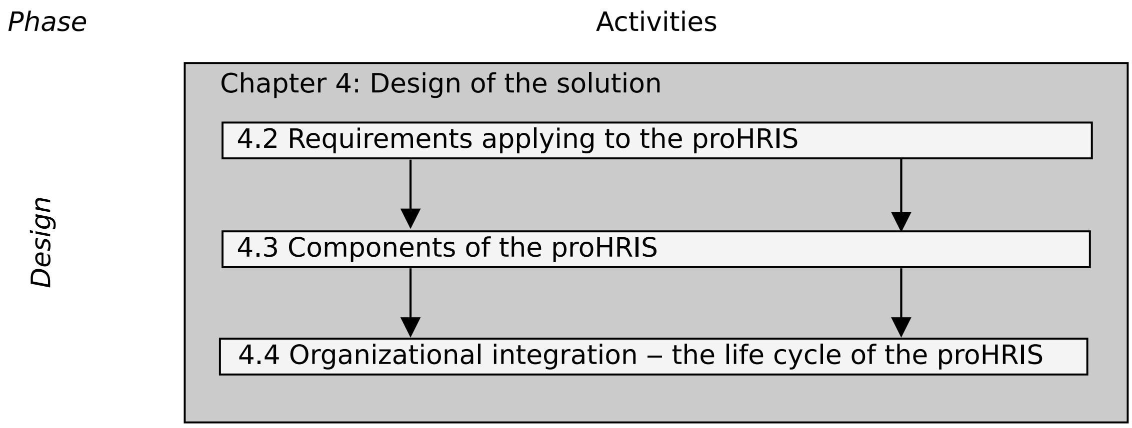


Figure 34: Activities performed for the design of the proHRIS.

As process orientation in the context of HRIS can have a wide range of meanings, a short discussion of the general notion of process orientation in the case of the proHRIS designed in this thesis precedes the three parts (section 4.2.1). An overview of the main parts of the design is given in figure 34.

4.2 Requirements applying to the process oriented human resource information system

4.2.1 Specification of the understanding of a process oriented human resource information system

Based on the delimitation of a process oriented information system, as well as that of a human resource information system in the last chapter, the concept of a proHRIS system can be further refined here. The following sections then go over the requirements that result from both the human resource aspects and the process orientation of the system, describe the individual components required for the fulfillment of those requirements, and integrate the system into the organizational context.

As noted in definition 11 a process oriented information system supports the management and/or the enactment of business processes. It does this based on explicit representations of the business process. Relating this understanding to that of a HRIS (the collection, structuring, supply, communication, and use of information to automate HR tasks as well as provisioning HR decision makers with relevant information; see definition 10) and that of process oriented HRM (see definition 7) three understandings of a process oriented HRIS can be identified. These three understandings can be summarized as “HR focused modeling and analysis system”, “HR process enactment system”, and “comprehensive proHRIS”. The different understandings are also shown in figure 35.

In the first understanding (see figure 35 a) a proHRIS supports specific tasks in the HR processes by serving as an informational basis to the actors. To achieve this the operational business processes of an organization are represented as business process models in the proHRIS. Relevant actors of the HR processes can then use these models to perform intelligence operations or change these models in a prescriptive manner to implement changes. In this understanding the proHRIS can be compared to a modeling and analysis system.

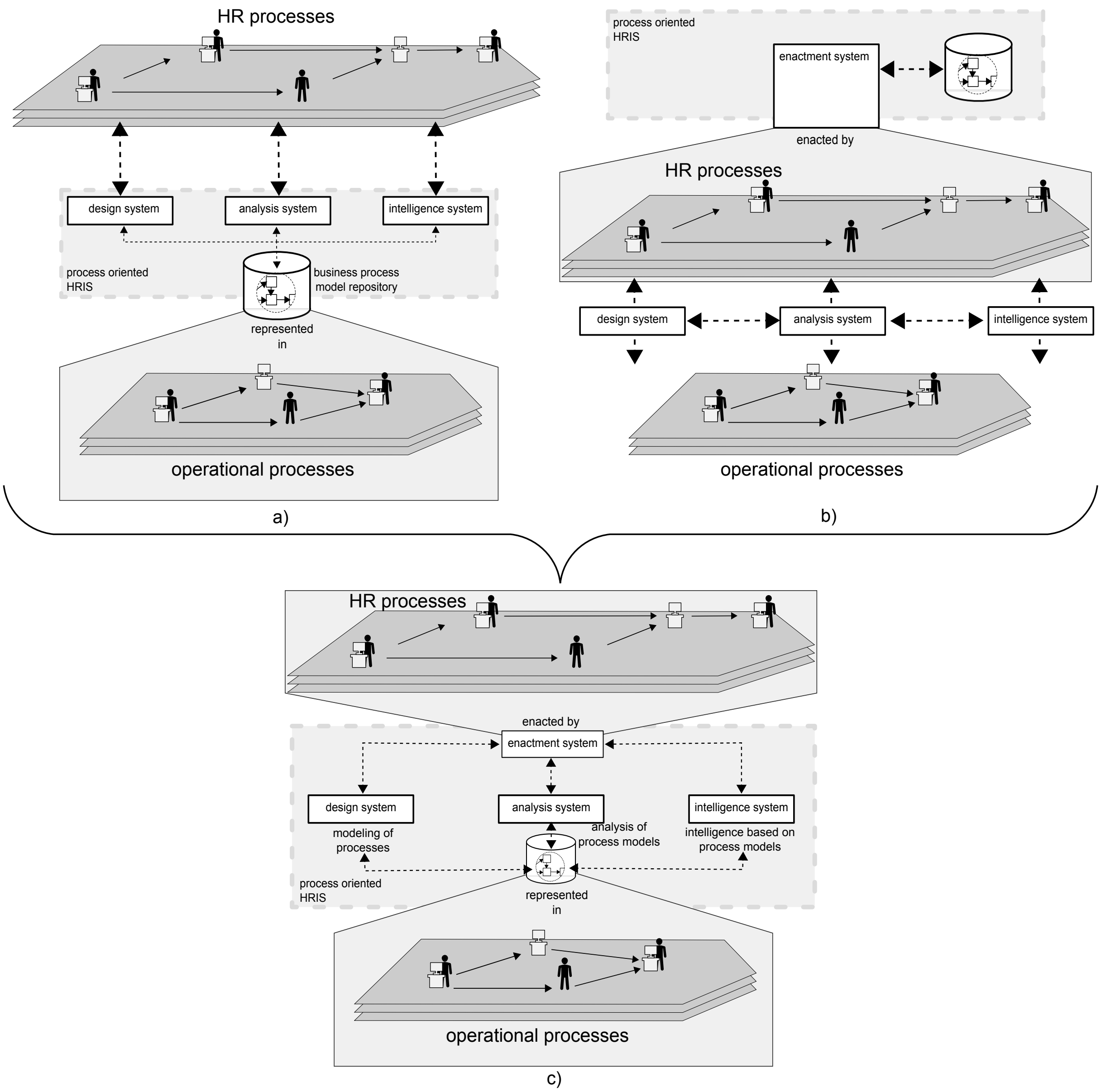


Figure 35: Three possible understandings of a proHRIS: a) the HR focused modeling and analysis system, b) HR process enactment system, and c) comprehensive process oriented HRIS.

A second understanding sees a proHRIS more as an enactment system of business processes (figure 35 b). The business processes that are enacted, however, are not the operational business processes of the organization, but the HR processes. The system ensures that tasks are executed following the given process definitions. The support for the specific tasks performed in the process is given by independent information systems (which of course could be controlled by the enactment system as well). In this understanding the proHRIS does not really differ from any operational BPMS / WfMS. The focus of the system also lies on an "internal" understanding of process orientation in HRM (see section 2.4.2).

Finally, a third understanding combines both previous views (see figure 35 c). In that case the proHRIS provides the functionality required for the execution of HR tasks based on process models as well as an enactment system that manages the execution of the HR processes. The main difference for the actual execution of the HR tasks between understanding a) and c) compared to understanding b) is that the systems that support the specific tasks are adapted to the HR context. In understanding b) HR tasks can still be executed with standard modeling and analysis tools, which does not offer specific support for HR specific needs. For the purpose of this thesis this support, however, is fundamental. Therefore, a proHRIS is defined as follows.

Definition 12. A process oriented human resource information system (proHRIS) is a human resource information system that allows for the modeling, analysis and evaluation of operational business process models with the goal of supporting a process based execution of HR activities and a process model based organization of HR relevant information for the making of decisions.

In concordance with the selected understanding the definition of a proHRIS focuses primarily managerial aspects. The enactment of the business process is not its purpose because for this thesis, this functionality belongs to a BPMS or WfMS. As a proHRIS requires process models in order to provide support for the HR tasks, it is mainly relevant in the context of loosely or tightly framed processes. It is, however, not as restricted in the specificity of the business process definition as systems that are designed for the enactment of those processes, as it does not necessarily require the information that is required for an (automated) enactment of the process. As will be discussed later (see chapter 4,) many features, however, require different information in the process models.

Regarding different forms of interaction that are supported by the system, the focus lies mainly on human to human interactions. As the definition explicitly excludes the enactment of HR processes, there is no real support for application to application communication. If, however, an understanding including enactment features is chosen, the communication aspects again follow those of WfMS or BPMS. The exclusion of enactment features also means that out of the four identified steps in the business process life cycle only three are supported by the system: design and analysis, implementation and evaluation. The support of the design and analysis phase is obvious, as the system provides modeling and analysis features for business process models. More specifically it provides additional analysis features compared to more generic design and analysis tools as it focuses on HR related issues. Do to this it can also provide support for the implementation of the business process, as this implementation comprises both a technical and an organizational implementation. Especially for the organizational implementation HR specific issues need to be addressed. In the evaluation phase the system can provide another point of view for the evaluation of the business processes. The focus lies, again, on the HR related issues that might be identified in the business process. The enactment phase of operational business processes is not directly supported, besides the integration of managerial activities during the process enactment. The expression of the characteristics (discussed in section 3.4.3) of process oriented information systems for a proHRIS are shown in figure 36.

The following sections elaborate on functional requirements that stem from the utilization of an HRIS in a process oriented context as well as the standard non-functional requirements. As these, however, do not differ much from the non-functional requirements in other HRIS or process oriented information system the focus lies on the functional requirements. Furthermore, the requirements are restricted to those relevant for a conceptual discussion of the system. In a practical implementation requirements from different concrete stakeholders in a specific

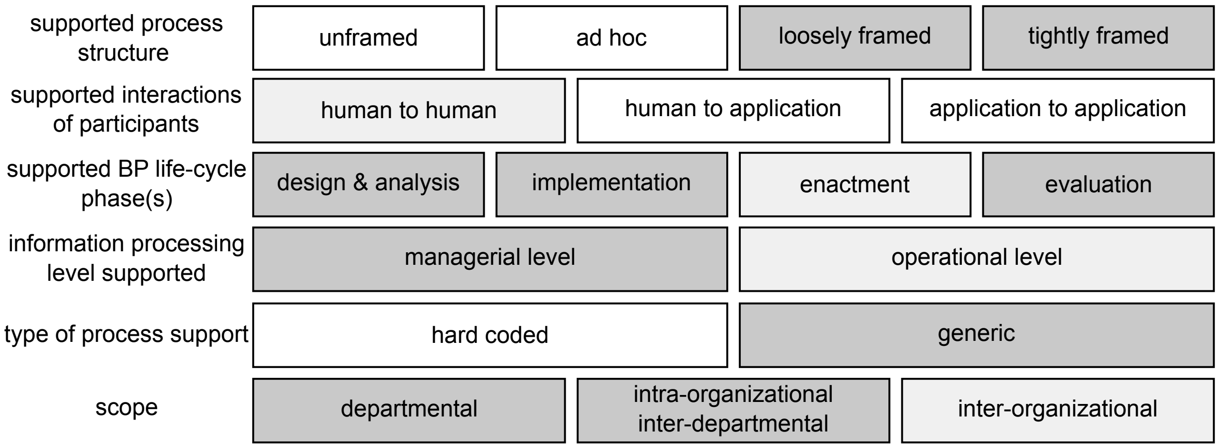


Figure 36: Expression of the characteristics in proHRIS.

organization would also play an important role.

4.2.2 Description of the general functional requirements

Based on the discussion of the fundamental understanding underlying the understanding of proHRIS in the previous section, the relevant functional requirements of the system can be identified by following each phase of the process oriented human resource life cycle (and, therefore, the business process life cycle) and the requirements resulting from the activities in that phase towards the system as well as general requirements resulting from the system being a synthesis of a HRIS in a process oriented setting. The gathering of the requirements follows an argumentative-deductive analysis (Wilde & Hess, 2007, p. 282) based on the literature about HRIS and process orientation of information systems as well as the delimitation performed in the last chapter. Furthermore, the focus of the identified requirements is primarily placed on requirements resulting from the combination of the two concepts and not those relating to IS in general.

The first phase of the business process life cycle is the modeling and analysis phase. In addition to the process design related activities within the context of a proHRM this phase also includes the assignment of employees to the process, as well as the analysis and optimization of the process in relation to HR aspects. One of the core functional requirements are, therefore, adequate modeling and intelligence features (**FR3**, **FR6**) as well as a modeling language able to express the concepts relevant for the solving of the problem tackled through those tasks (**FR1**). As the human resource aspects of business processes include a wide range of information specific to the organization at hand, such information has to also be available in the system. It can be kept in an organizational model (also referred to as resource model; e.g., zur Muehlen, 1999, p. 137; van der Aalst, 2013, p. 13) (**FR2**) which should be usable and manageable through the system (**FR4**).

As the processes might be modeled and used by different actors and at different points in time the system must provide the possibility to store the process models as well as organizational models used for the enrichment of the process models (**FR5**). This storage of models should especially support the work with different version and variants of process models to support the flexibility of the process models and the process oriented HRM (cf. Reichert & Weber, 2012, p. 50 ff.). Additionally, as process modeling and HR activities require the involvement of multiple users, the system should support their collaboration on a model level (**FR7**). This includes features such as notification of users about changes in processes they have an interest in, the possibility to comment on specific models and on changes, etc. (e.g., Theling, Zwicker, Loos, & Vanderhaeghen, 2005; Thomas & Scheer, 2006; Rittgen, 2009; Mendling et al., 2012).

Regarding the communication of the system with other information systems, the system should support collecting process and structural information from other sources, as to provide the relevant information to its users. Even though the proHRIS (in the understanding focused on in this thesis) will not act as an enactment system it should, therefore, be able to communicate and interface with systems such as WfMS, HR task specific HRIS (containing employee records, or existing qualification taxonomies), or even Data Warehouse if they contain process or employee specific performance indicators (**FR8**).

The communication with different information systems is relevant for the modeling and analysis phase as well as the implementation phase. While in the former the information flow is mainly from external systems towards the proHRIS, in the latter phase that flow is reversed. Here relevant personnel assignments and changes in the organizational structure can be forwarded to the other systems used during the enactment of the business process.

As the proHRIS itself is not used for the enactment of the operational business processes there are no direct functional requirements stemming from the enactment phase. However, throughout the enactment of the process the HRIS has responsibilities on a managerial level. It needs to be able to support HR actors with short term problems such as a provisional reassignment of employees in case of sickness or unplanned instance amounts. This especially involves short term solutions in staffing and compensation, but could (depending on the process run time) also have implications for development activities. As the proHRIS might also be able to solve some of these tasks automatically it is helpful to allow access to the features of the system from enactment systems, so that assignment operations can be performed by the more powerful (in respect to HR challenges) proHRIS instead of general purpose enactment systems. The system, therefore, should provide an application programming interface that would allow direct access to its features through other technical systems (**FR9**).

During the evaluation phase of the business process life cycle the proHRIS plays an important role too. Here employee and other HR related aspects are evaluated through a process oriented lens. This requires the system to, again, support the communication with different source systems that provide the required information (**FR8**, **FR9**). Further more the system needs to provide process oriented HR specific intelligence features (cf. Castellanos, Alves de Medeiros, Mendling, Weber, & Weijters, 2011; Grigori et al., 2004; Lawler, Levenson, & Boudreau, 2004; Strohmeier & Piazza, 2015) to allow for the evaluation of the processes regarding HR relevant aspects (**FR6**).

Table 7 shows an overview of the general functional requirements.

In addition to the general function requirements discussed above the system also needs to provide specific functionalities for the specific operational HR activities that are to be supported. These requirements are based on the general requirements, but targeted more specifically at the

Notation for operational business processes and HR relevant information	
FR1	Modeling notation able to represent problems adequately
FR2	Integration of organizational model
Working with augmented operational business process models	
FR3	Modeling and management of business process models
FR4	Management of an integrated organizational model
FR5	Sophisticated storage abilities for integrated models
FR6	Process based HR intelligence features
FR7	Support the collaboration of multiple users on a model level
Integration with external systems	
FR8	Interface with systems relevant to the collection or provision of information
FR9	API that supports access to relevant features for general purpose enactment systems

Table 7: General functional requirements of proHRIS.

different HR functions that are to be supported by the system. A discussion of these function specific requirements is provided in the next section.

4.2.3 Description of the requirements from HR functions

4.2.3.1 Staffing

Based on the general description of process oriented staffing the requirements of a proHRIS with regard to support for that function can be further refined. Figure 37 gives an overview of the main in- and outputs that should be provided by the proHRIS to support a process oriented staffing.

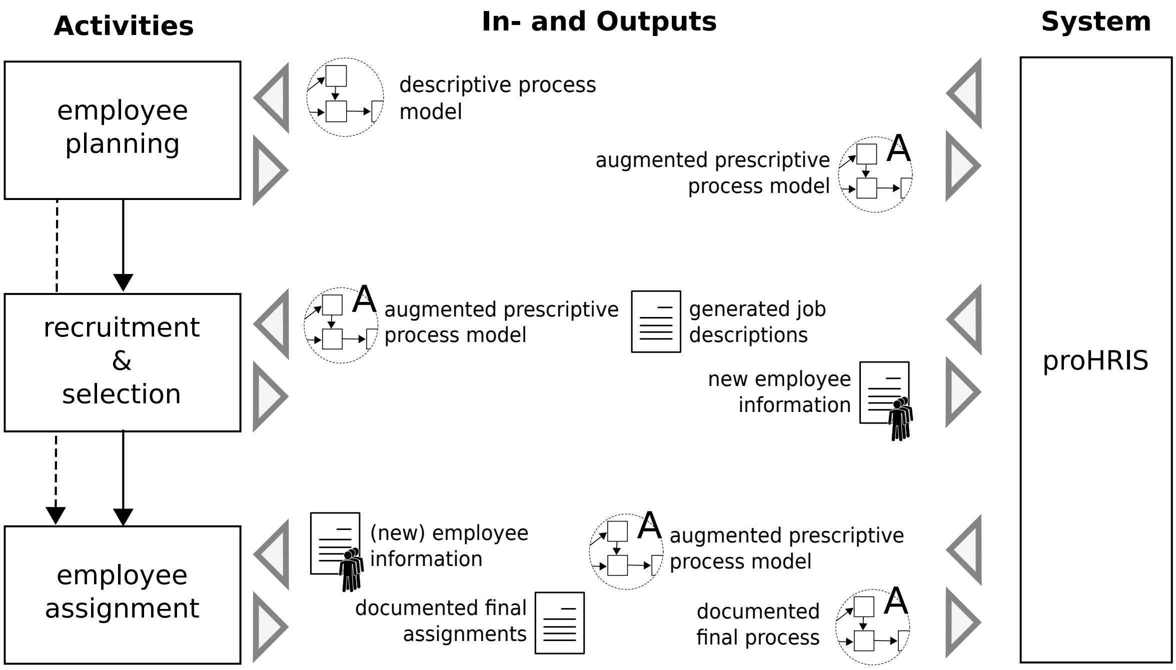


Figure 37: In- and outputs required for the support of the process oriented staffing.

To support the initial employee planning the system needs to provide a descriptive process model based on which planning scenarios are to be created. This constitutes the main output of the system in an initial step. Furthermore, it should provide information, either of analytical origin or of historical, about the possible future volume of process instances regarding the to be planned business process. Part of employee planning, in a first step, is to augment that process model with relevant information and to determine the requirements of each activity in the process. The proHRIS should provide facilities to support the input of such information and a way to store and work with the augmented prescriptive process model (**FR11-1**).

Furthermore, the system should be able to store and work with the additional information, as well as information about current employees: the employees available capacity, their qualification as well as information about other restrictions that should be taken into account such as preferences of the employees or if business process enactment is dispersed over multiple locations and staffing is done in an overall fashion, also in which location the employees are available (**FR11-2**).

To support the recruitment and selection activities the system should be able to interface with recruiting systems. As the recruitment process is not covered by the proHRIS (as it focuses on the operational business processes), such an interface is required for the smooth operation of the recruitment activities (**FR10-4**). The information sent to the recruiting system can be in form of a job description or job posting for the identified positions. It should also be possible to provide the job description information directly to the users (**FR10-3**). The information received from the recruiting system is that of new employees that are to be assigned to the process.

The specific intelligence features (cf. **FR6**) required for the staffing of employees should be provided by the proHRIS. This primarily includes the ability to analytically or by simulation optimize a possible assignment of employees to activities in the business processes (**FR10-5**).

But it also includes access and support of intelligence operations on historical process data for the purpose of extracting relevant information, such as historical values for average activity duration.

The support for optimizing assignments of employees to activities can come in different forms: the system can fully automate the assignment of employees or offer suggestions to the person performing the assignment on an employee to employee, or activity to activity basis.

When the assignment is finalized, employees have to be informed about their assignments and those assignments should be documented. The system should, therefore, be allow for the documentation of final assignments (**FR10-7**). It should also be able to output a documentation of the process and the assignments to individual users with specialized variants for different employees. This would, from its content, resemble a job description (cf. Caruth et al., 2009, p. 109 ff.; Gan & Kleiner, 2005), but be limited to the relevant process. If an employee is assigned to multiple processes, he or she would have multiple such descriptions.

An overview of the requirements resulting from a support of process oriented staffing are provided in table 8.

HR function specific requirements	
FR10	Support staffing based on business process models.
FR10-1	Allow the modeling of business process models that contain information relevant for the staffing process.
FR10-2	Offer the possibility to store instances of the concepts of activity, employee, and qualification as well as their properties as to support the optimization of the staff assignment.
FR10-3	Support the generation of job descriptions based on process models.
FR10-4	Ability to interface with a recruiting system.
FR10-5	Support the simulation and/or analytical optimization of staff assignments.
FR10-6	Provide access to historical process data to extract relevant information for staffing purposes.
FR10-7	Support documentation of personnel assignments for publication and use as basis for other HR functions.

Table 8: Functional requirements resulting from the support of process oriented staffing.

4.2.3.2 Appraisal

The central object for the performance appraisal process is the performance agreement. Most of the in- and outputs required by the system in the context of process oriented employee appraisals can be related to that item. An overview of the general in- and outputs is given in figure 38.

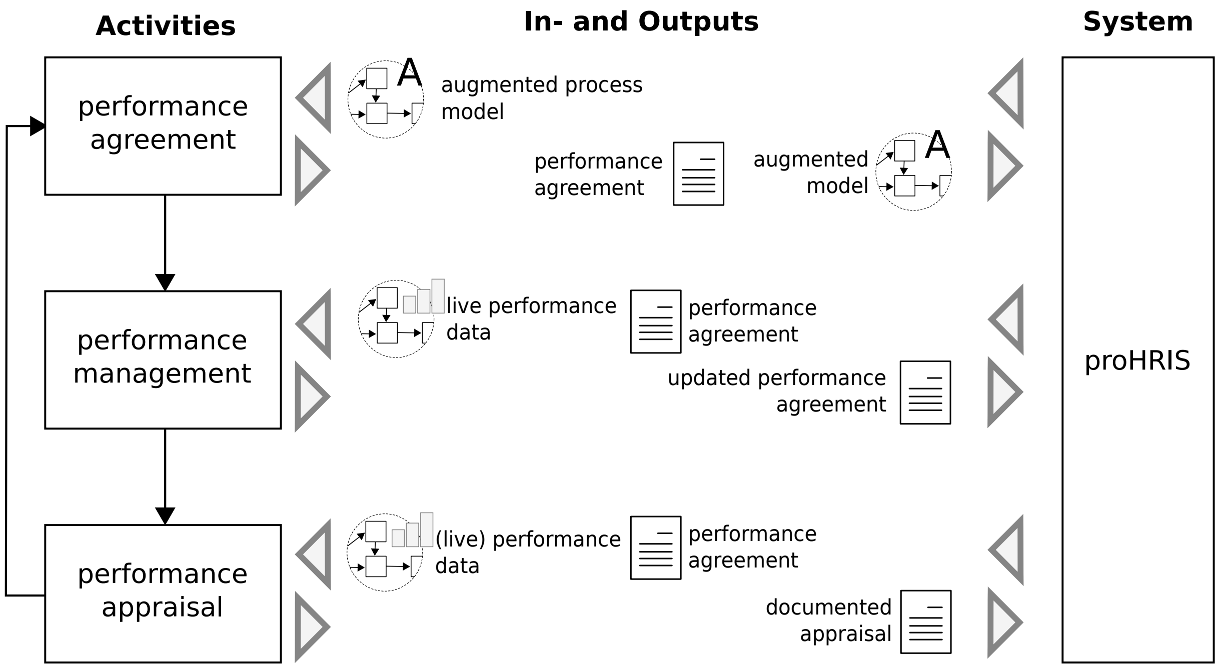


Figure 38: In- and outputs required for the support of the process oriented appraisal.

To create that agreement information about the operational business process in form of a business process model possibly with already included process and organizational goals is needed. If aspects regarding the available or missing qualifications of employees are to be included in the performance agreement the system needs support for a business process model augmented with this information (cf. **FR11-1**,**FR11-2**).

Based on the augmented business process models and input from the users of the system the proHRIS should be able to create, store and manage performance appraisals that are based on the deposited business process models and relate to the employees assigned to the specific activities in that model (**FR11-3**).

To be able to provide support to the management activities during the enactment of the process the system needs performance information about the operational process being enacted (cf. Neely et al., 2000; Heckl & Moormann, 2010, p. 119). That information can either come directly from enactment systems (cf. Muehlen, 2001; Glykas, 2011a; Dumas et al., 2013, p. 353), or be made available by process performance management system (PPMS) (e.g., Kueng, 2000) to the proHRIS (**FR11-4**).

These sources are also used during the regular performance appraisals in which results are documented and used for development initiatives, compensation schemes, and during staffing decisions. The information generated through the appraisal of the employees flows back into the organizational model in which the employees and their qualifications are stored. That information can then be used during staffing decision, as it identifies to which degree a process performer is qualified for a certain task. In extreme cases the system could even use historical performance data with respect to specific tasks to estimate future performance of processes with given employee assignments. As such the system should provide intelligence features based on historical performance data (**FR11-5**).

The proHRIS should allow the documentation and storage of performance agreements based on the stored business process models and assigned employees. To inform employees and managers of the current status of the appraisals adequate reporting functionality should be provided by the system (**FR11-6**). These reports should be available to managers for the employees they are responsible for and to employees concerning aspects of their own performance.

An overview of the requirements resulting from a support of process oriented appraisal are provided in table 9.

HR function specific requirements	
FR11	Support appraisals based on business process models
FR11-1	Allow the modeling of business process models that contain information relevant for process based employee appraisal.
FR11-2	Offer the possibility to store instances of the concepts of goals and measures as well as their properties as to support the planning and execution of process based employee appraisals.
FR11-3	Allow the creation and management of performance agreements based on specific business process models stored in the system.
FR11-4	Ability to interface directly with enactment systems or PPMS to recieve performance information for the operational management of employee performance.
FR11-5	Provide intelligence features for the analysis of historical process and performance data for the appraisal of employees as well as the identification of goals and relevant measures.
FR11-6	Provide reporting functionalities to inform employees and responsible managers of current performance status and allow short term responses to unexpected deviations.

Table 9: Functional requirements resulting from the support of process oriented appraisal.

4.2.3.3 Development

A process oriented approach to employee development is tightly interwoven with the staffing and appraisal of employees. As such, it shares many of the same requirements towards a proHRIS. Similarly to those areas the requirements applying to a proHRIS can be further refined based on the in- and outputs of the system during the execution of the development process. An overview of the general in- and outputs is given in figure 39.

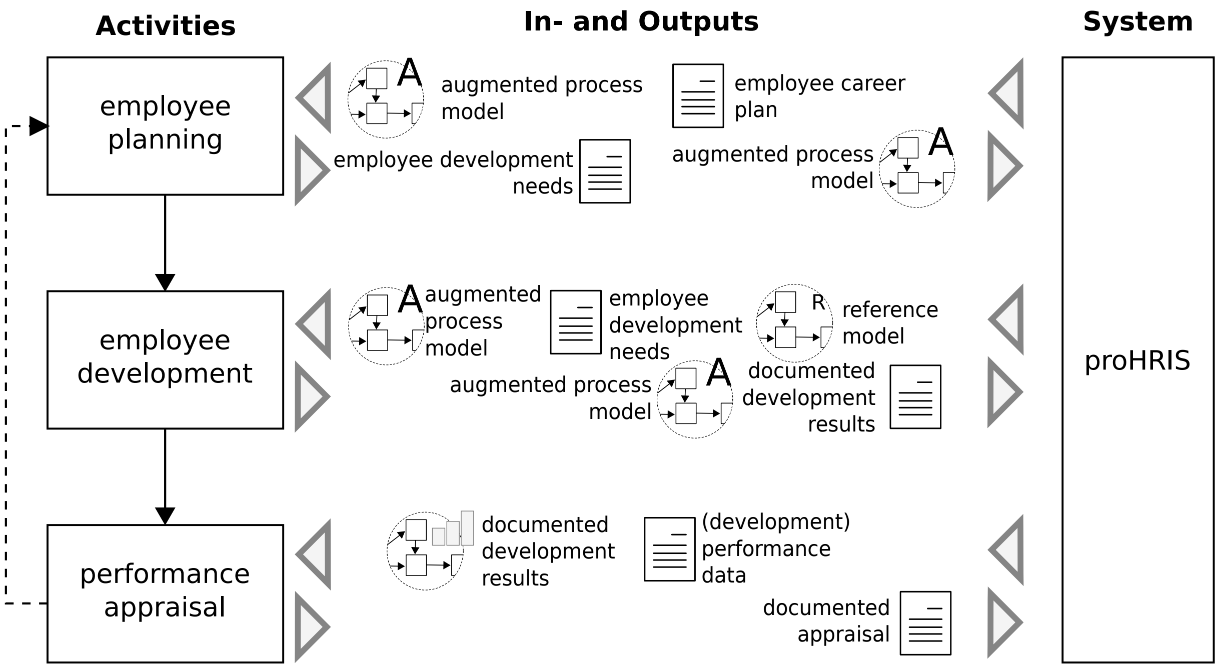


Figure 39: In- and outputs required for the support of the process oriented appraisal.

Central to the development of employees from a proHRIS point of view are the augmented business process model, the employees career and development plans, and results and performance data of the documented development employees have performed.

As with staffing and appraisal, the planning and execution of development activities for employees based on operational business process models requires the system to allow the creation, display, and editing of business process models that contain the relevant information for those activities (**FR12-1**). The additional information represented in the process model furthermore also should serve as data to be used in the further functionality of the system. The system should store and be able to work with the concepts of activities, qualification, goals, employees, trainings, and development needs (**FR12-2**).

The proHRIS needs to provide one or multiple augmented prescriptive process models that represent potential assignments of employees to process activities. On that basis possible development needs of employees can be identified and documented. Additionally, a career plan for the employee has to be available if his or her career wishes should be taken into account. Resulting from the planning steps the system is provided with concrete employee development needs for the employees involved in the process. Depending on the development strategy this can include development plans for all employees or only for a specific group. During the creation of training and development activities the system provides operational business process models as well as the development plans of the employees to the responsible for designing the activities. Additionally, the system can provide reference models (company wide, or industry wide) for educational purposes and their usage during the training of employees (**FR12-3**). If the training is done on the job in form of coaching during the enactment of the process or similar techniques are used, this can result in a change to the planned operational business processes.

The system should be able to interface with e-Learning systems or training management systems, to gather the information required for the planning of development activities and collect the results of the training activities (**FR12-4**). After the training and development activities have been performed the results are entered into the system, so that they are available for the appraisal of employees. These changes are then recorded in updated prescriptive models which the process owner can use as a basis for his or her decision which of the potential process plans should be enacted. For the performance measurement of employees and the development activities the systems needs to provide process performance data to the relevant actors. This includes functionalities to generate appropriate reports (**FR12-5**) based on data gathered from external systems (cf. **FR12-4**). Table 10 shows a list of the requirements from a support of personnel development activities.

HR function specific requirements	
FR12	Support development based on business process models
FR12-1	Allow the modeling of business process models that contain information relevant for process based employee development.
FR12-2	Offer the possibility to store instances of the concepts of activity, qualification, employee, goals, trainings, and development needs as well as their properties as to support the planning and execution of process based employee development.
FR12-3	Offer the possibility to create, store, and manage reference models of business processes for usage in development planning.
FR12-4	Offer interfacing abilities with e-Learning systems or training management systems for the purpose of planning development activities and importing results of performed training activities.
FR12-5	Offer the possibility to generate performance reports for usage in planning development activities for individual or groups of employees.

Table 10: Functional requirements resulting from the support of process oriented development.

4.2.3.4 Compensation

The main in- and outputs a proHRIS should provide to support a process oriented compensation are centered around the compensation and performance agreement (see figure 40). Again, the initial information for the design of the fixed and variable pay structures requires the system to provide functionality around (augmented) business process models.

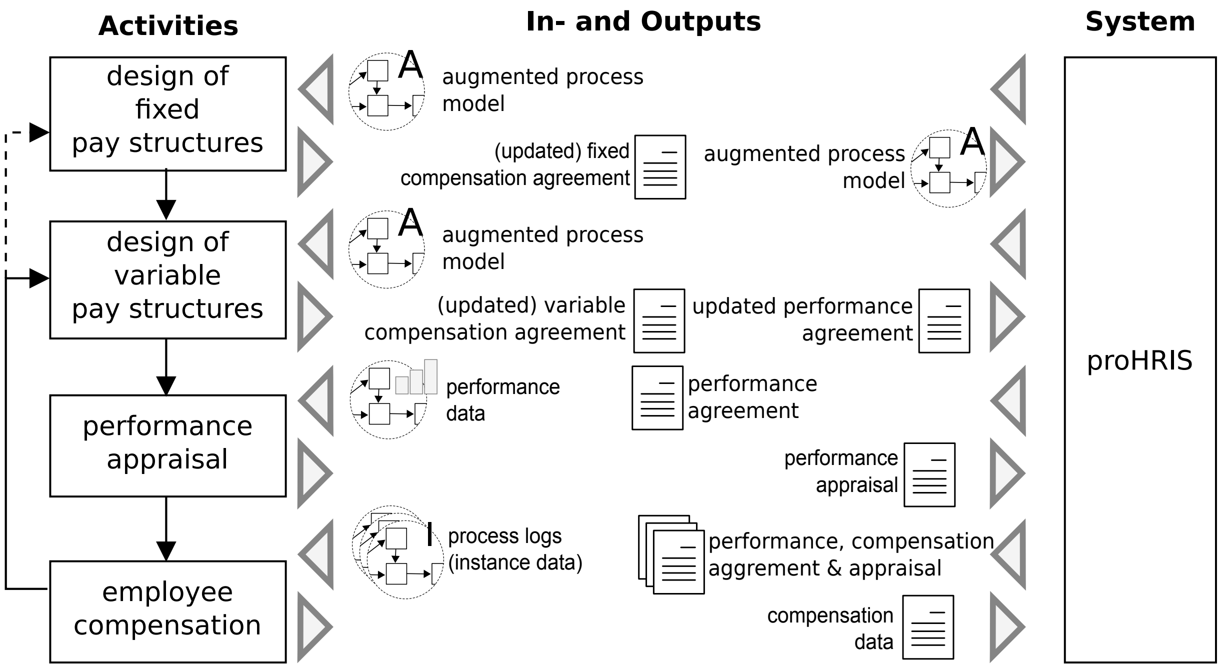


Figure 40: In- and outputs required for the support of the process oriented compensation.

For the design of those structures these models are analyzed, simulated, and augmented with compensation relevant information (cf. **FR13-1**, **FR13-2**).

Based on these models the compensation strategy and schemes can be designed. Depending on the information required for the fixed and variable parts of the compensation the business process models have to be enhanced with additional information. If only required qualifications, duration, or goals are required for the setting of wages and this information has already been added to the model in another HR function no further augmentation of the process models are required. However, if the compensation is to be based on additional characteristics these need to be added to the business process models.

Resulting from the two steps of pay structure design are the augmented process models and compensation agreements between the organization and the employee. In the case of variable pay based on set goals or specific process measures those compensation agreements also include performance agreements in which the employee is the appraisee (**FR13-3**).

For the appraisal of the employee performance data of the process and thus the employee is required. This is similar to the required input already discussed in the appraisal function. However, depending on the pay scheme more information is required. If, for example, the variable pay schemes include piecework pay, specific information about the amount of produced products are required. Other possibilities that require further information include a compensation based on the amount of process instances in which the employee was involved etc. Depending on the structure of the performance data already collected that information can be already present. To gather this information interfaces to PAIS or PPMS should be provided by the system (**FR13-5**). Furthermore, intelligence features for the data should be provided so that the relevant information can be extracted (**FR13-6**). Finally, the system should provide interfaces to payroll systems to forward the relevant pay information to them (**FR13-4**).

An overview of the requirements specific to a process oriented compensation are shown in table 11.

HR function specific requirements	
FR13	Support compensation based on business process models
FR13-1	Allow the modeling of business process models that contain information relevant for process based employee compensation.
FR13-2	Offer the possibility to store instances of the concepts of activity, qualification, employee, goals, measures as well as their properties as to support the design and implementation of process oriented variable and fixed pay structures.
FR13-3	Provide the possibility to create and manage compensation agreements that relate to specific business process models.
FR13-4	Provide the possibility to interface with payroll systems.
FR13-5	Provide the possibility to interface with PPMS or directly with PAIS to gather performance information and process instance information.
FR13-6	Ability to analyse, simulate and mine information from process instances for the calculation of variable pay of employees.

Table 11: Functional requirements resulting from the support of process oriented compensation.

4.2.4 Discussion of the non-functional requirements

Non-functional requirements (NFR) do not describe specific behaviors of the system, as do functional requirements, but can be used to judge the operation of it (Balzert, 2009, p. 463 ff.; Sommerville & Sawyer, 1997, p. 7 f.). Generally NFR can relate to different aspects of the system's life cycle (e.g., Witte, 2016, p. 54): They can specify aspects of the realization of the system (e.g., regarding the development method, the documentation of the system, the technical approval, etc.), they can define specific performance measures of the system (e.g., number of users, minimal response times, maximal load on specific hardware, etc.), or they define quality criteria (e.g., usability, reliability, security, etc.). The international norm ISO/IEC 25010:2011 defines a framework of eight quality criteria that can be applied to any form of (software) system (see also figure 41). The defined criteria can be used as a checklist to make sure all quality requirements of the system are met. However, the norm also notes that it is not practically possible to specify or measure all criteria for all parts of a large system (p. 5). Therefore, a decision on the importance of each characteristic and sub-characteristic has to be made in relation to the specific system at hand. This is attempted in the following paragraphs. The given description of the characteristics is, unless otherwise specified, taken from the ISO/IEC norm.

As a proHRIS is only designed on a conceptual level in this thesis it is not possible to define specific measures or instantiation of many sub-characteristics as they require the context of a specific organization. For example, the sub-characteristic of interoperability relates to the degree in which two or more systems can exchange and use the exchanged information. Specific

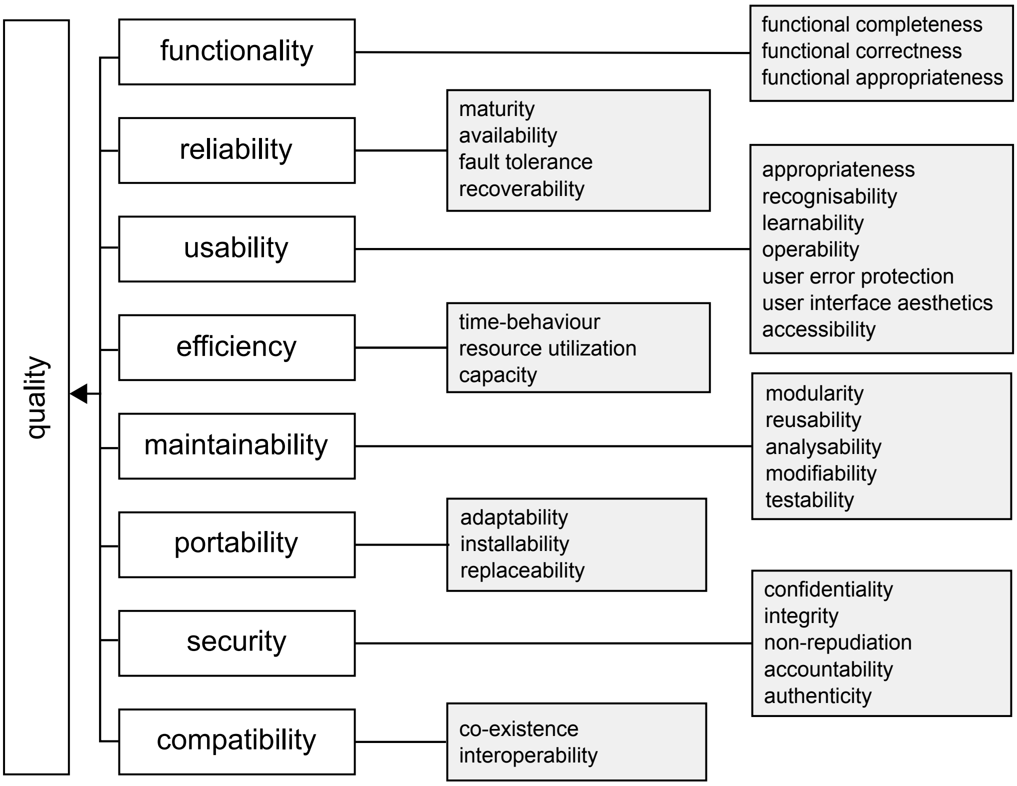


Figure 41: ISO/IEC 25010:2011 quality model of characteristics and sub-characteristics.

interoperability requirements regarding the system can not be made at this point, as it is not known what other information system are used next to the system. Such requirements can only be specified during concrete implementation projects in specific organizations. As such, no specific NFR will be defined in this thesis.

However, based on the nature of a proHRIS certain characteristics and sub-characteristics of the quality model can be highlighted as probably important for the implementation of a proHRIS. These are (sub-)characteristics that are either especially important from an organizational point of view, or result in implications for the functional requirements.

One important characteristic is that of compatibility, especially in form of **interoperability**. Interoperability describes the degree to which two or more system can exchange and then use information from each other (cf. Ford, Colombi, Graham, & Jacques, 2007). In a process oriented setting interoperability generally plays an important role, as orientation around the operational processes requires the different involved information systems to work well together. As HRIS often interact with different information system, even with other HRIS (following the best of breed architecture; see Kavanagh, Thite, & Johnson, 2012, p. 71) interoperability between the different HRIS is key. As a proHRIS furthermore interacts with additional systems such as the enactment system of the operational processes or business intelligence or monitoring systems, the interoperability quality of the proHRIS plays an important role (cf. Konstantas, Bourrières, Léonard, & Boudjlida, 2006).

Another important characteristic is that of **reliability**. Reliability describes the degree to which a system functions under specified conditions for a specified period. While with hardware products wear and tear factors in when judging the reliability of a product, this is not true for information system (which consist mostly of software). However, one important aspect of reliability according to the quality model described in the ISO/IEC norm is **recoverability**. Recoverability relates to how much of the data directly affected by an interruption or a failure a system can recover and if it can re-establish the desired state existing prior to the failure (cf. survivability; e.g., Westmark, 2004). As with any planning activity the final results of working with a proHRIS have a huge impact on the operational and, therefore, value creating processes in an organization. While planning normally does not happen on a just-in-time basis and lost data could be reproduced in time, it still represents a significant investment of time and resources. Furthermore, as the system can make use of historical process and organizational data (see **FR6**) the availability and the consistency of data storage play an important role for the usefulness of a proHRIS. Another aspect to consider in regard to the reliability of a proHRIS is that the organizational framework will change over time. New bills affecting employee to organization relation can be passed, or on a smaller scale, organizational focus might shift to aspects not previously thought of during system introduction. Therefore, there is an influence from the maintainability of the system, especially the **modificability** towards its reliability. The modificability characteristic represents how effectively and efficiently a system can be modified without introducing defects or degrading existing system quality. As an organization is a dynamic environment in which changes will occur possible modifications of the proHRIS have to be anticipated in its design as to not reduce the reliability of the system. One possibility in which to address this issue can, for example, be the (data-) models used by the system. The system should provide the possibility to extend the modeling language used to describe business process models and organizational models as to include features relevant for the specific organization (cf. the requirements of modeling languages; e.g., Kolovos, Paige, Kelly, & Polack, 2006; Frank, 2013, p. 135 ff.). See also Reichert and Weber (2012, p. 44 ff.) for a discussion regarding the required flexibility of process oriented information systems with respect to changes in business processes.

From an usability viewpoint an important characteristic of proHRIS is **user error protection**. The sub-characteristic stands for the degree to which a system protects users against making errors. As mentioned above, planning activities executed through the proHRIS can have a huge impact on the operational processes, in the worst case leading to the impossibility to correctly enact the operational processes. This can, for example, be the case if employees with missing qualifications or even authorization are assigned to task in a process. A proHRIS should offer such protection in form of the analysis and intelligence feature (**FR3** & **FR6**). These support the user in identifying modeling errors or mismatched employees.

Another important quality characteristic of a proHRIS is **security**. The security characteristic describes how strongly a system protects information so that only authorized actors have access to it. This characteristic is important because a proHRIS contains two of the most important organization internal information stores. Information about employees and information about the (internal) operational business process. Both can be seen as significantly contributing to an organization's competitive advantage (e.g., Hammer, 1990; Siddique, 2004; Hung, 2006; Kohlbacher, 2013). Both of these information stores should, therefore, remain private from external and/or unauthorized actors. Research in modeling languages explores ways how to create and synchronize public and private process models that display the same process with and without information meant only for internal actors (e.g., **?**). This is especially important since it leads to a trade-off between information sharing between business partners with the goal of globally optimizing the business process and the keeping of trade secrets. This also affects the functional requirement of the ability to store (process) models (**FR5**) as that has to be achieved in such a way that such security issues are considered (cf. Yan, Dijkman, & Grefen, 2012). Similarly, from a mostly internal point of view the **non-repudiation** characteristic plays an important role especially for actions that directly affect employee compensation. If (part of) an employee's compensation is based on performance goals created through the system (cf. Glykas, 2011a), it is important that such goals cannot be changed without the employees or the HR actors approval.

4.3 Components of the process oriented human resource information system

4.3.1 Description of the overall design

4.3.1.1 Overview of the components

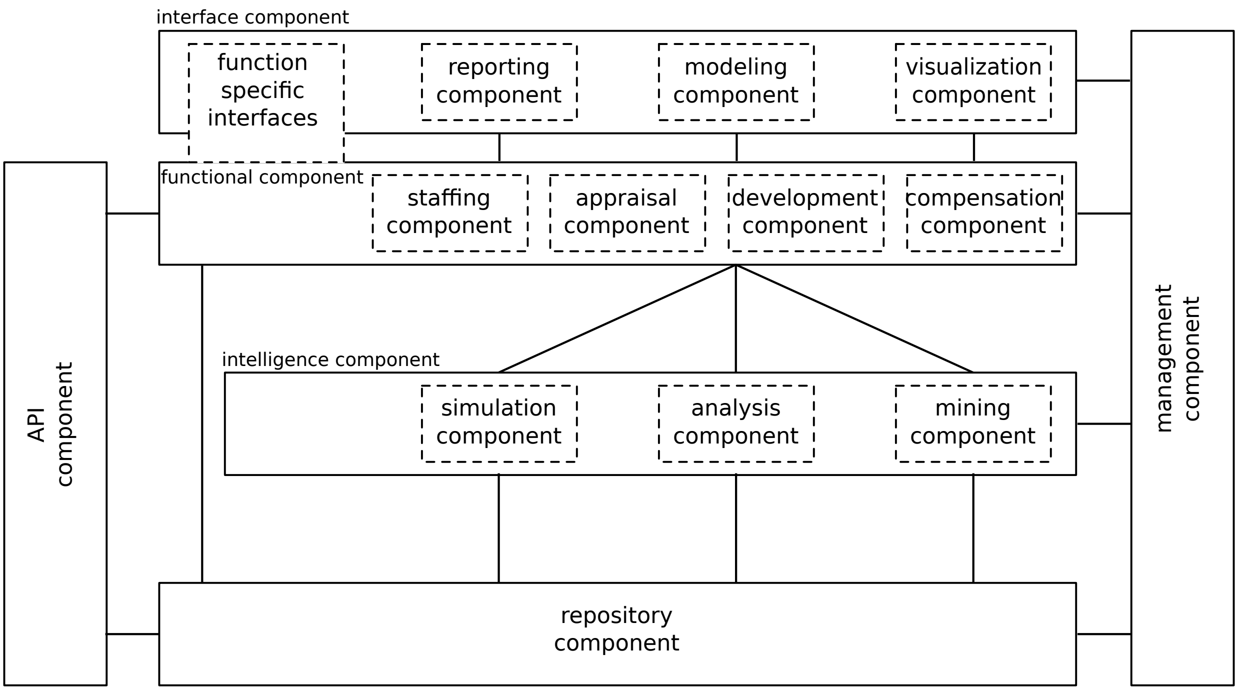


Figure 42: Overall design of the proHRIS.

Based on the requirements described in the previous section a design of the proHRIS can now be created. An overview of the components of the system is shown in figure 42. The system consists of many components which can be grouped into six main composite components: the interface component, the functional component, the intelligence component, the repository component, the management component, and the API component.

The repository component serves as storage for all models used in the proHRIS. It is the basis for most data storage and, thus, is one of the core components of the system. The intelligence component offers a broad range of features that allow the analysis and reasoning over the models stored in the repository component. The interface component offers different possibilities for the user to interact with the system (see section 4.3.1.2): the reporting component allows the generation of specific reports that can display information to active users of the system as well as send reports to relevant parties. The modeling component allows the creation and editing of (HR specific) models. The visualization component offers different ways of visualizing processes to highlight relevant information to the user.

In addition to these generic components of the system, the management and API components allow the integration and adaptation of the proHRIS into an existing IS landscape, while they are not directly used in day to day activities by the main actors, they are non the less integral to providing the required functionality.

The model repository, the intelligence component, and the interface component are tied together by the functional component to provide the specific requirements given for each HR activity. The staffing component provides support for the planning of employee assignments, i.e., the staffing requirements, the staffing possibilities, and the recruiting of new employees. The appraisal component supports the identification, measurement, and management of employee goals and performance measures resulting from their organizational and process counterparts. The compensation component supports the determination of employee remuneration, i.e., the identification or determination of fixed and variable pay structures and the implementation of process oriented remuneration strategies. Finally, the development component supports the identification of development needs and internal development opportunities as well as implementation of a process based development strategy.

4.3.1.2 Overview of the Actors

Before the individual components are discussed in detail it is sensible to present the different actors that interact with the system and the components. Three main actor types are intended: the “process owner”, the “process coach”, and the “process performer” (this follows the terminology coined by Hammer, 1997; cf. Neubauer, 2009, p. 173; ABPMP, 2009, p. 143 ff.; Kohlbacher, 2010, p. 136; Neumann, Probst, & Wernsmann, 2012, p. 319 ff.; Weske, 2012, p. 16; von Rosing, Scheer, & von Scheel, 2015). The process owner is the actor responsible for the operational business process he or she “owns”. His or her responsibilities regarding the process includes activities such as the concrete design and definition of the process, the definition of process performance measures and the documentation of the process (Hammer, 1997, p. 76). He or she is also responsible for the allocation of resources needed for the enactment of the process and the coordination of process performers. The process owner can manage the process and, in time, initiate redesign initiatives or take other actions if the process does not perform as expected or if other external factors change. Of course these activities are not performed by one person alone, but the process owner is, in the end, responsible for the performance of the business process and, therefore, accompanies it throughout its life cycle (see section 2.3.2 and figure 9).

While the process owner is an expert regarding the overall business process, he or she is not an expert in all the individual tasks that need to be performed. The actor of a "process coach" fills that role. The process coach is an expert for specific types of activities across many operational business processes. He or she is responsible for identifying the qualitative and quantitative requirements of the business process and finding fitting employees to fill those requirements. He or she accomplishes this by developing existing employees (see also section 4.3.3.4) or by acquiring new ones (see section 4.3.3.2 and Hammer, 1997, p. 117 ff.). This, however, requires in depth knowledge of how the activities in the process are performed and what requirements each activity has in relation to the qualifications needed. The process coaches knowledge is, therefore, focused on specific parts of the process and does not encompass the whole business process. Depending on the complexity of the process, process owner and process coach can be the same physical person.

The third type of actor interacting with the proHRIS is the process performer, i.e., the employee actually enacting the business process. While he or she does not have such a deep understanding of the overall process, ideally he or she understands the process in a general fashion and is aware of his or her place and the importance of his or her action for the whole process (e.g. Hammer, 1997, p. 16, 37; Hammer & Stanton, 1999, p. 7). He or she is knowledgeable in the individual activities he or she performs and interacts with other process performers to fulfill his or her duties. The different actors and their relationship with each other and the operational business process are shown in figure 43.

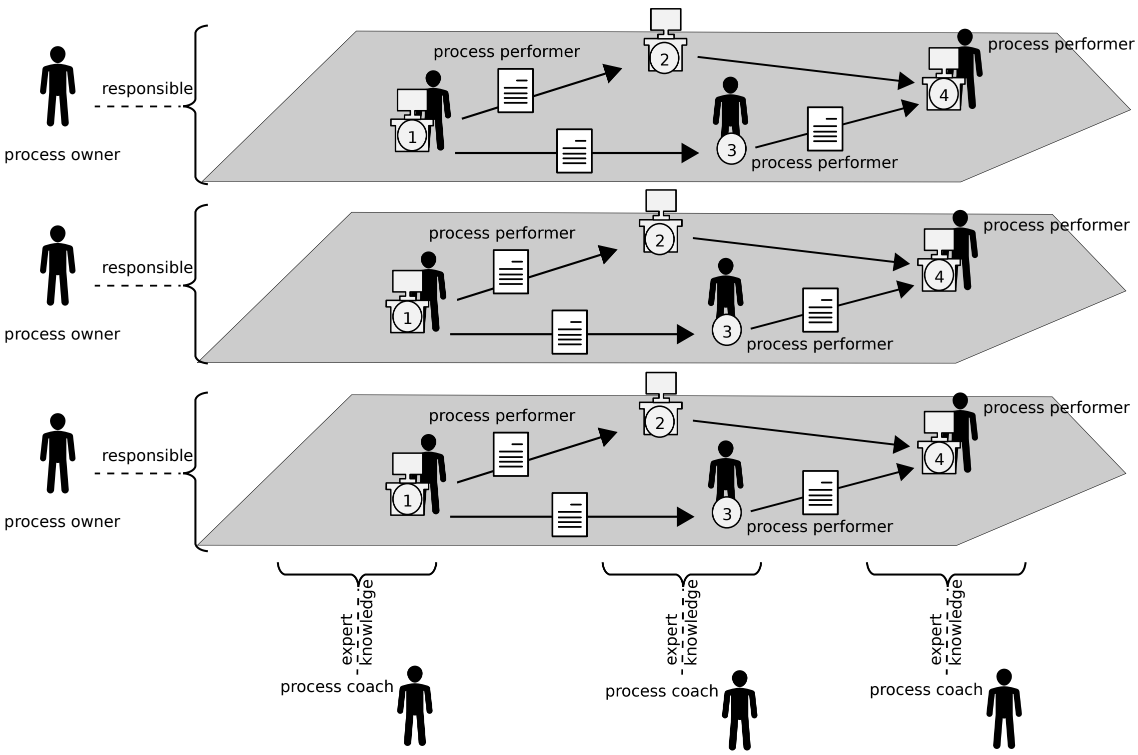


Figure 43: Relationship between the different actor types interacting with the proHRIS: the "process owner", the "process coach", and the "process performer" actor type.

4.3.2 Description of the generic components

4.3.2.1 Model repository

In the proHRIS the repository serves as the main data storage facility for most of the information used in the system (**FR5**). Figure 44 shows the different components relevant for a repository based on a literature review performed in Yan et al. (2012) but adapted for the use in a proHRIS. The repository, as used in a proHRIS, consists of three layers (in contrast to a standalone repository the user interaction is managed by a different component): a storage layer, a DBMS layer, and a repository management (RM) layer. The storage layer contains the different relevant models (process, qualification, organization, etc.), related data (simulation information, execution logs, etc.) as well as indexing information to allow for a fast navigation of the models. Often repositories save model information in an internal format to allow for a unified processing of models, as well as an external format, to allow for easy exchange of models with external tools. As the repository is used exclusively for the proHRIS such a redundancy is not needed here. The models are saved solely in an internal format that supports the fast and efficient processing of the models by the DBMS and RM layer.

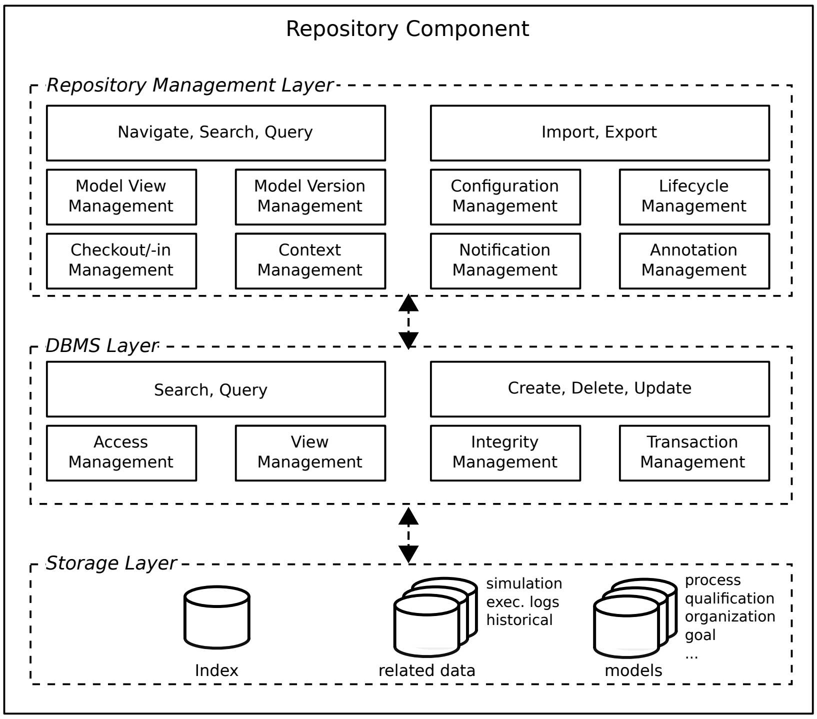


Figure 44: Components of the model repository (adapted from Yan et al., 2012, p. 385).

This is a fundamental difference to generic process repositories which need to support many modeling languages with different modeling notations and thus different conceptual meta models. The support of a single language that is adapted to the task at hand allows for a consistent representation of all involved models and navigation operations, but also analysis across these models (cf. La Rosa et al., 2011, p. 5f.). This consistent representation is key for integrating the different other models that are used in addition to the process models (**FR2**). However, the used internal models have to be kept adaptable so that they can be changed, when the relevant concepts for HR activities change or are appended (**FR1**).

The DBMS layer provides the classical features of DBMS adapted and optimized towards models: simple searching for models and the construction of complex queries on models, as well as the typical CRUD (create, read, update, delete) functionality. This layer of abstraction between the actual storage and the model specific actions is necessary as models can, for example, be saved in regular relational databases, which would require an understanding of the underlying storage to successfully search for models in the database. The DBMS allows creating queries based on the model structure instead of the underlying database structure. A query that could be given to the DBMS layer could, for example, be "return all simulation results performed using process models that include employee X". As the actual data required to generate the wanted information can span multiple different logical tables and database in the underlying storage layer that could be on multiple different physical components, the translation of the query is performed by the DBMS layer for the requesting party.

Additionally, the DBMS layer also offers different management features that relate to the NFR of the proHRIS. Access management ensures that the access to specific models or (in combination with the view management) elements in models is only provided under specified conditions (again, this is different from access permissions to database tables in the storage layers, as models can span multiple tables). Integrity management ensures that the models are logically valid, consistent, and accurate. The DBMS layer also provides transaction support; ensuring that operations are performed in a transactional manner, i.e., all operations are performed or none is. This prevents changes from leaving the repository in an inconsistent state.

The repository management layer provides repository specific functionality. This includes exposing navigation, search and query functionality to external components, as well as allowing the import and export of process or other models, as long as they can be converted into the internal format. The management of different model versions allows the tracking of changes performed in models, as well as the comparison of different versions. The management of configurations extends the versioning support by making it possible to store and maintain relationships between different versions of a process and different versions of other structures in the model (e.g., a version of an operational process model is linked to a specific version of the organization wide qualification model). To provide support for the different phases in the life cycle of a business process (see also section 2.4.3.2) the model repository keeps track for different states of models (i.e. design, enactment, evaluation, historical, etc.). Depending on the life cycle phase the repository ensures that some operations can be performed while others can not (e.g., process goals can only be changed during the design phase, but not during evaluation phase). The support for contexts allows users to create specific selection of models that are saved in the repository to quickly allow them access to that data (this can be represented to the user as a work space or a folder). This allows, for example, process coaches to collect models of all the processes in which they are involved and for which they can provide expertise. Annotation, notification and check-in / -out features support the collaborative work through the proHRIS (**FR7**). Checkout/-in features allow for marking models as being "in use" by specific users preventing conflicting changes to be made by another user while one user works on a model. The notification of users (or other components) when specific changes occur, such as changes to specific models, further supports the collaborative use of the system. The annotation management component allows users to augment (process) models with additional information. In its simplest form these are simple textual comments that can clarify modeling decision or (in the design phase) track existing semantic problems with modeled processes. While not in the framework proposed by Yan et al. (2012) it is added as a component here, because it represents an important aspect of collaborative modeling and modeling in general (e.g. Thomas & Scheer, 2006; Rittgen, 2009). Comment elements are intended in many modeling languages (see, for example the “Text Annotation” in the BPMN; OMG, 2011, p. 71) and provide the possibility to enrich models further. The support of this feature outside of the model itself however, allows a more streamlined representation of the comments or even discussion between participants across multiple model versions. Process owners and process coaches can discuss possible qualification requirements, or process performers can notify process owners of possible enactment problems with activities in the process (cf. Klein & Schumann, 2011). The annotation can also extend past simple textual comments to include specific semantic meaning. Activities could, for example, be tagged for augmented search functionality or related to terms in organization wide glossaries (cf. Mturi & Johannesson, 2014).

4.3.2.2 Intelligence component

In combination with the repository the generic process components offer functionalities that are used by the functional components to fulfill the functional requirements. In this section, therefore, the different generic components that augment the repository are presented. The generic functionality required for the proHRIS consists mainly of simulating processes, analyzing process models and performing process mining operations on process logs. These features are presented in the following as distinct components of the proHRIS.

However, it should be noted that this grouping is more a conceptual help for the discussion of the individual features. In practice the interface between analysis, simulation and mining is often fluent. Process mining tools include analysis functionalities as well as support for simulations. Partly this results from the need of simulation and mining methods of process models, that comply with specific quality criteria and that the verification of these criteria can easily be done with process analyses.

The analysis of process models can be split into two sub categories: quantitative analysis and qualitative analysis. The qualitative analysis focuses on structural aspects of the process and the organization, while the quantitative analysis focuses the performance related aspects. In the proHRIS the qualitative analysis is mainly performed by the analysis component and the quantitative analysis by the simulation and mining components. The goal of the analysis is, in simple terms, to provide answers about the represented object to the model user. In BPM the questions result from the need of the optimization and enactment of the process. As a failed enactment and a not optimized process results in additional costs the goal of the analysis of the process model is that of identifying problems in the represented operational business process. In the context of the proHRIS the analysis component offers the possibility to analyze the existing operational business process models against an arbitrary number of criteria. The topics of interest here stem from individual HR activities that are performed through the system. Relevant topics, therefore, include items such as:

▷ The set of qualifications required by the activities performed by an employee that he or she currently does not exhibit.

▷ The set of activities that have no employee directly responsible for them.

▷ The wage group result from a specific set of activities and assignment rules for an employee.

▷ The set of activities that are modeled in a parallel manner, but enacted by the same employee, therefore negating the paralleling.

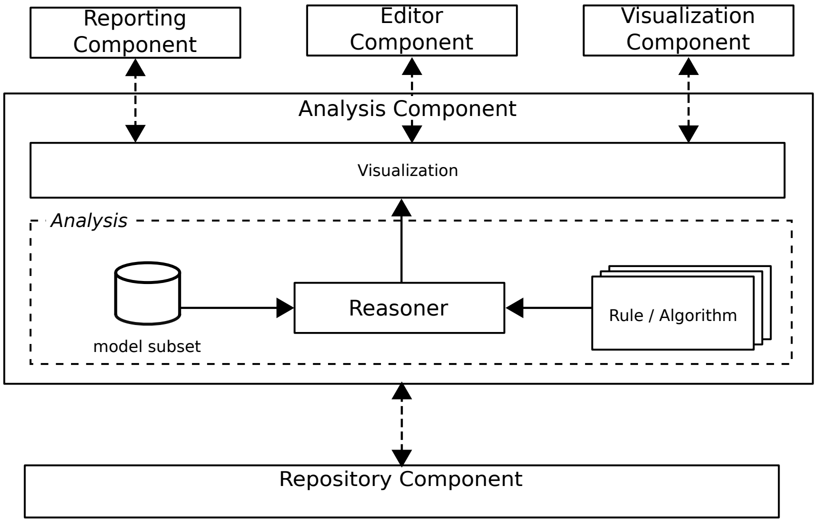


Figure 45: Analysis component of the proHRIS.

The structure of the analysis component in the proHRIS can be seen in figure 45. The analysis component uses the process models available from the repository and a reasoner applies a set of rules or algorithms on a selected subset of the models. The externalization of the rules and algorithms and the use of the reasoner, that applies them, allows for a greater flexibility in the analysis of the process models, important especially if the focus of the HR specific optimization shifts, e.g., through changes in the overall organizational strategy.

The simulation component of the proHRIS offers support for dynamic and quantitative analyses. While quantitative data (for example in the form of number of required employees for the successful enactment of an operational business process for a planning period) can be gathered in a tentative manner through the analysis of static process models with help of the analysis component, the accuracy of the data strongly declines with increasing complexity of process models and availability of input parameters. In this context the simulation of operational business processes can offer more accurate information. The general steps for simulating a business process in the proHRIS are shown in figure 46.

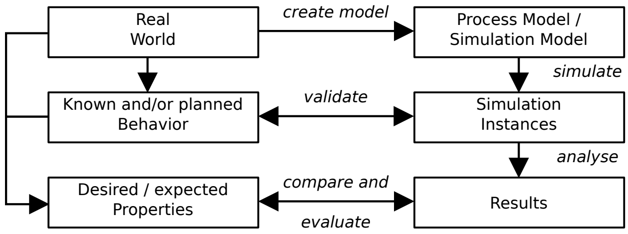


Figure 46: General steps of using the simulation component (cf. Desel & Erwin, 2000, p. 139; Gadatsch, 2010, p. 226 f.).

The real world is represented in a process model, or more specifically a simulation model, that captures the information required for the simulation. Depending on weather or not the current situation is to be modeled or a to-be process model is used, the normal process model is augmented with known or planned behavior. The parameters required for the simulation of processes include items such as (Dumas et al., 2013, p. 236 f.):

- a probability distribution for the duration of each activity
- other properties of the activity such as costs, added-value produced, etc.
- properties of the human resources assigned to the task such as hourly cost, working schedules, probabilities of sickness, etc.

It is important to note that an important and often over simplified aspect of simulation is the modeling of employees. While a simple representation makes sense for static analysis through the analysis component (the accuracy of the quantitative analysis is limited through the simplified handling of complex inter-relationships between activities anyway) in a simulated environment a naive representation of employees can lead to inaccurate results (for an in depth discussion of the problem and possible solutions see, for example, van der Aalst et al., 2010; as well as the literature mentioned there). To ensure the simulation produces realistic results test simulations should be validated against known behavior. The results from an analysis of the simulation instances can then be compared to the desired or expected properties of objects represented in the model and the situation evaluated.

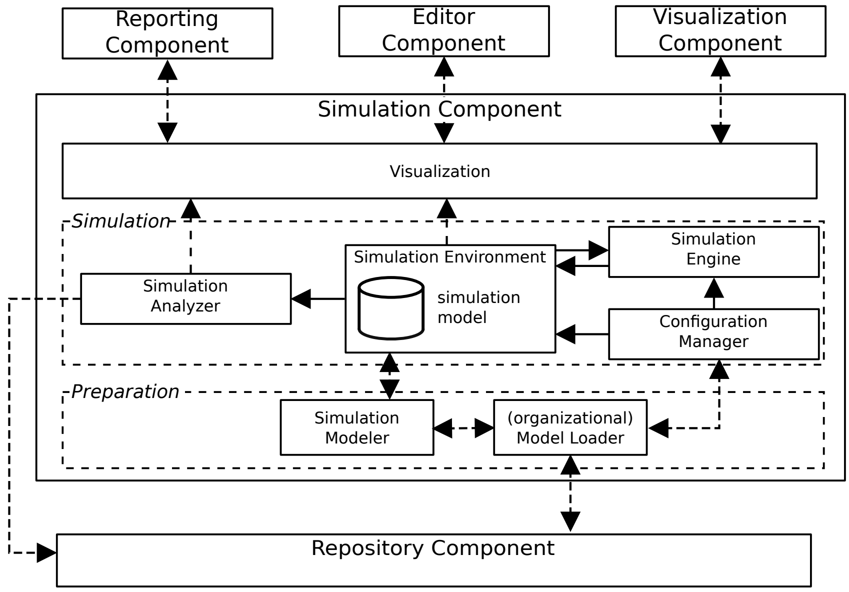


Figure 47: The simulation component of the proHRIS.

The simulation component in the proHRIS which is used to perform the simulation is shown in figure 47. The models used in the simulation are loaded from the repository. However, a simulation specific modeler (and model editor) is provided that converts the operational process models in models that can be used for the simulation. This includes an automatic conversion of the internal representation to one that is optimized to efficiency, but also includes a manual augmentation of the model with additional parameters required for the simulation.

The simulation model is then loaded in the simulation environment that is initialized with specific parameters that are set through a configuration manager. These parameters include specific information about the environment such as the calendar (including holidays) to use, specific set of restrictions that result from labor laws, etc. The simulation is then run by a simulation engine. The environmental and model specific parameters can be adapted after each simulation run when the model is validated against known properties. Once the configuration and model is calibrated the results of the simulation are passed to the analyzer who presents the results to the user. Another possibility is also that the results are passed back to the repository from where they can be used by the mining component. While the mining component normally works on historical process logs gathered from external PAIS, it is also possible to analyze simulations further by passing the simulation results to it.

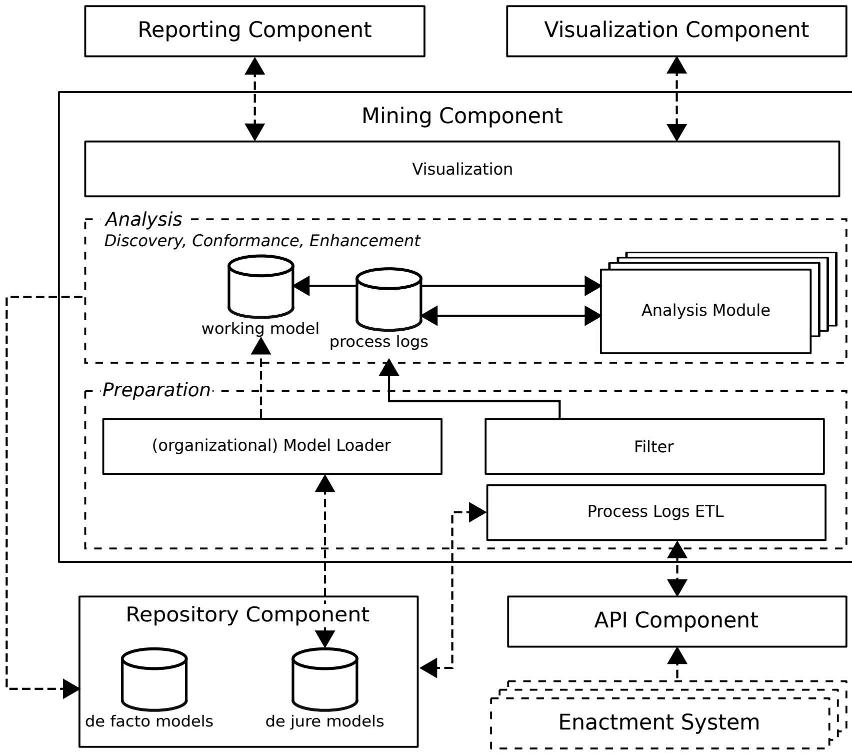


Figure 48: The mining component of the proHRIS (based on Grigori et al., 2004, p. 337; van Dongen et al., 2005, p. 447; Barborka et al., 2006, p. 111; van der Aalst, 2011, p. 227).

The mining component of the proHRIS offers generic process mining features (see figure 48). At its core the mining component consist of different modules that support advanced modeling and optimization features centered around business processes. The main areas are process discovery, process conformance monitoring, process model enhancement (see van der Aalst, 2011, p. 9 ff.), and process optimization (e.g. Castellanos et al., 2011):

- **Process discovery** relates to the creation of process models based solely on process logs gathered from different sources such as PAIS. Process logs have to at least contain information about what activity was performed, which process instance (or case) that activity belongs to, when it was performed and potentially by whom it was performed. With that, logs provide a sorted list of activities for each process instance in the order of their execution. Based on such logs specific algorithms can construct process models that fit the information contained in the logs. The α-algorithm is a simple example of a process mining algorithm that achieves this. Based on a collection of ordered lists $L = \{ABCD, ACBD, AED\}$ that represented multiple executions of a process (A-D are the activities) it can extract a process model based on the idea that activities that temporally follow each other have a logical relationship (in detail see van der Aalst, Weijters, & Maruster, 2004). In the proHRIS the discovery of processes is relevant if there are no process models available but process logs exists that can be used as a basis for the creation of process models.
- **Conformance checking** modules use both, event logs and existing process models, to identify discrepancies between the modeled process, and the actually enacted process.

There are two possible approaches. One is to discover a process independently of the existing "de jure" model and then compare the "de jure" with the "de facto" model. Another approach is to evaluate each process extracted instance against the "de jure" model and check if the order of activities recorded are valid under the given model (cf. Cook & Wolf, 1999; Adriansyah, van Dongen, & van der Aalst, 2011). In the proHRIS such conformance checks can be helpful during planning activities. As the process logs also provide an idea of the duration of activities they can be used to test the validity of planned staffing assignments or be used to set employee related goals if discrepancies are noted. The analysis can even be extend further than the structure of the process, it can also include the additional information that is available through the overall organizational model. One example is the evaluation of performance goals that require specific activities to be performed by employees; information that can be gathered through process logs.

- ▷ **Model enhancement** goes a step further than conformance checking. Here, process logs can be used to update process models. An important activity in the proHRIS as most HR activities rely on up-to-process logs. The mining component can propose changes to the existing process models, that can be saved back to the process repository. These changes can, for example, relate to activities that are not performed anymore, but the enhancement can also relate to augmenting existing process models with additional information. Through mining techniques the system can propose required qualifications for activities based on the qualification of employees performing the activities, or even extract current assignments between employees and activities from the logs.

- ▷ **Process optimization** features provided by the mining component allow for typical analysis of processes regarding their performance resulting in specific metrics that can be used to optimize existing processes. This information is again generated based on the process logs and the generated process models. Typical approaches include, for example, the analysis of factors leading to specific performance values in process instances. For this multiple instances are analysis regarding patterns that lead to specific values for performance metrics. As such it could be identified that specific combinations of process performers, instance properties (e.g. "sales value greater than 10000€" or "start time later than 17:00), and additional resources lead to a process duration that is above the set performances goals. The analysis can then be taken as a basis for changes to the process model that should prevent further delays.

To provide these features the mining component requires process models, which it loads from the repository, as well as process logs. These logs can either be available in the repository as well, or be imported through the API component from external enactment systems, or even non process aware legacy systems (e.g. Pérez-Castillo et al., 2011). Similar to classical mining applications the process logs have to pass through an ETL component (Vassiliadis & Simitsis, 2009) that extracts process information from the different log types and transforms the data so that it can efficiently be used in the analysis. Depending on the type of analysis these logs are potentially filtered further, e.g. to only include specific activities, or a specific time frame. The repository component provides the mining component with the "de jure" models. The repository also stores the models resulting from the analysis of the process logs as “de facto” models. “De jure” models represent processes as they are officially designed to be, while “de facto” models represent the process as it currently is in practice. The three core features described above all center around the differences between these “de jure” and “de facto” models.

4.3.2.3 Interface component

The proHRIS uses three interface components to support the interaction of the system with users, as well as function specific interfaces that support each individual HR function. In the following relevant aspects of the generic interface components are elaborated, while the interactions relating to specific HR functions are further discussed in the next section.

The three components mainly used for the interaction with the users are: the editor component, the visualization component, and the reporting component. Each of these components supports specific activities with differing goals. The editor component mainly supports modeling and analysis activities, i.e., the creation of new business process models, the augmentation of existing process models with HR relevant information, and the planning and documentation of changes in processes due to optimization initiatives. The focus of the visualization component is to help visualize the process and organizational model in such a way that relevant information is made visible to the involved party. The difference to the editor component is that the visualization aim at conveying information without the compromises the editor component makes to be allow for changes in the model through the user. The reporting component allows the creation of standardized reports for all participants and as such is similar to that of reporting mechanisms in most business information systems.

Name	Description
Integrated repository	The modeling tool provides access to a model repository that stores all models in a central database and facilitates navigation between different levels of aggregation.
Navigation capacity	Navigation capacity allows users to link and access models from within other models.
Additional attribute fields	The modeling tool provides access to all properties of the conceptual elements represented in the notation, independent of their (visual) representation in the specific syntax.
Hyperlinks to documentation	Specific links can be created to external documents such as spreadsheets or further documentation
Additional notations	The modeling tool allows the use of multiple notations to represent real-world phenomena. Models of different notations can be linked and combined.
New/custom notation elements	The creation of custom notational elements is supported and the conceptual model of the notation extended to include the new elements.
Notation filter	A filter restricts the set of elements that can be used by the modeler, thereby reducing the apparent complexity of the modeling notation.

Table 12: Common modeling tool functionalities (modified from Recker, 2012, p. 216).

The common features offered by modeling components are shown in table 12. The modeling component of the proHRIS offers these features either in an adapted fashion or through the interaction with the other components of the system: the repository functionality is provided by the repository component. For a full integration the specific additional possibilities have to be exposed to the user. This includes the different versions of process models, the possibility to display comments, references to external documents, other annotations, etc. As the notation used in the proHRIS is specifically developed and adapted for the use in a proHRM there is no need to support additional notations. However, the adaptation of the modeling notation has to be supported by the modeling tool in cooperation with the model repository as some specifics of the notation depend on the organizational implementation.

One important aspect that has to be supported by the modeling component as well as the visualization component is that adequately representing and handling the aggregation of operational business process or organizational models. In general terms a model abstraction is an operation on a (business process) model preserving essential (process) properties and leaving out other details in order to only retain information relevant for a specific purpose (Smirnov, Reijers, & Nugteren, 2010, p. 2). The abstraction still represents the same instance (or object) that is being modeled, but highlights different facets. The model that is the abstraction of another model is also still described by the same modeling notation (see figure 49).

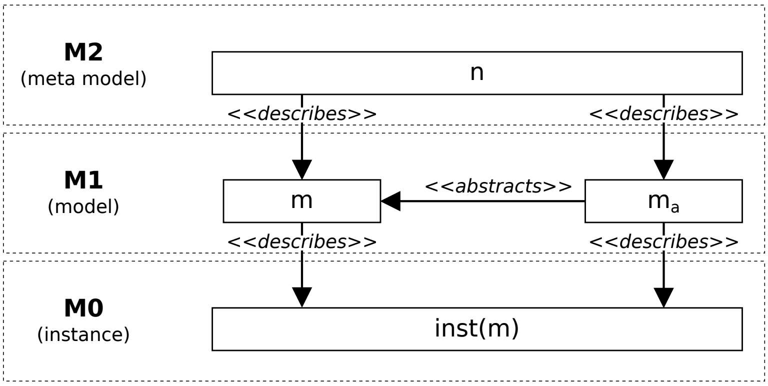


Figure 49: Concepts of model abstractions in MOF levels (from Smirnov et al., 2010, p. 3).

In the proHRIS the abstraction of models is mainly performed at the point of interaction between the application system and the human user. As such no new long terms models with specific views are created, but the abstractions are performed prior to visualization to the user through the editor component or the visualization component (similarly abstraction is also often referred to as process views or model views; cf. Bobrik et al., 2007; Eshuis & Grefen, 2008; Caetano, Pereira, & Sousa, 2012).

There is a range of literature researching possible strategies and algorithms for the intelligent and fitting automatic aggregation and elimination of elements with regard to the modeling goals. An overview about the methods is given in Smirnov, Reijers, Weske, and Nugteren (2012, p. 85 ff.). There the authors also develop a framework consisting of three relevant aspects regarding model abstraction: why, when, and how. The why aspect considers the reason for abstracting a process model, the when aspect deals with the conditions under which an element is affected by the abstraction, and the how aspect describes the method by which the abstraction is performed. In the following the implementation of abstraction features are discussed based on these three aspects (see also section 5.2.2).

Creating abstractions of models in the proHRIS can be done because of a multitude of reasons ("why" dimension). The most important one are the reduction of model complexity for a specific purpose as well as security related considerations. The understandability of process models is heavily influenced by the amount of elements that are displayed to the observer, as well as by the number of relationships between these elements (e.g. Schuette & Rotthowe, 1998; Mendling, Reijers, & van der Aalst, 2010, p. 10 ff.), therefore a reduction of the complexity by the editor or visualization component increase the utility of the models employed. From a security point of view the models contained in the proHRIS contain a wide range of information across organizational boundaries of the core operational business process of an organization. It furthermore contains employee specific information as well as performance related information (see the section 4.3.3.3). Not all the information should be available to all users. Depending on the user and permissions system employed the information available to process performers could, for example, be restricted to the processes they are involved in, their own employee data and the performance data of activities they enact. Without the possibility to abstract information from models many of the models would not be available to the process performer. One core premise of process orientation, however, is that employees understand and think in the processes they are involved in. This is hindered if the process models are not available to the employees because they might contain unavailable information. The abstraction methods allow the proHRIS to still be able to display process models to users and abstract them in such a way that the confidentiality of the system is not compromised.

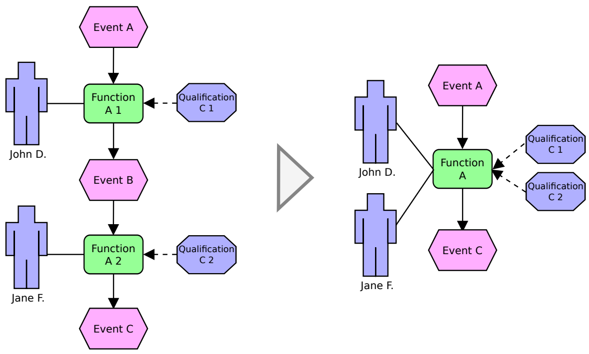


Figure 50: Example of aggregation operations and result information loss.

Abstraction operations can result in changes along two dimensions: the granularity level and the coverage level. Changes in the granularity result through aggregation of multiple elements, while changes in the coverage are achieved by the complete elimination of elements in the model. In the case of activities, multiple activities can be part of another activity on a higher level of aggregation. When this aggregation is performed, or the validity of a modeled aggregation tested, certain rules apply. For example, the duration of a function must always be at least as long as the duration of the shortest path through all child activities. Especially interesting for the proHRIS is how the HR relevant elements can be aggregated in concert with other objects. Any qualification that is required by an activity that is part of another activity is also a requirement of that activity. The assignment of human resources can similarly be extended to parent activities. The aggregation itself is not limited to occur on functional elements, but can also happen on an organizational or any other element that supports the aggregation relationship. However, the aggregation still results in a loss of information due to the nature of the modeling notation. Figure 50 shows an example of an aggregation. The aggregation results in the visualization of the assignment of employees to the same activity (on a higher level of abstraction). However, the information that not both employees require both qualifications is lost at this level.

The complete elimination of elements from the model allows to focus the model for a specific goal. Similarly, as with aggregation the criteria by which elements are shown or hidden can be set depending on the given requirements. Additionally, to security concerns the actual HR function through which the operational process model is observed provides these criteria. Table 13 shows example criteria by which the models can be abstracted.

Area	Example Goals	Example Criteria
staffing	Assign employees to a process that has yet unfulfilled requirements	Hide all activities that are fully assigned.
	Get an overview of the activities of a process an employee is involved in	Hide all activities that are not assigned to the given employee
	Plan potential alternative assignments based on performance appraisal data	Show activities, employees where the goals have not been fulfilled in the selected period.
appraisal	Identify the organizational goal that has the most influence on the process	Aggregate all goals as much as possible and only show the one that is most often connected to functions
	Identify employees that have the similar set of goals throughout the available operational processes.	Show all goals and the employees that are affected by them.
compensation	Identify cost drivers for a process	Show only the process path (if multiple exist) that results in the highest average work value for the process
	Get an overview of the components of an employee's wage group	Show the process and all elements that are used for calculating an employee's wage group.
development	Identify potential internal development opportunities	Show activities that provide qualifications and where those qualifications are used.
	Try to classify processes based on required qualifications	Aggregate qualifications used in processes to higher levels

Table 13: Example of reasons for process model abstractions in the proHRIS based on HR activity.

4.3.2.4 API and management components

The proHRIS has two additional components that do not directly interact with the end users on a daily basis, but are non-the-less critical for the fulfillment of the functional requirements. The management components is used for the configuration and maintenance of the system through an administrator and the API component is used for the integration with external information systems.

The management component is especially important in the context of the adaptation of the proHRIS to specific organizations, i.e. the adaptation of the modeling notation to fit organization specific HR strategy, as well as the adaptation of the intelligence features to reflect these changes. The management component, therefore, offers the possibility to implement changes in the modeling notation through an adaptation of the central meta-model that is used both in the model repository and the other generic components. The management component also allows for an adaptation of the intelligence components to reflect changes in that meta-model; i.e.

▷ the management of the rules and algorithms used by the reasoner in the analysis component,

▷ the adaptation of the simulation engine, analyzer, and simulation model to reflect the changes in the notation, if they have an impact on the simulation results, and

▷ the management of the analysis modules used by the mining component, if they are affected by changes in the modeling notation.

The management component also offers the possibility to customize the functional components to reflect the changes that lead to an updated modeling notation. For example, the specification of which analyses are sensible in which functional component.

Besides the functionality to handle changes in the modeling notation, the management component is also responsible for day-to-day administrative activities such as archiving historical models and reports, HR master data management, or user data management.

The API component on the other hand offers two main features. One is the bridge between the proHRIS and potential source systems from which the proHRIS can gather required data. The other is allowing access to the proHRIS from an external system allowing the integration of the proHRIS in overarching workflows. The API component, therefore, offers a standardized way for the other components of the proHRIS to communicate with external (legacy) systems. These systems include:

▷ Existing HR Systems such as recruiting systems, job boards, master data systems, payroll systems, training management systems, e-learning systems, etc.

▷ Existing PAIS, especially enactment systems: WfMS, ERP systems, etc.

▷ Existing performance management systems (PMS), especially those supporting a process oriented paradigm: PPMS

Additionally the API component also provides access to the proHRIS components to external systems. This can, for example, be relevant when new employees join the organization. While a new employee can without a problem be represented in the organizational model, there has to be a way to create a new account in the system for him to be able to profit from self service functionalities. The actual integration of different information systems with the proHRIS has to be designed according to a set of integration criteria (see Hohpe & Woolf, 2003, p. 63 ff.):

Application coupling While good integrative possibilities should be striven for, dependencies between systems should be avoided. Tightly integrated systems make many assumptions about the working of each other and changes in one system can lead to a break in the integration. The interface between each system should be generic enough so that it can be adapted to changes in the applications, but specific enough to provide the required functionality.

Integration simplicity To increase the manageability of the integration between systems the developed interface should be as simple and minimalist as possible. Changes in one of the systems, will eventually lead to a need to update the code responsible for the integration of both. However, the interface with the least impact might not provide the best possible integration.

Integration technology Which technology is used to achieve the integration can lead to varying amounts of required hard- and software. Classical problems, such as vendor lock in, additional development times, and maintenance requirements, can occur.

Data format The interfacing of two systems requires both systems to agree upon an overarching data model, or requires additional converters that convert data from one format to another. It should be noted that data formats of different systems can change over time leading to the need to reevaluate overarching models or converters.

Data timeliness A goal of the integration of two systems should be the minimization of the required time between the point in which data is generated in one system and available in another. If there can be latency in data sharing, this has to be taken into account in the design of the integration.

Data or functionality An important decision is whether applications should only share data, or be able to share functionality, i.e., invoke procedures in the integrated system. While functionality integration allows for a much tighter integration of two systems, it is also much more complex to achieve.

Asynchronicity In system internal executions, individual components of the system can receive feedback in a synchronous manner, i.e., the result of operations can be directly defined. When integrating different systems however, this is not given, either due to the physical distance of the individual systems, or the method of integration, it is possible that there is a lag between actions in one system and resulting actions in the other. The interface between the two systems should, however, be designed in such a way that systems can continue with their work certain that their requests are performed at a later point.

When interfacing external systems with the proHRIS each integration has to be evaluated and designed according to the criteria listed above. The actual integration can then take different forms, from simple exchanges of files, over using a shared database to the implementation of organization wide messaging systems through which individual applications can send messages to each other (see table 14).

Method	Description
file transfer	Each system produces files that are to be consumed by other systems and each system consumes the file produced by others.
shared database	A common database is used to share data across systems. In contrast to simple file sharing a common database requires both systems to agree upon a common data model.
remote procedure invocation	Each system exposes some of its procedures, so that they can be called by the other system.
messaging	Each system connects to a common messaging system and exchanges data, or invokes procedures by sending messages.

Table 14: Integration options regarding external systems (based on Hohpe & Woolf, 2003, p. 65).

4.3.3 Description of the functional components

4.3.3.1 Method of the component description

The description of each sub component of the functional component is achieved by four steps: a discussion how the described actors of the system are involved and their goals in interacting with the functional component, a description of relevant modeling entities, a discussion of necessary components to support the HR function and their interaction, and finally the presentation of two use cases that show the functionality in more detail. This approach borrows multiple concepts from the classical use case approach as outlined in the UML specification (Object Management Group, 2015) and practitioners/researchers recommendations (Rosenberg & Stephens, 2007, p. 49 ff.; Rotem-gal oz, n.d.; Cockburn, 2000). A short explanation of each step is described in the following.

Actors and goals The next step consists of identifying the main actors that interact with the functional component, as well as their goals. The delimitation of the actors in this chapter is not based on function or hierarchical consideration but is based on their role in relation to the operational business process.

Modeling concepts As business process models are used as central communicative medium, a specific notation (cf. section 2.3.3) has to be created for the system. This modeling notation also serves as means of integrating the different generic and functional components of the system. In a next step, therefore, the relevant concepts such a notation should at least include for the specific HR function are described.

Components The different subsystems of a proHRIS relevant for the support of that HR function are then described and their interactions delimited. This includes a description of the generic components involved in providing the required HR function support as well as the concrete functional component that integrates the different generic components to provide the support.

One problem faced when designing a complex system is the trade off between specificity and level of detail of the design. As discussed in section 4.2 the “modeling and analysis” understanding of a proHRIS is used in this thesis. This already restricts the specificity of the design to a certain degree. Still, a multitude of different activities can be comprised in an information system that should support the HR activities. Many features also depend on the concrete organizational, cultural, and legal context of the organization that the system is implemented in. This makes it impossible to create a detailed and complete design of a proHRIS without reducing how generalized the described design is. The goal of the following sections is, therefore, not to provide a complete detailed architectural description of the functional components of a proHRIS as it would be implemented in a specific organization, but to focus on key aspects that support the process orientation of such a system in an ideal-typical organization enacting a process oriented HRM.

To still be able to describe the system in more detail and make the proposed design decisions more tangible two specific use cases are presented for each functional component of the system. These use cases, while still described for an ideal-typical organization, offer a less abstracted point of view and hopefully help to better illustrate how a process oriented HRIS can support a stronger process orientation in HRM. The use cases loosely follow the template outlined by Coleman (1998) and include an use case diagram showing use cases (a short introduction to use cases is given in Malan & Bredemeyer, 2001).

4.3.3.2 Staffing component

4.3.3.2.1 Actors and goals The actors types involved with the staffing component are the process owner, the process coach, and the process performer. Each of the actors has specific goals relevant to staffing, that a proHRIS should help in achieving. The process owner wants to, ultimately, have a smoothly running business processes that fulfills all set performance measures. For this he or she needs employees that fit the qualitative as well as quantitative requirements. The process owner also needs to know if there are unfulfilled requirements in the process with regard to its human resources, so that he or she can initiate recruitment and selection activities. While he or she knows the general steps of the process and how they relate to each other, since he or she designed the process, he or she does not (necessarily) know the specific requirements of each activity in the process. The process coach helps in that aspect. His or her goal is to identify the specific requirements of each activity that falls into his or her purview and find employees that fit the qualifications of those functions. He or she requires the system to allow him document the requirements of specific tasks. The process performer on the other hand has a different set of goals. He or she wants to perform activities that fit his or her own capabilities, as to not be to difficult or to menial. Furthermore, he or she might have some specific preferences regarding functions he or she wants to perform or other employees he or she prefers to work with.

4.3.3.2.2 Modeling concepts For the successful staffing of a business process, three main concepts need to be represented by a notation that is used to model and analyze the business process models: activity, employee, qualification (cf. **FR10-1**, **FR10-2**).

Activity The representation of an activity is a central element of every business process modeling notation. Be it in form of functions (EPC), tasks (BPMN), or actions (UML). For the planning of employee assignment and the later assignment of those employees specific properties of that element are of importance. The activity must be modeled with information that allow the prognosis of its duration and frequency, so that possible assignment options can be evaluated with regard to the available time of employees. At least the duration of the activity and its frequency have to be included in the model. With that a simple calculation can be made to estimate the time needed for the cumulative executions in a give time frame.

For example, given one activity with a duration of 30 minutes ($duration = 30\,minutes$) and a frequency of 3 times per day ($frequency = 3$) the time needed for that activity per day is 90 minutes ($duration * frequency = 90\,minutes$). A simple assumption for the minimal working hours per week ($days\,per\,week = 5$) for an employee assigned to that activity can, therefore, be set at seven and half hours ($duration * frequency * days\,per\,week = 450\,minutes$).

More complex variations are conceivable. The frequency and duration can be given as probability distributions allowing for weighted intervals of required time for that activity in a given time frame. The information about average duration of activities can often be extracted from operational systems or small samples. This makes the gathering of that type of information easier. However, predictions based on that data are not always as accurate as temporal variations are not included. For example, the frequency of different tasks can vary depending on the seasons. Such detailed information, however, is more difficult to collect. The accuracy of the prediction can be further increase by taking into account the logical and temporal relationships between different activities or by further refining the duration into different types. For example, while a task may take 30 minutes to perform, the time an employee effectively has to actually perform tasks may be lower. During a production process an object might need to cool down between times when employees are working on it.

The prediction of process requirements based on simple average values has a number of problems however (e.g., Junginger, 1998, p. 9 ff. & 17 ff.). To gather more accurate results, therefore the simulation of process models has established itself (e.g., Fahrwinkel, 1995, p. 126 ff.; Giaglis, 2001, p. 217 f.; Gadatsch, 2010, p. 216 ff.; Dumas et al., 2013, p. 235 ff.).

Employee The concept of an employee is not often used in classical business process modeling notations. Most notations only include elements that represent abstract roles or organizational units in their vocabulary. An employee represents a specific physical person that works for the organization. As mentioned before the decision whether to include concrete employees in business process models is one involving the specificity of the model, as well as the effort needed to create it. A business process model containing only organizational units or specific rules is easier to create and more generic than a model that contains concrete persons of an organization. However, for the solving of the staffing problem the more specific the information are the accurate requirements predictions can be. The element representing employees should offer properties to uniquely define the employee as well as their contractual working times. Depending on the method of prognosis, this could include average working hours per week, or specific availability time tables. Additionally, depending on the organizational setting it might be useful to include the cost of the employee as a property that is tracked. An assignment can then be evaluated also regarding the personnel cost incurred by it (cf. Zülch, Rottinger, & Vollstedt, 2004 where simulation of possible assignment is used to reduce overall personnel cost of production processes). When designing the specific elements and relationships representing employees or requirements of activities a wide range of additional requirements should be taken into account (e.g., Cabanillas, Norta, Resinas, Mendling, & Ruiz-Cortés, 2014; Cabanillas et al., 2011)

Qualification The concept of a qualification is normally not included in business process modeling notations. For the assignment of employees to tasks, however, it is of such great importance that an explicit modeling of the qualifications in the business process model seems adequate. The inclusion of qualifications in the process model instead of an external database of qualifications additionally allows analysis over the process model (**FR3**, **FR1**; cf. Schuster, 2012) and if the organizational model (**FR2**) contains structural information or even relationships with a higher degree of semantic meaning (e.g., in form of an ontology: Schmidt & Kunzmann, 2007; Macris, Papadimitriou, & Vassilacopoulos, 2008), the system can even make more accurate estimations of the required and available employees.

The concept is used very loosely here and includes many concepts such as skills, knowledge (cf. Leyking, Chikova, Martin, & Loos, 2010), and competencies (in their meaning as ability and authority; cf. Schuster, 2012, p. 49 ff.). Similar to the properties of the activities, the more accurate and detailed the concept is used in the modeling language the more accurate forecasts of possible requirements can be. One possible way to define qualifications needed is by using the REFA schema (REFA - Verband Für Arbeitsstudien Und Betriebsorganisation e. V., 1987). Here the requirements of tasks are split into mental demands, physical demands, accountability, working conditions. Those requirements can represent different qualifications an employee should have to be fitting for the given tasks. Another possible variant is to set the focus on the concept of competencies (cf. Le Deist & Winterton, 2005; Remus, 2002; Remus & Schub, 2002; Leyking & Angeli, 2008; Loos et al., 2007).

The information about the type and structure of the concrete concept used in an organization is something that has to be decided upon the implementation of the system in a specific organization, often in coordination with the workers council (e.g., J. Gutmann & Bolder, 2012, p. 33 f.). See also section 4.3.3.4 for the possible advantages of modeling qualifications, or knowledge in business process models.

Additionally to these core concepts, depending on the specific organizational context, other concepts might be relevant. This includes concepts such as a location, a goal (see also section 4.3.3.3), preferences of employees or managers (cf. M. L. Peters & Zelewski, 2007), working conditions of the task, etc. Which of the concepts are included in the models, is a question of availability of information and how it fits in the HRM strategy of the organization. If the working conditions are not systematically tracked and documented, adding this concept to the modeling language has very little use.

Of course the modeling notation can also be extended to include concepts for short term staffing decisions, with the concepts of shifts, and working calendars added to the model. To allow for the addition of new concepts and elements the notation used should be extendable (cf. **FR1**).

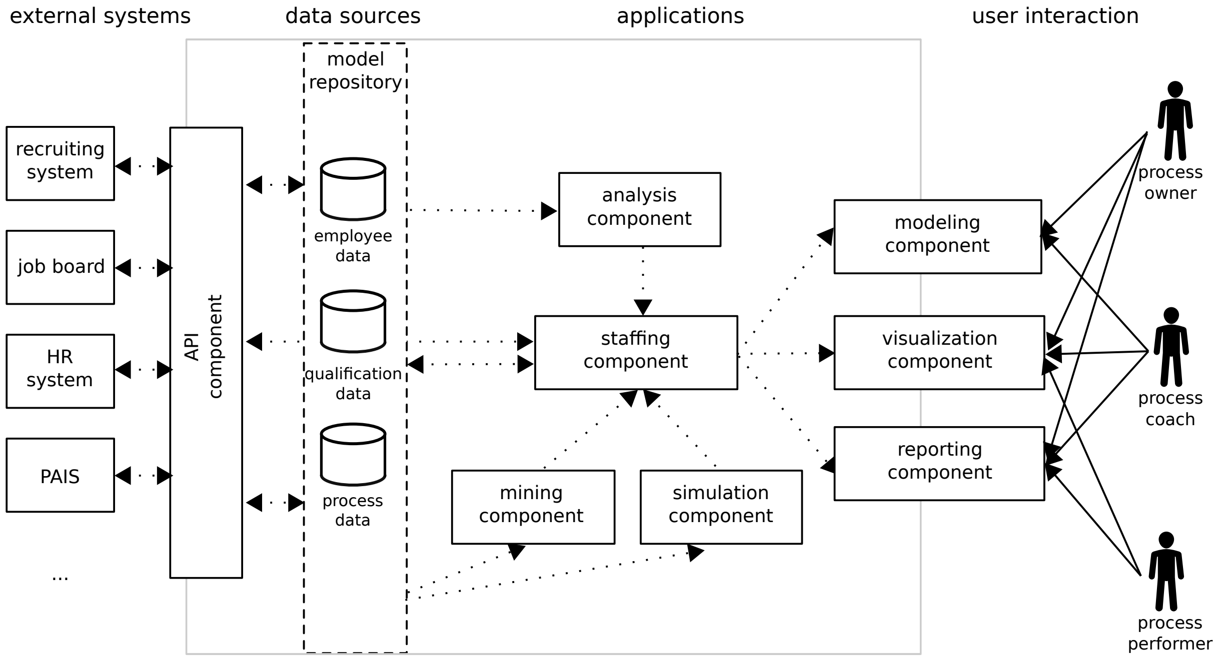


Figure 51: Components of a proHRIS supporting the staffing function.

4.3.3.2.3 Components The components of the proHRIS supporting the staffing function are shown in figure 51. The main staffing functionality is provided by the staffing component. It is supported by the intelligence component and its sub components the simulation component, the analysis component, and the intelligence component. In combination these components provide features exposed in the interface component, esp. through the modeling component, the reporting component, and the visualization component. The components interact either directly or indirectly with the model repository in which the relevant models are saved. Through the inclusion of the API component the staffing component can also directly communicate with external systems requesting or providing relevant information.

The main features that are provided by the staffing component in correspondence to the automate/informate paradigm (see p. 69) are discussed in the following. The information of the actors can happen either in form of augmented display during the usage of the system, for example, in form of highlights of specific functions in the model or overlays during the visualization of the model (for a more complex example of visualization see, for example, De Leoni, Adams, van der Aalst, & ter Hofstede, 2012). The delivery of the information can also be performed by explicit request, for example, answering a query about the qualification of a specific process performer or finding all activities in the process that have no process performer assigned to them. A sample of the informational features provided by the staffing component are:

- ▹ The staffing component shows the process owner existing operational processes and their status regarding their assigned employees (for an example of the analysis of current personnel status with regard to business processes see H. Gutmann, 2011).
- ▹ For each process the contained tasks as well as their requirements can be shown to the process owner to support him in identifying the best fitting employee. The information about specific tasks can be shown to process coaches to allow them to maintain the requirements of these tasks.
- ▹ For each employee their qualifications and/or preferences are also provided to the process owner for the same reason.
- ▹ The systems shows the value of hypothetical assignments of employees to process tasks made by the process owner to allow him to evaluate the quality of his assignment. This can be done either on an activity per activity level or on a process level, i.e., show how "good" an assignment of an employee to a specific activity is or how good the assignment of a group of employees to a process is.

From an automation point of view the staffing component should perform tasks instead of the process owner, the process coach, or the process performer. Thereby easing their workload regarding the staffing activities. The automation features include the following examples.

- ▹ generate one or more assignments of employees to tasks or processes.
- ▹ infer the preferences of employees regarding specific activities based on their previously provided preferences either to the same or other activities.
- ▹ infer possible requirements of activities based on similar activities or the qualification of employees having performed that activity previously.
- ▹ preselect applicants based on their qualifications and the resulting value of possible employee to process assignments.
- ▹ generate the documentation of the final employee to process assignment.
- ▹ generate job postings / job descriptions for use in other systems or publication.

To provide the described features the staffing component interacts with the other components and acts as a bridge between them.

The modeling component is the main interaction point for the process owner during staffing activities. Through it he or she creates augmented business process models either from scratch or by modifying existing models imported from external systems such as WfMS or other PAIS (**FR8**, **FR9**). The modeling component (in form of a model editor) is directly interfaced with the staffing component as it provides the information required for a fitting assignment. For this the staffing component can use the process model from the model repository as well as the information about employees. This allows it to e.g., overlay relevant information in the model editor about the currently selected element. The staffing component can also include information from the analysis component such as possible semantic modeling problems. The intelligence component can be used to provide further information gathered from historical data to users of the system. For example, the process coach can be provided with possibly required qualifications of an activity based on historical data about that activity or previous performers of that activity. In the same way simulations can be used to evaluate potential assignments. Which of the three components are used to support the actors in practice depends on multiple factors such as the complexity of the process, the available information, and possible time restrictions.

The visualization component can be seen as a feature restricted modeling component. Here the user, can view (augmented) process models in different types of visualization but not change the underlying process model. One example of the advantage of an explicit visualization component is that of the understanding of the process and the system (Reichert, 2012). Specific users can be given a simplified view of the process model to start with, only to allow for an expansion later on. This can be a process performer that first sees only those tasks he or she is directly working on and how they are connected in the process flow. He or she can then gradually display more and more relevant tasks to increase his or her understanding of the overall process.

While the modeling and visualization components offer mainly visual in-system representation of the business processes, the reporting component allows for the generation of reports about the operational business processes. These reports can stem from simulation results, process analysis or process intelligence activities. They can be used as information source for the process owner, process coach or process performer. The process owner can generate reports about missing personnel assignments or quality of existing assignments. The process coach can generate reports that inform him about non maintained qualification requirements and process performers can receive reports that inform them about their position in the process and task that they are assigned to, thus fulfilling the documentation and communication task of the staffing function.

The model repository serves as database for the augmented process models. The models stored in the model repository can come from 2 sources. Either the data comes from an external system such as an existing PAIS in which the process model is used, or a system which the employee master data is stored. The model can also be created from one of the components. For example, the modeling component, through input of the user creates a process model that is then stored in the repository.

The API component is used by the staffing component to communicate with external systems. This communication can be one-way or two-way. A specific interface between the proHRIS and a recruitment system or job portal can be used to push out generated job postings. It is also possible to have an interface to a recruiting system that supports the import of applicants into the proHRIS so that they can be tentatively used during the assignment of employees to activities in a process.

In the next two section to specific use cases are discussed that show, on a more detailed level, how staffing can be supported by a proHRIS.

4.3.3.2.4 Use case: Plan employee assignment for new process with existing employees

Description The use case at hand describes how a process owner can plan the assignment of employees for a new process with currently available employees. A diagram of the discussed use case is shown in figure 52. The use case looks at a specific type of employee assignment.

Other reasons for the assignment and other contexts are imaginable. The diagram displays the main use case as well as other use cases and their relationships. Every use case is either included by other use cases (is a necessary part of them) or extends one or more other use cases (i.e., can be part of them, but does not necessarily have to be; see Object Management Group, 2015, p. 638 ff.; cf. Rosenberg & Stephens, 2007, p. 64 f.). The main use case "plan employee assignment" is completed when a specific assignment of existing employees to a business process that did not have any employees assigned to it beforehand has been chosen by the process owner and is transferred to an enactment system.

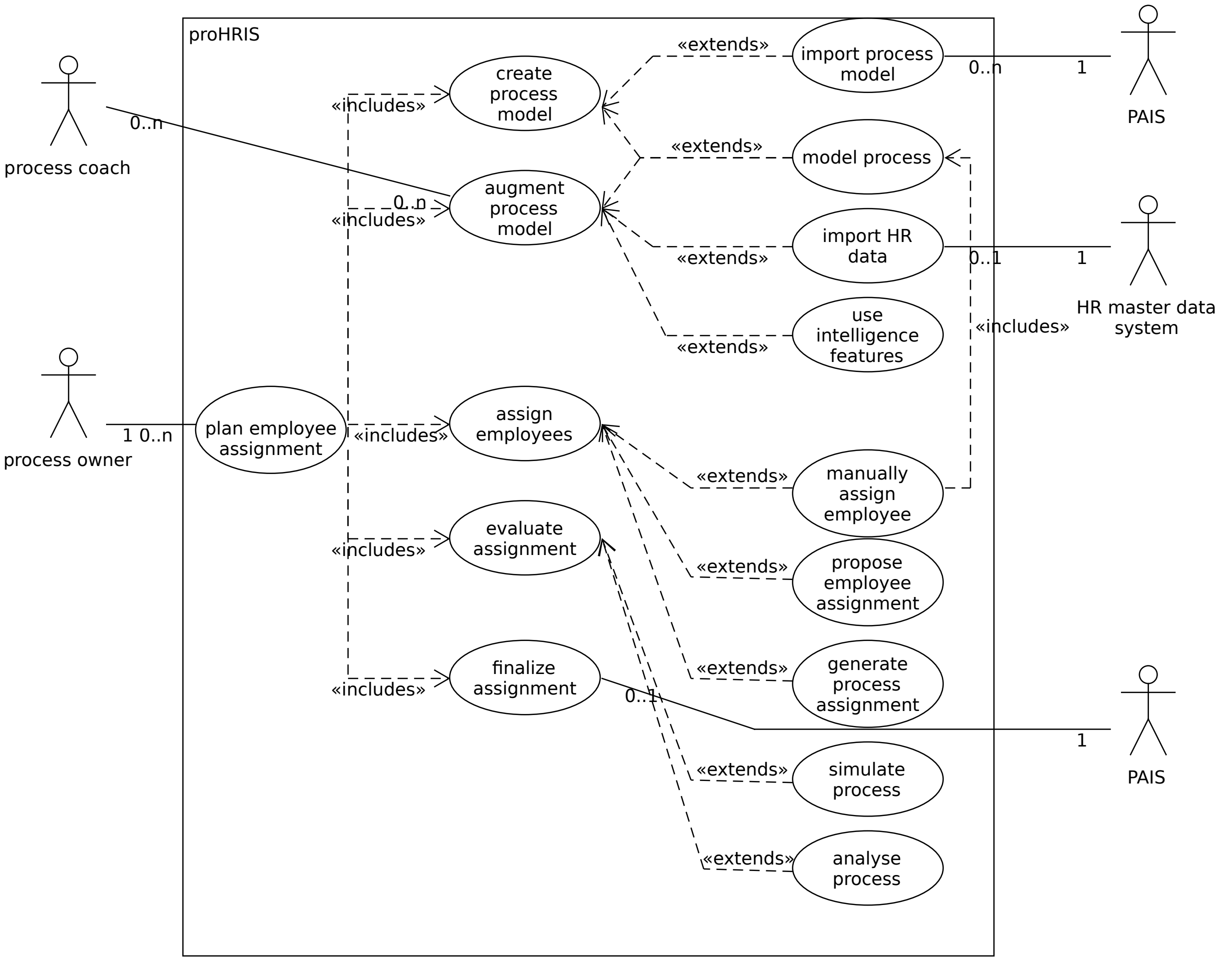


Figure 52: Use case diagram for the use case: Plan employee assignment for new process with existing employees.

Assumptions There are several assumptions being made in this use case. It is assumed that some other PAIS is available. That other system is assumed to be a suitable source for not augmented business process models. A further assumption is that another external system exists that contains all employee master data, i.e., data that is specific to the employee but not related to the currently enacted business processes. This includes the qualifications of employees and (if available) their preferences regarding activities or other topics. It is also assumed that the import of a qualification model for the organization has already been performed before the execution of the scenario, or that it is performed during the use case "augment process model". It is furthermore assumed that the system is implemented in a distributed manner, i.e. that several persons can work on process models from different work spaces at different locations. At the end of the use case the chosen assignment is transferred to an enactment system. It is assumed, that the system can work with the augmented process model and, e.g., assign roles to users based on the personnel assignments. A further assumption is that such a result is sufficient for the planning phase and that no time sheets or duty rosters are needed.

Actors The main actor of the use case is the process owner. His goal is to create an – under the given restrictions – optimal assignment between employees and the activities in a new business process. Additionally, process coaches could be involved during the creation of the augmented process model. They either adapt the model themselves or are consulted during the extension of the model to include necessary information such as the qualification requirements or time requirements. Additionally, the actors PAIS and "HR master data system" are involved in the use case. PAIS represents an external system in which processes can be enacted as well as modeled. The "HR master data system" represents a system in which the data of employees is centrally saved for reuse in the organization. This could, for example, be a ERP system that is employed for payroll processing.

Steps One successful scenario in the use case is as follows. The process owner decides to assign employees to a new process. He or she first creates a model of the process in the system. There already is such a model in the external PAIS in which case he or she imports it into the proHRIS (UC: "import process model").

Once the model is available in the proHRIS he or she needs to include HR relevant information in the classical process model (UC: "augment process model"). He or she has delegated those tasks to multiple process coaches who are experts in the specific areas. The process coaches add information about the probable duration and frequency of the functions to the model and create elements for the qualifications each function requires (UC: "model process").

Once the augmented process model is completed the process owner starts with the assignment of employees to the process (UC: "assign employees"). He or she uses the automatic assignment functionality of the system to create a first assignment of the employees to the activities (UC: "generate process assignment") and then evaluates this assignment through simulations (UC: "evaluate assignment", "simulate process"). Based on the results he or she makes some manual changes: he or she does not approve of the small safety margins with regard to the workload for specific process performers and manually changes them resulting in an additionally required assignment.

Having decided on the final assignment the process owner pushes the planned process to an external PAIS which uses the information to enact the new process (UC: "finalize assignment").

Variations

1. In use case "augment process model": The initial process model does not come from

an external PAIS. Instead, the process owner creates the business process model from scratch (UC:“model process”).

2. In use case “augment process model”: The process coaches use the system’s intelligence features to look for similar functions in other processes in order to wage probably duration, frequency and required qualifications (UC: “use intelligence functionality”).
3. In use case “assign employees”: the process owner does not let the system assign employees to activities, but does so himself (UC:”manually assign employees”). Alternatively he or she uses the recommendation feature of the system and lets the system recommend employees for specific activities and then selects an employee to be assigned (UC: “propose employee assignment”).
4. In use case “evaluate assignment”: the process owner uses simpler process analysis functionalities instead of simulations to evaluate the process assignment accepting less accurate predictions in favor of a quicker result (UC: “analyze process”).

Non-functional requirements Based on the use case a subset of relevant quality criteria of an proHRIS can be further discussed (see section 4.2.4). The **compatibility** (and especially the **interoperability**) of the system is important for this use case because the system has to interact with multiple other systems to support the process owner and the process coaches. In this case the system has to interact with a PAIS to import business process models as well as to export the enhanced models. It also needs to interact with a HR master data system to import the HR data used to augment the process models. In a similar fashion the **non-repudiation** sub-characteristic (of the **security**) is relevant, as the process owner needs to know who of the process coaches has assigned which required qualification to which activity. At the same time it is also important that later on the final assignment, that was transmitted to the enacting PAIS, can be traced back to the process owner who finalized it, as it might be possible, that multiple physical persons are defined as process owner for an operational process. This can, for example, happen if the process owner changed over time, or if multiple persons share the responsibility.

Another relevant quality characteristic whose impact can be shown through the use case is **user error protection**. As multiple actors work on the operation process model (process owners, and process coaches) errors should be identified as soon as possible because otherwise work might continue under false assumptions. Here the system can perform additional checks based on historical process information and the qualification structure to try to support the user and prevent possible errors.

One aspect to note concerning the **reliability** characteristic and especially the **recoverability** is that there is a sort of redundancy for the final assignment if it is transferred to an enactment PAIS. In case of data-loss a re-importing of finalized assignments from the target system, to try to recover them, could be useful. Nevertheless, information loss would still be present, as probably not all information would be transferred (for example, information relevant for the non-repudiation characteristic).

4.3.3.2.5 Use case: Generate job posting for a process with unfulfilled employee requirements

Description The second use case described here to make the design of a proHRIS more concrete in relation to the staffing of a business process is that of creating a job posting for a vacancy. A diagram of the main and other involved use cases is shown in figure 53. The generation of job postings can be seen as part of identifying the qualitative and quantitative gap and the attraction of qualified employees (see figure 11). There can be many reasons for a generation of job postings relating to a specific business process. Following the previous use case, for example, it could be that after the assignment of existing employees there is still a quantitative (or qualitative) gap concerning the full assignment of employees to the operational business process. Another reason for the generation of a job posting could be the foreseeable retirement of a current employee assigned to the process. In that case it might be helpful not to directly search a new employee that fulfills the exact requirements the retiring employee has, but to analyze whether the process can be further optimized by reassigning the tasks to other employees so that a new employee can be more easily found. Such an analysis is only necessary, however, if finding a replacement for the leaving employee might pose a problem. Whatever the reason for the creation of the job posting might be the use case is considered completed once the job posting has been transferred to an existing recruiting system.

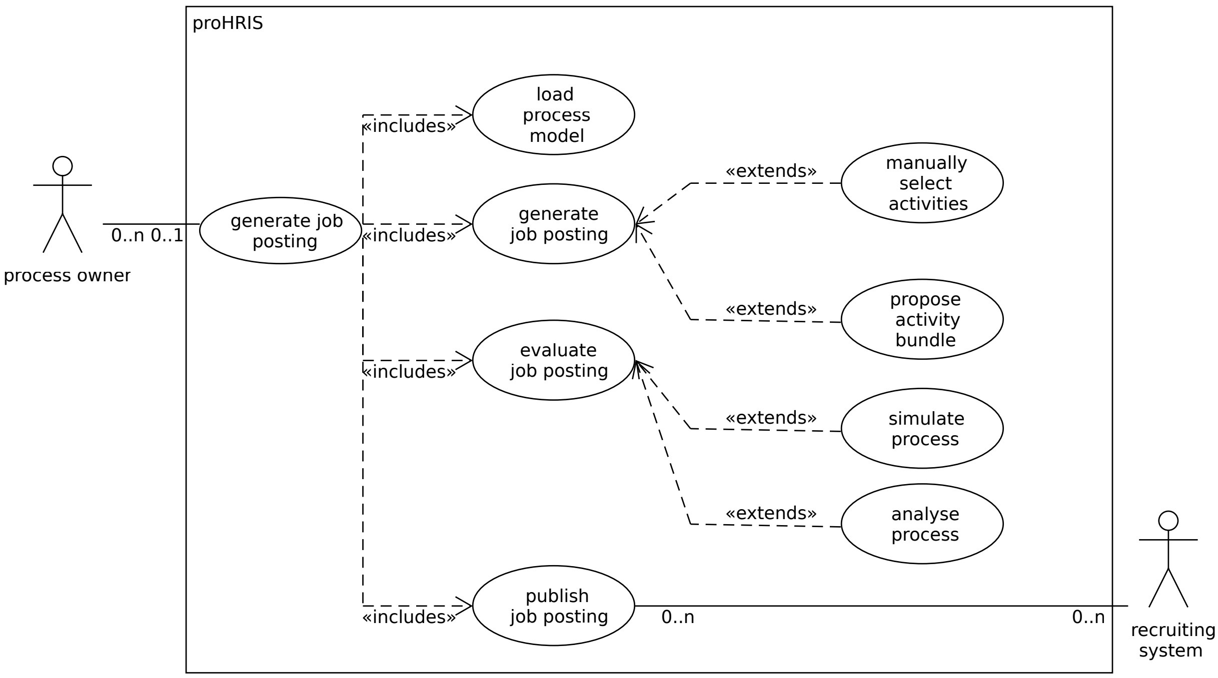


Figure 53: Use case diagram for the use case: Generate job posting process with unfulfilled employee requirements.

Assumptions The use case makes several assumptions. The first assumption is that there is an operational business process model to which employees have been assigned but which is still not fully staffed. Without such a gap there is no need to perform the generation of a job posting for the process in question. Another assumption is that there is a recruiting system capable of accepting the job posting information and interpreting it. This could be achieved, for example, by providing the job posting data in some standard format such as the "HR open standards" (HR Open Standards Consortium, 2016).

Actors Two actors are involved in this use case. The process owner is the main actor of the use case. He or she initiates the use case and wants to generate a job posting for an open position in his process. Additionally, the actor "recruiting system" is involved in the use case. This role represents an available recruiting system that focuses on the recruitment of employees and accepts a job posting as an input.

Steps To successfully complete the use case "generate job posting" the following steps are performed. The process owner has to select the business process model for which he or she wants to generate a job posting (UC: "load process model"). He or she then selects the activities that should be performed by the potential employee (UC: "manually select activities"). The system can then generate a job posting for the selected activities (UC: "generate job posting for activities"). In a next step the process owner analyzes the generated job posting and acquired results on the operational process if a fitting candidate is found and hired. He or she can do this through the use of the simulation feature of the system, resulting in a valuation of the proposed job posting and its positive effect on process performance (UC: "simulate process"). In a final step the process owner is presented with a textual representation of the job posting which he or she finalizes by inserting non-process specific information and adding organization specific formulations to the text of the posting. Once satisfied with the job posting the process owner initiates its export to the recruiting system (UC:"publish job posting").

Variations

1. In use case "generate job posting for activities": The process owner does not manually select the activities that should be selected for the job posting but asks the system to generate the job posting based on specific criteria (UC: "propose activity bundle").
2. In use case "evaluate job posting": The process owner does not simulate the operational business process model to evaluate the selected job posting but uses analysis features of the system in order to assess the effects of the selected job posting.
3. In use case "publish job posting": The resulting job posting is not transferred to a recruiting system, but instead the generated job posting is manually sent out by mail, printed or forwarded to an internal job posting system (Caruth et al., 2009, p. 141).

Non-functional requirements The relevance of some previously mentioned quality characteristics can again be shown in this use case. The **usability** of the system is strongly influenced by the **operability**. Especially in the case of the generation of job postings and final editing of postings it is important that the system is easily usable (ISO/IEC 25010:2011, 2011, p. 12) as such activities are not performed every day and for the process owner a long period may have passed between actual usages of the system. The user interface, therefore, needs to be intuitive. The **interoperability** of the system plays an important role in this use case, too. The system should interact with an external recruiting system and be able to communicate the job postings to it. It could also be necessary to make provisions with regard to the possibility to modify the job postings structure. Organizational or social changes might lead to a change in the presentation of job postings or a change in the communication channels as is currently seen with the shift to online services and social media sites (e.g., Jobvite, 2014, p. 10).

4.3.3.3 Appraisal component

4.3.3.3.1 Actors and goals The general discussion about process oriented appraisal has not focused on the different actors involved. No actors have been defined besides the very generic roles of appraiser and appraisee. The reason for this is that, again, who assumes either role is something that is organization-specific and depends on a multitude of factors including the performance management strategy or the overall organizational strategy of the organization. In combination with the three process actor types envisioned for the system (see 4.3.1.2) different configurations are possible. The role of appraiser can be assumed by all three actor types: the process owner, the process coach, and the process performer. The role of the appraisee is generally assumed by the process performer. However, the process owner of one process can still be the appraisee in a process where he or she is the process performer. Classical structures would suggest the process owner as the main appraiser. He or she has a vested interest in the effective enactment of the process and is mainly responsible for its performance. However, it is also possible to include the process coach as an appraiser, as he or she is an expert in specific areas of the process. Appraised employees tend to perceive appraisals as unfair if the appraiser seems ill-informed of the topic of the appraisal (e.g., Folger & Cropanzano, 1998, p. 122). Another possibility is to include other process performers in the appraisal of their peers (peer-rating or peer-review; e.g., Folger & Cropanzano, 1998, p. 124; Armstrong, 2009, p. 159) or to include the possibility of process performers to evaluate themselves (self-assessment; e.g., Armstrong, 2009, p. 137 f.; Caruth et al., 2009, p. 255; cf. Fletcher, 2001, p. 477).

Another dimension to consider is whether the assessment of process performers is conducted on an individual level, or on a team level. An organization with process teams working on enacting processes might profit from a team based performance appraisal instead of individual appraisals (cf. Lam & Schaubroeck, 1999 Hammer & Stanton, 1999; Kuwaiti & Kay, 2000, p. 1413; Armstrong, 2000, p. 149 ff.; Hammer, 2007, p. 15).

4.3.3.3.2 Modeling concepts Additionally to the concepts already discussed in the last section (task, qualification, employee), the following concepts should be represented in a modeling language to support the process based appraisal of employees.

Goals Central to the idea of fair and perceived as fair appraisals are employee goals that transparently show how they relate to process goals and organizational goals. To be able to represent this in the modeling notation there should be a possibility to model (process, employee, and organization) goals and the relationship between them (cf. Korherr & List, 2007a; Markovic & Kowalkiewicz, 2008; Behnam, 2012). The identified goals should follow the “SMART” mnemonic (specific, measurable, achievable, relevant, time framed; e.g., Townley, 1993, p. 229; Plevel, 1994, p. 66; Armstrong, 2006, p. 506) which can be supported by connecting them with specific measures and specific processes or tasks; making them specific, measurable and relevant. Typical properties the goal elements should include are a name, a short description of the goal, the specific time frame for the achievement of the goal, etc.

Measures Adding measures or "information objects" (cf. Stefanov & List, 2005; Korherr & List, 2007a) as elements to process models allows a clear documentation of where measurements can take place, what and how it is being measured as well as where information about specific performances can be collected from. When these measures are also linked to (employee or) process goals they provide the direct link between operational activities, their performance, and the high level organizational goals. Measure elements could include properties describing their name and properties identifying which IS can be used to gather the required data.

Additional transparency can be achieved if goals are not only related to the activities and processes to which they pertain but also to who will appraise the achievement of goals or fulfillment of targets. The notation should allow to explicitly model the responsibilities of the parties involved making the process transparent for the appraisee. The concrete structure, the goal and measure concepts, as well as their relationships strongly depend on the organizational context into which they are implemented. The modeling of goals and their relationship to employees or overarching organizational goals only makes sense if these goals are defined in the organization in which the system is to be used.

4.3.3.3.3 Components The necessary system components relevant for a proHRIS to support the process oriented appraisal of employees are shown in figure 54. The core component of the appraisal support is provided by two components: the performance management component and the appraisal component. The appraisal component is directly involved in the user interaction and provides forms and interfaces for the appraisers and the appraisee to conduct the performance evaluation as well as the collection of relevant data.

The performance management component is the central component that manages the appraisal support. Therefore, it controls and uses the generic modeling, visualization, and reporting components and initializes them in a way relevant for the support of the appraisal of employees. The main user interaction can be split into two phases: the planning phase and the enactment phase (see the life cycle of business processes in section 2.3.2). During the planning of the performance appraisals the appraisers use the modeling component to augment the process model with relevant goals and measures. They are supported in this collaborative work by being able to share visualizations and generate reports for specific aspects of the performance agreements which they can share with the appraisee.

During the enactment of the process the appraisal component comes into focus. Here concrete appraisals can be collected and the performance of appraised employees documented. If amendments of performance agreements or updates to the measures are required these can be documented through the use of the general generic components.

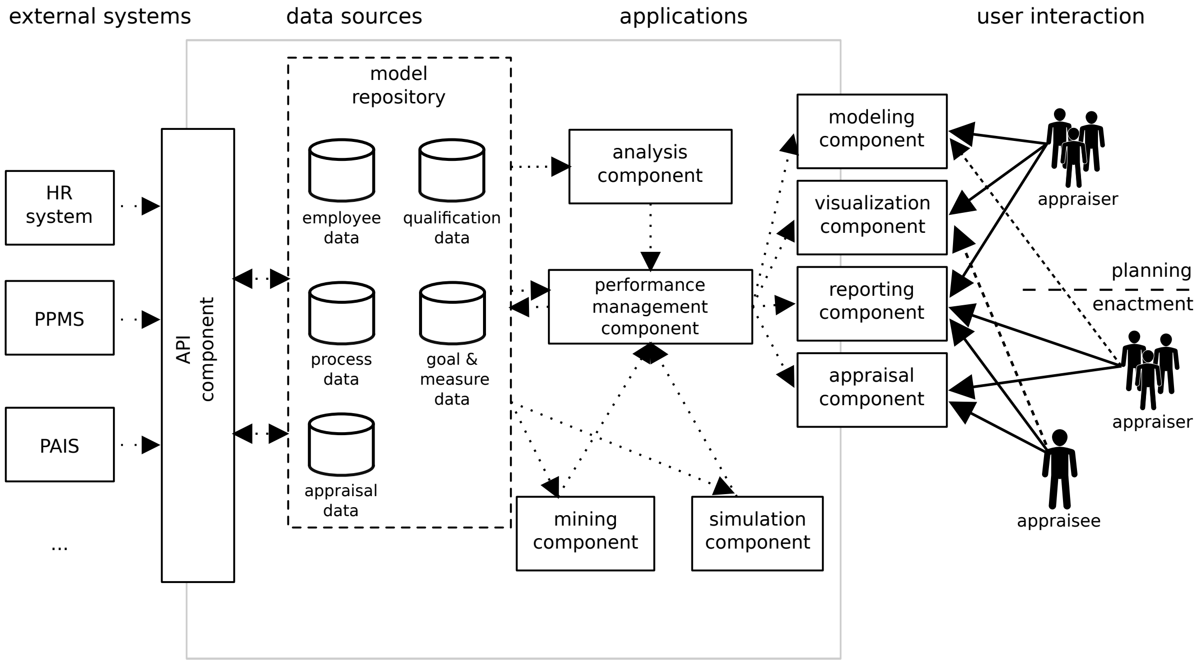


Figure 54: Components of a proHRIS supporting the process oriented appraisal of employees.

To fulfill its purpose the performance management component accesses the model repository that contains a model of the employees, the qualifications, the processes and the goals and measures necessary for the measurement of the process performance. Furthermore, the component accesses and stores appraisal data. It is debatable whether the appraisal data should be subsumed into the model repository, as on the one hand it will not be visually represented in a process model. Furthermore, the purpose of the model repository is to adequately represent the dynamic nature of business process (changing over time) while the appraisals once performed are not liable to future change. On the other hand the appraisals are directly linked to specific processes as well as process goals and measures or required qualifications of the process. The appraisal also relates to a specific version of an operational process and it could lead to incorrect conclusions if an appraisal is observed with respect to another version of the operational business process model, as goals, relevant measures or requirements might have changed.

As in staffing the proHRIS supports the employees by providing relevant information as well as automating tasks. The system provides informational support, for example, in the following cases.

- ▷ Through the use of the intelligence components the system can provide appraisers with relevant goals for similar tasks, or previous versions of the same process. In a more advanced setting intelligence features could also be used to support appraisers in identifying the measures and goals which have previously or in another context (process) lead to the greatest performance increase for the operational process when used for the performance agreements.
- ▷ By providing reports to appraisers and appraised employees the system can keep both parties up to date on the current performance of the process and the status of goals and performance targets. This information is directly linked to the processes and allows to

easily identify possible bottlenecks.

- ▷ The visualization component offers quick access to goal and measure structures to help appraisers identify goals that are currently not being measured or conflicting measures for similar goals, thereby increasing the quality and the transparency of the appraisals.

- ▷ The proHRIS can aggregate and summarize data collected from the PPMS or operational process enactment systems. Linking, for example, average enactment times of process instances to performance targets of the process type.

The proHRIS can also help to automate tasks during the appraisal of employees. Some possibilities are:

- ▷ Through a combined use of enactment systems and their connection to the proHRIS through the API component performance data can be directly integrated into the appraisal of employees without having to manually collect that information.

- ▷ The system can automatically assign goals to employees based on the tasks they are involved in and the goals defined for these tasks.

- ▷ Through the knowledge which employees perform the processes together the system can support the overall management of the appraisals if peer ratings are used by automatically informing relevant peers of their need to evaluate other process participants.

A more detailed insight into how a proHRIS could support appraisers is given by the following two use cases.

4.3.3.3.4 Use case: Define employee goals

Description The use case "Define employee goals" describes how an appraiser can use the proHRIS to create goals for the planning of an employee's performance agreement. The use case itself and the associated use cases are visualized in figure 55. The use case is seen as being part of the planning phase of the performance management process in which the process's performance (and thus the employee's) is conceptually first planned as well as goals and targets defined and linked to it (cf. Armstrong, 2000, p. 34 f.). In a next step the process is then enacted and the employee's and the process's goals tracked. Displayed in the use case are only those steps that directly relate to the interaction with the system.

Assumptions Several assumptions are made for the use case. The main assumption is that there exists already a process model of the process in which the employee is used. The employee to be appraised is further assumed to be involved in only one single process, so that the modeling of goals and the analysis is restricted to that process. It is assumed that there is already some method set for the given organization to derive more specific goals based on general organizational goals. It is assumed as well that such organizational goals have been defined. In the given use case the goals of the employee are being gathered based on one process he or she did not work on before. In case goals are being gathered in a second iteration of the performance management cycle historical values and the result of previous

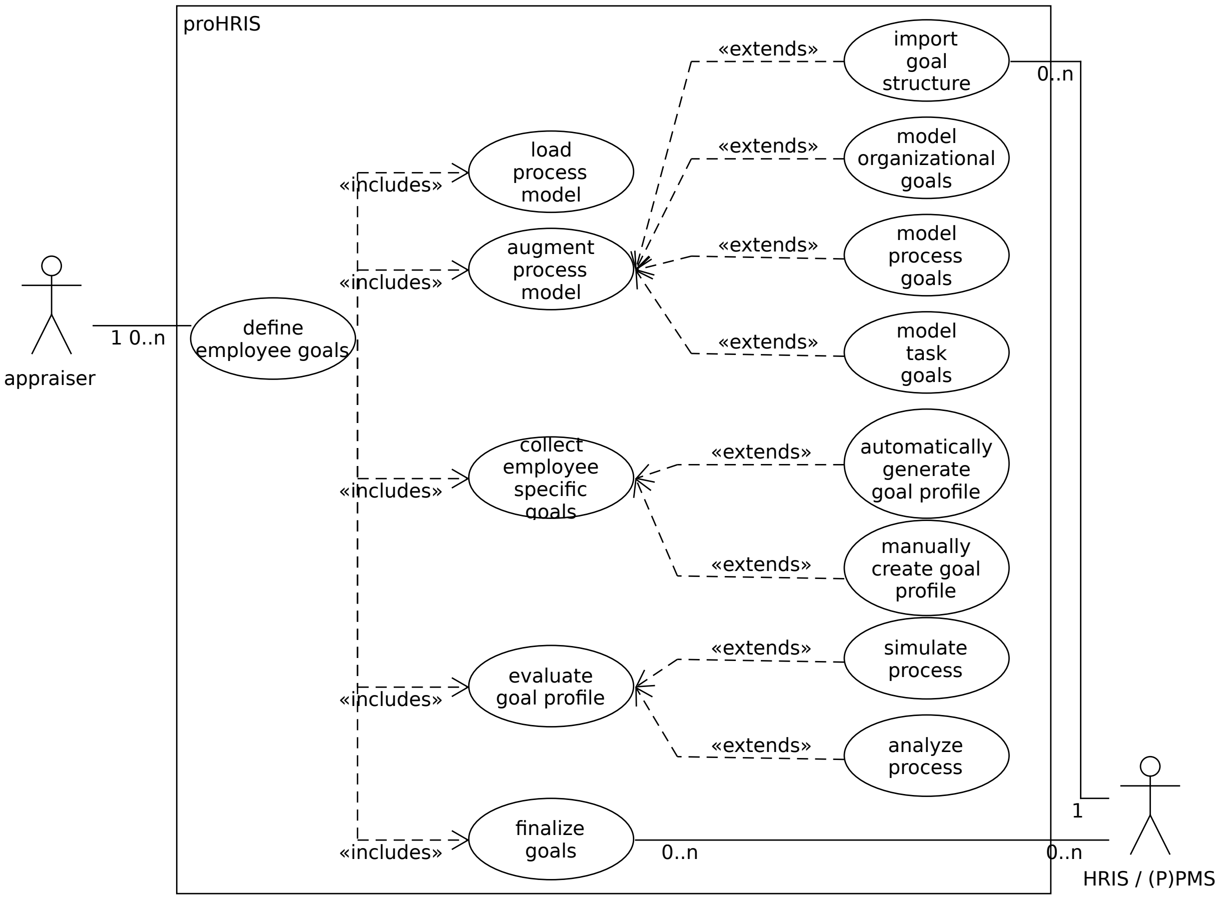


Figure 55: Use case diagram for the use case: Define employee goals.

appraisals would probably be taken into account. A further assumption is that there is either a HRIS or a PMS/PPMS which contains information relevant to the definition of the employees goals. That system is also one to which the resulting goal assignment can be exported. If such a system would not exist, it is also possible that the proHRIS designed here is used to support the further appraisal process; this possibility is not included in the given use case. It is also assumed that one appraiser defines the goals by himself, i.e., there is no system supported cooperation between different appraisers or a feedback loop between appraiser and appraisee, with the appraisee being involved in the definition of the goals at this stage.

Actors Two actors are involved in this use case. The main actor is the appraiser. His goal in this use case is to collect the relevant goals for the appraisal of an employee. The use case is completed when the appraiser either can transfer the "goal profile" (collection of goals) to an external HRIS or (P)PMS or when he or she can display a finalized version of the goals for further use in the appraisal process. Another actor defined in the use case is a "HRIS or (P)PMS". This actor represents an HRIS such as a talent management system, an ERP system with support for employee management, or a (process) performance management system that is used for the operational management of the employees and/or process goals. Such a system can provide valuable information to the modeling and analysis of employee, process and organizational goals. Depending on the workflow in the organization it might also be necessary to export specific employee goals to that system as they are used for the operational appraisal of employees.

Steps In order to successfully complete the given use case the following steps must be performed. First the appraiser loads the process model (UC: "load process model"). He or she then augments the model by importing existing organizational and process goals from a PPMS (UC: "import goal structure"). As the PPMS does not define goals on the task level, but only on a process level, the appraiser then models goals for specific tasks of the process (UC: "model task goals"). The system provides support in this step by showing him which tasks are yet without goals, or more specifically by highlighting those tasks in which the employee to be appraised is involved. Satisfied with the quality of the goals in the process model, the appraiser chooses to let the system generate the goal profile for the given employee (UC: "automatically generate goal profile"). The goal profile can serve as a basis for the performance agreement between appraiser and appraisee. As the profile was automatically generated, the appraiser evaluates its quality, e.g., by simulating the process and identifying the effects of the goals on the employee's workload (UC: "evaluate goal profile" and UC: "simulate process"). For example, if the PPMS also includes measures that are linked to specific tasks of the process (such as "average lifetime of process instances") and the goals (e.g., "average lifetime of instances below 1 hour") have been linked to defined measures, the system can show the appraiser what this means for specific tasks and, therefore, for specific employees (e.g., the result might be that the employee needs to perform tasks 10% faster than was previously planned).

Once the appraiser is satisfied with the quality of the goal profile he or she finalizes the definition and sends the specific employee goals to the PPMS (UC: "finalize goals").

Variations

1. In use case "augment process model": The appraiser does not import the goal structure from an existing system, but instead creates it himself. He or she creates the organizational goals (UC: "model organizational goals") based on vision statements of the organization and goals defined in those, he or she then identifies and models the process goals (UC: "model process goals") and based on those he or she derives specific goals for each activity in the process (UC: "model task goals").
2. In use case "collect employee specific goals": The appraiser does not let the goal profile be automatically generated by the system, but instead selects the goals relevant for the goal profile himself (UC: "manually create goal profile"). A reason for this could, for example, be that some goals have been created by process coaches and are very function specific. However, the process owner as the main appraiser wants the process performers to focus on (for him) more important goals which he or she manually selects.
3. In use case "evaluate goal profile": The appraiser uses process analysis tools instead of simulations to evaluate the goal profile (UC: "analyze process"). If a process is not modeled on such a detailed level, that a simulation can be performed, the

appraiser might choose to restrict himself to use process analysis features to evaluate the goal profile. This could include simple semantic analyses identifying activity goals that have not been put into relation with process goals or organizational goals and, therefore, hinder the transparency of the appraisal of employees. More complex analysis can also be performed in which the appraiser uses intelligence features to identify goals and (measures) that have helped to increase the performance of other processes more or have been more readily accepted by appraised employees. The system could also show similar goals in profiles based on their characteristics (such as time frame, related measures, number of related tasks, etc.)

Non-functional requirements As the use case relates to information directly relevant to the appraisal of the employee which can have an extensive impact on the employee's and the organization's relationship the importance of the **non-repudiation** sub-characteristic (of the **security** characteristic) is shown. As the performance agreement between appraiser and appraisee is based on the goals and measures defined beforehand in the system it is imperative that these items do not change without the knowledge of the appraiser and appraisee. In fact for the given use case nearly all security related sub-characteristics are important. The system must ensure that goal profiles are only created and changed by persons that should change the profiles (**confidentiality** and **authenticity** sub-characteristics).

The interaction of the proHRIS with external information systems shows again the importance of its **interoperability**. This, however, strongly depends on the existing information system landscape in the organization in which the system is to be used. If no other IS are used for the appraisal of employees the interoperability does, of course, not play such a prominent role.

The protection of appraisers from modeling goals in a wrong way is also a requirement that is shown to be important in this use case (**user error protection** sub-characteristic). The system needs to prevent modeling errors in the creation of goals (and measures), as these errors have an impact on the appraisal of any employee involved in the process. Similar to errors in staffing this can be achieved by ensuring that the created model follows all syntactical and semantic modeling rules; warning appraisers when their model becomes invalid or semantically incorrect.

As goals are modeled in the system and put into relation with other goals and measures it is important that the **adaptability** of the system is ensured. The way in which goals are tracked and measured, or even the way in which the appraisal of employees is performed is liable to change in the course of time, or can even change from one part of an organization to another. A proHRIS while focusing on business processes should allow for a wide range of different methods of appraisal or at least be adaptable to changes in that regard.

4.3.3.3.5 Use case: Measure employee goal achievement

Description The use case "Measure employee goal achievement" can be positioned in the performance management step of the appraisal activities discussed in section 2.4.3.4. During the enactment of the process the performance of the process and therefore the performance of the employees enacting the process have to be monitored. The very short term management of the process's performance can be characterized as being purely reactive. Here the process owner monitors currently running process instances and tries to intervene if problems occur that lie outside of the defined scope. This use case is a sample of a longer term management. While the processes are not redesigned or structural changes performed, the process owner monitors performance targets and takes action if it becomes clear that the goals might not be reached. Central to this is the measurement of current employee goal achievement. During the overall analysis of process performance the process owner can also address the performance of individual employees. If there are any problems with the performance the process owner as the appraiser can then inform the process performer (as the appraisee) of those. Even if the achievement of the goals is within target parameters the process owner can still communicate this to the process performance providing regular feedback (the use case is shown in figure 56).

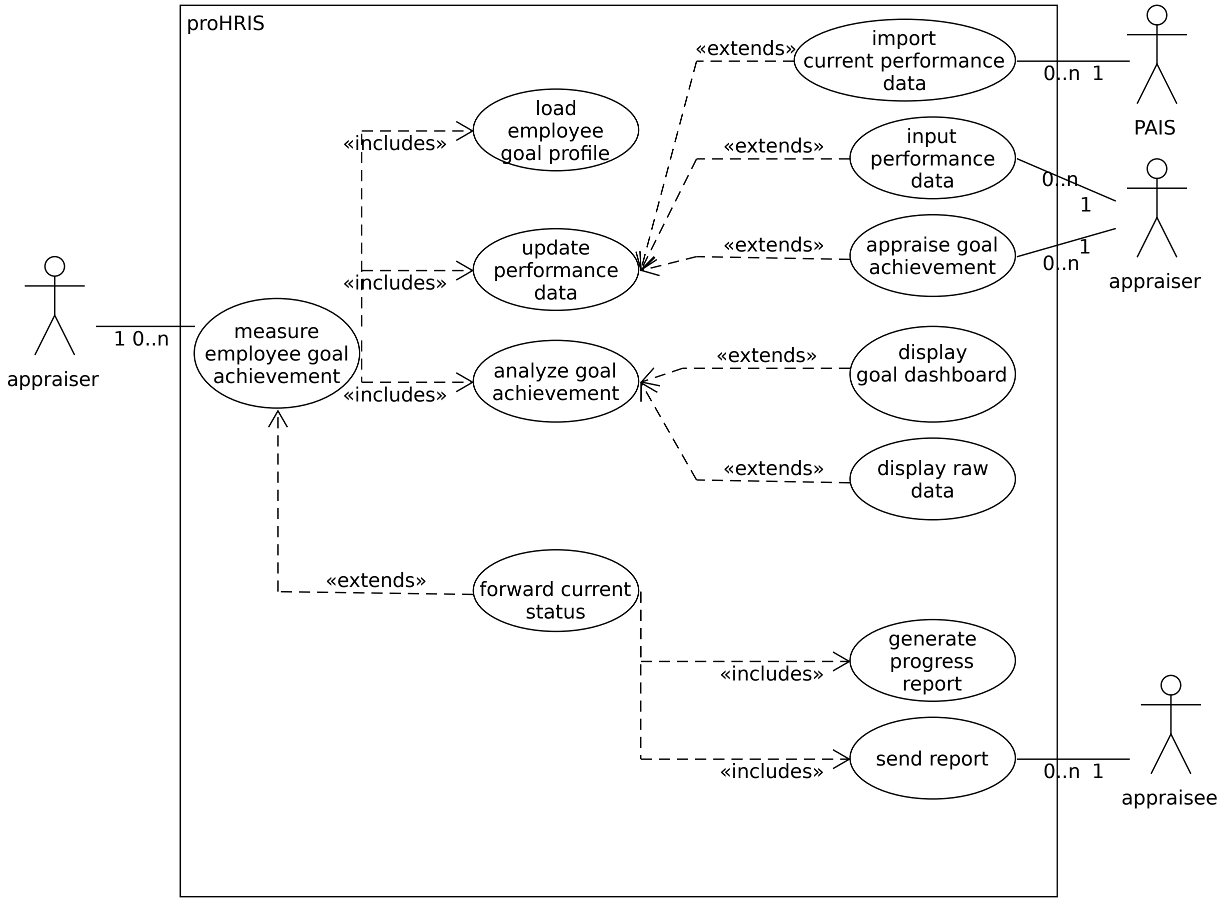


Figure 56: Use case diagram for the use case: Measure employee goal achievement.

Assumptions To be able to describe a sensible use case several assumptions have been made in this instance. First the operational process is assumed to be supported in its enactment by a PAIS which keeps logs of the enacted instances. Furthermore, it is assumed, that not all performance data is available through this system, but some data has to be gathered directly by human actors. The employee goal profile is assumed to have been created in a previous step, so that it is available for the measurement of the achievement of the goals (see table 15).

Employee:	John Doe		
Process:	General system maintenance		
Process Goal	Goal	Activity	Description
reduce overall maintenance duration to under 2 days	reduce time to perform check on machine #432 to under 2 minutes	check machine #432	Average duration of activity check machine #432 should be lower than 120 seconds for the observed time frame.
prevent machine downtime due to wear and tear	minimize missed replacement of worn out parts	replace worn out parts	Cause of machine downtime should be “wear and tear” in less than 5% of cases for the observed time frame
ensure customer satisfaction with maintenance	follow organizational guidelines during phone calls with customers	request customer decision on additional maintenance operation	During calls to customers the organizational code of conduct should be followed. This is evaluated through 3 randomly sampled recorded calls.

Table 15: Exemplary sample content of goal profile.

Actors Three actors are involved in this use case. The appraiser initiates the process. His goal is to monitor the current status of the employee goals related to the operational business process and forward the status information to the appraisee to keep him updated and possibly talk to him about problems. The use case is completed, when the appraiser has successfully forwarded the current status of the employee goals to the employee or if he or she does not deem that necessary when he or she has analyzed the current status for himself. There is also another aspect in which the “appraiser” actor is involved. If there are goals which require a manual entry of data, the appraiser performs this task. It should be noted that – while remaining the same actor – it does not have to be the same person that enters the data. For example, if peer-appraisals are performed by the organization, the appraiser that enters the data could be another process performer instead of the process owner. The actor “PAIS” represents an enactment system which supports the enactment of the operational process. It keeps event logs of actions performed and can link them to specific activities in the process model. The third actor involved in the use case is the appraisee. He or she is informed by the system of the result of the measurement of the goal achievement.

Steps The first step performed in the use case is that the appraiser loads an employee’s goal profile for monitoring (UC: “load employee goal profile”). This can, for example, be done from a specific process view, in which the enacting employees are listed. In a next step the performance data is updated. This is done by automatically importing the current performance data from the PAIS into the proHRIS (UC: “import current performance data”). Following the example shown in table 15 the PAIS transfers the average duration of the task “check machine #432” to the system. This can be done either on request from the appraiser or by batch processing at specific intervals. Additionally, to the automatic data transfer some information has to manually to be entered (UC: “input performance data”). Following the second goal in table 15 this could be the case if the analysis of machine downtime is not something that is supported by the PAIS, but instead stored on paper or in some other format not readable by the system. The appraiser, therefore, enters the number of overall cases and the number of cases for which the reason was “wear and tear”. The appraiser can subsequently analyze the current goal achievement (UC: “analyze goal achievement”). To support this the system displays a dashboard that contains all the relevant information with clear status information about which goals figure within expected parameters and which need further attention. The appraiser decided it is not necessary to notify the appraisee of the current status and the use case concludes.

Variations

1. In use case: “update performance data”: If goals are formulated in such a way that the system can not calculate the achievement rate by itself or if data input is not a sensible solution, the appraiser can manually appraise the goal achievement and log his appraisal instead (UC: “appraise goal achievement”). This can be the case if the measurement of the achievement is done by testing random work samples of the appraisee (see third goal in table 15).
2. In use case: “measure employee goal achievement”: They appraiser wants to inform the appraised employee of the current status of his goals and he or she, therefore, forwards the current status to the employee. For this the system first generates a report and then sends this report to the appraisee (UC: “forward current status”, UC: “generate progress report”, UC: “send report”).

Non-functional requirements In this use case the importance of the **security** characteristics of the system are shown, too. As the information handled here is directly relevant to the further relationship between organization and employee the system has to ensure that no data of the appraised employee can be changed later without knowledge of the involved parties (**non-repudiation**). Especially data from the steps “import performance data”, “input performance data” and “appraise goal achievement”. For the latter two it is also important that the system records who exactly has entered the data so that **accountability** and **authenticity** are ensured. As data can be entered manually, user errors are possible. Here the system should try to ensure the sanity of the input to prevent user errors (**user error protection**). The consideration regarding the **adaptability** of the system from the previous use case apply for this use case as well.

4.3.3.4 Development component

4.3.3.4.1 Actors and goals The main actor of the development is the development recipient (cf. Drumm, 2008, p. 347; Solga et al., 2011, p. 30). Seen from a process oriented perspective this is the process performer. However, to qualify as a development recipient the process performer has to fulfill three requirements: he or she has to have a need for development, dispose of the ability to be developed and he or she must be supporting his or her development. With an unlimited budget all employees who fulfill these requirements could be classified as development recipients, if there are limited resources, however, a selection has to be made (see Drumm, 2008, p. 345). The goal of the development recipient in the context of a proHRIS is to get assigned to a development activity that will help fulfill his or her development need and perform this activity.

Another relevant actor is the process owner as the direct supervisor of the process performers. He or she is responsible for their development as far as they relate to the operational business process. He or she decides, who gets selected for process related development activities and uses the proHRIS to identify development needs. His or her goal is to ensure the performance of the process enactment, addressing problems that lead to performance problems in the process, either by redesigning the process, or by improving the quality of process performers where necessary. He or she performs this task in combination with the process coaches. As discussed in section 4.3.3.2, process coaches are experts in specific parts of the business process. They help with the appraisal of employees in these specific areas (see section 4.3.3.3) and identify development opportunities for the process performers (cf. Hammer, 1997, p. 118; Neubauer, 2009, p. 173). Being expert in their respective process areas, process coaches can also serve as trainers in the organization internal development activities (cf. Hill et al., 2006, p. 21), imparting their knowledge to the process performers. Their goal is to supply the relevant resources to the part of the process they are responsible for, either through recruitment or development of employees.

4.3.3.4.2 Modeling concepts A modeling language supporting the development activities needs to provide a broad collection of concepts. The concepts that should be available in the modeling language also depend on how much of the actual development of the employees is directly supported by the system. For example, if the curriculum of a training activity is directly based on an operational business process, it would be possible to track the completion of the curriculum through the model. Using the model as a guideline trained employees could be lead through the process while completing the curriculum. Such an approach would result in a need for additional information to be saved in the process model. But as this is mainly used during the enactment of a specific development process such concepts are not elaborated upon here (cf. section 4.2.1). It is important to note that well documented business processes can also in themselves serve as documents for the training and development of employees. To be able to perform their task process performers must have the knowledge required by the activities in the process, e.g., knowledge about market state or customer preferences, but also knowledge about the process itself, e.g., which activity follows which (cf. Remus, 2002, p. 149). In a strongly process oriented context the knowledge about the process itself is even more relevant (cf. section 2.3; Rosemann & vom Brocke, 2010; and e.g., Hammer, 2007).

With a focus on the design and planning of development activities the following concepts should be available in a modeling language.

Activity In addition to the information represented in the concept of an activity already discussed in the context of the other HR functions, the concept should include some specific properties relevant for development activities. In order to be able to use the operational activities themselves for training and developing employees some information about the qualifications that can be acquired by performing the activities or the business process needs to be represented. For example, the enactment of small scale claim processing could provide the knowledge and experience to performers so that they can enact more business critical processes. There also needs to be a way to note if an activity is suitable for employee coached enactment, i.e. an enactment where one employee performs an activity in cooperation with another one while learning the activity itself.

Qualification The concept of qualification is mostly used as a requirement for activities in other HR functions. For the purpose of employee development it can be advantageous to allow the modeling of qualification provisioning through activities. The use of this in specific organizations, however, depends on how qualifications are handled in the organization itself. If they only represent formally certified abilities, the enactment of activities alone is not sufficient for acquiring the qualification. Such aspects have to be integrated into the development strategy and fitting measures set into place to handle these cases.

If the concept of qualifications is understood in a broad term (as is done here, see the discussion of qualification in section 4.3.3.2 on page 125) it also makes sense for the development of employees to include hierarchies or relationships between different qualifications in the model. The concepts could also be related to sources of storage, or materials which contain information pertinent to the qualifications (see also training below; for an example see Loos et al., 2007, p. 188). With the modeling of qualification requirements at the activity level and of qualification availability on an employee level the system can help identify qualification requirements for specific employees (for an in depth example see Leyking et al., 2010)

Goal When developing training activities and educational curricula around business processes, it is important to make the goals of the activities and process relevant to the trained employees and the trainers. As such process models containing related activity and process goals as well as relationships between goals can be used as a source of information for the training of employees. Furthermore, the design of training activities can take these goals directly into account focusing on activities that aim at supporting the specific goals (see the success factors of employee development on page 45). Goals can also be related to development needs (see below) to specify which development need arises from failure to achieve specific process goals or performance targets.

Employee The concept of an employee is fundamental to the modeling of development relevant information. As mentioned before the employee should be related to the qualifications he or she already exhibits and through his assignment to activities it is possible to derive required qualifications for the employee. In the case of a self-service type of employee training offers and the inclusion of specific training opportunities in the model the employees themselves could easily find and select fitting training opportunities. The employee element in the model should also retain information about the availability of the employee for training measures. This would allow an easier evaluation of possible assignments for which the employee needs further training and for which he or she does not have all qualifications necessary.

Training The inclusion of specific training opportunity types in the model is a possibility to link and group qualifications into specific packets that can be acquired simultaneously. Such a modeling allows for an easier needs management for specific training instances, as the system can provide direct information about potential recipients of training opportunities. Similarly, specific activities can be identified in the model as training opportunities. Training types can also be used for documenting training activities which may help improve the performance of process performers without directly relating to a certified qualification. An example of this could be social sensitivity training courses or team work training courses for employees that have problem working with customers or other employees.

Development need The concept of a development need allows to explicitly document that a specific qualification gap is to be filled. The need is relationship between a specific qualification or training and a specific employee. The explicit representation of a need allows for the cooperative decision making about what qualifications a process performer should be imparted with. Through the connection to a specific qualification element in the model that is connected to an activity, the development need can also document why an employee should be imparted with a specific qualification, i.e., the source for the need. While such a source might be easily derived if the development need stems from the current personnel assignment or performance data, if it is related mainly to the personal career advancement of an employee or plans for potentially moving the employee to another process that argumentation is not transparent unless explicitly represented in the model.

4.3.3.4.3 Components Based on the discussion above the required system components for a proHRIS that supports the development of employees can be described. Figure 57 gives an overview of the required components that provide the support.

The development component interfaces with the performance management component, the staffing component, the training management component and the intelligence components to provide the required support for the development activities. An example of the information support the system provides is given in the following.

- ▷ The process owner is supported in deciding about development possibilities through analysis functions provided by the system that can inform him about potential development opportunities. The system informs the process owner and the involved process coaches which employees have development needs, which employees are available for development opportunities, which employees can be trained directly through the tasks they are assigned to and for which employees training activities have to be planned. If training activities have already been created or have been imported from external training management systems through the API component the system can inform the process owner and process coaches about available training opportunities fitting the development needs. If training opportunities do not yet exist process coaches have the possibility to create fitting training sessions through the use of the training management component. In a setting of limited resources the process owner and process coaches have to solve an assignment problem sim-

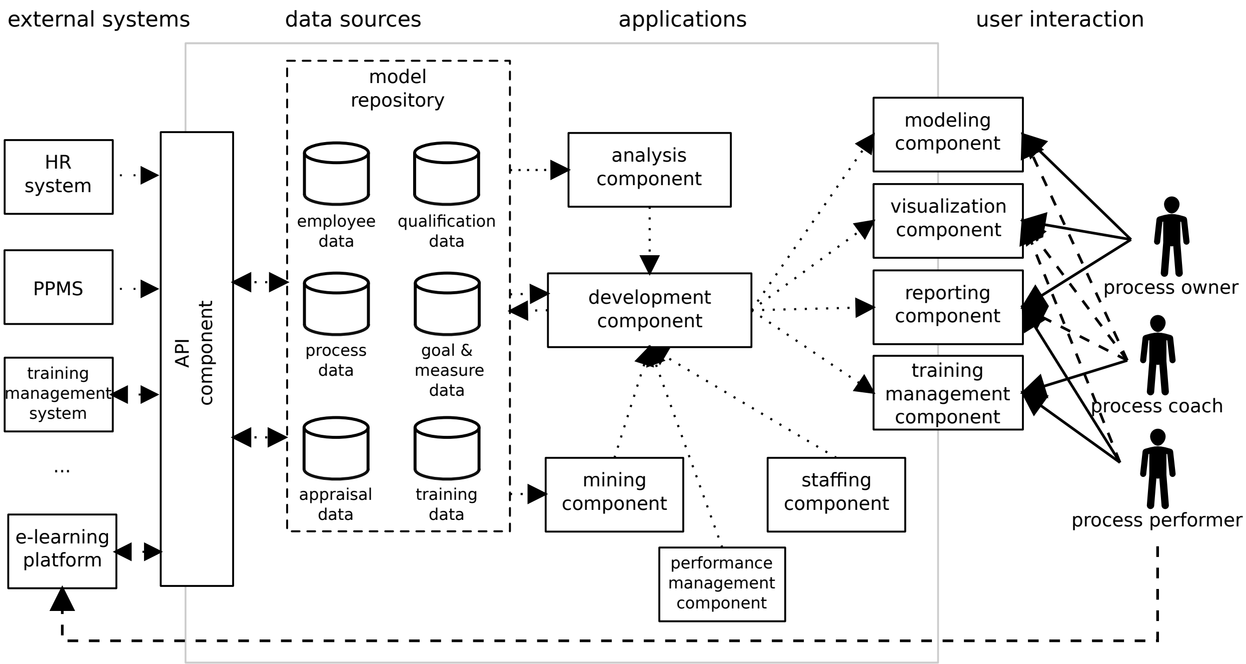


Figure 57: Components of a proHRIS supporting the process oriented development of employees.

ilar to the one faced during staffing. However, here training opportunities, the provided qualifications, the development needs of process performers, and their assigned tasks are the components that have to be assigned and optimized.

- In a self-service setting the system can provide process performers with fitting training opportunities that relate to their currently enacted activities based on the process models and process performance data gathered from PPMS. This is achieved through the use of the visualization component, which can show the employees their operational process and possible training opportunities for the tasks they are involved in, or in a job-enlargement setting (cf. Scholz, 2000, p. 515; Kugeler & Vieting, 2000, p. 223) potential activities they might qualify for with further training. Through the training management component process performers can then directly manage training activities and request assignment to available training sessions.
- Similarly the system can provide information to process owners, process coaches and process performers relating to career management. For employees the system can show them possible activities they qualify for, or (expanding from the single operational process discussion) similar processes in the organization that they would be qualified to work in. Similarly, this information can be given to process coaches or process owners to support them in managing high potential employees that fall under their responsibility.
- The system provides information to process coaches about the performance of process performers in their area and enables them in this way to identify possible development needs. This can be done through reports, or through specific visualizations of the process model, in which performance data is overlaid over the process activities. The system can also provide information to process coaches and process owners about missing development

opportunities so that they are aware that wanted assignments might not be possible if development opportunities are not found.

Additionally to the informational support the proHRIS can also automate specific activities that otherwise have to be manually performed by process owners, process coaches, or process performers.

- ▷ Through the interface to external systems, such as training management systems or e-learning platforms, the system can automate the management of qualification data for employees or even automate the assignment of training activities to employees if specific criteria are met. For example, the system could assign training in specific activities to process performers if the performance data from the previous iteration of the life cycle do not match a certain minimum level.
- ▷ This assignment of employees to training opportunities can happen on an individual level for each process performer, or support the process owner and process coaches for optimal assignments of potential training recipients to available training opportunities. In combination with the staffing components the system could also infer the development effort for given staffing possibilities.
- ▷ It is also possible for the system to propose groupings of qualifications for training activities. This can be done based on data gathered from the intelligence component or based on reference models provided on an organizational or industry level. This can simplify the creation of training activities for specific qualification groups and generally support the design of the training curriculum.

The required information for the development component and the connected components is provided by the model repository. The repository, therefore, has to contain additional information to the process models, employee data and further organizational data. Specifically this means data about the training activities, as well as possible training reference models, and detailed qualification models. If the career wishes of employees should be taken into account this information has to be linked to the employee element in the repository as well (for example from an external HR system).

4.3.3.4.4 Use case: Identify development needs based on potential process assignments and performance data

Description The use case "Identify development needs" describes how the process owner or process coaches can identify development needs in the process model. These result from qualifications that employees do not possess but are required from activities the employees are assigned to, from not fulfilled performance criteria, or from planned assignments of the employee in planned processes. The use case represents one of the first steps in a process oriented approach to the development of employees. However, as there is a possible feedback loop between development activities and planning activities of staffing, results of the needs identification could also be of use in staffing. Figure 58 shows an use case diagram of the use case.

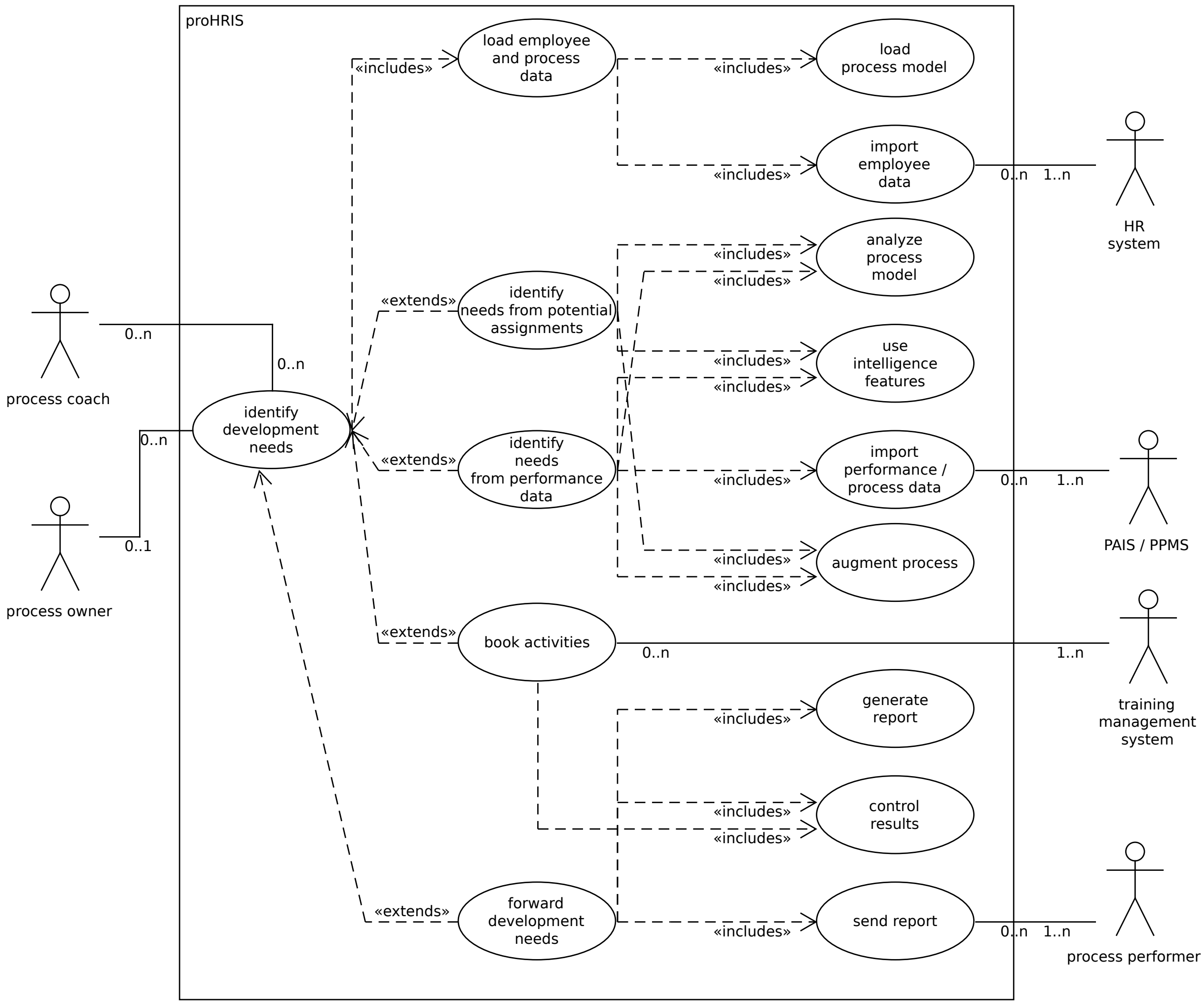


Figure 58: Use case diagram for the use case: Identify development needs based on potential process assignments and performance data.

Assumptions The use case presented here makes several assumptions. One main assumption is that the information generated is only used for further development of employees and not for other HR functions. It is assumed that an HR system that can interface with the proHRIS exists which contains the information about employees relevant for the given case, as well as a PAIS or PPMS that can provide process performance data as well as process logs to be analyzed. It is furthermore assumed that the development strategy of the organization expects employees to be informed about their development needs. This could, for example, be the case, if employees are to manage their training on their own in a self-service like fashion. A certain fulfillment rate of training activities with regard to their development needs might be part of the performance agreement. Another assumption in this use case is that an automatic creation of development needs by the system is not wanted in the given organization, the system just offers informational support, while process owner, or process coaches still manually document the development needs they decide to specify.

Actors The use case involves six actors. The three human actors are the process owner, process coaches, and the process performer for which the development need is identified. Additionally, an HR system, a PAIS / PPMS, and a training management system are involved in the use case. The process owner is the main initiator of the use case. His goal is to decide on the concrete development needs of the process performer for the next life cycle iteration. He or she reaches this goal with the support of one or more process coaches, that can support him in the areas of the process they are experts in. The HR system represents an HRIS that provides employee data to the proHRIS that the system can use to inform the process owner and process coach about relevant information concerning the employee if that data is not already available in the system. The PAIS / PPMS represents a system that supplies the proHRIS with performance data about previous enactments of the process, especially those regarding the employee for whom development needs should be identified. The training management system actor represents a system that is used for the operational management of training activities within (or outside of) the organization. It allows the booking of training activities and generally manages the training process. Activities included are, e.g., attendance tracking, grading support, and training evaluation. In this understanding it also includes, for example, typical e-Learning platforms which comprise a similar set of features.

Steps In order to complete the use case successfully it is necessary to perform the following steps. When the use case is initiated the system loads the process and planned processes in which the employee is involved and relevant performance data (UC: “load employee and process data”). The actual identification of needs is split into two parts: the identification of needs based on potential assignments of the employee (UC:”identify needs from potential assignments”) and the identification of needs based on the actual and required performance of the employee (UC: “identify needs from performance data”).

The identification of needs based on potential assignments can take two forms. First, the needs can be identified based on the assignments explicitly determined in planned processes. Second, the needs can be derived from potential activities in the process for which it would make sense for the employee to perform them additionally to the activities he or she is already performing, or that he or she should perform instead of some of the activities he or she is currently performing. This can make sense if some activities currently have no employee assigned, or if “job-enlargement”, “job-enrichment”, or “job-rotation” initiatives are to be performed (cf. Armstrong, 2006, p. 332).

An exemplary algorithm that uses analysis features (UC: “analyze process model”) to gather the potential development needs from a single process is shown in figure 59. The criteria for the inclusion of specific activities in order to expand the activities assigned to the employee should be defined during the implementation of the system. Relevant criteria could be a) the amount of qualifications already available to the process performer b) whether the potential activity already has an employee assigned to them or not c) how many other employees available for the process posses the required qualifications d) what the stance of the given employee is with regard to the potential activity, etc.

Similarly to the gathering of potential development needs through analysis features, the system uses intelligence features to identify potential development needs (UC: “use intelligence features"). This can range from typical similarity recommendations ("employees with similar activity assignments also have the following qualifications. . . ") to more complex algorithms from predicting possible requirements towards the employee in the future.

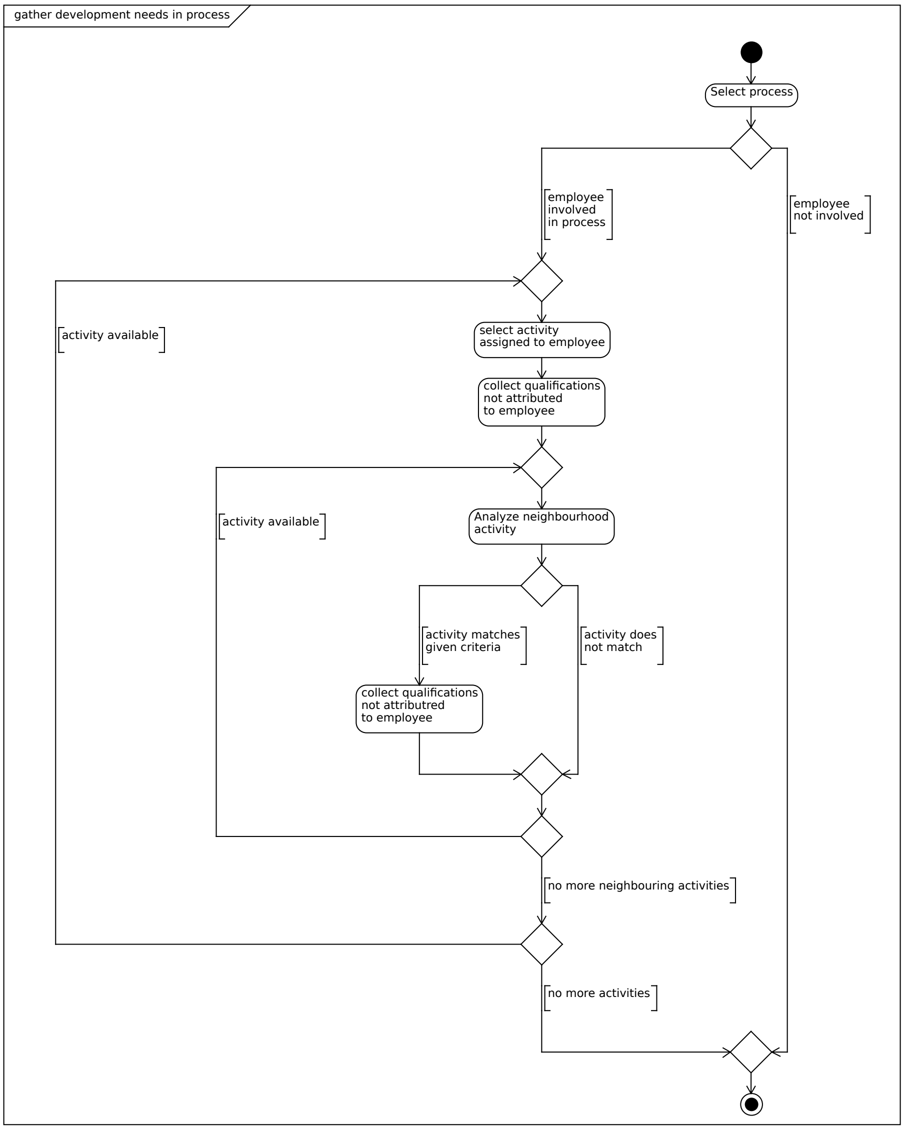


Figure 59: Activity diagram of an exemplary algorithm to gather potential development needs based on a given process model.

After having selected which development needs should be specified for the given employee and process, the process owner or process coach augments the process model with the relevant information (UC:"augment process model") by adding a special development needs element to the process model and relating it to the employee and the qualification.

The identification of development needs based on the performance data (UC:"identify needs from performance data") is similarly performed based on intelligence features or the analysis of the process model. For an analysis based collection of development needs information about what development need results from which failed performance target or process goal has to be available in the process model. This can be illustrated by the following example. One process goal could be "less than 10 customer complaints per process life cycle iteration". A training "customer communication" would exist that comprises techniques to handle problems during the enactment of activities involving customers. An activity in the process would have a target value of "< 10 complaints" assigned to it as a target measure and would also specify a development need for the qualification "customer communication" in case that target measure is not achieved. An analysis over the process model combined with the performance data from the PPMS could then propose the "customer communication" training type as a development need for the employee assigned to the activity that fails to meet the target measure. If such a measure seems sensible to the process owner analyzing the process model, he or she accepts that development need.

After having analyzed the process and decided upon which development needs are to accepted the process owner augments the model explicitly creating the development need in the process model and saving it to the process repository (UC: "augment process model").

In a final step the process owner generates a report containing all defined development needs (UC: "forward development needs", "generate report") and checks them for errors or inconsistencies (UC: "control results"). If there are any problems, he or she updates the process models to fix them. Once the process owner is satisfied with the development needs set for the employee, he or she sends the report to the employee so that he or she is informed about the development needs assigned to him (UC: "send report").

Variations

1. In use case "identify development needs": The use case is not initiated by the process owner, but by a process coach. After the initiation, he or she focuses only on the activities within his purview. He or she also does not perform the forwarding of the development needs to the process performer. This is done by the process owner at a later time, when the other process coaches have also selected the development needs resulting in their area of expertise.
2. In use case "identify development needs": The identification of development needs is only done by one of the possible ways. Either through the performance data (UC: "identify needs from performance data"), or through potential assignments (UC: "identify needs from potential assignments"). This can, for example, be the case if a new process is being designed and implemented. In such a case no performance data is available and it would not make sense to derive development needs from this process.
3. In use case "identify development needs": instead of sending a report with development needs to the process performer the process owner directly books training activities for the process performer (UC: "book activities"). This variation includes additional steps, however, which are not displayed here.

Non-functional requirements As the proHRIS has to interact with external HRIS and PAIS the **interoperability** criterion is an important quality criterion for this use case. Furthermore, the **modifiability** is especially important since the derivation of recommendations for development needs depends for the most part on rules specific to the organization implementing the proHRIS. These rules have to be as easily changeable as possible so that the system can quickly adapt to change in the strategy of the organization and the goals of the operational processes. Criteria such as **security** are relevant here, also because of the cooperative nature of the identification of development needs. While it might be necessary for multiple process coaches to access the process model and perform analysis based on the process model and performance data, it might be undesirable that process coaches have unlimited access to the performance data of an employee regarding his actions outside the scope of the process coaches purview. To prevent this a broad system of access rights has to be available so that each user can have fine-grained access rights to the model and the data.

4.3.3.4.5 Use case: Select training activity in a self-service setting

Description The use case "Select training activity in a self-service setting" describes how a process performer can select a reasonable training activity based on the operational process he or she is involved in as well as his career plans. It can be located as part of the development steps either during the planing phase, i.e. at the end of the employee planning step, or during process enactment and at the start of the employee development phase. As the self-service of employees offers them the freedom to plan, select and execute training activities independently the concrete placement of the activities is up to the employee. The use case is visualized in figure 60.

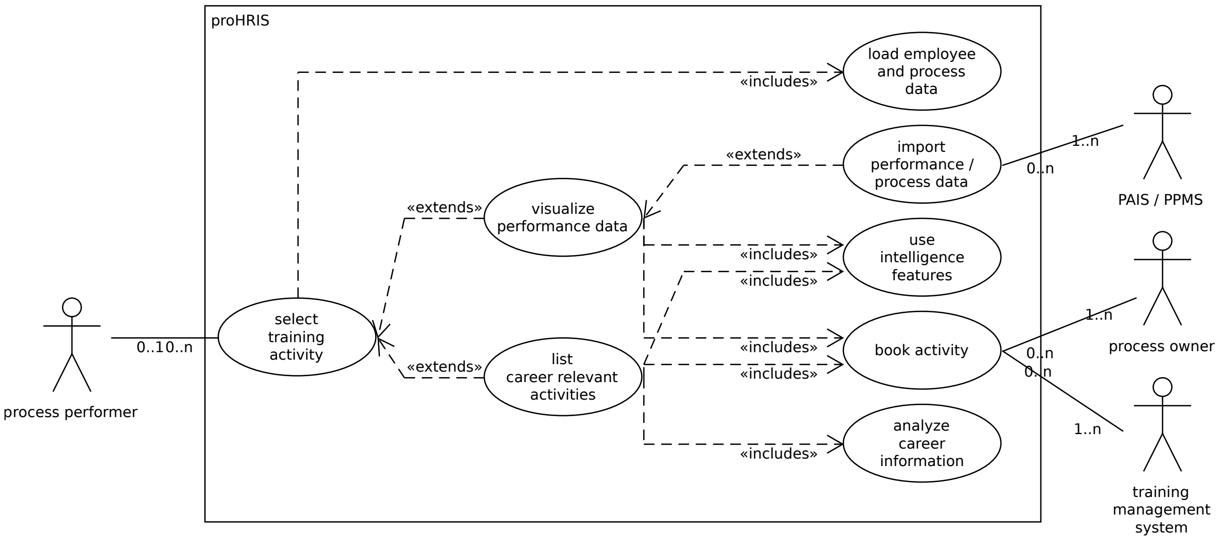


Figure 60: Use case diagram for the use case: Select training activity in a self-service setting.

Assumptions The primary assumption for this use case is that a self-service strategy involving the independent selection of training activities by employees is part of the overall development strategy in the organization. Another assumption is that training activities which fit the potential development needs of the employees have been designed and are represented in the proHRIS. It is further assumed that career information related to the process performer are available to the proHRIS and can be used for the recommendation features.

Actors Four actors are involved in the use case: The process performer, the process owner, a PPMS/PAIS, and a training management system. The process performer is the main actor of the use case. He or she wants to select one or more training activities that fit his current search profile. These activities include either training activities which result from his performance in the last iteration of the process life cycle or activities that will help him to promote his career goals. The process owner is affected by the use case as he or she has to allow the booking of activities of the individual process performer (cf. the use case "identify development needs" in section 4.3.3.4.4 on page 148). His goal is to support the process performer in the identification of relevant development needs and the successful participation in training activities. Two external information systems are also involved in the use case. One is a PAIS / PPMS that provides performance (process and employee) data for the recommendation features of the system and the other is a training management system, which handles the operational management of the provided training activities.

Steps To successfully complete the use case, the process performer looks at specific visualizations of the process he or she is performer of (UC: "visualize performance data"). For this, the system first has to load the relevant process and employee data (UC: "load employee and process data"). To visualize the performance data the system loads the current data from the PPMS (UC: "import performance/ process data") and then offers the user visualizations of the operational business process that include the goals and target measures as well as current performance information relevant to the process performer. Through the use of intelligence features and typical features of the visualization component, such as searching in the model, zooming through different aggregation levels in the model, or displaying specific "views" on the model, the proHRIS supports the process performer in identifying the training opportunities that can help him improve his and the process's performance.

It is possible that such training activities can lead to bottom-up optimizations of the operational process as well. An example could be as follows: a process performer peruses the visualization of problems with an unwanted amount of customer complaints regarding a part of the process or a specific activity. The system proposes a training activity using casework techniques (see page 48) which can take place if enough participants are interested. As such a goal is generic enough for occuring in multiple operational processes, process performers from different processes or even departments meet and try to find solutions for the quality problem of the involved operational processes. The solution might be based in the communication of the process performers with the customers, but it also might stem from an inherent problem in the processes' design that leads to problems with customer satisfaction. Here process performers might identify other processes in the organization where such errors do not occur and emulate the part of the process that offers a greater quality. In the next life cycle iteration of the operational business process the optimizations identified in the training activity can then be implemented in the process.

Once the process performer has decided upon an activity, he or she can book the activity provisionally in the system pending the approval of the process owner. The process owner can check the bookings of the process performers, e.g., against budgetary constraints and then confirm the booking of the process performer.

Variations

1. In use case "select training activity": The process performer does not decide upon his training activities based on his current performance in the operational business process he or she is enacting, but focuses on training activities that can help him further his career. For this he or she views possible training activities under the context of his career opportunities (UC: "list career relevant activities"). To support the identification of training activities with relation to career aspirations of the employee, it is also possible to use process visualization techniques by showing the process performer potential processes and requirements he or she can be involved in. Of course classical recommendation techniques can also be used (UC: "analyze career data").
2. In use case "visualize performance data": If the performance data is already available in the system, or no process performance data can be gathered from the PPMS as the operational process in question is a new process or redesigned process the importing of data for that specific process does not happen (UC: "import performance / process data"). It is still possible that the performance data from other processes can support intelligence features to identify possible requirements of the process even if no process specific performance information are available yet.

Non-functional requirements As with any self-service based service, the **authenticity** of users plays an important role. It must be ensured that the person booking training activities, or looking at performance data of an employee is the employee himself, or someone that is authorized to do so (**confidentiality**). As with the other use cases that involve external information systems, the **interoperability** is an important quality characteristic. It also poses an additional challenge as the proHRIS serves as an interface between different types of information systems which may in the positive case be aware of the process by themselves (PAIS/PPMS) or in the negative case may have no notion of business processes at all (training management systems). Interlinked with the interoperability, therefore, is the **adaptability** of the system. As a broad range of different information systems can be linked to the proHRIS, the communication between those systems requires the adaptation of the proHRIS unless there is a standardized interface. The adaptability is also relevant with regard to the systems internal features, as career based recommendations as well as performance based recommendations are based upon the process and other organizational models available in the proHRIS. Recommendations (through analysis and intelligence features) have to be adapted to the specific manifestation existing in an organization.

4.3.3.5 Compensation component

4.3.3.5.1 Actors and goals There are basically two actors involved in a process specific compensation. The process owner as the responsible actor for the successful and cost effective enactment of the operational business process and the process performers as the actors actually enacting the operational process. The goal of the process owner is to compensate the process performer for the enactment of the process, taking into account the criteria mentioned before. The main goal is to motivate the process performer to complete the same (or similar) tasks in the future. For that the compensation has to be fair, transparent, and at least equal to that of competitors (both inside and outside of the organization). Competitors, here, are not necessarily understood as other organizations that sell the same products, but are entities that can offer work to the employees.

The process performer wants to be compensated for the enactment of the business process. The compensation should be fitting to the effort he or she made to achieve the process goals (the effort bargain; e.g., Behrend, 1957).

Process coaches can also be seen as actors in the compensation process, however, they mainly serve as information source for the process owner insofar they can provide information about the relevant characteristics of activities performed by process performers during the enactment of the process. They are also the experts who can best qualify the difficulty of activities in the process that fall under their purview.

4.3.3.5.2 Modeling concepts A business process modeling language should include concepts to represent process and activity characteristics relevant for the definition of the pay structure. However, which specific characteristics are required depends on the organization specific compensation strategy and wage determination method. Some concepts mentioned in the context of other HR functions can, for example, be used for the wage determination.

- ▷ Qualifications (see section 4.3.3.2) included as requirements of activities can be used to determine the wage of the employee assigned to that activity. As discussed before the qualification requirements could be ordered with respect to their difficulty or complexity and impact the work value of the activity that requires them (factor-ranking).

- ▷ Goals and measures (see section 4.3.3.3) that are normally added for performance management reasons could also be used to evaluate the importance or difficulty of an activity. The reasoning could go as follows: the more specific goals are assigned to an activity (or process) the more it affects the overall success and performance of the business process. Therefore, an employee that performs activities with many goals attached to them should have a higher base pay then an employee who performs activities that are not as crucial to the success of the organization. Such a reasoning, however, can lead to pay difference between employees that perform very similar activities in different contexts what could be perceived as unfair as the main difference lies in the amount of responsibility for the success of the overall process. It is also possible to image compensation strategies in which activities with many goals lower the potential base pay of employees, if it is assumed, instead, that the activity is covered by the variable pay portion of the wage. This would be similar to the differentiation between direct costs and indirect costs for production, where indirect costs are represented by base pay, while direct costs are represented by variable pay.

- ▷ Depending on the level of detail in the process model even employees could be used as a measure for the value of an activity or process. If, for example, no detailed information about the activities is available in the process model, the base pay of employees previously enacting the activities could be taken as a measure to estimate a fair amount of pay for this kind of activity.

More characteristics could be relevant for the determination of the wage of employees. Depending on the context of the organization, e.g., the location at which an activity is to be performed might affect base pay of an employee with the reasoning that employees that have to travel should be compensated in form of a higher pay in relation to employee who do not have to.

One simple concept that could be included into the modeling language is that of a "work value" for activities. The work value here is understood as an objective value for the difficulty of the concerned activity. The work value can be used for the definition of the relative pay grades between different employees. The absolute monetary value would have to be decided by the organization in a next step (Bullinger, 1995, p. 228). The relative pay grade of an employee could then be decided by the average value of the work value of the activities he or she performs.

4.3.3.5.3 Components To support a process oriented compensation of employees components similar to the support of process oriented appraisals are required. This is to be expected, as appraisals play a central role in the HR process. Figure 61 shows an overview of the required components.

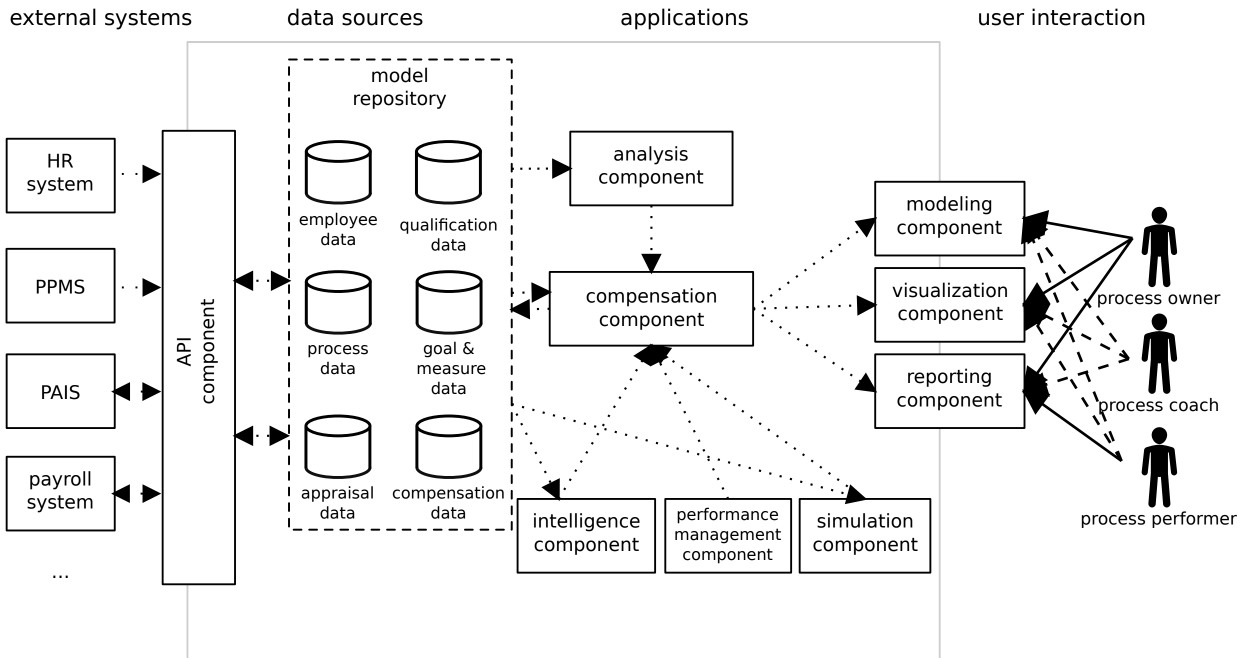


Figure 61: Components of a proHRIS supporting the process oriented appraisal of employees.

The central component is the compensation component that coordinates the features of the generic analysis, intelligence, and simulation components. Furthermore, it interfaces with the performance management component (see section 4.3.3.3) to make use of appraisal information in the compensation of employees. For the sake of clarity the interface between the performance management component and other components is not shown in the figure (the relationships are the same as shown in figure 54 in section 4.3.3.3).

The main user interaction takes place, similar to staffing and appraisal, through the modeling, visualization and reporting components of the system. The design of the compensation structure by the process owner, for example, is performed through the modeling component. Feedback and discussions with process performers and process coaches involved in the design are supported through the visualization and reporting component. The main interaction with the system the process performer has, however, is performed through the reporting component. Here he or she can receive information about his or her compensation agreement and current status of his or her compensation.

The data sources used are similar to the ones required for the appraisal components with the addition of compensation specific data. This includes compensation agreements as well as relevant model elements such as goals, measures or other requirements used for the definition of the compensation structure. The external systems interfacing with the proHRIS to enable the support of compensation activities are PAIS, PPMS, and HR systems such as the payroll system. PAIS or PPMS provide the information about process enactments in form of aggregated performance data, or process execution logs which the system can analyze to determine the wage of the employee or define the pay grade.

Informational support by the proHRIS is provided through the design and definition of the compensation structure, as well as during the enactment of the business process. Some examples of specific informational support are as follows.

- ▷ Through the use of the analysis and intelligence components the proHRIS can provide the process owner with clear information about the relative difficulty of processes and activities. Similar activities (structurally similar, or having the same characteristics) can be identified and potential discrepancies in the recorded difficulty discovered.
- ▷ When designing the variable pay structures, the proHRIS can show the process owners relevant measures and goals for the organization, specific processes, or concrete activities. Different analyses can be employed to ensure that each identified goal is measured at some place in the process and that at least one employee has that goal in his performance agreement. If goals are not linked to individual performance agreements, there is no incentive for employees to work towards achieving that goal. The intelligence component can provide information about historical goals and measures as well as their achievement rate allowing for a more sensible strategy relating to the amount of goals or the size of the incentive needed for effective motivation of employees to achieve the given goal.
- ▷ With the help of data from PPMS or generic PAIS the proHRIS can calculate specific parts of the compensation of employees such as instances of the process performed by the employee (in the case of piecework type compensation). Such an analysis also allow for the identification of unclear responsibilities in process models and potential discrepancies in pay. If employees are "on paper" assigned to an activity but in practice such activities are performed by other employees, this should lead to changes in both pay grades.
- ▷ Through reports and visualization of processes (and process instances) employees can transparently see how their current compensation package is configured. Regular reports

about the achievement rate of their process related goals can keep them motivated and informed about the status of the performance and compensation agreements.

In addition to the information providing features, the proHRIS also provides automation features for the support of employee compensation. Examples of automation for specific cases are given in the following.

- ▷ The proHRIS can automate the activity evaluation based on the process models and on the criteria supplied by the process owner. This can be achieved through the intelligence component (e.g., through decision tree algorithms) which can group different activities based on their characteristics. This would even support template tasks as centers for the created groupings where process coaches or the process owner would design exemplary activities for specific difficulty classes.
- ▷ In a similar fashion the actual assignment of employees to specific pay classes can be achieved through the analysis component and the explicit assignment of employees to activities in processes.
- ▷ Through the interface with PAIS or PPMS the actual compensation calculation for employees relating to their process specific base pay and process specific variable pay can be performed. The relevant data can be extracted from performance data of the process, the appraisals performed in the appraisal component and potentially raw process logs from other PAIS. The calculated salary can then be forwarded to a payroll system or another HR system that performs the actual dispensation of monetary funds.

The following two use cases show in more detail what is involved in identifying the difficulty of activities and through this assigning employees to specific pay groups.

4.3.3.5.4 Use case: Analyze activity difficulty for compensation structure design

Description The use case “Analyze activity difficulty” describes how the process owner can initiate the process of evaluation of activities needed for the design of fixed pay structures (see figure 62). Before one of the different methods for the ordering or grouping of activities and/or processes with respect to their requirements can be performed the difficulty of the individual activities has to be determined. In this use case it is achieved by specifying a “work value” for that activity. The work value being a number representing the difficulty of the activity with respect to all other activities relevant to the compensation structure. Based on that determination the employees performing those activities can then be assigned into different compensation groups or a relative ranking be established. While displayed here for a single activity when a new process is designed this use case will be embedded into a more complex use case of evaluating all process activities with respect to their requirements and difficulty.

Assumptions Several assumptions are made in this use case. First it is assumed that there already is an existing process model that contains HR relevant information based on which the use case can be performed. If this is not the case, the process model would have to

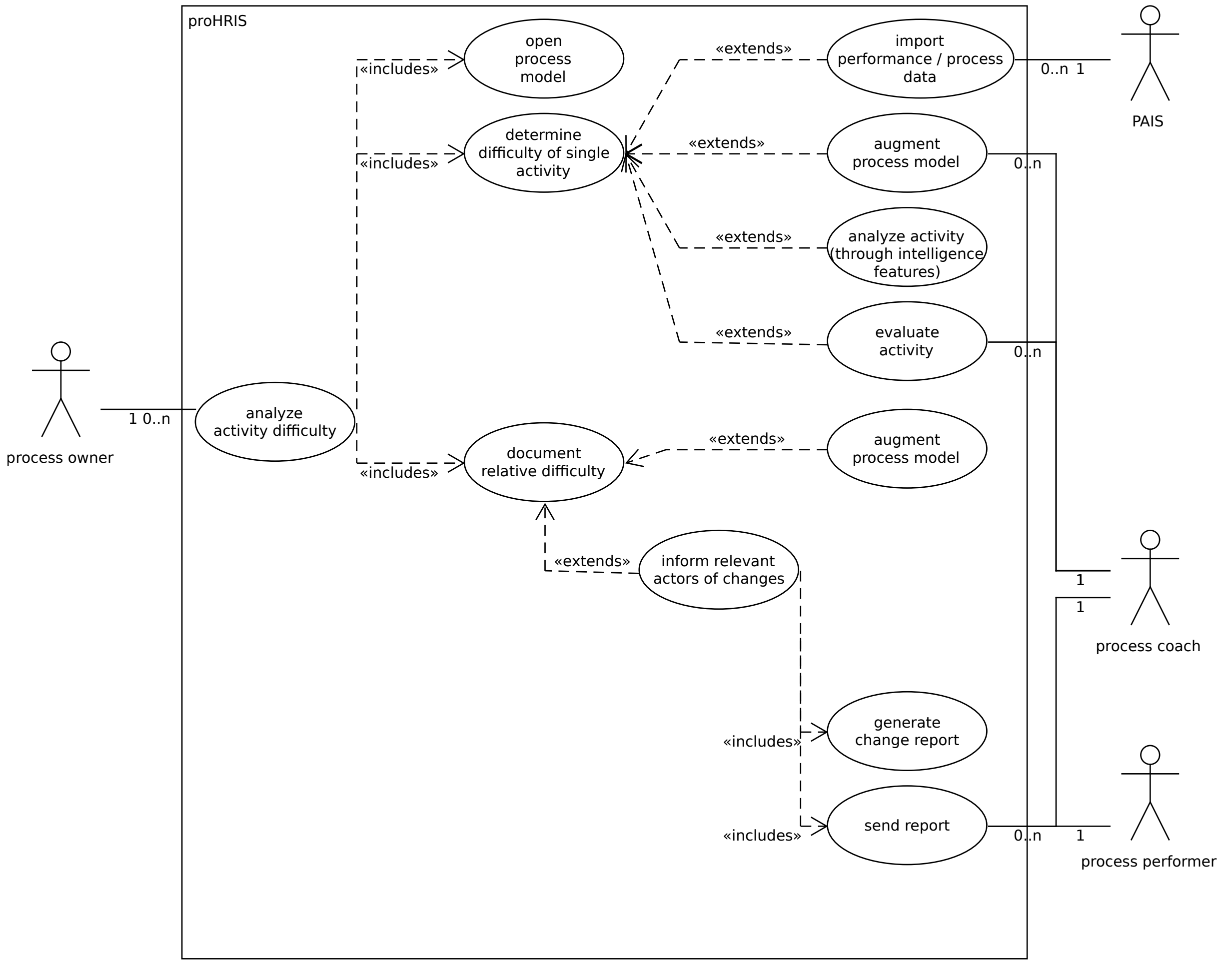


Figure 62: Use case diagram for the use case: Analyze activity difficulty for compensation structure design.

be first created and augmented to include HR relevant information (e.g., use case “plan employee assignment” in section 4.3.3.2.4). Furthermore, the assumption is made that there is a PAIS that can provide process performance data or process logs which can be used to further analyze the process. In case of a new process this could also come from prototypical executions of the process.

A base assumption for the use case is, of course, that some specific fixed compensation structure has been designed in which the difficulty of tasks needs to be integrated. In this use case a specific work value for the activity will be calculated which should represent the difficulty of the activity in relation to other activities in the organization. Therefore, a compensation structure that is based around the work value of different activities is assumed.

Actors Four actors are involved in the given use case: the process owner, the process coach, the process performer, and a PAIS. The process owner is the main actor of the use case. He or she initiates it by wanting to analyze the difficulty of a specific activity for the later assignment of the process performer to a wage group, or for the direct calculation of the employee’s fixed compensation. The process coach, as an expert of specific parts of the process can support the process owner in this task. If the process owner does not rely completely on proHRIS features to define the difficulty of the activity, the process coach can perform an evaluation of the activity to formulate its work value. The process performer is involved in the use case as the recipient of information about the difficulty of the activity he or she performs. Another recipient of that information is the process coach. As he or she can be responsible for functionally similar activities in different processes, he or she should be informed about changes in how their difficulty is rated. Depending on the compensation strategy next steps could involve feedback of the process performer, or the process coach. The strategy could also prohibit changes in the set difficulty of activities without agreement from process coaches as they ensure the consistency of evaluations throughout their area of expertise. The last actor involved in the use case is a PAIS. Here this actor includes any system that can provide the proHRIS with information about the performance or execution of the process at hand and other activities as basis for different intelligence or analysis features to determine the difficulty of the activity.

Steps To successfully complete the use case the process owner first has to load the process model in which the activity is included (UC: "open process model"). He or she then determines the difficulty of a single activity. To do this there are two principal possibilities. First the process owner can choose to decide on the difficulty of the activity himself, based on information provided by the proHRIS. For this the system has to gather as much data as possible about the activity, the process or other activities in the organization (UC: "import performance / process data). If the information the process owner wants to use for the determination of activity difficulty, such as required qualifications, number of planned instances of the activity, or goals of the activity, are not already present in the process model, the model has to be augmented in that regard (see sections 4.3.3.2 & 4.3.3.3, as well as the use cases described there). Based on the information available in the process model and the information gathered from the PAIS. The proHRIS can then support the determination of the activities' difficulty through different features based on its analysis and intelligence components (UC: "analyze activity"). The specifics of how to calculate a work value based on the information present in the model have to be decided upon during the design of the reward principles. Once the work value of the activity has been decided upon by the process owner he or she documents it in the process model itself (UC: "augment process model").

Variations

1. In use case "determine difficulty of single activity": The process owner can also use the knowledge of a process coach instead of existing algorithms in the software. This can, for example, be the case if specific types of activities are to be individually evaluated by experts in the reward principles. The system supports this collaboration (see **FR7** on page 93) by allowing process coaches and process owner to collaboratively work on the modeled process and exchange information (UC: "evaluate activity").
2. In use case "document relative difficulty": The proHRIS informs relevant actors of changes in the process model by notifying them of the new difficulty (UC: "generate change report", "send report"). The relevant actors can be process performers

assigned to that activity, or process coaches in which area of expertise that activity falls.

Non-functional requirements As the compensation is one of the most sensitive subjects between employer and employee, the **security** of the system certainly is a crucial aspect of its quality. Similar to the other use cases the **non-repudiation** characteristics has a huge impact on its quality and acceptance with the employees as well as **integrity**, **accountability**, and **authenticity**. Employees have to trust that the system will not change their assigned base salary without the consent of the relevant parties. Similarly, the system has to provide adequate **user error protection** to prevent unfairness and in-transparencies in the compensation scheme, due to errors in the modeling of process or organizational elements. To support the different possible types of analysis and the concrete intelligence features required to support specific reward principles and, therefore, compensation schemes, the system's **modifiability** plays an important role. As those specific features are based on organization specific decisions, they have to be adapted during the implementation of the system in an organization.

4.3.3.5.5 Use case: calculate monetary compensation based on fixed and variable components

Description The use case "Calculate monetary compensation based on fixed and variable components" represents a very flexible use case performed with the help of the system. The compensation meant here is the compensation relating to the specific operational business process in which the employee acts as process performer. The use case can be initiated by specific actors, such as the process owner or the process performer. It can also be initiated automatically, for example, at the end of the accounting period, to transfer relevant data to the overall payroll system. The calculation of the complete (variable and fixed) compensation that is based on the process can be used during the planning phase, when new processes are designed to identify the process's personnel costs approximately. It can also be used by the employee during the process's lifetime and account period to preview the current status of his potential compensation. An overview of the use case and related sub use cases is given in figure 63.

Assumptions The use case described here is related to many aspects of a proHRIS and, therefore, makes many assumptions with regard to prior activities. It is assumed that augmented process models exist to which employees are assigned (see section 4.3.3.2). It is furthermore assumed that specific performance management activities such as goal setting and performance agreements have been completed (section 4.3.3.3). To be able to use specific performance data and to approximate goal achievement the process enactment has to have started. Otherwise, the calculated monetary compensation would be limited to the fixed component. It is also assumed that a specific reward strategy has been initiated and that the necessary information to calculate the fixed components of employee process compensation are present. Another assumption is that there is a PAIS from which that performance data can be collected, as well as a general payroll system to which process

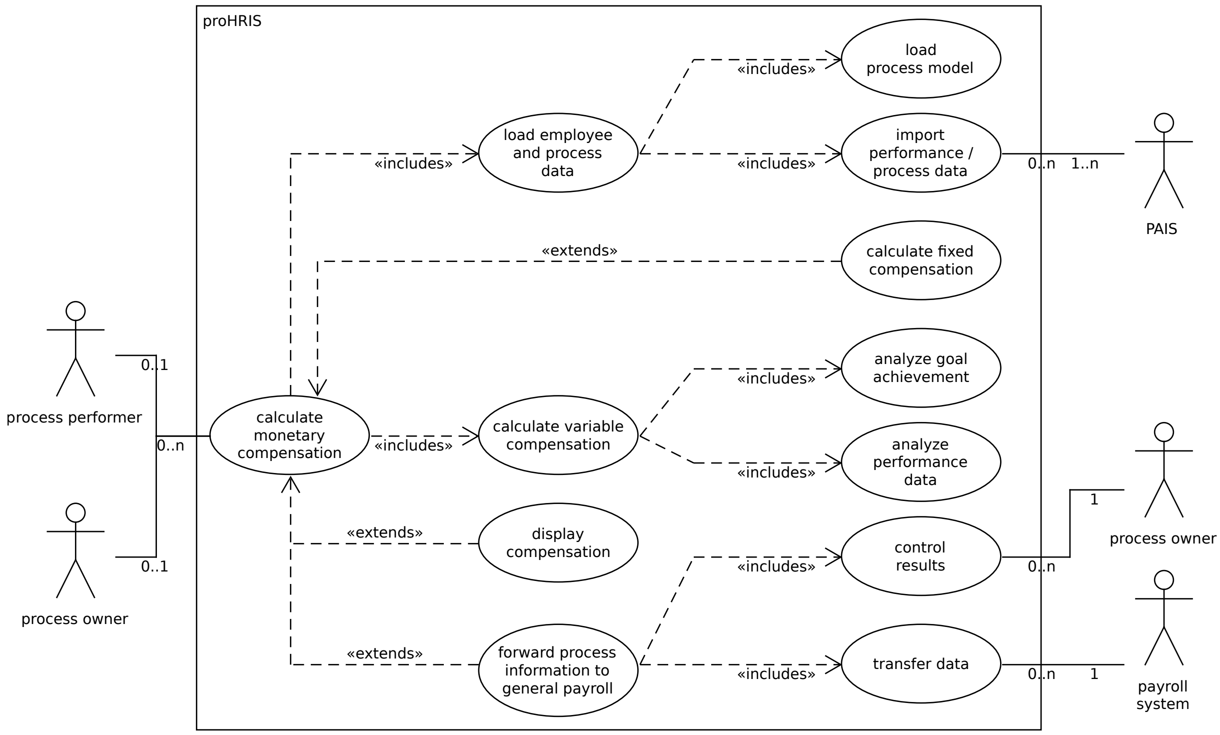


Figure 63: Use case diagram for the use case: Calculate monetary compensation based on fixed and variable components.

specific data can be forwarded.

Actors This use case involves up to five actors, depending on who initiates the use case. The process performer when initiating the use case wants to get current information about the status of his monetary compensation. This could occur during the current accounting period in order to know how much money he or she will get at the end of the period. This could also happen before the beginning of the period for a new process in which the process performer is involved to potentially give feedback relating to monetary implications of him enacting the process. Another actor that could initiate the use case is the process owner. During the design and analysis phase or the implementation phase of the process life cycle the process owner could calculate the overall compensation of all employees to assess the personnel cost of the process. Potentially this could lead to a redesign of the process, which implies a lower value for the fixed components of employee compensation. It can also be used as a communication tool during the negotiation of the process owner with employees to motivate them to work on another (new) operational business process. The process owner can also be involved in the use case if the actual final compensation is to be forwarded to the payroll system. Here he or she acts as the last control instance as he or she is in the end responsible for the successful enactment of the operational business process.

Two types of systems are potentially involved in the use case: a PAIS and a payroll system. The PAIS actor represents an enactment system or PPMS which can provide the proHRIS with performance information about the current operational business process by which the calculation of compensation is performed. The payroll system actor represents a payroll system which will coordinate the final payout of the monetary compensation of the process performers.

Steps To successfully complete the use case the following steps have to be performed if the use case is initiated by a process performer wanting to gather information about his current compensation status for the operational business process. To be able to provide the process performer with the required information the proHRIS has first to collect the performance data from an interfaced PAIS (UC: “import performance/process data”) after having loaded the relevant process model (UC: “load process model”). Depending on how specific the employee’s compensation agreement is, the proHRIS calculates the fixed component of the employee’s compensation (UC: “calculate fixed compensation”) based on the information given in the process model. In a next step the variable part of the compensation can be calculated. For this performance data and goal achievement are analyzed (UC: “analyze goal achievement” and “analyze performance data”) with regard to the employee’s compensation and performance agreements. The resulting compensation is then displayed to the process performer (UC: “display compensation”).

Variations

1. In use case “calculate monetary compensation”: The use case is not initiated by a process performer, but by the process owner to gather information about the potential or current compensation of a process performer in his operational business process.
2. In use case “calculate monetary compensation”: The use case is not initiated by a human actor but instead started by the system itself because, for example, the accounting period has ended. The system calculates the variable and fixed components of the compensation and then forwards that information to the general payroll system (UC: “forward process information to general payroll system”). The process owner, as responsible for the operational process, controls the results of the calculation to make sure no information was missing or errors occurring. In case of missing information or possible errors he or she can, for example, communicate with process coaches functionally responsible for the tasks to which the assigned goals where not evaluated and solve the problem (UC: “control results”). Once the process owner signs off on the results the data is transferred to the payroll system (UC: “transfer data”).
3. In use case “calculate monetary compensation”: If the fixed components of the compensation have already been computed, or they do not rely on process specific information it is not necessary to calculate them again. This can, for example, be the case if the reward strategy is based on fixed compensation solely determined by the available qualifications of the employees (see page 51) and only the variable components are related to the operational business process.

Non-functional requirements The relevant quality criteria for this use case are mostly centered around the **security**, **reliability**, **usability**, and **maintainability** characteristics. From a security point of view it is important that the integrity of the information is preserved so that compensation related information is not changed without matching authorization.

The assurance of non-repudiation, i.e., the assurance that events can be proven to have taken place, is another important factor for the calculation of monetary compensation as it is with any employee related features. The reliability of the systems plays an important role because the compensation of the employees hinges on the performance information available in the system. Potential failures must not lead to missing information about the performance and compensation agreements or performance data as this will directly impact the employee's compensation. One sub characteristic of reliability that is, for example, not as important in this use case is availability. This information is mostly not required on a real-time basis. It seems sufficient when the system can provide reliable access to up-dated compensation data on certain hours of a day. Even if this data is only available on a certain day of the week this does not impact the quality of the system as do the usage of faulty data or the missing of data for the compensation of employees. As compensation schemes and the reward strategy of organizations can be very diverse the system's maintainability heavily depends on how easily adaptable the system is to the specifics of the organization it is used in (**modifiability**).

From an usability point of view the **user error protection** plays an important role in this use case, too. This is especially shown as the use case explicitly requires the go ahead from the process owner before compensation data is passed to the payroll system. Here features indicating potential problems to the process owner can help ensure the smooth execution of later payroll.

4.4 Organizational integration – the life cycle of the proHRIS

After having described the different components of the proHRIS, this section describes how the proHRIS can be used in the organizational context to support the process oriented management of the human resources. In the following each phase in the business process life cycle is related to the HR activities performed during that phase with the proHRIS and the activities performed to adapt the proHRIS to possible changes.

A summary of the different activities during the process life cycle is given in figure 64.

As noted in chapter 2 (see p. 19 ff.) the beginning of the life cycle of a business process can be seen in the design and analysis phase. Here business processes are explicated through process models. While the proHRIS is not specifically designed to support the organizational design of business processes, it can support the design of operational processes by supplying HR related information to the modeler of the processes. As such the enhancement of process models to include HR relevant information should not be seen as a secondary task but integrated into the primary task of creating business process models of existing (or to-be) business processes. These models should be analyzed regarding organizational and HR related weaknesses. This planning of operational processes is affected by nearly all functional components of the proHRIS.

Business process models have to be augmented with information about the required qualifications, the activity related goals, and potential performance measures. This requires the additional organizational models to be up-to-date, i.e., the goal structure from overall organizational goals to specific activity goals to have been created, the qualification catalog to be

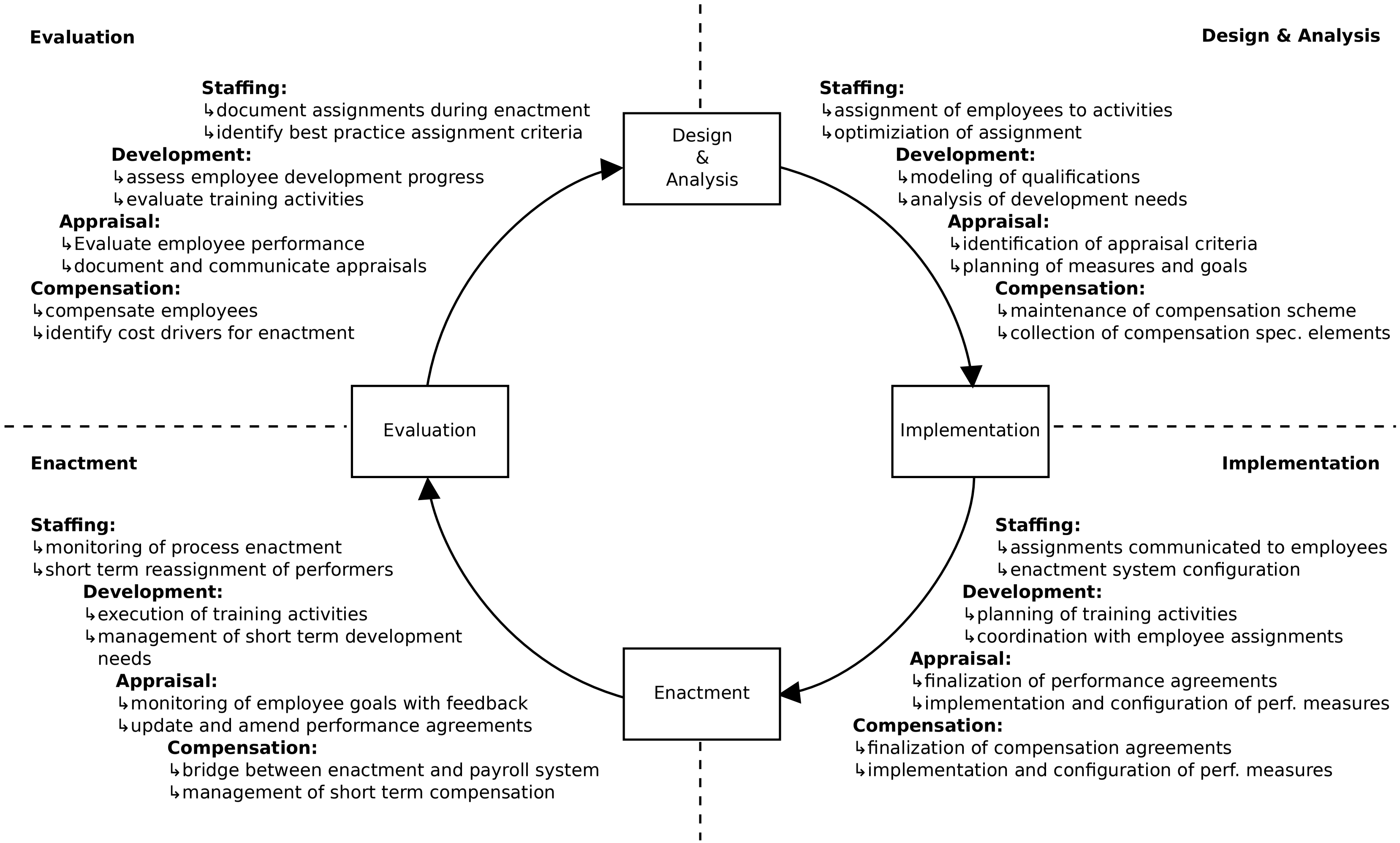


Figure 64: proHRIS related activities in the business process life cycle.

maintained and the availability of possible performance measures to be documented. To allow for any reasonable planning of employee assignments the process model also has to be modeled on a level detailed enough that an assignment of individual employees makes sense. This includes the model containing the HR relevant properties for activities and other elements.

The design of the process continues with the assignment of employees to activities in the operational business process. The static and dynamic analysis features of the proHRIS can offer additional information to the process owner to optimize the assignment of the different process performers. The process owner has to respect limits included in the model regarding qualifications of employees, their available working time, etc. The assignments can also be optimized with regard to historical data, i.e., employee assignment changes based on performance data gathered during the previous cycle of the process.

The assignment of employees has to be coordinated with possibilities of recruiting new employees or developing existing employees. The possibility to recruit a new employee for a specific set of activities within a process can lead to reasonable changes to further assignments. Similarly, the lack of training opportunities for specific qualifications can hinder the assignment of specific employees to tasks. As assignment of employees can also have an effect on the monetary compensation of employees, aspects relating to remuneration have to be taken into account. This can result in specific analyses that mark employees at not being able to be assigned to activities outside of a specific wage group, or analyses warning of great discrepancies between wages of employees involved in similar activities. As such the planning of employee development initiatives (if provided for by the development strategy) has to be performed in combination with the planning of employee assignments.

Similarly, the maintenance of appraisal schemes has to be performed and it should be ensured that there are adequate measures in place to appraise the employees assigned to the business process. Those measures and appraisal goals can be gathered from existing historical processes, or be created fitting into the goal structure of the overall organization. Depending on the chosen appraisal strategy it must be ensured that the goals set for the process and the modeled activities are precise enough to serve as basis for the performance agreement of the employee.

The implementation of the business process entails the introduction of the business process in the organizational context, i.e., the technical implementation in application systems, as well as the organizational implementation. The technical implementation lies outside the scope of this discussion, but the organizational implementation hugely affects the human resources of the organization. One of the plans created during the design and analysis phase of the process is now communicated to all involved parties.

Employees receive their respective assignments from the proHRIS either through organizational channels, i.e., process owner to process performer, or directly via notifications by the system itself. The proHRIS also communicates with connected systems and forwards relevant information about employees; e.g., it forwards to access control systems the information which employees should be able to access which specific areas, depending on their assignments. In this way process enactment systems can also get the information necessary for their configuration.

The development needs have been finalized during the design phase and the valid training activities can now be organized. Depending on the development strategy training activities that have not previously existed are now created and, e.g., outsourced to external service providers. In that case development activities need to be planned and coordinated with the finalized time table of employees. In this phase process performers, or process owners in their stead, also decide on training activities for the following enactment period. The planning horizon for training activities can also spawn multiple life cycle iterations, i.e., performing training activities that will result in possible assignments in a future process life cycle iteration.

During the organizational implementation of the process the employees also finalize their performance agreements. Based on the models created during the previous phase the modeled goals and performance measures are assigned to employees. This is done based on historical data and the assignment of the elements between each other in the model. The process owner is also responsible for ensuring that the relevant performance measures are defined and measure points documented (e.g., Weske, 2012, p. 384 f.). Application systems that are used for the collection of performance measures need to be configured. If no specific performance measures for the business process have been defined up to now, the process owner defines the relevant measures and relates them to the overarching organizational goals. They serve as beacons for process performers to identify relevant performance criteria during the enactment of the process.

Similar to performance related measures the measures and characteristics used for the compensation that have been designed in previous phases have to be implemented and configured, e.g., there have to be systems in place that can track compensation relevant transaction for each process performer so that process specific remuneration can be performed. The compensation agreements with employees are finalized when the planning of employee assignments is completed.

The enactment of the business process normally takes place without the involvement of the proHRIS, through one or more enactment systems (cf. the understanding of process orientation in HRIS in section 87).

During the enactment of the business process the proHRIS supports the management of the process performers and their performance. Through the data mining component the process logs from enactment systems can be analyzed and performance problems quickly identified. Process conformance is monitored and exceptions are handled. Exceptions can, for example, come up in form of deviations in the process flow, deviations in employee assignments, or deviations from average enactment time for activities. From a staffing point of view, this means that short term changes in the assignment of employees can occur, e.g., prolonged sickness of an employee leading to the reassignment of additional performers to the business process to compensate for the lack of manpower.

From a development point of view, training activities are performed and their success is tracked. If reassignment of process performers leads to new development needs short term activities can be initiated for the involved party. Such cases, of course, can also lead to changes in appraisal and compensation for specific employees and thus models and plans have to be adapted if employee reassignments occur. The employee goals and their performance is generally monitored during process enactment and employees receive regular updates on their goal status, or a warning if there are problems with performance related measures, so that the source of the problem can be identified and if possible removed. This can also result in one-off training activities for employees which need to be managed in the system.

Depending on the compensation scheme, employees receive remuneration per performed activity instance or completed process instance. In such cases the process progress is tracked and relevant information forwarded to the payroll system when necessary. Changes in the process design, the employee assignments, or performance measures can lead to a short term redesign of processes. The redesign is handled either through small changes in the implementation of the process (e.g., the implementation of process performance measures) or through broader redesign initiatives due to identified fundamental problems in the process.

In the ideal-typical life cycle the evaluation of the business process represents the final step of one iteration of the process's life cycle. Here the process is evaluated regarding its performance and results of this phase can lead to a redesign of the process in a new iteration of the process in the design and analysis phase.

As the assignment and management of employees is tightly integrated to the enactment of the operational business process the evaluation phase of the process also offers possibilities for the evaluation of the employees assigned to the process. In fact due to the process being performed by the employees, an evaluation of the process is always also an evaluation of the employees. During the evaluation phase, the central generic component is the data mining component. Based on process logs of the enacted process, the performance measures relating to process specific goals can be measured.

The evaluation phase offers the possibility, from a staffing point of view, to document (if not already done) the final assignments with which the process was enacted. Potentially leading to internal best practice scenarios that show criteria for ideal assignments that result in a low need of reassignments during the enactment. An overall evaluation of the process assignment can also speed up further design and analysis activities as potential problems with the assignment would need to be addressed in the process design.

The assessment of the employee development progress, while not directly related to the operational business process is a prerequisite for the potential assignment of the employees in a new iteration of the business process life cycle. If the development of the employees has not progressed as expected alternative assignments and process designs have to be explored. In combination with the evaluation of the development progress of employees, the different training activities can be evaluated and the relevant models updated for the next iteration of the life cycle. The evaluation of training activities can, however, sometimes lag behind one or multiple iterations of the process as the effects of the training are not directly apparent. An analysis of a process that shows poor performance can result in the identification of inefficient training activities or wrongly attributed qualification requirements. However, such identification necessitates at least one process iteration with the training completed.

The performance result of the process and the activities as well as specific employee performance goals can be evaluated regarding the performance agreements that have been concluded between process owner and process performers in the implementation phase. The final appraisals of employees can then be documented and communicated to the relevant parties. This can have an influence on assignment in next process iterations, or potentially highlight the development needs of employees for the given process.

Based on the appraisal of the employees the compensation of employees can be finalized, i.e., the employees can receive their fixed and variable pay. Additionally, potential cost drivers resulting from the enactment can be identified based on the compensation of the employees performing the process. A documentation of this information can be used during the design and analysis phase of the next iteration of the operational process during analysis or as base values for process simulations.

4.5 Preliminary Conclusions

This chapter presented one of the main knowledge contributions of this thesis: the design of an ideal-typical proHRIS. This has been achieved by identifying the requirements resulting from a process oriented enactment of the classical HRM activities. Based on those requirements a design was proposed by describing the individual components of the system as well as how they can be integrated to offer specific functionalities required by the different HR functions. The base for the process orientation of the system is provided by a process repository that allows for the management and storage of models (see section 4.3.2.2), as well as a modeling notation that links business process specific information to HR specific information required by the specific HR functions. Models created in such a notation contain the required information to perform HR activities based on the models of operational business processes.

The design of four specific functional components that integrate the generic functionality toward a specific set of tasks has also been presented. The components cover the areas of staffing, development, appraisal, and compensation. The actors involved in those components have been specified and their goals in the specific area explained. The specific in- and outputs of the individual components have been described and the interaction of the components that result in these communications discussed.

In addition to the general description of the context of the components (functional area), two exemplary use cases have been described per functional component to describe the components on a lower level. Finally, the discussion of the proHRIS and its interactions based around the business process life cycle have given an overview of the general usage of the proHRIS during the life cycle of a business process and have shown how the proHRIS can be used to support a proHRM.

5 Demonstration and evaluation of the process oriented human resource information system

5.1 Approach of this section

To assess the feasibility of the proposed solution the chosen methodology includes two possibilities: the demonstrations of the solution and the evaluation of the solution. The proposed solution was demonstrated by means of a prototype for the area of staffing. In this chapter this prototype is presented and appraised with regard to its implementation of the general design of the proposed solution as well as the result of the usage of the prototype.

The focus of the prototype is on the functional area of staffing, as it cannot cover all functional features. Based on this selection the requirements developed in section 4.2 are adapted and refined for the specific context of the prototype. Additionally, the more generic requirements towards a modeling notation to be used within the context of the proHRIS and the relevant requirements are used to develop a specific notation that is used in the prototype, the HREPC.

The description of the prototype is based on the overall design proposed in chapter 4. The relevant components of the proHRIS that are implemented in the prototype are described and their relationship explained. After the presentation of the prototype, a description of a specific use case that was enacted with the support of the prototype is given.

Furthermore, a qualitative evaluation of the design is performed based on the requirements targeted at the proHRIS. The assessment focuses on the requirements elicited prior to the design of the systems and the coverage of the requirements by the design itself as well as the prototypical implementation.

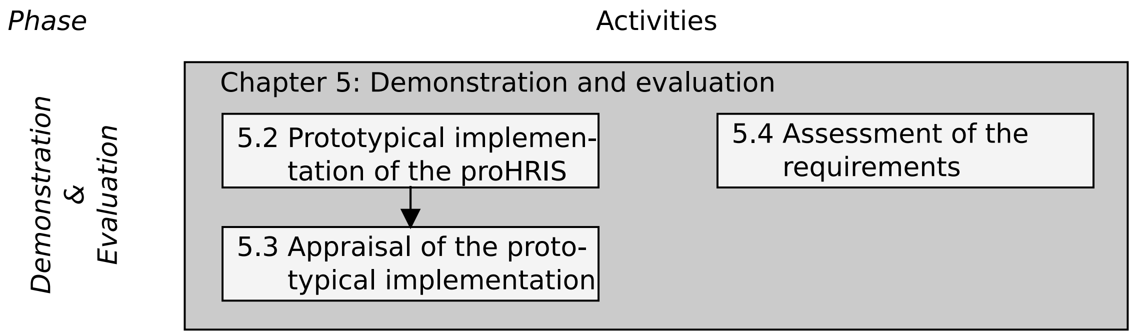


Figure 65: Activities performed for the demonstration and evaluation of the proHRIS.

5.2 Prototypical implementation of the proHRIS

5.2.1 Discussion of the implementation specific requirements

5.2.1.1 Staff assignment as selected sub function for the prototypical implementation

The prototypical implementation described here focuses on a specific subset of the functionality offered by the proposed proHRIS design presented in chapter 4. As described there, four main functional areas are supported by the proHRIS: staffing, appraisal, development and the compensation of employees. Each of these areas is imperative for the proper enactment of a process oriented HRM. However, for the prototype a sub function of staffing was chosen. The reason for this is that the assignment of employees to specific activities in the process is the central binding point between the organizational goals and activities to achieve these goals as well as the employee that perform the activities.

At its core the goal of all HR activities is to supply the organization with a workforce able to perform the activities needed to achieve the organizational goals (see also chapter 2). From a practical standpoint each possible implementation of HR function specific functionality relies on the existence of specific process models and assigned employees. Without such an assignment it is not possible to identify or set goals and performance criteria for employees, thus the appraisal of employees relies on a specific employee assignment. Similarly, the identification of development needs and training opportunities is not possible without specific qualification requirements resulting from employees assigned to specific tasks, as such also the development of employee, as long as it should support organizational goals, is not possible without specific employee assignments. The compensation of employees, is also a result of the specific assignment of employees to activities.

The developed prototype further restricts its scope to a narrow part of the staffing function, the actual assignment of staff to specific activities. This fits into the second and third step described in section 4.3.3.2. The prototype is built around a simplified version of the classical staff assignment problem (e.g., Holness, 2003; Holness, Drury, & Batta, 2006; Kuhn, 1955; M. L. Peters & Zelewski, 2007). This means that no shift schedules or similar results are aimed for. Instead, the assignment is concerned with how many employees should be assigned to an activity in an observed time frame to ensure that the overall amount of time required by the activity can be fully provided, taking into account additional requirements of that activity.

The simplified assignment problem, therefore, consists of a set of activities $F = \{1, 2, \ldots, m\}$ and a set of employees $E = \{1, 2, \ldots, n\}$. Each activity $i \in F$ has specific requirements $r_i = \{t_i^r, q_i^r, p_i^r, c_i^r\}$ (with t_i^r representing the required time in the observed time frame, $q_i^r = \{Q_n, \ldots, Q_m\}$ a set of specific qualifications that are unconditionally required, $p_i^r = \{Q_n, \ldots, Q_m\}$ a set of qualifications that are optionally required and c_i^r a maximum hourly wage that the organization is willing to pay for an activity). Each employee $j \in E$ exhibits certain characteristics $c_j = \left\{t_j^o, q_j^o, c_j^o\right\}$ (with t_j^o being the overall time an employee is available for assignment, $q_j^o = \{Q_n, \ldots, Q_m\}$ a set of qualifications the employee has, and c_j^o the hourly wage of the employee). Additionally, employees have preferences with regard to activities, with $p_{i,j} = \{-1, 0, 1\}$ representing the preferences of an employee (e.g., $p_{1,2} = 0$ means employee 2 has no like or dislike for activity 1, whereas $p_{3,2} = 1$ means employee 2 has a positive attitude towards activity 3).

An employee is assigned to an activity for a specific amount of time $a_{i,j} = \{t \mid t \in \mathbb{N}\}$. Each activity can have multiple assigned employees ($a_{1,3} = 100; a_{1,5} = 50$ means activity 1 is performed by employee 3 for 100 time units and by employee 4 for 50 time units). The collection of all individual assignment is, in the end, the result of the staff assignment operation ($A = \{a_{i,j} \mid i \in F, j \in E\}$; the set of all assignments).

The assignment of employees to activities underlies specific constraints. The unconditionally required qualifications should be satisfied by each employee assigned to activities ($a_{i,j} \in A \colon q \subseteq q_j^o$) and each assigned employee should have an hourly wage that is below the set maximum for the given activity ($a_{i,j} \in A \colon c_j^o \leq c_i^r$). In the context of a single assignment the employee should also have enough available time left to perform the assignment ($a_{i,j} \leq t_j^o - \sum_{x \in E, x \neq i, a_{x,j} \in A} a_{x,j}$).

In addition to those unconditional requirements, each assignment can be attributed a value. This value increase with each additional optional qualification an employee has by a factor eq for each optional qualification. Furthermore, it increases by the factor ew for the amount the employees wage is under the maximal payable wage and is influenced by the factor ep depending on the preference of the employee. The value of an assignment can, therefore, be described through the function $v(i,j) = a_{ij} \times \left(eq \times \left|p_i^r \cap q_j^o\right| + ew \times \left(c_i^r - c_j^o\right) + ep \times p_{i,j}\right)$.

For the overall assignment solution additional constraints apply. The required time of the activities should be equal to the overall assigned time ($x \in F \colon t_x^r = \sum_{,j \in e, a_{x,j} \in A} a_{x,,j}$). The overall the amount of time an employee is assigned to activities should not surpass his or her available time ($k \in E \colon t_k^o \leq \sum_{,j \in f, a_{j,k} \in A} a_{,j,k}$). The overall assignment value can be seen as the collection of the value of all individual assignments $V = \sum_{i,j \mid a_{i,j} \in A} v(i,j)$. When finding an optimal solution, that overall assignment value should be maximized. In the prototype this assignment problem is, however, not solved by the system itself. Instead, to solve this assignment problem the user of the prototype will step by step assign employees to activities until all activities have enough employees assigned to them. The system will only provide feedback about the quality of the assignment and offer suggestions for possible assignments of employees to specific activities.

5.2.1.2 Requirements relating to the prototypical implementation

The requirements described in section 4.2 naturally relate to the prototypical implementation. However, as the prototypical implementation is restricted to a specific subset of the staffing function the requirements can be further refined into prototype specific requirements (**PR**).

With regard to the modeling notation the two general requirements noted are the ability to express the concepts relevant for the problems to be tackled by the system (**FR1**), as well as an integration in the modeling notation of the specific organizational aspects (**FR2**). Specifically for staffing this means a modeling notation able to express the concepts of employees, activities, qualifications, and any other concept relevant for the support of staffing in general. For the prototype this translates specifically into representing the concepts required for a simplified employee assignment. The questions to be answered by models created through the notation are the following: "Given a specific set of employees with available times and qualifications which assignment of employees to activities promises the best outcome given a certain set of additional constraints?", "What activities remain that are not fully assigned to employees?", and "Which employees have not a full workload?". For the following HR functions relevant sub questions can be, for example, "What additional qualifications are required by the assigned employees?" or "What requirements are there for a new employee that should join the organization?". As identified in section 4.3.3.2 the core concepts to represent are the activity as a way to represent the activities in the operational business process for which executing employees have to be found and the employees, as representing the people that are hired by the organization to enact the specific activities. Additionally, the concept of a qualification is used as a way to represent the requirements of activities and abilities of employees. To represent the required manpower of activities and available time intervals of employees a very simple representation is chosen. Each function should have some value for the time required to fully perform them given a certain observation context (e.g., a quarter of a year) and each employee should have a number of hours he or she is available in that context. More detailed representation of the availability and temporal requirements of functions are, however, not required for a prototypical demonstration of the proHRIS.

PR1 The modeling notation used in the prototype should be able to represent the concepts of activity, qualification, and employee as well as the relationships between them (**FR1**, **FR10-2**).

PR2 The modeling notation should include the possibility to represent adequatly the organizational structure reguarding the given elements.This includes the dependence of qualifications between each other as well as relationships between processes on different levels of abstraction (**FR2**, **FR10-2**).

To support the working with HR augmented process models it was specified that a proHRIS should support the modeling of such models as well as typical management features (**FR3**, **FR4**). As seen in the discussion of the model repository component (section 4.3.2.1) the management of process models includes a wide range of features. For a prototype it is sufficient to be able to easily show how work can be performed with the augmented model. The requirement are, therefore, restricted to the possibility to create, edit, save, and delete process models. The editing functionality of the prototype should support the specific modeling notation created for the assignment of employees to operational processes. The ability to store process models (**FR5**) in the context of the planning of employee assignments includes especially the possibility to create different model variants for different scenarios in the assignment of employees (see section 4.3.3.2; Armstrong, 2006, p. 372).

PR3 The prototype should provide an editor that supports the creation of models in the specific notation that includes the required concepts (**FR3**, **FR4**, **FR5**).

PR4 The prototype should provide management features regarding models created in the new notation. This especially includes the possibility to create, edit, save, and delete models in the given notation (**FR3**, **FR4**, **FR5**).

PR5 The prototype should offer the possibility to create different scenarios for planning the assignment of specific employees to a given operational business process (**FR3**, **FR4**, **FR5**).

The requirement of specific intelligence features for the given HR function translates to different required analysis possibilities in the prototype (**FR6**, **FR10-5**). Generally the system should be able to tell the user if the created process model with employee assignments is valid. The idea of process verification and validation (e.g., Mendling, 2009) can be extended further than conformance with the syntactical rules (specific and abstract) of the given notation, soundness, or well structuredness of the model itself. The prototype should be able to provide the user with support in evaluating the validity of the performed assigned, i.e., the consistency between the model and the planned real world assigned to operational business process. While this cannot be fully automated the system can provide the user with information about the consistency between the modeled state and the underlying assignment problem as well as its constraints. As such, three main requirements can be defined regarding the required HR intelligence features.

PR6 The prototype should provide the user with information about the syntactical correctness of given model (**FR6**).

PR7 The prototype should provide analyses to the user that inform him about the validity of the model given the constraints of the underlying assignment problem (**FR6**, **FR10-5**).

PR8 The prototype should offer the user assistance in assigning employees in such a way that the assignment problem constraints are not unsatisfied (**FR6**, **FR10-5**). The system should specifically provide information about possible employees that can be assigned to a specific task with regard to selected constraints of the general assignment problems.

The requirement of model level support of multiple users (**FR7**) is not explicitly adopted for the prototypical implementation, as it is not imperative for a demonstration of supporting the staffing function. Furthermore, the integration with external systems is not extensively required in the context of a prototype (**FR8**, **FR9**, **FR10-4**) as such only minimal support should be provided by the system.

PR9 The prototype should provide access to the models, analysis, and organizational data to external systems (**FR9**, **FR10-4**).

5.2.2 Description of the modeling notation

The human resource event based process chain (HREPC) is an example of a modeling notation that fulfills the requirements for a usage in the context of the described prototype. The HREPC is based on the notations used in the ARIS method (e.g., Scheer, 1999; see also the "ARIS business process meta-model" in Scheer, Thomas, & Adam, 2005, p. 133 ff.) and is mainly an extension of the EPC notation (e.g., Mendling, 2008; Nüttgens, Feld, & Zimmermann, 1998; Scheer et al., 2005). The previous section has identified several concepts that should be included in a (business process) modeling notation to support a process oriented approach to HRM. In this section the representation of concepts in the EPC are extended or new representations added to fit the concepts named in the previous section. The discussion here will focus on specific elements affected by the extension of the EPC notation and not on the fundamentals of modeling with the EPC (and, therefore, with the HREPC). For a discussion of the fundamentals of the EPC, a description of all elements, the modeling rules, and a discussion of existing challenges in EPC creation the reader should refer to the extant literature (e.g., Mendling, 2008; Mendling et al., 2010; Nüttgens & Rump, 2002; Rittgen, 2000; Scheer & Nüttgens, 2000; Scheer et al., 2005; van der Aalst, 1999a).

As noted in section 2.3.2 a modeling notation consists of a visual aspect and a conceptual aspect. The visual aspect (specific syntax) focuses on the visual representation while the conceptual aspects specifies what concepts are represented in the notation, how they can be related to each other, and what the meaning of concepts and relation is. A simple example based on the EPC is shown in figure 66.

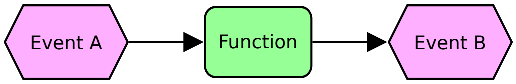


Figure 66: Simple example of a model based on the EPC.

The figure shows three specific concrete syntax elements: an EventShape element (Hexagon), a FunctionShape element (rectangle with rounded corners), and a ControlFlowShape (line with filled arrow). A syntax rule relevant for the figure is that EventShapes are connected to FunctionShapes by ControlFlowShapes. Another rule is that EventShapes can not be connected to each other by ControlFlowShapes. Further relevant rules include, for example, that each diagram has to have at least one EventShape that only has a ControlFlowShape leading out of it and one having only a ControlFlowShape pointing to it, that each ControlFlowShape must be connected to one EventShape and one FunctionShape, etc.

While through these rules a correct visual model can be produced, there is no information in the concrete syntax about the meaning of the diagram (besides the meaning the observer assumes through their names). The conceptual aspect of the notation has to explain what such a representation stands for: that the concept that is represented is the notion of a business process, that consists of different activities which are executed in a logical and temporal order and result in specific states of the world, that each ControlFlowShape represents a temporal and logical order between the activities represented through the FunctionShape and which state in the world leads to which activity being performed and which state results from performing which activity.

As a notation can have multiple different concrete syntaxes, but the abstract syntax remains the same, the following discussion focuses on the concepts of the abstract syntax rather than the concrete visual elements. So no specifications about the size, color, naming conventions, etc. will be made regarding the concepts themselves. Instead, visual aspects are only shown in specific examples to provide additional clarifications in specific points and show how the conceptual elements and relationships could be visualized.

For this purpose a meta-model of the conceptual aspects is created. This meta-model is expressed in terms of UML class diagrams (see Object Management Group, 2015) and represents the concepts as classes. It shows the concepts used and the relationships between them. For the purpose of clarity properties are not shown in the diagram.

Function

In the HREPC activities are represented by the Function element. Functions represent those activities that can not be further refined (atomic activities) as well as activities that can be further refined and expressed in a business process model. A Function can, therefore, relate to another Function by being its sub-function. A sub-function relationship exists if the activity represented by a Function is performed when enacting the upper Function , i.e. "record performance data" would be a sub-function of "perform performance appraisal", as a process performer would need to record the performance data to successfully perform the appraisal. As provided in the EPC Functions are related to Events which they either cause or are triggered by. An Event represents a specific state of the world. In the case of an implementation in an enactment system this translates to specific states of the system. For example, the event "customer e-mail arrived" can trigger functions that deal with handling the request from the customer. The relevant meta-model section is shown in figure 67.

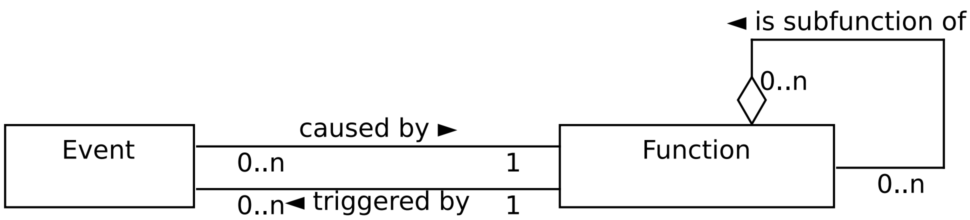


Figure 67: HREPC abstract meta-model: Function and Event.

For an use in the prototype the following properties are additionally required on an Function element: duration, frequency, automation, training opportunities, etc. The Function element can also contain additional properties depending on the organizational context. If, for example, there is a limit for the number of employees that can perform a certain function because of restrictions that lie outside the scope of the processes Functions or the respective other elements (e.g., Software) can be augmented with the relevant information.

The duration and frequency properties can be used by the analysis and simulation components and through them in the staffing and development of employees (see also section 4.3.3.2). The automation property provides information about whether the Function represented by the element requires human interaction. This is relevant for the identification of assignment needs. A Function completely performed by a machine or a software program, while possibly taking a long amount of time, would not need to be assigned an employee.

Qualification

The concept of a qualification is represented by a Qualification element in the HREPC (see figure 68). While this concept also exists in the ARIS method, the usage here differs (e.g., qualifications are assigned to specific "roles" there; cf. Scheer, 1999, p. 50,58).

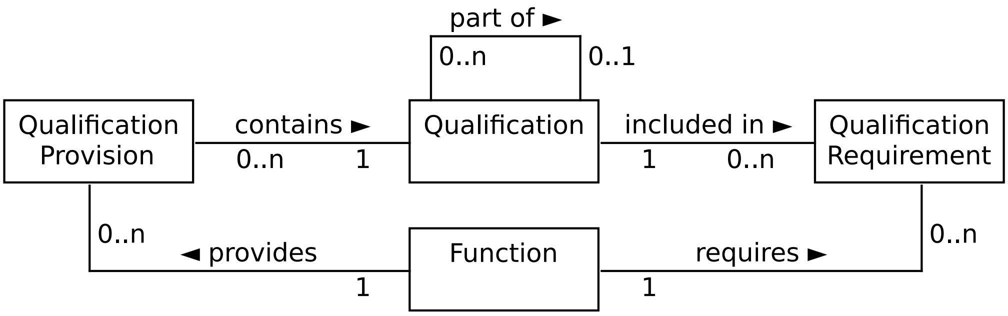


Figure 68: HREPC abstract meta-model: Qualification.

The exact meaning of a Qualification element is left to the organization using the proHRIS. However, as the qualifications are used as requirements by functions and as results of training activities, Qualifications should represent explicitly measurable features of an employee, otherwise it can't really be ascertained whether an employee has a specific qualification, or if he or she has acquired that qualification by performing a training activity (cf. Jung, 2007, p. 134 ff.). This measurement is represented in different levels at which an employee has the specific qualification, i.e., an employee can have the Qualification "English" at the level 1 through 10. This setting is, however, chosen here only as a way to demonstrate the functionality in the prototypical implementation. In a real world implementation of the proHRIS, the representation of the Qualification concept and its properties should depend on the development strategy, knowledge management strategy, or qualification catalog of the implementing organization. In most cases, a more complex representation of qualifications and their relationships should be used. Which would lead to an adaptation of the modeling notation to support the new semantics (an example of a more complex representation of qualifications is given in section 5.3).

When relating Qualifications to Functions two types of relationship are possible: the Function requires the Qualification or the Function imparts it. When a Function requires a Qualification, further differentiation have to made. The requirement can be optional, i.e. it would help with enactment of the activity if the employee has a specific qualification, but it is not impossible for him to perform the activity if he or she does not have it. Qualifications that are not optional, however, lead to the inability of the employee to perform the function due to missing abilities, or external regulations. The requirement is also at a certain level range. For example, a process coach might have decided that for a specific activity the employee performing the activity needs at least a certain level of proficiency in the qualification. To represent these restrictions the concepts of a Qualification Requirement is used. The Qualification Requirement represents a qualification at a certain level interval, which is required (possibly optionally) for a specific Function.

The relationship that represents the potential provision of qualifications is kept simple in the HREPC as it is meant to serve as a guideline for process coaches and process owners during the planning of development activities and not as a hard criterion for the assignment optimization. As such, a Function provides one or more Qualifications.

Employee

An important element in the HREPC is the Employee. There is a concept of an employee in the ARIS method, however, it is mostly used in organizational charts and kept very simple. In it, employees are, for example, not directly related to qualifications, but perform certain roles in the organization (e.g., Scheer, 1999, p. 57). Through these roles a relationship between employees and qualifications is established. While this gives information about what activities employees perform and the qualification they might use for those activities, HR relevant information about the actual qualifications of employees is not represented. Therefore, the Employee element in the HREPC differs from that in the ARIS method (see figure 69).

Another specificity of Employees is that they do not represent types of objects as do Functions. An Employee represents a specific employee in the organization. The element stands for a specific instances. The required properties for that element for a usage in the proHRIS are the name of the employee as well as some unique identifier with which he or she can be identified (e.g., employee number). If the employee should have access to the proHRIS as well a connection between the employee in the model, as well as the user account used by him needs to be made. The element should also contain information about the working time of the employee, the wage of the employee, and any further information that can help with optimizing the analysis functions used in the different HR functions. The assignment of Employees to specific Functions is represented through an Employee Assignment element. Each assignment can have additional properties such as the overall time of the assignment in the relevant time frame. The possession of a Qualification by an Employee is modeled through the use of an Employee Qualification element. This element represents that a specific employee has a specific qualification at a specific qualification level. Depending on the needs of implementing organization additional arguments, e.g., the time at which the employee last passed a formal evaluation to measure this possession could be added.

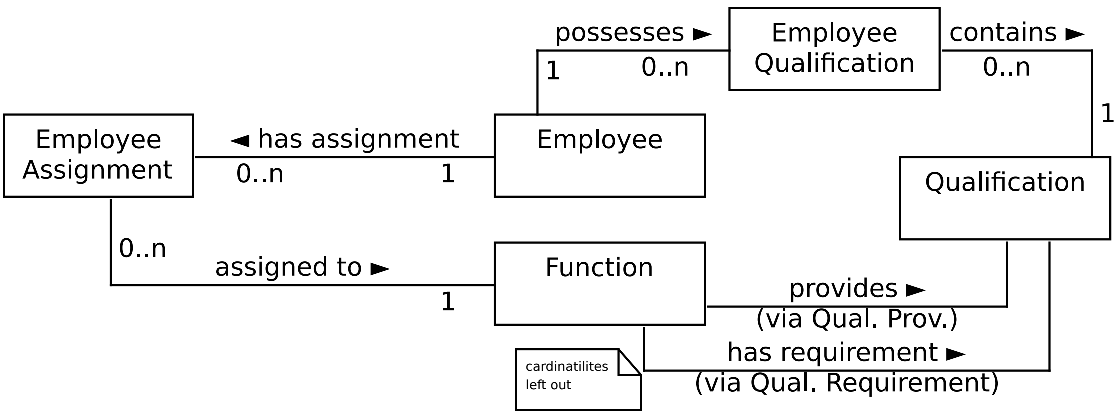


Figure 69: HREPC abstract meta-model: Employee.

5.2.3 Description of the prototype

5.2.3.1 Overview over the prototype

The implemented prototype is based on the design of the proHRIS proposed in chapter 4. However, not all components have been implemented and those implemented have several restrictions place upon them. As discussed above, the focus of the prototype lies on supporting the personnel assignment in the HR function staffing. The relevant components that have been implemented are shown in figure 70. The focus of the prototype lies in implementing a staffing component for the employee assignment as described in the previous section. The prototype also focuses on the modeling component. While some reports are generated in function specific interfaces, no in depth implementation of a reporting component or visualization component is performed. Concerning the different intelligence components the proHRIS can have, only an analysis component is implemented. No implementation of the simulation or mining component is performed. The prototype includes an internal repository which contains the different models, as well as an externally available API.

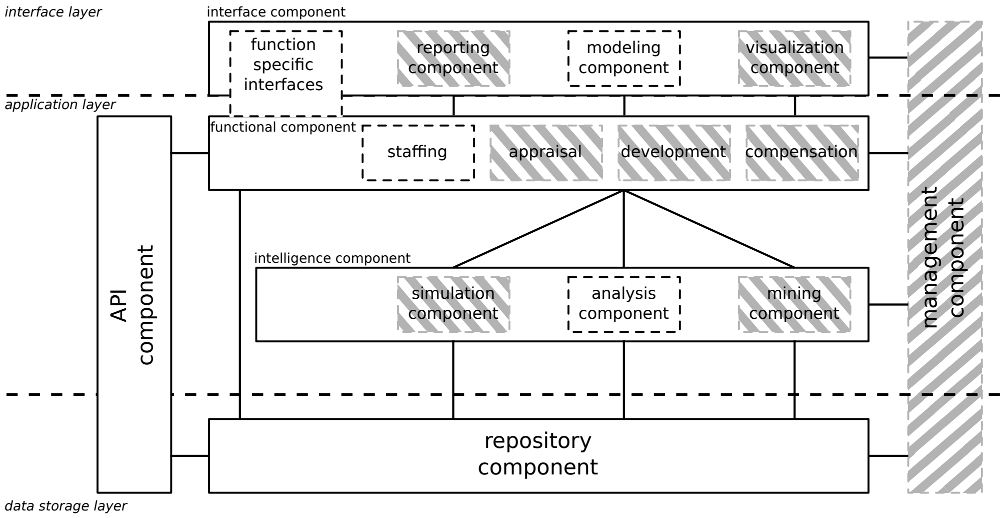


Figure 70: proHRIS components implemented in the prototype..

The prototype is implemented in form of a web application that is composed of two parts. The server-side components (created in Java) as well as client-side components (created in HTML and JavaScript). The server-side components include a graph based database (Neo4j; Neo Technology, n.d.) that provides the underlying storage layer for the repository component. The client-side components are created using the ExtJS Framework (Sencha Inc., 2016) and include a general purpose modeling component (ORYX; see N. Peters, 2007; Tscheschner, 2007) that is used as a basis for the notation specific modeling component required for the prototype. The overall design of the prototype is shown in figure 71.

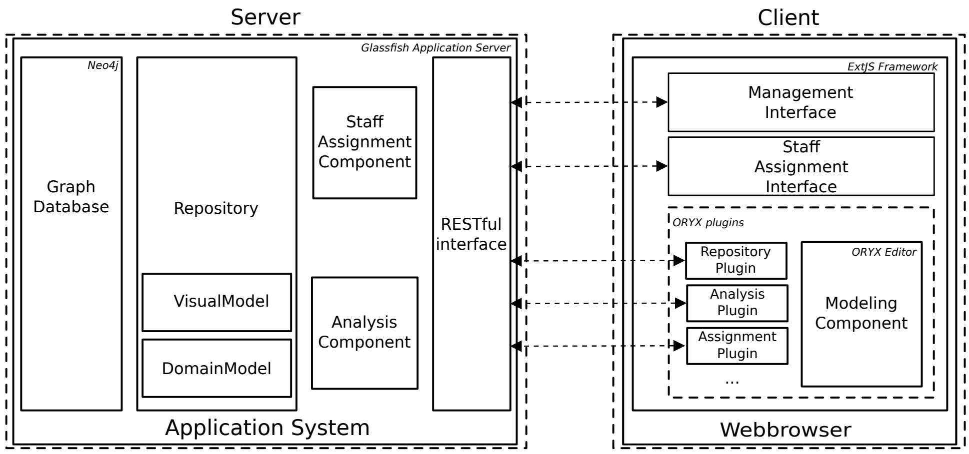


Figure 71: Overall design of the prototype.

5.2.3.2 Description of the repository component

The repository component in the prototype uses a graph database as the underlying storage technology. Graph databases are one subclass of the non-relational databases. These type of databases are meant to offer a higher performance and greater flexibility than classical relational databases (e.g., Robinson, Webber, & Eifrem, 2013, p. 9 ff.). For the use in a process oriented system a graph database offers the advantage that the underlying storage model and most process modeling notations share the same basic premise (a graph based structure). As such items from the conceptual model can be more directly mapped to the underlying storage model allowing for easier and less convoluted access to the data. As such the different elements of the HREPC are mapped to nodes and edges of the graph represented in the graph database.

Figure 72 shows how the storage in different nodes of the graph database translates to the conceptual model of the HREPC in the concrete and abstract syntax as well as to the final visual representation of the model elements to the user. One important aspect in the repository is the differentiation between concrete syntax and abstract syntax as it allows for the use of multiple concrete representations for the same abstract model. In the prototype this is achieved through the use of different programmatic layers that are transparently connected through Java interfaces.

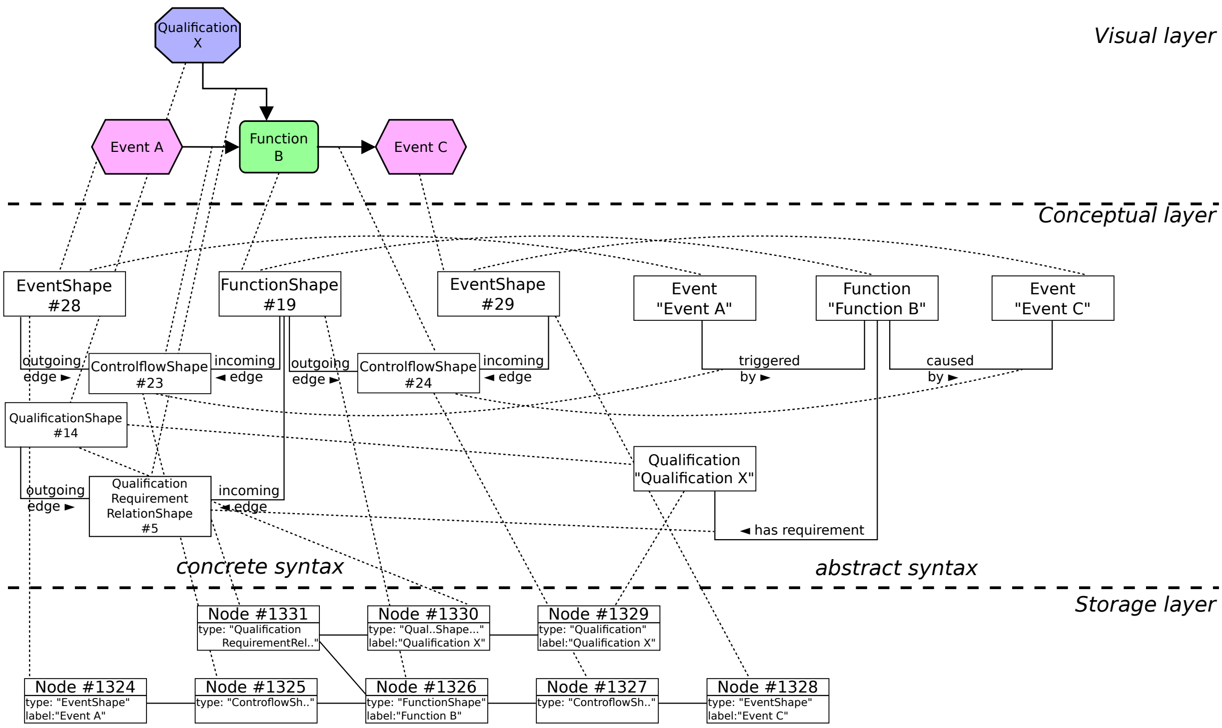


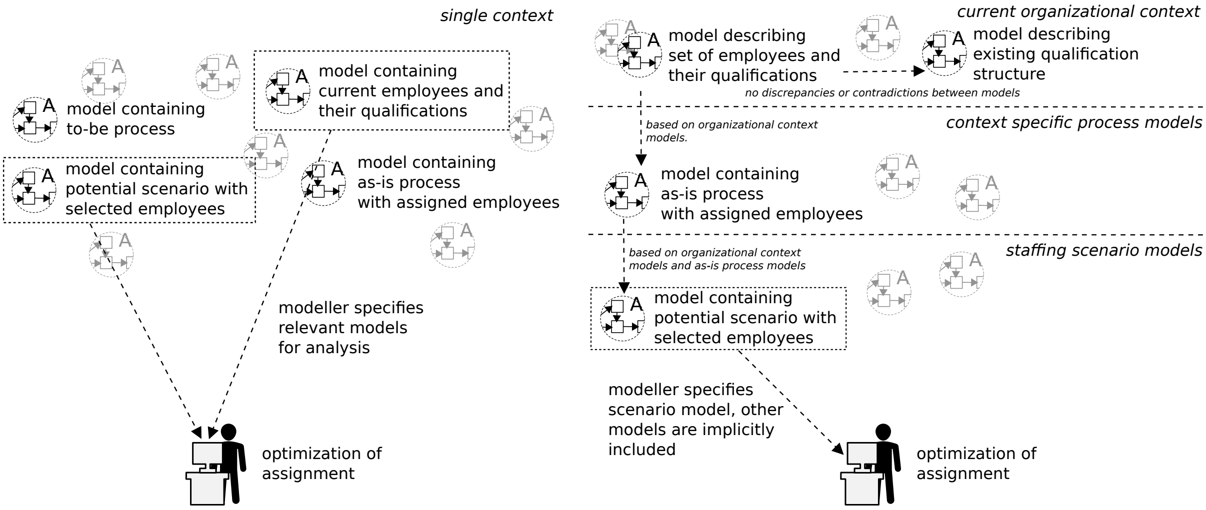
Figure 72: Relationships between visual representation, conceptual model, and storage of augmented process models in the prototype.

One of the main challenges for a model repository or a proHRIS lies in the synchronization of the model representations created and edited by the users in the concrete syntax and the representation of the model in the abstract syntax in the information system itself. An often used solution is to keep two separate instances of the models in the system, a model in the concrete syntax and one in the abstract syntax. Changes in the concrete syntax model are then mapped to the model in the abstract syntax (e.g., Ráth, Ökrös, & Varró, 2010; Baar, 2008). In the repository of the prototype the differentiation between the concrete and abstract model is performed through different classes, with the details of the implementation abstracted through interfaces.

Operations related to the concrete syntax model are performed by classes in the package de.unisaarland.mis.visualmodel that contains the interfaces Canvas and Shape. The Canvas represents the "drawing" context in which the different visual elements are created, while Shapes represent the different elements of the concrete syntax. While there is a generic ShapeImpl class different specializations allow for the "understanding" of model elements by the system. For example, a FunctionShapeImpl class contains the logic to represent the FunctionShape of the concrete syntax. That class then has specific methods to query other connected shapes. If another concrete syntax was designed, specific implementations of the shape interface would allow the support of the adapted notation.

The abstract syntax model is represented in the de.unisaarland.mis.domainmodel package which contains specific interfaces for all relevant abstract entities (Function, BusinessProcess, Qualification, Employee, etc.). Specific classes that implement these interfaces then allow for the mapping between the concrete and abstract syntax model. For example, the FunctionImpl class implements the Function interfaces and uses the specific FunctionShapeImpl instances to query relevant information of a function in the abstract syntax. As such, the qualifications required by a function can be queried through the interface method Function.getRequirements() which would return a collection of QualificationRequirements representing the specific qualifications that are required by the given activity. The specific implementation FunctionImpl.getRequirements() uses the FunctionShapeImpl and traverses the graph collecting all QualificationShapeImpls connected to the FunctionShapeImpl through a QualificationRequirementRelationShapeImpl. As such, another concrete syntax can be supported by a different implementation of the Shapes and, for example, Function interface.

Another important aspect of the repository implementation in the prototype is the integration between the process model and the other organizational models (the employee and qualification model). This differentiation is required because part of the models are static while others represent potential scenarios. During the design phase of the life cycle of the business process, the as-is process model is changed to a to-be process model which is then implemented. However, the structure of the qualification elements existing and the employees employed by the organization as well as the qualification they are fixed for the process of creating the new to-be process model. For longer term plans the qualifications of employees can of course change by the change is very limited. They are a constraint posed upon the to-be process model that needs to be satisfied. As such there are two possible ways of representing this state of fixed and variable models in the system. One possibility is to not differentiate on a model level, but instead leave it up to the user of the system to ensure consistency in the created models and the current state of employees and qualification structure. In such a case there is no specific link between different models unless expressively specified by the modeler. This is the typical behavior of modeling tools. Each model stands by itself and contradiction in models, i.e., one models claims employee "Marc H." has the qualification "SAP Module: PP" on level 3, while in another model he has



(a) Single context for all models. (b) Specific classes of model in different contexts.

Figure 73: Different possibilities to handle as-is and to be models.

the qualification “SAP Module: PP” on level 7, are only seen as problematic by the system if the user explicitly asks for an analysis over those two models. For the assignment of employees this either means that the modeler creates a model containing all the required information or selects a group of models that is to be used for the assignment of employees to the process model (see figure 73, esp. 73a).

Another possibility is to define specific types of models in the system that are inherently linked to each other. In this case there are specific types of models that represent the current organizational context and these models are automatically linked by the repository not allowing any discrepancies or contradictory information in models that are to represent the context. Specific process model that represent the as-is process models and assignments can then be created and they are based upon the organizational context, i.e., only qualification previously already defined in the organizational context models can be used to define the requirements of business processes in the as-is process models, or assigned to newly defined process in to-be process models. The creation of a specific assignment model requires the existence of models specifying processes to be planned and describing the organizational context. The modeler selects an existing process for which the assignment of employees in a specific time frame is to be planned (see also the section 5.2.3.3). The available qualifications and especially employees are limited by what is described in the models of the organizational context (see figure 73b).

The prototype is designed around the second approach. The differentiation between different model types has some advantages over the usage of a single context in which all models are kept independently from each other. The system ensures the consistency of all models in the organizational context. While enforcement of a global organizational context restricts the possible models that are created with the prototype, it ensures that no conflicting models are created. Especially in an area where multiple scenarios can be created by multiple process owners the usage of the same underlying organizational context ensures that the different plans are not contradicting each other, or that conflicts are identified as soon as possible. The usage of a central collection of organizational context models also allows for the easier import and change of new information into the system. If new information about employees or the qualification structure used by the organization is imported into the system, all existing models in the organizational context can be invalidated or archived. In a single context approach while new models containing the new updated information can be created in the system, there is no easy way to identify which models contain the relevant information that is now not outdated.

The repository provides access to the models through a RESTful web service (e.g., Richardson & Ruby, 2007) which is used by the client-side components of the system, or external systems to access the contained models. A specific plugin in the modeling component allows access to the repository from the client side and manages the loading and saving of models.

5.2.3.3 Description of the application layer components

The core application components of the prototype are provided by a generic analysis component that can be used to analyze process models given specific criteria, as well as staff assignment specific component that provides the specific functionality for the assignment of employees.

Staffing component

The main functionality of the prototype is provided by the staff assignment component that is split into a server side and client side part. On the server side, a PersonnelPlanningService component provides the specific staff assignment functionality. The core classes used to represent the different concepts of the problem space are the MatchingScenario, MatchingPlan, and PlannedEmployee classes.

The PersonnelPlanningService manages the different scenarios that can be used for the planning of the employee assignment. Each scenario contains a selection of operational business processes that are to be planned in coordination. The MatchingScenario represents a specific planning scenario that is to be planned by the process owner. The MatchingPlan represents an operational business process that is to be planned. The selection of possible MatchingPlans is restricted to the existing set of organizational context specific operational business process models that exist in the process repository. Each operational business process model in the repository represents a business process as it should be enacted in the organization. A MatchingPlan then represents a specific group of realizations of this process in a specific time frame with specific employees in the organization.

In addition to MatchingPlans for the processes of the organization a scenario also contains a set of PlannedEmployees. These represent the employees that are to be included in the business processes that are planned. The set of planned employees is, again, based on the selection available from the organizational context. Furthermore, the possible qualifications of employees are restricted to those defined in the respective models, as the prototype shows a short term personnel assignment in which qualifications of employees do not have the time to change. The available time of employees can be set to account for employees being planned in processes outside the scope of the given scenario.

On the client side the staffing component is represented through a specific ExtJS application that manages the MatchingScenarios and MatchingPlans exposed by the server.

Analysis component

The analysis component of the prototype provides features to validate the process models with regard to its abstract and concrete syntax as well as semantic correctness. The analysis component is split into a server-part which performs analysis over the abstract syntax model, as well as analyses spanning multiple concrete syntax models and a client side component that can analyze the given concrete syntax models that is currently the focus in the client.

On the server side different classes implementing the Validator interface can be used to traverse the abstract syntax model and identify problems. For the concrete staffing problem tackled in the prototype a MatchingPlanValidatorImpl class is used, that is specifically tailored to analyze operational business process models from a given scenario. The MatchingPlanValidatorImpl class identifies problems such as missing information in the model (no set time for activities, missing frequencies of activities, etc.). The missing qualifications for assigned employees, missing assignment of employees to functions that should be planned in the scenario, contradictions between the planned process model in the scenario and the organizational context, (e.g., the employee being assigned for more time than the organizational context says he or she is available), etc. To achieve this, the MatchingPlanValidatorImpl uses a collection a further nested Validator implementations (FunctionValidatorImpl, ModelValidatorImpl, EmployeeMatchValidatorImpl, etc.) that each test for specific problems in the abstract syntax model.

On the client side the analysis component is represented through a plugin for the modeling component that exposes the server side functionality on the client as well as offer simple syntax checking for client side models.

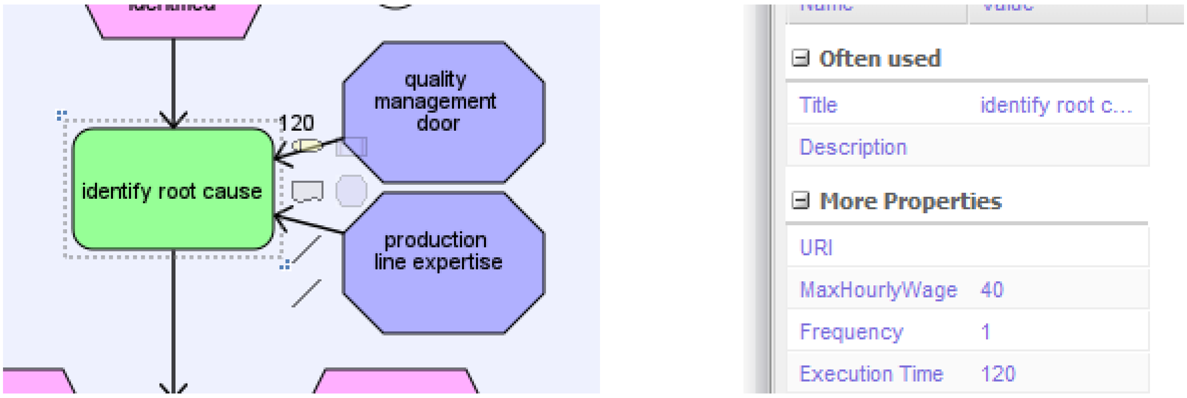
Modeling component

The modeling component of the prototype is completely implemented on the client side of the system. Its basis is provided by a general purpose modeling tool that has been adapted to fit the requirements of the prototype. This includes the definition of the modeling notation in a language parseable by the tool (see appendix A) as well as the creation of specific plugins that allow the communication of the modeling tool with server side components.

Plugins communicate with the main Canvas component of the modeling tool through a PluginFacade. The facade exposes methods through which plugins can interact with the canvas, listen for, and raise events. Plugins can also add graphical user interface (GUI) elements to the modeling tool through the facade and handle the user interaction with these elements. For example, the analysis plugin creates a button in the GUI to start an evaluation of the model. To achieve this the plugin request the currently existing model from the facade and forwards it to the server. There the analysis component temporarily updates the existing state of the model and analyses the resulting process structure. The results of the analysis are sent back to the analysis plugin on the client which uses the facade to display the results visually inside the canvas.

5.2.3.4 Description of the user interface layer components

The user interface of the prototype is constructed as a web application that uses the browser and the standard web technologies (HTML, CSS, JavaScript) to display the interface to the user. There are five views mainly relevant for the user. A welcome screen that serves as an entry point



(a) Augmentation of the process model with qualifications.

(b) Setting of specific function element properties.

Figure 74: Activities performed for the augmentation of the process model.

to the application, a repository browser, a simple model management tool for the organizational context models, a staff assignment interface, and the modeling editor. The repository browser allows the user access to the existing models, allows the creation of new models, and offers the possibility to delete models. The simple management tool, allows for the import of a qualification model and the employee data from Extensible markup language (XML) documents, simulating the import from an external system. The staff assignment interface allows the user to display existing scenarios, create new scenarios and assign employees, as well as specific process to be planned. The interface of the modeling editor consists of the canvas that displays the current process model, as well as the elements (menus, panels, windows) created by the different plugins that extend the functionality of the tool.

5.3 Appraisal of the prototypical implementation

5.3.1 Demonstration of the functionality based on an exemplary use case

To show how the prototype supports the assignment of employees an adapted version of the use case discussed in 4.3.3.2.4 is enacted here. The individual steps of the use case are discussed in the following.

Similar assumptions as those made in the original use case are made for this enactment. It is assumed that the models in the organizational context have already been created before the assignment of the employees is performed. These models represent the existing qualification structure in the organization as well as the existing employees and their qualifications. A process model for the specific operational business process used in the assignment here already exists, but still needs to be augmented with HR relevant information.

The augmentation of the process model is performed by the process owner and the relevant process coaches that add relevant information to the existing process model that are needed for the support of the assignment of employees to the process. In the prototype's case this includes the definition of qualification requirements for activities (see figure 74a) as well as the setting of additional properties for the function elements representing the activities (figure 74b).

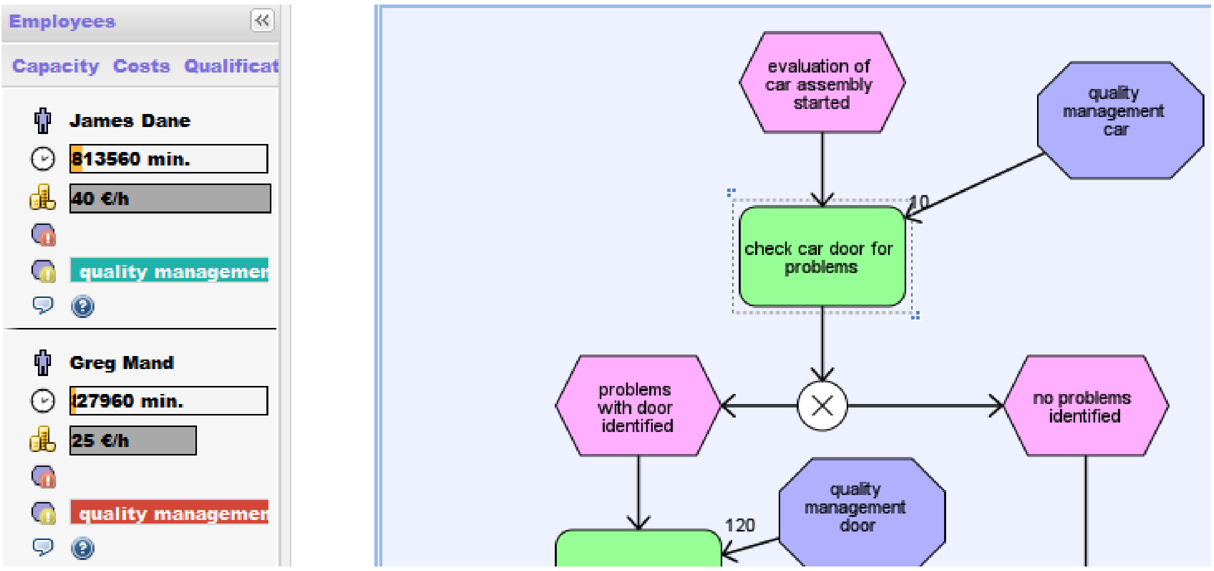


Figure 75: Overview of the employee list in the prototype supporting the assignment.

Once the process model is augmented it can be used for the assignment of employees. The assignment of employees is always specific to a certain planning context for which the concrete assignment plan is created. Multiple assignment plans for different processes can coexist in a single scenario, but only one plan per process model can be active at the same time. Active plans are used for the process overarching calculation of employee workload. The assignment itself is performed in a specific GUI that combines the editor view, with an additional employee list, that the system populates with the employees available in the current scenario. The list is sorted by specific criteria set by the user. These criteria include the qualifications of the select function and of the employees, the wage of the employees, the available time of the employees, the preferences of the employees with regard to the selection function, etc.

The assignment itself is performed by the user by dragging an employee from the list of available employees to a specific function and confirming the amount of time the employee should be assigned to that function. The model is then updated with the employee assigned to that function. The list of employees is also updated to take into account the new state of the represented scenario. The user then assigns employees to the functions by browsing through the model and assigning employees to the respective tasks. Figure 75 shows the employee list and an extract of the operational process model. The selected function "check car door for problems" requires the qualification "quality management car". The system proposes the employee "James Dane" instead of the employee "Greg Mand" even though the wage of "James Dane" is higher (40€/h vs. 25€/h) because he has the required qualification "quality management car". Both employees' workload allows them to perform the function without restriction and they do not have specific preferences for the selected function.

Once the user has performed the assigned to his or her liking, or even during the assignment process itself, he or she can use the analysis component of the system to evaluate the model with regard to problems with the planned assignments. Figure 76 shows an example of the analysis results in form of an overlay over the visual model of the assignment. Problems with the assignment and the process definition itself are shown as traffic lights at the relevant items. In the

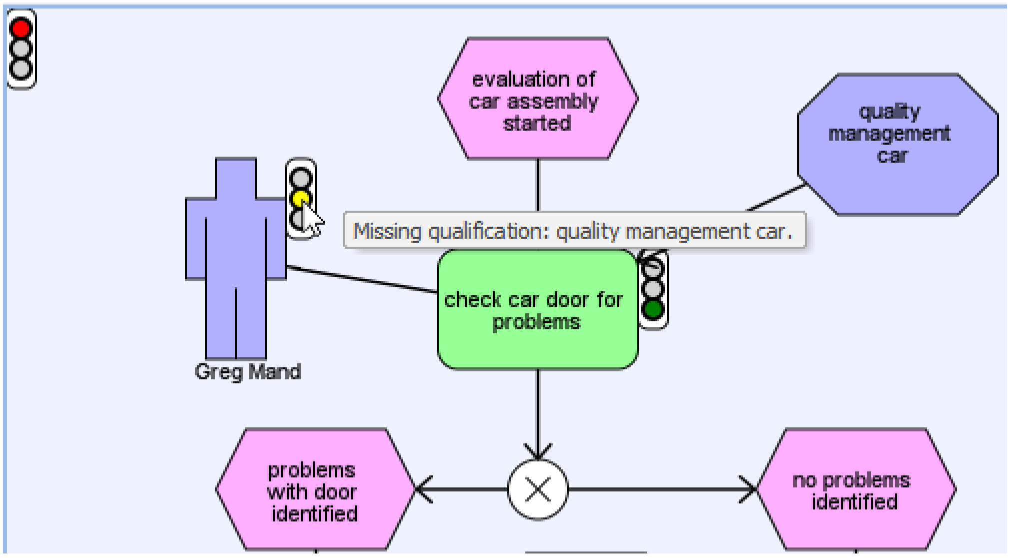


Figure 76: Example result of assignment model analysis.

example the employee “Greg Mand” has been assigned to the function discussed previously, but as he does not have the required qualification the system detects a problem with the assignment. As the qualification is set as optional a yellow light is shown to symbolize that while the employee can still enact the activity he is missing a qualification that would benefit the enactment itself. In addition to the analysis of the assignment itself, the system can also provide general information, for example, about overall personnel cost, taking into account all assigned employees and their hourly wage. Through this different planned processes can be compared or different scenarios evaluated against each other.

In the initial use case the finalizing of the assignment was described as pushing the resulting planned model to a PAIS for enactment. As the prototype is not connected to any enactment system, this step can not be achieved. The planned model itself can be output either in serialized format (see also appendix A) or in form of reports that can inform the involved actors about the assignments. Additionally, the RESTful interface of the prototype can be used to access the finalized scenarios from an external system.

5.3.2 Discussion of the prototypical implementation

For the prototypical implementation of the proHRIS the general requirements where further specified with regard to the specific use case that is focused on in the prototype.

To fulfill the requirement of a notation that can represent the concepts of activities, qualifications and employees as well as the relationships between them (**PR1**) the HREPC notation was developed. It includes the relevant concepts as well as the necessary specifications to use these concepts in the context of staff assignment. Additionally, the notations allows for the representation of relationships between qualifications, as well as between activities on different abstraction levels (**PR2**). To support the adequate display of the organizational framework in which the different operational business processes take place the prototype differentiates between organizational models that describe the context, as well as specific process models that are restricted to the description of the actual operational business process, its requirements and employee assignments. These models, however, do not allow changing the organizational context, which is assumed to be fixed for them.

The editor component allows for the creation and editing of models in the HREPC notation (**PR3**) and the repository component offers the possibility to manage the models independently (**PR4**). The editor additionally interfaces with the analysis component to offer simple syntactical analysis, as well more in depth semantic analysis of the created models (**PR6**).

Through a specific staffing component different scenarios can be created and specific assignment plans for operational business process created and compared (**PR5**). The scenarios are based on the previously defined models describing the organizational context and only allow limited changes to the model during planning (i.e., the assignment of employees). The staffing component also directly offers a list of assignable employees that best fit the currently highlighted Function element. Supporting the user in the effective and correct (with regard to the given constraints) assignment of employees to activities.

The assignment is further supported by specialized functionality of the analysis component for the evaluation of assignment plans. The analysis component can be used to analyze the assignment with regard to its quality based on criteria of the organizational context and the assignment constraints (**PR7**).

The final requirement set for the prototype was the possibility of external systems to access the saved models, analyses and organizational data (**PR9**). This is achieved through the RESTful interface on the server side of the system. This, however, restricts the available analysis to those that are performed on the server side of the system. The typical single model syntax analysis, which is solely performed on the client side of the system can, for example, not be accessed through the interface.

During the implementation of the system some interesting issues which require further research have been encountered and should be noted here.

One of the main ideas of the prototype was the differentiation between different types of models. While these different model types allow for a contradiction free collection of different models, all based around the same organizational context, they heavily restrict the creation of models by single users. As the information relating to the organization context can not directly be defined in the process models used to represent the operational business processes. This separation forces the users into a specific order of steps for the assignment of employees (process follows software). During the usage of the prototype this has sometimes led to problems, as the editing of process models or organizational context models was wished for.

A case can be made for the restriction on the modeling of qualification to employee relationships to be less strict: the possibility to deviate from the current organizational context would allow for the assignment of specific additional qualification to employee for the context of the planned scenario. This could allow the planning of longer term assignments taking into account the possibility of employees to be acquire new qualifications. The resulting development need of the employee could even be derived from the scenario and presented to the respective employee. However, such a modeling approach assumes that employees will be able and willing to acquire the qualification assigned to them in the given scenario. If that is not the case the plan created for the assignment of the employee is not valid. In a process redesign setting, changes to the processes can be prescribed from the top down, i.e., the process owner decides which steps are performed in a process (barring any external regulatory organ). When changing properties of Employee elements, or their relationships to qualifications, or functions, this strict order is not present anymore. The preference of an employee towards specific activities in a process, or towards working with individual other employees can not simply be changed through a change in the model. Team exercises and workshops can try to affect employee stances but the changes are gradual at best.

If the system does not pose any restrictions on the modeled external components, the responsibility to keep track of these discrepancies lie with the user of the system. This is insofar problematic as it contradicts the basic idea of the system supporting the user in the staffing process.

Another issue that became clear during the development of the prototype is that the visualization of the operational business process models plays an important role in the support provided by the system. The prototype offers a very visual model centric approach to the assignment of employees. This was initially chosen because it ensures a very tight integration between the solving of the assignment problem and while respecting the specificity of the operational business process. Furthermore, research in cognitive sciences indicates that visual notations can have a number of advantages over other forms of presentation (e.g., Cheng, Lowe, & Scaife, 2001; Moody, 2009; Moody, Heymans, & Matulevicius, 2009; Scaife & Rogers, 1996). However, many aspects play a role in the quality and effectiveness of the notation that is used. While on an abstract syntax level the expressiveness and semantic power of the notation play an important role for the range of analysis that can be performed with it, on a concrete syntax level the design and other characteristics of the visual elements play an important role for the advantages of using a visual notation. Different variables (e.g., “Bertins variables” in Carpendale, 2003; Garlandini & Fabrikant, 2009; Genon, Heymans, & Amyot, 2011) have been identified which influence the usefulness of the elements. While the created elements for the HREPC generally try to follow the design guidelines outlined in the literature, no in depth investigation of visual element quality was performed.

One problem area is, for example, the choice which properties of the abstract syntax model to visually represent in the notation of the concrete syntax model. The relationship between a Function and a Qualification the Qualification Requirement, for example, has a range of properties (see section 5.2.2) which are not visually represented through the concrete syntax. The optionality of a qualification requirement is only visible through the properties in the modeling tool of the prototype and not in the visual representation of the model. In the concrete syntax of the HREPC as implemented for the prototype, the Qualification Requirement is expressed through an edge between a QualificationShape element and a FunctionShape element. A missing visual cue about the optionality of the requirement can lead to confusion, e.g., if the assigned employee does not have the required qualification, but the system acknowledges that the activity can still be enacted. Only through a check of the properties of the relationship can the user identify that the qualification is in fact only optional and does not hinder the enactment of the process.

A way of visually encoding the optionality in the concrete syntax would be to change the “grain” variable (Genon et al., 2011, p. 380) of the edge if the requirement is optional. A solid

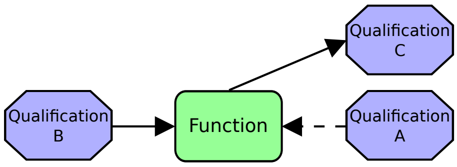


Figure 77: Example visualization of qualification requirements of an activity in a concrete syntax model.
The activity provides the qualification "Qualification C" (the edge points to the FunctionShape). It requires both "Qualification B" and "Qualification A" (the edges point towards the QualificationShapes). The requirement of "Qualification A" is optional (the edge has a dashed line).

edge would represent a mandatory requirement, while a dashed line would represent an optional requirement (e.g., figure 77). Another possibility is to display the QualificationShape itself with a dotted border. While such changes increase the expressiveness of the concrete syntax they also increase scale of the syntax rules a modeler or reader of models created in the notation must know (graphical complexity; cf. zur Muehlen & Recker, 2008, p. 478). Further research is needed to identify the best trade off between expressiveness of the visual representation and ease of use and understandability of the representation.

Another aspect linked to the expressiveness of the modeling notation is that of complexity management. One major flaw of visual notations is complexity (Genon et al., 2011, p. 388). The more information is contained in HREPC model the more elements are displayed to the audience. The HREPC and the prototype use abstractions to reduce model complexity. As discussed before (see section 4.3.2.3) abstractions can result in a change of granularity or a change of coverage. For both issue that needs to be solved is which is the abstraction level that reduce the complexity of the model adequately without hiding required information from the user of the system. A change in granularity with regard to activities can be problematic for the task of staff assignment, as the goal is to assign employees to specific activities. An unreflected aggregation lead to a decrease of precision for the assignment.

However, if activities are grouped by specific criteria, the model complexity could be reduced while still providing adequate information to the user to perform his or her task. For example, activities that require the same qualification but are mutually exclusive could be represented to the user as a single activity. This would allow a reduction in complexity of the model while still allow for the assignment of employees.

Another possibility to reduce the complexity of the model is a reduction in coverage. The prototype implemented a plugin on the client side of the staff assignment component to reduce model coverage. This plugin offers the possibility to temporarily hide all qualification to get an overview of the process structure without all qualification elements showing. While this gives a good overview of the process flow, the qualifications are required for a meaningful assignment of employees. On the other hand, if the suggestive system of the staff assignment component is used, the user already visually receives feedback about the missing and available qualifications of employees. For a choice on which elements of the model can safely be abstracted away without impeding the staff assignment task more research is needed. This is especially true as changes in the syntax of the modeling notation can also be used to reduce information loss on abstraction operations.

5.3.3 Example extensions of the HREPC

The HREPC as described here was kept very close to the original EPC and only augmented with the elements required for the specific problems focused on in the prototypical implementation. More complex abstract syntax changes can be sensible for a HREPC relevant for all functional areas of the proHRIS. In the following some changes to the concepts used in the implementation as well as other concepts that are relevant for the overall proHRIS are described. It is shown how through the further use of logical operators (already present in the classical EPC) more complex states can be represented and used for a more involved analysis of requirements. The concepts of training activities, development needs, goals, and measures are also introduced to show how these could be represented in the HREPC.

5.3.3.1 Qualification

The HREPC as described in section 5.2.2 has a very simple notion of qualifications. Each stands by itself and does not relate to other qualifications. Relevant for the matching of employees to activities, however, is the notion relationships between qualifications as well as more complex relationships in the requirement of qualifications. A more complex example of the treatment of qualifications in the HREPC is possible.

A Qualification might supersede another Qualification. For example, an employee having the qualification “Advanced English” might not explicitly have the qualification “Basic English” but still be able to enact the activity. Furthermore, for the matching of employees to activities it is also relevant if an employee has a qualification to a bigger degree than some other employee, as this might reduce the time needed to impart the qualification to the employee. Continuing the example from section 5.2.2 an employee having the qualification “Basic English” while not fulfilling the requirement of the qualification “Advanced English” for an activity, still matches the activity better than an employee having no English skills at all. To be able to express these nuances an adapted version of the HREPC defines different relationships between Qualifications: a Qualification can include another Qualification, be part of another Qualification, or it can be equivalent to another Qualification (see figure 78). To be able to represent that qualifications can require one or more different other Qualifications logical operators (as known from the EPC) are used. The logical relationship is represented through a generic Collection that is implemented by different specific collection throughout. Here it is implemented by the Qualification Collection. A Collection can be further specify by an Exclusive OR Collection, an OR Collection, or an AND Collection An AND Collection. These represent the different logical combinations that are available. A Qualification Collection including three Qualifications represents, for example, that an employee having a qualification also has all three of the included qualifications.

Based on the more complex conceptualization of Qualifications, a more complex relationship between Functions can be represented. While a Function still either provides or requires Qualifications, the requirement of Qualifications can be modeled with logical operators in mind. Similar to the relationship between qualifications, an activity “inform supplier” might require (besides other qualifications) either the qualification “English” or the qualification “French” because the

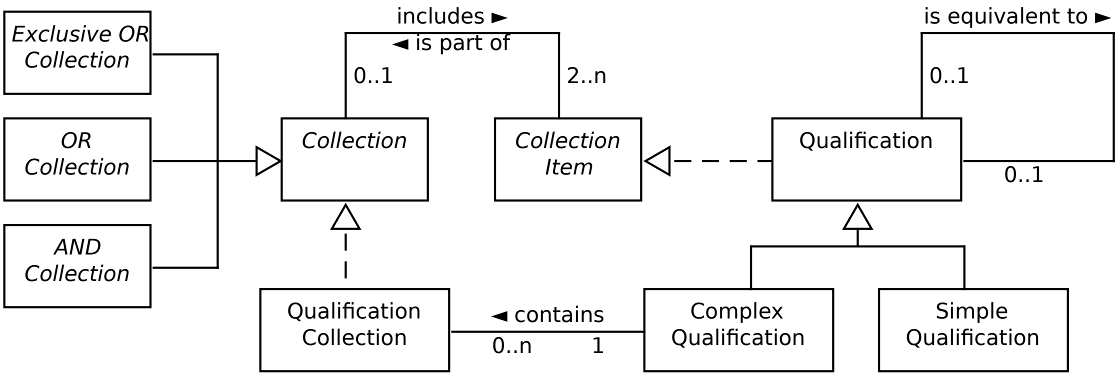


Figure 78: HREPC abstract meta-model: Qualification.

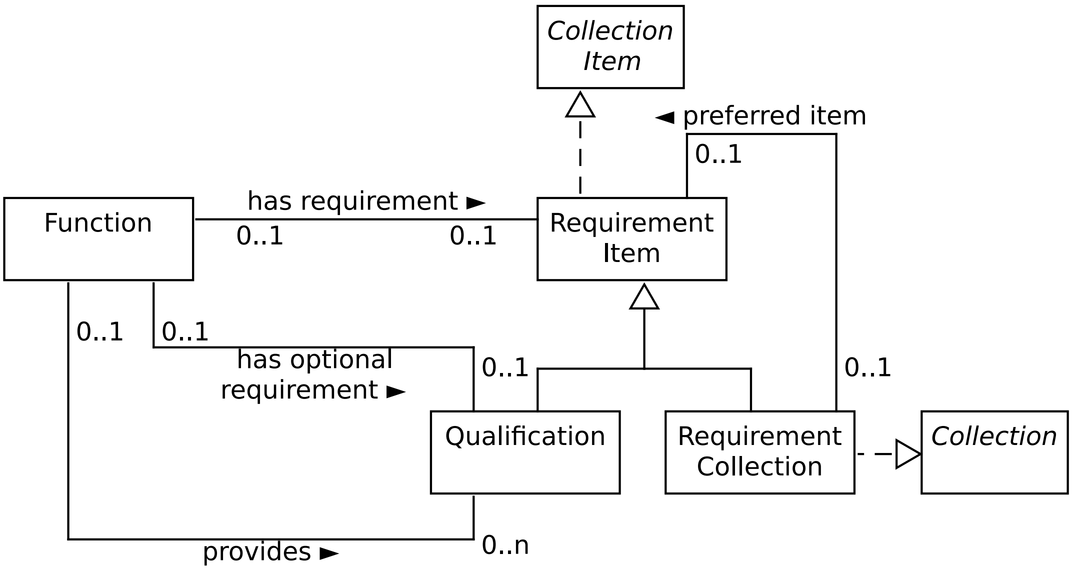
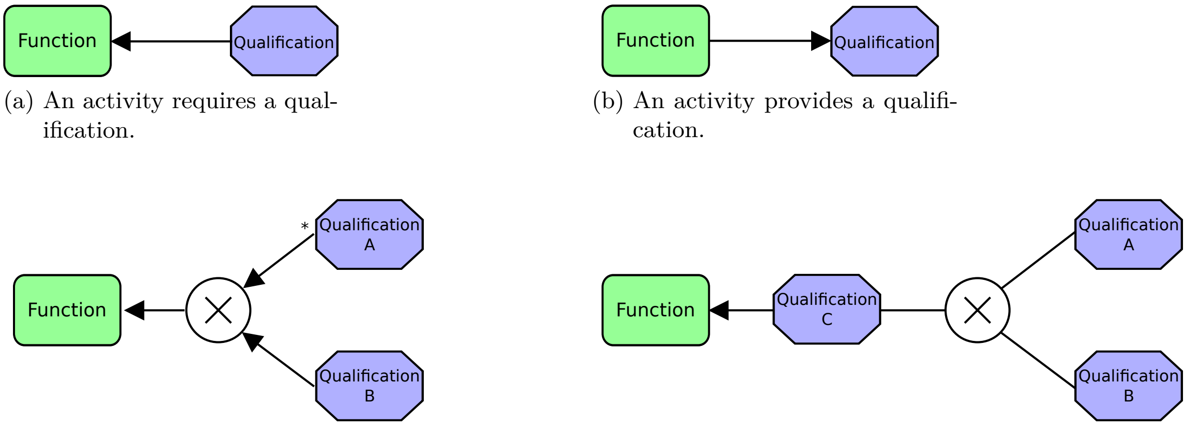


Figure 79: HREPC abstract meta-model: relationship between Function and Qualification.

business partner only can communicate in those two languages. The HREPC uses logical operators to represent requirements of the Function as they allow to express a greater number of specific cases. As such the logical operations AND, OR, XOR are used. In the meta-model this is represented through different classes (see figure 79). A Function requires (potentially optionally) a Requirement Item. A Requirement Items is either a qualification or a collection of requirement items, a Requirement Collection (which uses the Collection template). These collections contain at least two other Requirement Items (through Collection Item) and can mark one as the preferred one.

Visually, the relationship between a Function and Qualifications can be represented in the HREPC through a connection between the FunctionShape element and the QualificationShape element. In its simplest form the relationship is represented simply as a directed edge with a dotted line, a RelationShape (see figure 80). The FunctionShape can be connected to one QualificationShape through the RelationShape. The edge can be directed towards the QualificationShape (in this case the Function has one required item, which is the Qualification itself; figure 80a) or it can be directed towards the FunctionShape, in that case the Function provides the represented Qualification (figure 80b). The representation of more complex relationships makes use of the logical connectors. For example, an activity might require one of two qualifications, i.e., the per-



(a) An activity requires a qualification.

(b) An activity provides a qualification.

(c) An activity requires one of two qualifications explicitly.

(d) An activity requires a qualification consisting of one of two other qualifications.

Figure 80: Example representation of possible relationships between activities and qualifications.

former speaking either English or Spanish. This can be represented in two ways: either through a Qualification Requirement Collection or through a Complex Qualification. The first option uses an XORConnectorShape to represent the Qualification Requirement Collection as well Qualification-Shapes for the contained Requirement Items which are Qualifications (figure 80c). The preferred item relationship is displayed through a star along the edge leading from the QualificationShape to the connector. The second option uses an XORConnectorShape to represent a Qualification Collection (figure 80d). This example assumes that a specific qualification is available in the organization that forces the employee to have either one or the other qualification.

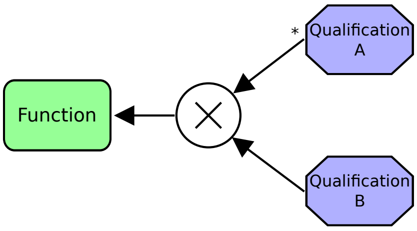
Some examples of the semantics resulting for the matching are given in figure 81.

As seen above, a Function can also optionally require a Qualification. This relationship bypasses the Requirement Item as logical operations with optional items do not make sense. Instead, the Qualification is directly related to the Function as optionally required.

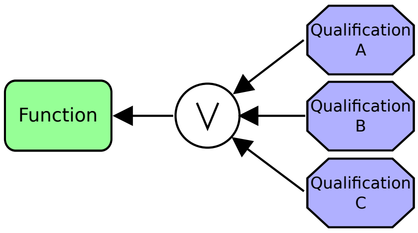
While this could be seen as a qualitative deficiency of the notation (e.g., Fettke & Loos, 2003), the additional ease-of-use and understandability outweighs that, as it is much simpler to differentiate between optional and not optional qualifications.

5.3.3.2 Training Activity

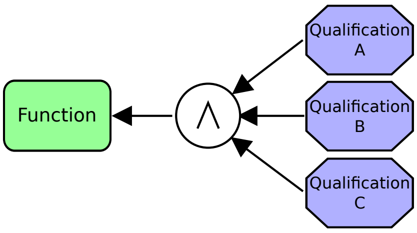
In addition to their relationship to activities, qualifications can also be related to Training Activity elements. These represent either organization internal or external activities that allow employees to acquire specific qualifications. Normally the model represents Training Activity as a type and not as a specific Training Activity Instance. For planning and assignment of employees it might, however, be useful to either directly use concrete Training Activity Instances, or to relate those instances to specific Training Activity types. Due to this the specific properties that are required when modeling training activities depend on how the proHRIS is integrated in the overall IS architecture. If, e.g., the proHRIS is connected to a learning management system, the training activity types might have an identification properties that allows them to be linked to training activity instances management in the learning management system (cf. section 4.3.3.4.5). If the



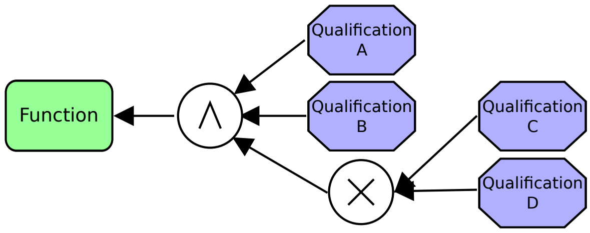
(a) An employee must have either "Qualification A" or "Qualification B" not both.



(b) An employee must have at least one of the qualifications A, B, and C or any combination.



(c) An employee must have all the qualifications A, B, and C.



(d) An employee must have qualifications A and B, as well as exactly one of qualification C or D

Figure 81: Example of impact for matching of employees of logical operators in function relationship relationships.

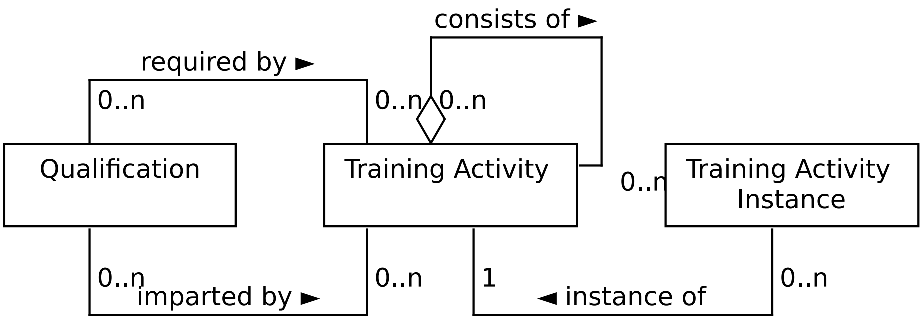
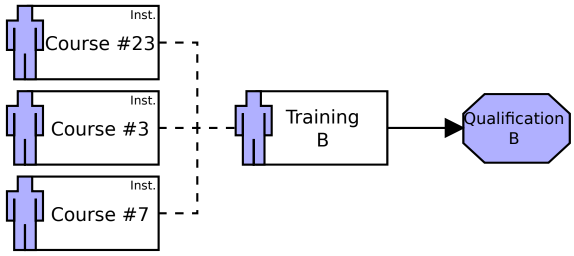


Figure 82: HREPC abstract meta-model: Training Activity, Qualification, and Training Activity Instance.

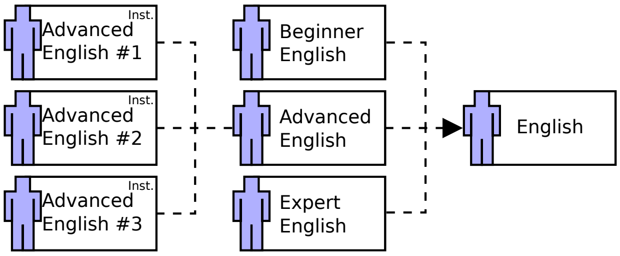
training of employees is to happen during their working time, a property denoting the workload of the training activity, can be included as a property of the Training Activity and used for planning the available working time of employees assigned to activities in the next planning period. The section of the meta-model about Training Activity types and instances is shown in figure 82.

Figure 83 shows an example of possible relationships between Training Activitys (and instances) as well as Qualifications. A Training Activity can require and provide qualifications similar to a function. This is represented through a Training Activity Shape that is connected to a Qualification Shape through a RelationShape (figure 83a). Again the direction of the edge symbolizes the requiring or imparting relationship. To visualize the instantiation of a Training Activity the Training Activity Shape is used and a small "Inst." label in the corner shows that this represents an instantiated activity. To show which Training Activity is instantiated a RelationShape is used to connect the Training Activity Shapes. The edge does not need to be directed, as there is only one type of relationship between Training Activity and Training Activity Instance and each instance

(a) A training activity “Training” requiring “Qualification A” and providing “Qualification B”.



(b) A training activity “Training B” providing “Qualification A” and the courses (23,3, and 7) that offer the “Training B”.



(c) A training activity “English” and consisting sub activities as well as specific implementing instances.

Figure 83: Examples of representations of the training activity in the HREPC notation.

can only be connected to one Training Activity (figure 83b). The visualization of the hierarchical relationship between Training Activitys, however, requires a directed edge, as otherwise it is not clear, which Training Activity is part of which (figure 83c).

5.3.3.3 Employee to Function relationship

Employees are related to Functions through an Assignment Collection and the Function Assignment. Each employee can be assigned to one or more functions. Such an assignment documents, that the employee should perform the function he or she is assigned to. The Function Assignment is an own element as it can also have properties, these include, for example, how much of time the function required should be performed by the employee (cf. allocation of resources in Jung, 2007, p. 160 ff.). The same templates that are used for Qualifications and their assignment to Functions are used here again, so that different combinations of employees can perform an activity. However, the semantics are different. The Alternative Collection represents that each employee is an alternative to the other assigned employees. Each can perform the activity by himself. The Combined Collection represents that both employees are needed for the successful enactment of the activity, but they do not need to work concurrently. The Concurrent Collection represents that both employees work at the activity at the same time. This allows, for example, to represent functions that require both employees to be present while Alternative Collections represent functions that require only one of the two.

Figure 85 shows an example of this and its visualization. Through the use of an AndConnectorShape it can be modeled that two (or more) employees have to work together to perform the function (e.g., due to a four-eyes-principle). For a valid assignment both employees then have to have enough available time for the whole workload (figure 85b). The XORConnectorShape is used

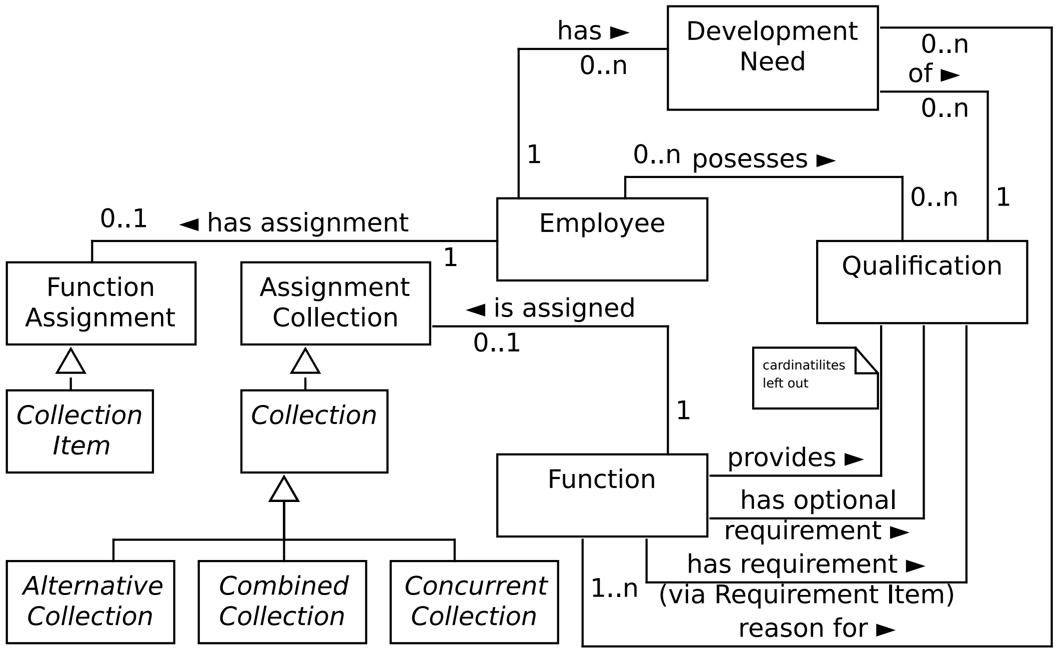
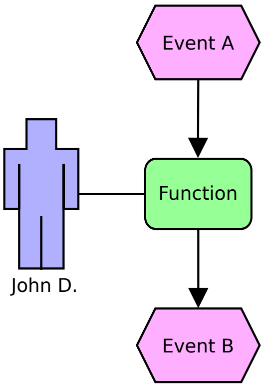


Figure 84: HREPC abstract meta-model: Employee, Qualification, Function, and Development Need.

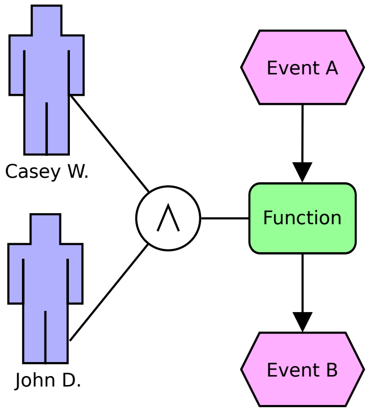
to represent alternative assignments (figure 85d), while a connection without any connectors is the default that represents a Combined Collection where all employees are required to perform the activity but are not required concurrently but in sequence.

5.3.3.4 Development Need

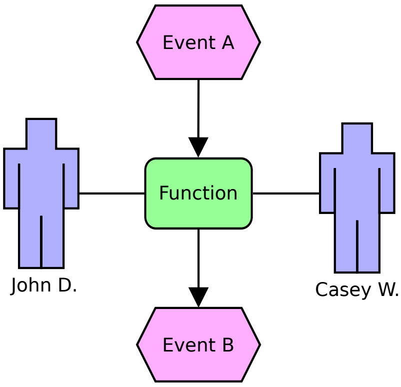
Another concept regarding development activities that is included is the HREPC and shown in figure 84 is that of a development need. A Development Need represents a documented decision that a given (missing) qualification should be acquired by an employee and why it should be acquired. The representation of a Development need differs from that of other concepts, as it does not stand by itself but always involves an Employee, the Qualification he or she should acquire, and the Function that is the reason for that need. The concrete visualization of an Development Need, the DevelopmentNeedShape , however, is an edge between a EmployeeShape and a QualificationShape. Through the connection of that QualificationShape with a FunctionShape the relevant Function for the need is made available. Figure 86 shows an example of an employee “John D.” requiring the qualification A while being assigned to that function (figure 86a) as well as Marc V. having a documented development need for qualification A while not being assigned to that function (figure 86b). The meaning of the diagram shown in that figure is: Marc V. should acquire qualification A so that he can perform the connected function. It should be noted, however, that this leads to the possibility of a syntactical correct model (two FunctionShapes connected to the same QualificationShape) being semantically unclear (if an DevelopmentNeedShape is used to connect an EmployeeShape to that FunctionShape it is not clear which Function is the reason for the development need). In such a case the model should be clarified.



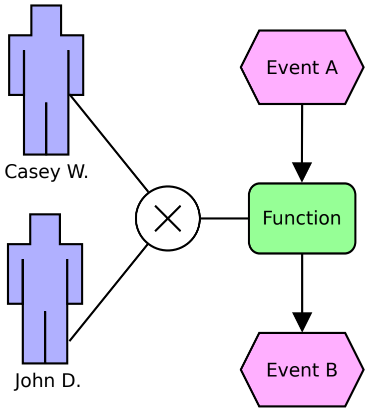
(a) An employee directly assigned to a activity.



(b) Two employees have to work together to perform the activity. Each employee has to be available all the time.

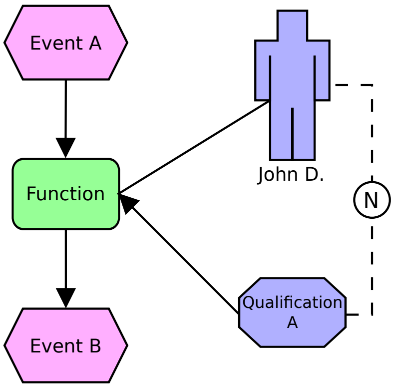


(c) Two employees share the workload of an activity, but the assignment is not exclusive, i.e., one employee cannot substitute for the other.

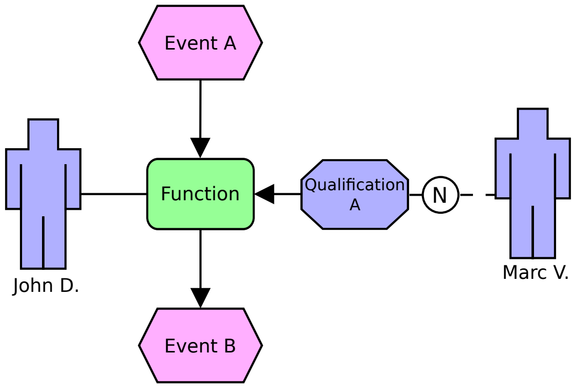


(d) Two employees share the workload of an activity. Each one can work independently of the other one. The logical either-or connector shows that only one or the other is needed for performing an instance of the activity (in contrast to figure 85c one employee can substitute for the other).

Figure 85: Example of employee assignment with and without logical operators.



(a) An employee that performs the activity has a development need.



(b) An employee not performing the function has a development need. The meaning of the model is (relating to the need): employee Marc V. should acquire "Qualification A" so that he can at some point perform the activity.

Figure 86: Examples of development needs representation in the HREPC notation.

5.3.3.5 Goal and Measure

Relevant for the appraisal (and compensation) of employees are goals and performance measures. Employees can also be connect to performance measures or goals. Goals represent organizationally desired results for the activities in a process. Goals are typically organized hierarchically with organizational goals resulting in goals for business processes and the business process goals being broken down into specific goals for activities and thus employees.

There is already an element for representing the concept of goals in the ARIS meta-model (Scheer, 1999, p. 22 ff.). The semantics of the goal element focus on organizational goals, specifically it is based on a critical success factors approach (following Rockart, 1979). Goals can be subordinated to each other and a structure of goals can be established. Furthermore, functions can be related to goals by supporting them. This support relation extends to overriding goals. While this simple structure allows for linking activities to organizational goals, attempts have been made to allow for a more complex modeling of goals and their relationship towards functions (see the literature review in section 2.4.2.4; e.g., Cardoso et al., 2009, 2010). For an use in the proHRIS a further breakdown of the wide organizational goals (which are defined by upper management) makes sense. These process level (or activity level) goals relate to a specific activity and the more broad organizational goals (see figure 87). The distinction between types of goals serves the clarity of the model and allows specific users to focus on relevant aspects of the model, or even modeling tools to filter process models accordingly (cf. Klug, 2011, p. 50). Each goal can be affected by a Function, a Business Process, and/or an Employee. To be measurable a Goal can be quantified through a Measure (the relationship between measures is not shown here; e.g., von Schneyder, 2006; Gladen, 2011). Measures themselves rely on data provided by Application Systems that are used to support (or perform) specific activities.

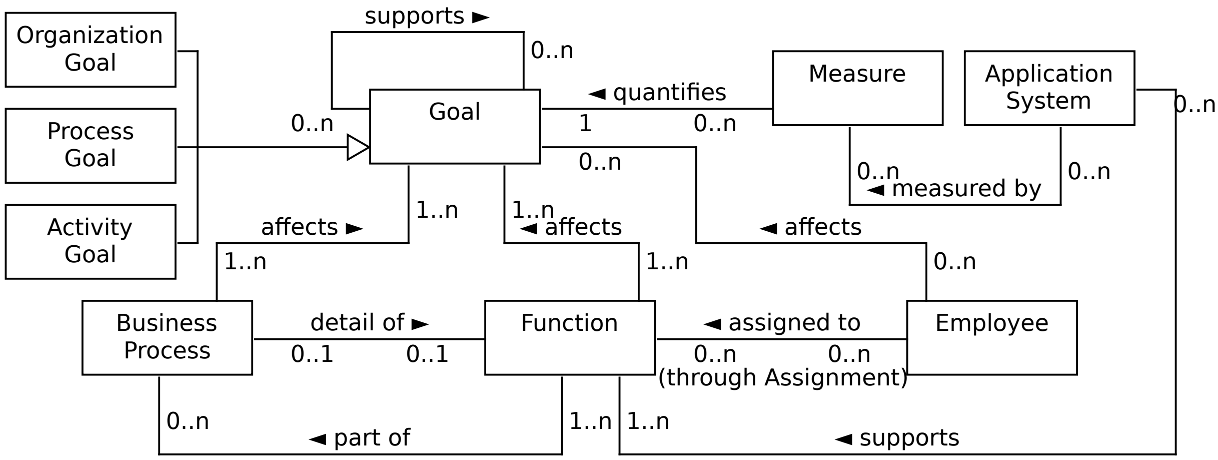


Figure 87: HREPC abstract meta-model: Goal and Measure.

5.4 Assessments of the requirements

5.4.1 Approach of this Section

While the general design of the proHRIS was presented in the previous chapter and a demonstration of the functionality was performed in the previous sections, no in depth discussion of the requirements and how are fulfilled by the system was performed. This section therefore discusses each of the requirements defined for each of the different HR functions and analyses through which components of the proHRIS the requirement is fulfilled and in what fashion. Additionally, the human aspects of the systems mainly responsible for the successful fulfillment of the requirements are further refined. As such, while the design of the system mainly focused on the application system this section bridge the design towards the full understanding of an information system.

Each of the following sections in turn discuss the requirements defined for proHRIS on a HR function basis. In a final step the results are then synthesized regarding the general requirements of the system that are not dependent on a specific HR function.

5.4.2 Discussion of the staffing requirements

The requirements towards the system from the staffing function are collected under the requirement of supporting staffing based on business process models (**FR10**). The requirements where defined as follows:

FR10-1 Allow the modeling of business process models that contain information relevant for the staffing process.

FR10-2 Offer the possibility to store instances of the concepts of activity, employee, and qualification as well as their properties as to support the optimization of the staff assignment.

FR10-3 Support the generation of job descriptions based on process models.

FR10-4 Ability to interface with a recruiting system.

FR10-5 Support the simulation and/or analytical optimization of staff assignments.

FR10-6 Provide access to historical process data to extract relevant information for staffing purposes.

FR10-7 Support documentation of personnel assignments for publication and use as basis for other HR functions.

The creation of specific models is supported by the modeling component as well as by the model repository. Through the definition of a specific modeling notation encompassing relevant HR concepts (through the management component) as well as the semantic understanding of that notation by the modeling component and the model repository the system can provide the required support (**FR10-1**, **FR10-2**). While the components can provide the underlying facilities,the fulfillment of the requirement strongly depends on the quality of the modeling notation. If the modeling notation is to strict, relevant aspects for the staffing of process can not be represented adequately. On the other hand, if the notation is to vague and allows multiple interpretations, the system cannot precisely deduce the required information.

This also applies to the creation of job descriptions based on the information available in the HR augmented process model (**FR10-3**). The model repository allows the execution of specific queries through the staffing component, which is then passed to the reporting component to create specific documents containing a description of the activities and requirements regarding a specific potential employee of the process. If such a job description can be successfully generated strongly depends on the completeness of the process model, as well as the amount of detail stored within. Additionally, the more detailed the concepts are represented in the notation and the more information about the concepts are stored in the system, the more detail the generated job description can contain.

<table>
<tr><th>Requirement</th><th>Relevant components</th><th>human / organizational aspects</th></tr>
<tr><td>FR10-1,FR10-2</td><td>▷ modeling component
▷ model repository
▷ management component</td><td rowspan="4">▷ modeling notation quality
▷ model quality
▷ data quality (of additional concepts)
▷ organizational conventions</td></tr>
<tr><td>FR10-3, FR10-7</td><td>▷ model repository
▷ staffing component
▷ reporting component</td></tr>
<tr><td>FR10-4</td><td>▷ API component
▷ model repository
▷ staffing component</td></tr>
<tr><td>FR10-5, FR10-6</td><td>▷ model repository
▷ staffing component
▷ intelligence component</td></tr>
</table>

Table 16: Assessment of the requirements and their fulfillment in staffing.

For the required interface to external systems, such as a recruiting system (**FR10-4**) many of the same aspects are important. On top of the quality of the notation and the models themselves the existence of organizational conventions about which level of detail to use for the created models and the consistency of the understanding of the concepts across IS play an important role. The interface itself can be achieved through the API component which allows for the exchange of information from the staffing component, based on the models stored in the model repository, with other systems.

The requirements of supporting the simulation based or analytical optimization of staff assignments (**FR10-5**, **FR10-6**) can be achieved through the use of intelligence component, especially the analysis and simulation component. Based on the models stored in the model repository specific analysis or simulations can be conducted through the staffing component to allow for an optimization of the staff assignment. Again the quality of the notation and the models strongly affect the results of the optimization possibilities offered by the system. A discussed previously, for example, the simulation of business process requires information about duration and frequency of tasks. The more detailed that information is the more precise the simulation results are. Without any information about the frequency or the duration of activities no optimization regarding the "load" of the process can be performed.

Finally, the documentation of existing or planned staff assignments is similar to the generation of job descriptions (**FR10-7**). Such a documentation can be provided by the staffing component through the reporting component based on information in the model repository. The focus simply shifts from querying the model repository about information concerning potential jobs in the process to actually assigned employees in the process.

An overview of the requirements and the components responsible for their fulfillment, as well as the relevant criteria are shown in table 16.

5.4.3 Discussion of the appraisal requirements

The requirements towards the system from the appraisal function are collected under the requirement of supporting appraisals based on business process models (**FR10**) and consist of the following requirements:

FR11-1 Allow the modeling of business process models that contain information relevant for process based employee appraisal.

FR11-2 Offer the possibility to store instances of the concepts of goals and measures as well as their properties as to support the planning and execution of process based employee appraisals.

FR11-3 Allow the creation and management of performance agreements based on specific business process models stored in the system.

FR11-4 Ability to interface directly with enactment systems or PPMS to receive performance information for the operational management of employee performance.

FR11-5 Provide intelligence features for the analysis of historical process and performance data for the appraisal of employees as well as the identification of goals and relevant measures.

FR11-6 Provide reporting functionalities to inform employees and responsible managers of current performance status and allow short term responses to unexpected deviations.

As with the respective staffing requirements the modeling of business process models containing relevant information for a process based appraisal and the possibility to stored the relevant concepts (**FR11-1**, **FR11-3**) is offered by the modeling component in combination with the model repository. Additionally, the specific interface provided by the appraisal component can support the augmentation of business process models with exactly the concepts required for the success performance management of the process and the employees and the execution of the appraisals. Again the quality and expressiveness of the used modeling notation that is given to the system through the management component and the amount of detail put into the process models created through the modeling component have an important impact on the amount and sort of support that can be offered through the system.

The ability to create and manage performance agreements (**FR11-3**) is provided through the appraisal component by the performance management component in combination with the model repository and the reporting component. The business process models relevant for the performance agreement can be pulled from the model repository by the appraisal component and presented to the relevant parties in form of specific reports created by the reporting component. As such the same components can fulfill the requirement of providing reports to the employees and managers informing them of current performance (**FR12-5**). Important human or organizational factors in the fulfillment of the requirements are the definition of clear organizational conventions regarding the definition of performance measures and criteria in the business process models as well as a clear definition of the sources for the (objective) values of the measures. Without clearly defined conventions, a modeling notation and models explicitly implementing these conventions the values and appraisals of employees are strongly restricted and comparison hindered. Similarly, only clearly defined organizational conventions regarding possible sources and the format of data form these source for the measurement of the performance of employees along the process allow for the creation of sensible reports with regard to possible performance bottlenecks in the process.

The information required for the performance management of employees and operational business processes mainly stems from the specific systems used by employees to fulfill the specific tasks of the process. The information of system usage and process performance can be extracted by the proHRIS from specific enactment systems or PPMS (**FR11-4**). The interface between those systems and the proHRIS is provided by the API component. The link between the gathered data and the relevant operational business processes or employees is then created by the appraisal component based on the information available in the model repository. Important for a successful connection of performance data from external systems and the employee is a clear definition of information provided by the systems and specific organizational conventions for the extraction of information from those systems.

<table>
<tr><th>Requirement</th><th>Relevant components</th><th>human / organizational aspects</th></tr>
<tr><td>FR11-1, FR11-3</td><td>▷ modeling component
▷ model repository
▷ management component
▷ appraisal component</td><td rowspan="4">▷ modeling notation quality
▷ model quality
▷ data quality (of additional concepts)
▷ organizational conventions</td></tr>
<tr><td>FR11-3, FR11-6</td><td>▷ model repository
▷ performance management component
▷ appraisal component
▷ reporting component</td></tr>
<tr><td>FR11-4</td><td>▷ API component
▷ model repository
▷ performance management component</td></tr>
<tr><td>FR11-5</td><td>▷ model repository
▷ performance management component
▷ intelligence component</td></tr>
</table>

Table 17: Assessment of the requirements and their fulfillment in employee appraisal.

Similarly to its use in the staffing function, the usage of intelligence features can provide additional support in a process oriented appraisal (**FR11-6**). The possibility of analyzing and simulating process models is provided by the intelligence component in combination with the process repository and under then coordination of the appraisal component. Again the quality of possible simulation results or, for example, process mining results are dependent on existing organizational conventions that include provisions for the information required for the success simulation of processes or homogenize information about process instances across revisions. An overview of the requirements, the most relevant components and the organizational aspects are given in table 17

5.4.4 Discussion of the development requirements

To support a personnel development based on business process models (**FR12**) the following requirements should be fulfilled:

FR12-1 Allow the modeling of business process models that contain information relevant for process based employee development.

FR12-2 Offer the possibility to store instances of the concepts of activity, qualification, employee, goals, trainings, and development needs as well as their properties as to support the planning and execution of process based employee development.

FR12-3 Offer the possibility to create, store, and manage reference models of business processes for usage in development planning.

FR12-4 Offer interfacing abilities with e-Learning systems or training management systems for the purpose of planning development activities and importing results of performed training activities.

FR12-5 Offer the possibility to generate performance reports for usage in planning development activities for individual or groups of employees.

The modeling and management of business process models as well as of the concepts of activities, qualifications, employees, goals, trainings and development needs (**FR12-1**, **FR12-2**) are provided by the modeling component, the model repository, and the administration component. The training management component, furthermore, allows for the specific augmentation and linking of process models with information relevant for the management of the training activities of employees. Additionally, these four components also provide the functionality required for the creation, storage and management of reference models that are to be used in development planning (**FR12-3**). The development planning is then coordinated by the development component.

Requirement	Relevant components	human / organizational aspects
FR12-1, **FR12-2**, **FR12-3**	▷ modeling component ▷ model repository ▷ management component ▷ training management component	▷ modeling notation quality ▷ model quality ▷ data quality (of additional concepts) ▷ organizational conventions
FR12-4	▷ API component ▷ model repository ▷ development component	
FR12-5	▷ model repository ▷ development component ▷ intelligence component ▷ reporting component	

Table 18: Assessment of the requirements and their fulfillment in employee development.

The created models and reference models are used through the training management component to allow employees to select adequate training opportunities for their development needs. The system should also interface with existing e-Learning platforms or training management systems (**FR12-4**). Such functionality is provided by the API component which allows access to the model repository mediated by the development component. For a success fulfillment of the requirements the organizational conventions regarding the relevant concepts and overall development strategy are of importance. Without a clear definition of which training opportunities are available and at what level of detail the qualifications defined in the modeling notation should be captured the support the system can provide is restricted. Table 18 gives an overview of the requirements and the components mainly responsible for their fulfillment.

5.4.5 Discussion of the compensation requirements

The required support of a business process model based compensation (**FR13**) is specified through the following requirements:

FR13-1 Allow the modeling of business process models that contain information relevant for process based employee compensation.

FR13-2 Offer the possibility to store instances of the concepts of activity, qualification, employee, goals, measures as well as their properties as to support the design and implementation of process oriented variable and fixed pay structures.

FR13-3 Provide the possibility to create and manage compensation agreements that relate to specific business process models.

FR13-4 Provide the possibility to interface with payroll systems.

FR13-5 Provide the possibility to interface with PPMS or directly with PAIS to gather performance information and process instance information.

FR13-6 Ability to analyze, simulate and mine information from process instances for the calculation of variable pay of employees.

As with the other HR functions the support of a process based compensation of employees requires the possibility to model business process models that contain the information relevant for the determination of the compensation of employee or groups of employees (**FR13-1**, **FR13-2**). The required functionality is, again, provided by the model repository, the modeling component and the management component.

The possibility to create and management compensation agreements (**FR13-3**) based on the created business process models is provided through a combination of the compensation component, the model repository and the reporting component. The relevant business process models are supplied by the model repository upon request of the compensation component, which then uses the reporting component to create the compensation agreements and make them available to the relevant employees.

<table>
<tr><th>Requirement</th><th>Relevant components</th><th>human / organizational aspects</th></tr>
<tr><td>FR13-1, FR13-2</td><td>▷ modeling component
▷ model repository
▷ management component</td><td rowspan="4">▷ modeling notation quality
▷ model quality
▷ data quality (of additional concepts)
▷ organizational conventions</td></tr>
<tr><td>FR13-3</td><td>▷ model repository
▷ compensation component
▷ reporting component</td></tr>
<tr><td>FR13-4, FR13-5</td><td>▷ API component
▷ model repository
▷ compensation component</td></tr>
<tr><td>FR13-6</td><td>▷ model repository
▷ compensation component
▷ intelligence component
▷ reporting component</td></tr>
</table>

Table 19: Assessment of the requirements and their fulfillment in employee compensation.

To gather the information required for the determination of fixed and variable pay components, the proHRIS has to interface with external systems such as enactment systems or PPMS (**FR13-5**). Additionally, the result of the determination of the compensation often has to be forwarded to specialized systems dealing with day to day payroll activities (**FR13-4**). To provided this functionality the systems uses the API component in combination with the compensation component. The required information is then saved into or queried from the model repository. As in the other HR functions to fully fulfill the requirements of interfacing with the external systems, the organizational conventions regarding the saved models, the compensation strategy, etc. are of importance (e.g., which model related information should be used for the determination of the compensation).

A success full support of the compensation function also requires the possibility to perform intelligence operations on the models with regard to the questions of importance for the determination of fixed and variable pay structures (**FR13-6**). Such functionality is provided by the intelligence component in coordination through the compensation component with information queried from the model repository. Specific required reports can be generated through the reporting component. An overview of the requirements and relevant components is given in table 19.

5.4.6 Synthesis regarding the requirements

The manifestations of the more general requirements towards the proHRIS can also be grouped with regard to the specific activities performed in the individual HR functions. The two requirements regarding the availability of a modeling notation (**FR1**) that can represent the problems encountered in each HR function and the integration of the organizational model (**FR2**) provide the basis for all other functionality of the system. While an exemplary modeling notation was presented in combination with the design of the system, the specific notation used in an implementation and the specific concepts represented in that notation are strongly dependent on the organizational convention present in the organization in which the system is implemented. Given a specific modeling notation and an integrated organizational model the system can provided the required facilities to model and manage business process models (**FR3**) . This is achieved through the modeling component and the model repository. More specific representations of the required information and their relationships between each other, which do not necessarily related to the operational business process models (**FR4**) can also be stored in the model repository and managed through the modeling component, or through specific views in the relevant functional components. The storage ability offered by the model repository is specifically tailored to the requirements of a business process model based execution of the supported HR functions (**FR5**). This includes the possibility to create queries on the model level and not on a table or column level for example.

The extensive intelligence functionality required by the system (**FR6**) is used by each functional component in different manifestations and also to a different degree. The usage of the intelligence functionality can happen in the background, for example for the recommendation of specific employees for a task during the task assignment, or as explicit intelligence operations that result in reports being generated and regularly forwarded to relevant users.

While the support of collaboration efforts through the system is not explicitly reiterated in the specific requirements of each HR function (**FR7**) it is non the less fundamental in allowing a holistic approach spanning all HR functions. The baseline for such a collaboration is provided in the model repository. However, specifics have to be decided upon by organizational convention.

The requirements regarding the different HR functions have shown the need for the proHRIS to interface with a multitude of different systems (**FR8**, **FR9**) through a consistent API. This functionality is provided through the API component which offers a unified way of querying information from the system and allows the systems to gather information from external sources. Again, while the API component offers a baseline for the interaction between the proHRIS and other systems, the individual configurations for such an integration have to be performed on a system by system and organization by organization basis.

Overall the assessment of the requirements has therefore shown, that the design of the proHRIS as proposed here offers the required functionality from an application point of view. Each elicited requirement is fulfilled through the combination of one or more components of the system and their interaction. For a complete implementation of the IS in an organization, however, additional steps have to be taken into account. These must, for example, include the definition of a fitting modeling notation, the agreement on relevant concepts for the inclusion in the notation and the organizational model represented in the system.

6 Conclusion

The idea of business process orientation in organizations has matured from a new approach to corporate change that advocated the "obliteration" of existing organizational structures (Hammer, 1990) to a holistic approach of organizational design that encompasses all areas of the organization.

Nowadays the definition, documentation, and analysis of operational business processes are a core step in most organizational optimization initiatives as well as a foundation for the implementation of any enterprise wide information systems (cf. Harmon & Wolf, 2014, p. 12).

The goal of this thesis was to develop a design for a HRIS that would allow an integration of HRM activities into an existing process oriented landscape. This goal is based on the premise that three main aspects hinder a holistic process orientation in HRM: missing process focused methods, a missing language that can combine HRM and BPM concepts, and missing information systems that can use these languages to allow a process focused method to be successfully implemented in organizations. The proposed design should have implications for at least two of these factors. The development of a process oriented HRIS directly relates to the third aspect. The design directly shows how an HRIS can (under the premise of a fitting notation) support the execution of HR activities that employee process focused methods. It shows how these individual activities can be coordinated and integrated into an overall HRM framework. While no specific notation is prescribed, the characteristics of notations that can be used in such a context are also further delimited and while no specific process focused methods are provided in detail, the description of the proHRIS can also act as a framework in which such methods can be further elaborated.

This thesis follows a design-oriented approach to IS research. In this context the research approach of this thesis can be positioned as exaptation in the DSR knowledge contribution framework, i.e. the creation of new solutions based on existing ones that are adapted to a new problem context. The specific research approach of the project published in this thesis consists of four main steps: the problem analysis, the solution design, the solution demonstration and evaluation, and the communication of the results (which is achieved through this thesis). To achieve an in depth analysis of the problem (and delimit the new problem context for which a solution was to be designed) a general understanding of process orientation in HRM was developed and the concept of a proHRM as understood for this thesis defined (chapter 2). As the specific tools and methods used by a proHRM are (similarly to those in the classical HRM) contingent on the external influences on the organization, proHRM was delimited by its general characteristics instead of prescriptions of specific tools or methods to be used. proHRM is characterized by a focus the operational business processes of an organization. This also means that it creates solutions, not for specific departments or other structure based frameworks, but for specific business processes. The best employee is not the one most fitting for the department, but the one most fitting for the process. proHRIS is also generally more decentralized than classical HRM with HR activities under the responsibility of the process owner, or specific process coaches. As such, the general overarching functions of HRM have a different realization in proHRM. The delimitation of proHRM therefore constitutes one of the main knowledge contributions of this thesis.

In a second step the specific characteristics of both HRIS and process oriented IS in general where used to derive requirements for the proHRIS. The category of HRIS covers a wide range of different types of systems that help to collect, structure, supply, communicate, and use information with the goal of either automating a specific HR related task, or of providing information to HR decision makers. The process orientation of IS can be characterized by multiple dimensions. It is affected by how structured the processes are that are supported by the IS, the types of interactions they support, which phases of the process life cycle they support, if the focus on managerial or operational activities, if the support is hard-coded or provided in a generic way, and what the scope of the support is that is provided by the IS. While the spectrum of some of these dimensions does not necessarily reflect the degree of process orientation (e.g., a system provides mainly operational support while another provides mainly managerial support, no real assertion about the degree of process orientation can be made), they allow a sophisticated analysis of the respective systems. Other characteristics have a fundamental impact on the design of a proHRIS. One such characteristic is that of hard-coded and generic process support. A hard coded process support implies that the system was developed with respect to a specific process and would require adaptation, if the actual process differs from the process that it was developed for. As a proHRIS needs to support as many types of operational business processes the support should be implemented in a generic way (see section 4.2).

Based on this analysis of the problem domain, a solution in form of a design for a proHRIS was created and constitutes the main knowledge contribution of this thesis. The design itself focuses mainly on higher levels of abstractions as to not make to many prescriptions with regard to the methods or tools used to perform the HR activities, while a more detailed description is offered in specific use cases that are presented.

The system is composed of multiple components, some of which are generic, while others directly related to some HR activity. The generic components show possible ways of interacting with business process models, while the functional components show how the generic components can be combined and used to support a process oriented approach to specific HR activities. The core of the system is provided through a model repository which allows for the storage and management of models created in the HR augmented process notation.

In addition to a description of the system itself, the design also offers insight into the requirements of a modeling notation that supports both general BPM activitiesand process based HR activities. The core requirements elicited during the design result from its use both in the generic components and the concrete domain represented by the functional components. The functional components represent the need of specific components and rules of the language to adequately represent the object domain (see 4.3.3; cf. Frank, 2013). The generic components on the other hand provide more general required characteristics of the notation, e.g., they require them to be analyzable, executable, etc.

The description of the design in the thesis is complemented by a practical implementation of the design in a prototype. This prototype serves as demonstrator for the feasibility of the design and focuses on the staff assignment problem. It constitutes a knowledge contribution in form of a specific instantiation of the designed solution. A specific notation was developed in concert with the prototype, the HREPC, which represents the problem domain and integrates it in the classical process modeling notation EPC. The functionality of the prototype is further demonstrated through the enactment of a specific use case. This enactment also offered insights into additional challenges that future implementation of the prototype need to address: e.g., the exploration of whether a more structured approach to the model is more successful or if the modeler should be allowed as much freedom as possible, or the implementation of additional concrete syntaxes that allow the creation of more problem specific visual notations.

One shortcoming of this thesis is the lack of an in depth empirical evaluation of the proposed design. Instead, the evaluation of the design itself is based on the insights gained through the implementation and use of the prototype and transference of insights from the prototype to the overall design, as well as an argumentative assessment of the fulfillment of the previously set requirements. The evaluation highlights, for example, the importance of the modeling notation for the successful implementation of a proHRIS, the challenges resulting from the high level of abstraction of the design, and conveys a notion of the characteristics required in an organization that aims at introducing a proHRIS.

While this type of evaluation offers interesting starting points for further iterations of the design and additional research projects, one future goal should certainly be the empirical evaluation of the proposed design through case studies in real organizations. Interesting research topics during such a case study could be the identification of specific design characteristics which have the most impact on the success of an proHRIS. It would also be interesting to see if and how these characteristics differ from those of classical HRM or typical PAIS.

Another interesting aspect would the more stringent placement of proHRIS in the context of process (management) maturity models. The specific levels of process management maturity at which organization require proHRIS for all HRM functions could be better delimited. It could also be investigated if each HRM function is required at the same maturity level in a process oriented flavor, or which part of a proHRIS should be introduced first. Certainly staffing is one of the obvious choice, with many approaches already providing examples of such integration. However, it could be that a focus on a process oriented compensation of the employees could further support the idea of process orientation in the employees themselves and, therefore, lead to a stronger overall support of BPM.

As seen throughout this thesis the integration of HRM and BPM is an important topic for future development of process orientation in organizations and the making explicit of that integration through a common notation, integrated methods, and supporting information systems a prerequisite. The proposes design for a proHRIS in this thesis is a contribution towards achieving this integration.

Appendix

A Extract of HREPC concrete syntax definition in ORYX

The ORYX modeling tool editor offers the possibility to define specific StencilSets that represent concrete syntax definitions of modeling notations (see N. Peters, 2007). A StencilSet definition for the ORYX editor generally consists of vector graphics (SVG files) representing the visual elements of the notations, raster graphics (PNG, JPEG, or similar) for displaying previews in the editor, and a JSON file describing the concrete syntax rules. In the following the relevant parts of the StencilSet definition for the Function element are shown to give a more in depth description of the concrete syntax used in the prototypical implementation.

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<svg xmlns="http://www.w3.org/2000/svg" xmlns:svg="http://www.w3.org/2000/svg" xmlns:oryx="http://www.b3mn.org/oryx" xmlns:xlink="http://www.w3.org/1999/xlink" width="102" height="62" version="1.0">
  <defs></defs>
  <oryx:magnets>
    <oryx:magnet oryx:cx="0" oryx:cy="30" oryx:anchors="left" />
    <oryx:magnet oryx:cx="50" oryx:cy="60" oryx:anchors="bottom" />
    <oryx:magnet oryx:cx="100" oryx:cy="30" oryx:anchors="right" />
    <oryx:magnet oryx:cx="50" oryx:cy="0" oryx:anchors="top" />
    <oryx:magnet oryx:cx="50" oryx:cy="30" oryx:default="yes" />
  </oryx:magnets>
  <g pointer-events="fill">
    <rect id="celem"  oryx:resize="vertical horizontal" x="0" y="0" width="100" height="60" rx="10" ry="10" stroke="black" stroke-width="1" fill="#96ff96" />
    <text oryx:fittoelem="celem" font-size="11" id="text" x="50" y="30" oryx:align="middle center" stroke="black"></text>
  </g>
</svg>
```

Listing A.1: Content of node.function.svg

The node.function.svg (listing A.1) defines the visual layout and representation of the function element in the editor. Additionally it contains information relevant for the editors working such as points on the visual representation at which edges should preferably connect.

```
[...]
{
  "type": "node",
  "id": "function",
  "title": "Function",
```

```
    "groups": ["Functional View", "Control View"],
    "description": "A business function that is performed as part of the process.",
    "view": "node.function.svg",
    "icon": "new_function.png",
    "defaultAlign": "south",
    "roles": [
      "function",
      "all",
      "FunctionMorph"
    ],
    "properties": [
      {
        "id": "title",
        "type": "String",
        "title": "Title",
        "value": "",
        "description": "The title of this Function.",
        "popular": true,
        "readonly": false,
        "optional": true,
        "refToView": "text",
        "wrapLines": true
      },{
        "id": "time",
        "type": "Integer",
        "title": "Execution Time",
        "value": "",
        "description": "Duration of the function's execution (in minutes)",
        "tooltip": "",
        "readonly": false,
        "optional": true,
        "refToView": "timetext",
        "length": "12",
        "wrapLines": true
      },{
        "id": "frequency",
        "type": "Integer",
        "title": "Frequency",
        "value": "",
        "description": "The Ammount of times this function is executed per Week.",
        "tooltip": "",
        "readonly": false,
        "optional": true,
        "length": "12",
        "wrapLines": true
      },[...], {
        "id": "maxhourlywage",
        "type": "Integer",
        "title": "MaxHourlyWage",
        "value": "",
        "description": "max wage of an executing employee",
```

```
57        "tooltip": "",
58        "readonly": false,
59        "optional": true,
60        "length": "12",
61        "wrapLines": true
62      },{
63        "id": "isfullyautomated",
64        "type": "Boolean",
65        "title": "Is fully autmated",
66        "value": false,
67        "description": "Indicates whether the function is performed fully automated or if an employee is necessary.",
68        "tooltip": "",
69        "readonly": false,
70        "optional": true,
71        "length": "12",
72        "wrapLines": true
73      }]
74    }
75    [...]
```

Listing A.2: Initial Function element definition in the StencilSet

Additionally to the definition of the actual element (listing A.2), which contains information about the properties of the Function, the StencilSet also contains the syntax rules for the concrete syntax (listing A.3). The properties can relate to specific visual elements defined in the SVG file (see line 21 of listing A.2, which relates to the SVGElement with the id “text”). This allows properties to have a visual expression in the notation.

The specific rules define which edge can connect to which node (“connectionRules”) and how many connections of the same type can be defined in a model (“cardinalityRules”).

```
[...]
"rules": {
  "connectionRules": [
  {
    "role": "epcEdge",
    "connects": [
    { "from": "event", "to": ["function", "connector", "interface"]},
    { "from": "function", "to": ["event", "connector", "function", "interface"]},
    { "from": "connector", "to": ["event", "function", "connector", "interface"]}
    ]},
  {
    "role": "executes_relationEdge",
    "connects": [
    {"from": "function", "to": ["employee"]},
    {"from": "employee", "to": ["function"]}
    ]},
  {
    "role": "qualification_requirements_relationEdge",
    "connects": [
    {"from": "function", "to": ["qualification"]},
```

```
    {"from": "qualification", "to": ["function"]}
    ]},
  [...]
  ],
  "cardinalityRules": [
  [...]
  {
    "role": "function",
    "incomingEdges": [
    {
      "role": "epcEdge",
      "maximum": 1
    }],
    "outgoingEdges": [
    {
      "role": "epcEdge",
      "maximum": 1
    }]
  }
[...]
```

Listing A.3: Relevant syntax rules for the Function element in the StencilSet

A StencilSet definition as described here results in the editor allowing the editing of models in the defined notation. The editor itself holds the model in two formats, one JSON document which is easily machine readable and allows further work on the model on the server side of the system, as well as a SVG document that exactly represents the visual representation of the model (see figure 88 and listing A.4).

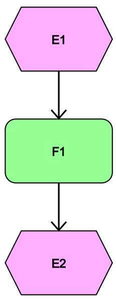


Figure 88: SVG graphic representing a simple model.

```
{
  "resourceId": "new",
  "bounds": {"lowerRight": {"x": 500,"y": 500},"upperLeft": {"x": 0,"y": 0}},
  "stencilset": {
    "url": "/proHRM/stencilsets/hrepk/hrepk.json",
    "namespace": "http://b3mn.org/stencilset/hrepc#"
  },
  "ssextensions": []
  "properties": {
    "title": "",
    "version": "",
    "author": "",
```

```
      "description": ""
    },
    "stencil": {
      "id": "diagram"
    },
    "childShapes": [
    {
      "resourceId": "oryx_A06A4F8A-36A2-48F3-923A-918D10676F3B",
      "properties": {
        "title": "E1",
        "frequency": "",
        "description": "",
        "bgcolor": "#ffafff"
      },
      "stencil": { "id": "event" },
      "childShapes": [],
      "outgoing": [{"resourceId": "oryx_F42940F0-DA10-4053-90B6-DCB4DA561C14"}],
      "bounds": {"lowerRight": {"x": 310,"y": 180},"upperLeft": {"x": 210,"y": 120}},
      "dockers": []
    },{
      "resourceId": "oryx_0242DAF7-6095-4591-96E0-050DE0D0D3D4",
      "properties": {
        "title": "F1",
        "time": "",
        "frequency": "",
        "description": "",
        "refuri": "",
        "bgcolor": "#96ff96",
        "maxhourlywage": "",
        "isfullyautomated": false
      },
      "stencil": {"id": "function"},
      "childShapes": [],
      "outgoing": [{"resourceId": "oryx_1A551AB3-1D36-48D7-8B17-8F45454E572E"}],
      "bounds": {"lowerRight": {"x": 310,"y": 285},"upperLeft": {"x": 210,"y": 225}},
      "dockers": []
    },{
      "resourceId": "oryx_F42940F0-DA10-4053-90B6-DCB4DA561C14",
      "properties": {
        "probability": ""
      },
      "stencil": {"id": "controlflow"},
      "childShapes": [],
      "outgoing": [{"resourceId": "oryx_0242DAF7-6095-4591-96E0-050DE0D0D3D4"}],
      "bounds": {"lowerRight": {"x": 260,"y": 224.46875},"upperLeft": {"x": 260,"y": 180.53125}},
      "dockers": [{"x": 50,"y": 30},{"x": 50,"y": 30}],
      "target": {"resourceId": "oryx_0242DAF7-6095-4591-96E0-050DE0D0D3D4"}
    },{
      "resourceId": "oryx_BDB7AEB6-3C1C-47CF-AD25-DDF998472178",
```

```
      "properties": {
        "title": "E2",
        "frequency": "",
        "description": "",
        "bgcolor": "#ffafff"
      },
      "stencil": {"id": "event"},
      "childShapes": [],
      "outgoing": [],
      "bounds": {"lowerRight": {"x": 310,"y": 390},"upperLeft": {"x": 210,"y": 330}},
      "dockers": []
    },{
      "resourceId": "oryx_1A551AB3-1D36-48D7-8B17-8F45454E572E",
      "properties": {
        "probability": ""
      },
      "stencil": {"id": "controlflow"},
      "childShapes": [],
      "outgoing": [{"resourceId": "oryx_BDB7AEB6-3C1C-47CF-AD25-DDF998472178"}],
      "bounds": {"lowerRight": {"x": 260,"y": 329.46875},"upperLeft": {"x": 260,"y": 285.53125}},
      "dockers": [{"x": 50,"y": 30},{"x": 50,"y": 30}],
      "target": {"resourceId": "oryx_BDB7AEB6-3C1C-47CF-AD25-DDF998472178"}
    }]
  }
```


Listing A.4: JSON document of a simple model in the HREPC notation.

B Results of the literature analysis

The following table contains the raw results of the literature analysis performed to evaluate the state-of-the-art of process orientation in HRM. For a discussion of the different items tracked in the table see section 2.4.2.

Table 20: Raw results of the literature analysis

Source	Area			Result				approach			HR Function					proc. underst.		
	BPM	HRM	practice	method	model	tool	discussion	design	behavioural	other	general	staffing	appraisal	development	compensation	external	internal	HR focus
Buchwald et al. (2012)	✓	✗	✗	✓	✗	✗	✗	✓	✗	✗	✓	✗	✗	✗	✗	✓	✗	✗
Cardoso et al. (2009)	✓	✗	✗	✗	✓	✗	✗	✗	✓	✗	✗	✗	✓	✗	✗	✓	✗	✗
Hartmann and Wolf (2012)	✓	✗	✗	✗	✓	✗	✗	✓	✗	✗	✗	✗	✓	✗	✗	✓	✗	✗
Lodhi, Köppen, Wind, Saake, and Turowski (2014)	✓	✗	✗	✗	✓	✗	✗	✓	✗	✗	✗	✗	✓	✗	✗	✓	✗	✗
Fallgatter (2013)	✗	✓	✗	✗	✗	✗	✗	✗	✗	✓	✗	✗	✓	✗	✗	✓	✗	✓
Glykas (2011a)	✓	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗	✗	✓	✗	✗	✓	✗	✓
Busch (2007)	✗	✓	✗	✗	✓	✗	✗	✓	✗	✗	✗	✗	✓	✗	✗	✗	✓	✓
Soffer and Wand (2005)	✓	✗	✗	✗	✓	✗	✗	✗	✓	✗	✗	✗	✓	✗	✗	✓	✗	✗
?	✗	✓	✗	✗	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗	✓	✓	✗	✓
Jereb et al. (2009)	✗	✗	✓	✗	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗	✓	✗	✓	✓
Rösler (2003)	✗	✓	✗	✓	✗	✗	✗	✓	✗	✗	✗	✗	✗	✗	✓	✓	✗	✓
Bahl et al. (2005)	✗	✓	✗	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗	✓	✗	✓	✗	✓
Binner (2003)	✗	✓	✗	✓	✗	✗	✗	✓	✗	✗	✗	✗	✗	✓	✗	✓	✗	✓
Bullinger, Mytzek, and Zeller (2004)	✗	✓	✗	✗	✗	✗	✓	✗	✗	✓	✗	✗	✗	✓	✗	✓	✗	✓
Koch and Meerten (2003)	✗	✓	✗	✗	✗	✗	✓	✗	✓	✗	✗	✗	✗	✓	✗	✓	✗	✓
Krauß and Mohr (2004)	✗	✓	✗	✗	✗	✗	✓	✗	✓	✗	✗	✗	✗	✓	✗	✓	✗	✓
Tramm (2009)	✗	✓	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗	✗	✓	✗	✓	✗	✓
A. Maurer and Rauner (2011)	✗	✓	✗	✗	✗	✗	✓	✗	✓	✗	✗	✗	✗	✓	✗	✓	✗	✓
M. Fischer (2005)	✗	✓	✗	✗	✗	✗	✓	✗	✓	✗	✗	✗	✗	✓	✗	✓	✗	✓

Table 20: (cont.)Raw results of the literature analysis

Source	Area			Result				approach			HR Function					proc. underst.		
	BPM	**HRM**	**practice**	**method**	**model**	**tool**	**discussion**	**constructivistic**	**behavioural**	**other**	**general**	**staffing**	**appraisal**	**development**	**compensation**	**external**	**internal**	**HR focus**
Loos et al. (2007)	✓	✗	✗	✓	✓	✗	✗	✓	✗	✗	✗	✗	✗	✓	✗	✓	✗	✓
Etz-Stuttgart (n.d.)	✗	✗	✓	✗	✗	✓	✗	✗	✗	✓	✗	✗	✗	✓	✗	✓	✗	✓
Fuchs-Kittowski and Walter (2002)	✓	✗	✗	✓	✗	✗	✗	✓	✗	✗	✗	✗	✗	✓	✗	✓	✗	✓
Kraemer et al. (2007)	✓	✗	✗	✗	✗	✓	✗	✓	✗	✗	✗	✗	✗	✓	✗	✗	✓	✓
Böhm and Härtwig (2005)	✓	✗	✗	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗	✓	✗	✓	✗	✗
Müller et al. (2005)	✗	✗	✓	✗	✗	✗	✓	✗	✗	✓	✗	✗	✗	✓	✗	✓	✓	✓
Haak and Eekhoff (2004)	✗	✗	✓	✗	✗	✓	✓	✗	✓	✗	✗	✗	✗	✓	✗	✓	✗	✗
Neiger and Churilov (2004)	✓	✗	✗	✗	✓	✗	✗	✓	✗	✗	✗	✗	✗	✓	✗	✓	✗	✗
Fuchs-Kittowski et al. (2003)	✓	✗	✗	✓	✗	✗	✗	✓	✗	✗	✗	✗	✗	✓	✗	✓	✗	✓
Jablonski, Horn, and Schlundt (2001)	✓	✗	✗	✗	✗	✓	✗	✓	✗	✗	✗	✗	✗	✓	✗	✓	✗	✗
Pritchard and Armistead (1999)	✓	✗	✗	✗	✗	✗	✓	✗	✓	✗	✗	✗	✗	✓	✗	✓	✗	✓
Scheer (1996)	✓	✗	✗	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗	✓	✗	✓	✗	✓
Zucchi and Edwards (2000)	✓	✗	✗	✗	✗	✗	✓	✗	✓	✗	✗	✗	✗	✓	✓	✓	✗	✓
Maier and Remus (2003)	✗	✓	✗	✓	✗	✗	✗	✓	✗	✗	✗	✗	✗	✗	✗	✓	✗	✓
Böttcher (2002)	✗	✓	✗	✓	✗	✗	✗	✓	✗	✗	✓	✗	✗	✗	✗	✗	✓	✓
Gontard (2006)	✗	✓	✗	✓	✗	✗	✗	✓	✗	✗	✓	✗	✗	✗	✗	✗	✓	✓
Gutschelhofer (1996)	✗	✓	✗	✗	✗	✗	✗	✗	✗	✓	✓	✗	✗	✗	✗	✓	✓	✓
Ortner (2008)	✗	✓	✗	✗	✗	✗	✓	✗	✓	✗	✓	✗	✗	✗	✗	✓	✗	✓
Potoczek (2011)	✗	✓	✗	✗	✗	✗	✓	✗	✗	✓	✓	✗	✗	✗	✗	✓	✗	✓

Table 20: (cont.)Raw results of the literature analysis

Source	**Area**		**Result**					**approach**			**HR Function**					**proc. underst.**		
	BPM	**HRM**	**practice**	**method**	**model**	**tool**	**discussion**	**constructivistic**	**behavioural**	**other**	**general**	**staffing**	**appraisal**	**development**	**compensation**	**external**	**internal**	**HR focus**
Hammer and Stanton (1999)	✓	✗	✗	✗	✗	✗	✓	✗	✗	✗	✓	✗	✗	✗	✗	✓	✗	✓
Škrinjar et al. (2010)	✓	✗	✗	✗	✗	✗	✓	✗	✓	✗	✓	✗	✗	✗	✗	✓	✗	✓
Turner et al. (2007)	✓	✗	✗	✗	✗	✗	✓	✗	✓	✗	✓	✗	✗	✗	✗	✓	✗	✗
Willcocks and Smith (1995)	✓	✗	✗	✗	✗	✗	✓	✗	✓	✗	✓	✗	✗	✗	✗	✓	✗	✓
Willmott (1994)	✓	✗	✗	✗	✗	✗	✓	✗	✓	✗	✓	✗	✗	✗	✗	✓	✗	✓
Zucchi and Edwards (1999)	✓	✗	✗	✗	✗	✗	✓	✗	✓	✗	✓	✗	✗	✗	✗	✓	✗	✓
Glykas (2011b)	✓	✗	✗	✗	✗	✓	✗	✓	✗	✗	✓	✗	✗	✗	✗	✓	✗	✓
Swenson and Farris (2009)	✓	✗	✗	✓	✗	✗	✗	✓	✗	✗	✓	✗	✗	✗	✗	✓	✗	✗
Schuster (2012)	✓	✗	✗	✗	✓	✗	✗	✓	✗	✗	✓	✗	✗	✗	✗	✓	✗	✗
Kabst et al. (1996)	✗	✓	✗	✗	✗	✗	✓	✗	✓	✗	✓	✗	✗	✗	✗	✓	✗	✓
Cakar and Bititci (2002)	✗	✓	✗	✗	✓	✗	✗	✓	✗	✗	✓	✗	✗	✗	✗	✗	✓	✓
Schönenberg (2010)	✗	✓	✗	✓	✗	✗	✗	✓	✗	✗	✓	✗	✗	✗	✗	✗	✓	✓
Stroppi et al. (2012)	✓	✗	✗	✗	✓	✗	✗	✓	✗	✗	✓	✗	✗	✗	✗	✓	✗	✗
Zhu, Recker, Zhu, and Santoro (2014)	✓	✗	✗	✗	✓	✗	✗	✓	✗	✗	✓	✗	✗	✗	✗	✓	✗	✗
Rummler and Brache (2013)	✓	✗	✗	✗	✗	✗	✓	✗	✓	✗	✓	✗	✗	✗	✗	✓	✗	✓
Wickramasinghe (2012)	✗	✓	✗	✗	✗	✗	✓	✗	✓	✗	✓	✗	✗	✗	✗	✓	✗	✗
Becker, Weiß, and Winkelmann (2011)	✓	✗	✗	✓	✗	✗	✗	✓	✗	✗	✓	✗	✗	✗	✗	✓	✗	✗
Kohlbacher and Gruenwald (2011)	✓	✗	✗	✗	✗	✗	✓	✗	✓	✗	✓	✗	✗	✗	✗	✓	✗	✓
Ohtonen and Lainema (2011)	✓	✗	✗	✗	✗	✗	✓	✗	✓	✗	✓	✗	✗	✗	✗	✓	✗	✓

Table 20: (cont.)Raw results of the literature analysis

Source	**Area**			**Result**				**approach**			**HR Function**					**proc. underst.**		
	BPM	**HRM**	**practice**	**method**	**model**	**tool**	**discussion**	**constructivistic**	**behavioural**	**other**	**general**	**staffing**	**appraisal**	**development**	**compensation**	**external**	**internal**	**HR focus**
Neves, Caetano, Tribolet, Sinogas, and Mendes (2001)	✓	✗	✗	✗	✓	✗	✗	✓	✗	✗	✓	✗	✗	✗	✗	✓	✗	✗
Heravizadeh et al. (2009)	✓	✗	✗	✗	✓	✗	✗	✓	✗	✗	✓	✗	✗	✗	✗	✓	✗	✗
Drumm (1995)	✗	✓	✗	✗	✗	✗	✓	✗	✓	✗	✓	✗	✗	✗	✗	✓	✗	✓
Russell and van der Aalst (2008)	✓	✗	✗	✗	✗	✗	✓	✓	✗	✗	✓	✗	✗	✗	✗	✓	✗	✓
Armistead and Rowland (2007)	✓	✗	✗	✗	✗	✗	✓	✗	✗	✓	✓	✗	✗	✗	✗	✓	✗	✓
Bennour and Crestani (2007)	✗	✓	✗	✗	✓	✗	✗	✓	✗	✗	✓	✗	✗	✗	✗	✓	✗	✓
Hammer (2007)	✗	✓	✗	✗	✗	✗	✓	✗	✓	✗	✓	✗	✗	✗	✗	✓	✗	✓
Jeston and Nelis (2006b)	✓	✗	✗	✗	✗	✗	✓	✗	✗	✓	✓	✗	✗	✗	✗	✓	✗	✓
Cakar et al. (2003)	✓	✗	✗	✗	✓	✗	✗	✓	✗	✗	✓	✗	✗	✗	✗	✗	✓	✓
Scheff (1994)	✓	✗	✗	✗	✗	✗	✓	✗	✓	✗	✓	✗	✗	✗	✗	✓	✓	✓
Kugeler and Vieting (2000)	✓	✗	✗	✗	✗	✗	✓	✗	✗	✓	✓	✗	✗	✗	✗	✓	✗	✗
Kueng and Kawalek (1997)	✓	✗	✗	✗	✓	✗	✗	✓	✗	✗	✓	✗	✗	✗	✗	✓	✗	✗
J. Fischer (1996)	✓	✗	✗	✓	✗	✗	✗	✓	✗	✗	✓	✗	✗	✗	✗	✓	✗	✗
G. Maurer (1996)	✓	✗	✗	✗	✗	✗	✓	✗	✗	✓	✓	✗	✗	✗	✗	✓	✗	✓
Reiß (1984)	✗	✓	✗	✗	✗	✗	✓	✗	✗	✓	✓	✗	✗	✗	✗	✓	✗	✓
Remus and Schub (2002)	✗	✓	✗	✓	✗	✗	✗	✓	✗	✗	✓	✗	✗	✓	✗	✓	✓	✓
Kalpic and Bernus (2006)	✗	✓	✗	✓	✓	✗	✗	✓	✗	✗	✓	✗	✗	✓	✗	✓	✗	✗
Beretta (2002)	✓	✗	✗	✗	✗	✗	✓	✓	✗	✗	✗	✗	✓	✗	✗	✓	✗	✓

Table 20: (cont.)Raw results of the literature analysis

Source	**Area**		**Result**					**approach**			**HR Function**					**proc. underst.**		
	BPM	**HRM**	**practice**	**method**	**model**	**tool**	**discussion**	**constructivistic**	**behavioural**	**other**	**general**	**staffing**	**appraisal**	**development**	**compensation**	**external**	**internal**	**HR focus**
Korherr and List (2007b)	✓	✗	✗	✗	✓	✗	✗	✓	✗	✗	✗	✗	✓	✗	✗	✓	✗	✗
Bronzo et al. (2013)	✓	✗	✗	✗	✗	✗	✓	✗	✓	✗	✗	✗	✓	✗	✓	✓	✗	✗
Huang et al. (2012)	✓	✗	✗	✓	✗	✗	✗	✓	✗	✗	✗	✓	✗	✗	✗	✓	✗	✗
Termer et al. (2012)	✓	✗	✗	✗	✗	✗	✓	✗	✗	✓	✗	✓	✗	✗	✗	✓	✗	✓
Cabanillas et al. (2011)	✓	✗	✗	✓	✓	✗	✗	✓	✗	✗	✗	✓	✗	✗	✗	✓	✗	✗
H. Gutmann (2011)	✗	✗	✓	✓	✗	✗	✗	✗	✗	✓	✗	✓	✗	✗	✗	✓	✗	✓
Sandau (2011)	✗	✗	✓	✓	✗	✗	✗	✗	✗	✓	✗	✓	✗	✗	✗	✓	✗	✓
Landgraf and Lenhardt (2013)	✓	✗	✗	✓	✗	✗	✗	✓	✗	✗	✗	✓	✗	✗	✗	✓	✗	✓
J. vom Brocke and Rosemann (2010)	✓	✗	✗	✓	✗	✗	✗	✓	✗	✗	✗	✓	✗	✗	✗	✓	✗	✓
Eberlein-Gonska (2010)	✗	✗	✓	✓	✗	✗	✗	✗	✗	✓	✗	✓	✗	✗	✗	✓	✗	✓
Ouyang et al. (2010)	✓	✗	✗	✗	✓	✗	✗	✓	✗	✗	✗	✓	✗	✗	✗	✓	✗	✓
Junge and Kretschel (2008)	✗	✓	✗	✗	✗	✓	✗	✓	✗	✗	✗	✓	✗	✗	✗	✓	✗	✓
Rinderle-ma and van der Aalst (2007)	✓	✗	✗	✓	✗	✗	✗	✓	✗	✗	✗	✓	✗	✗	✗	✓	✗	✓
Ly et al. (2006)	✓	✗	✗	✓	✗	✗	✗	✓	✗	✗	✗	✓	✗	✗	✗	✓	✗	✓
Shen et al. (2003)	✓	✗	✗	✓	✗	✗	✗	✓	✗	✗	✗	✓	✗	✗	✗	✓	✗	✓
Muche (2002)	✗	✓	✗	✓	✗	✗	✗	✓	✗	✗	✗	✓	✗	✗	✗	✓	✗	✓
Junginger et al. (2000)	✓	✗	✗	✗	✗	✓	✗	✓	✗	✗	✗	✓	✗	✗	✗	✓	✗	✓
Fahrwinkel (1995)	✓	✗	✗	✗	✗	✗	✓	✓	✗	✗	✗	✓	✗	✗	✗	✓	✗	✓
Merdian (2005)	✗	✓	✗	✓	✗	✗	✗	✓	✗	✗	✓	✓	✗	✗	✗	✓	✓	✓

Table 20: (cont.)Raw results of the literature analysis

Source	**Area**			**Result**				**approach**			**HR Function**					**proc. underst.**		
	BPM	**HRM**	**practice**	**method**	**model**	**tool**	**discussion**	**constructivistic**	**behavioural**	**other**	**general**	**staffing**	**appraisal**	**development**	**compensation**	**external**	**internal**	**HR focus**
Nikolaos, Stavros, Sotiris, and Theodoros (2004)	✗	✓	✗	✓	✗	✗	✗	✓	✗	✗	✓	✓	✗	✗	✗	✓	✗	✓
zur Muehlen (2004a)	✓	✗	✗	✓	✗	✗	✗	✓	✗	✗	✓	✓	✗	✗	✗	✓	✗	✗
Koschmider et al. (2012)	✓	✗	✗	✓	✗	✗	✗	✓	✗	✗	✓	✓	✗	✗	✗	✓	✗	✓
Stroppi, Chiotti, and Villarreal (2011)	✓	✗	✗	✗	✓	✗	✗	✓	✗	✗	✓	✓	✗	✗	✗	✓	✗	✗
Etoundi et al. (2006)	✓	✗	✗	✗	✓	✗	✗	✓	✗	✗	✓	✓	✗	✗	✗	✓	✗	✓
Signavio GmbH (n.d.)	✗	✗	✓	✓	✗	✗	✗	✗	✗	✓	✓	✓	✗	✗	✗	✓	✗	✓
Hüsselmann (2006)	✗	✓	✗	✓	✗	✗	✗	✓	✗	✗	✗	✓	✗	✗	✓	✓	✗	✓
Leyking and Angeli (2008)	✓	✗	✗	✓	✗	✗	✗	✓	✗	✗	✗	✓	✗	✗	✗	✓	✗	✓
Overall: 102	61	33	8	33	22	8	38	56	25	18	49	25	10	23	6	94	13	74

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