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“Human-orientation in WFMS: Analysis of existing systems
and design of a HC-PAIS user interface”

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Annotations

For reasons of a more fluent readability, it was refrained from using gender-neutral language within this work. Person-related terms are referred to in male form only, though such reference equally applies to female and male persons.

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1 Introduction

Process-aware information systems (PAIS) are software systems that allow the management and automatic execution of operational processes based on process models. An example for PAIS are workflow management systems (WFMS) that are used for executing and controlling predefined workflows. With the help of these systems an effective and efficient task allocation amongst a company's resources is enabled, whereby resources, in this context, refer to services, software applications but also human resources, i.e. workflow participants. [13] However, the integration of humans has not been paid much attention to in the area of PAIS so far. Accordingly there are plenty of unexploited research potentials regarding the development of human-centric concepts, which must not be unused, especially because human orientation in PAIS and the thereof resulting user acceptance of these systems are critical factors for high performance and business success. [20, 21]

1.1 Research issue

Businesses deploy WFMS because they allow for a faster, more flexible and qualitatively better process handling at cost-effective conditions [17, 29]. However, the great disadvantage to this approach is the rigid structure that is prescribed by these systems in order to achieve the named benefits. The adherence to the fixed schedule is often experienced as too restrictive by the employees because it leaves no room for individual initiative or personal responsibility at carrying out one's job. As a consequence users' motivation to work may decrease, which in turn has a negative impact on their performance at task execution. Besides, also the fact that employees are viewed as potentially replaceable human resources, who serve to fulfil a given purpose within the WFMS, affects their job satisfaction negatively and reduces their acceptance to work with these kinds of systems. [33]

The negative effects on the workflow participants are a major problem insofar as humans play a central role within the sphere of WFMS and the number of people working with PAIS technology these days is rising continuously [15]. Especially in the service industry there are many processes that involve manual tasks, which require the integration of human abilities for proper processing and therefore cannot be executed fully automated by an application or a machine [20]. For this reason it is necessary to shape the named systems in a user-centric way by adjusting them to the employees' demands and needs.

The intended implementations that address human-orientation in PAIS are called Human-Centric Process-Aware Information Systems (HC-PAIS). In this context human-

orientation stands for the integration of user's skills, competencies, knowledge, ideas, wishes, needs and also goals into the system. It is assumed that this form of human inclusion can provably increase employees' motivation and satisfaction to work with PAIS and as a consequence improve their performance at task execution. However, the stated issue has received too little attention within interdisciplinary PAIS research so far, thus it is still a challenge of this field of study to provide innovative concepts and proven solutions that address this topic. [21]

1.2 Goals and contribution

The intended goal of this work is to develop a HC-PAIS user interface mock-up that overcomes the negative impacts of a WFMS regarding its human users. On the one hand, this is to be achieved by providing a user-friendly workflow client application that is equipped with established but also innovative features, which facilitate the daily work with the WFMS. On the other hand, it is intended to integrate employees' skills, experiences, preferences, goals and needs into the system in a way that increases their motivation and satisfaction to work with the PAIS. This aim will firstly be realized by including proven workflow patterns at the general configuration of the WFMS. Thereby the work item distribution as well as the task assignment and execution processes will be shaped according to the users' need. At the same time some novel features will be incorporated in the workflow client application, which allow users to set their individual experience goals and task preferences. The stated information will then be used as crucial factors for the task allocation in order to support the ambitions of the workflow participants.

The aimed approach of providing a HC-PAIS user interface is novel in that sense that there has not emerged a comparable solution from PAIS research so far. Indeed there are scattered works [1, 15, 16, 20, 22, 23, 33] that contribute towards concepts that support a tighter integration of humans in PAIS, but they concern only individual aspects of the problem, whereas the proposed work comes up with an overall approach that combines various of these issues. The thesis at hand contributes the following values added:

- The identification of potentials that can be used to render the workflow client application of a WFMS more human-centric and their summarization into an evaluation scheme that can be used for further (analysis) purposes.
- The analysis of existing WFMS regarding the human-orientation of their workflow client applications in order to receive an impression of the current situation on the market.

- The development of HC-PAIS user interface mock-ups that demonstrate the identified requirements concerning human orientation in PAIS.
- The evaluation of the developed mock-ups by qualified experts in order to obtain information about their validity.

In order to realize the above-named objectives successfully the following research questions were deduced that will be used as a road map for the progress of this work:

- What might motivate users of WFMS to work with such systems?
- How do user interfaces of existing WFMS look like?
- How human-centric are user interfaces of existing WFMS?
- How could a human-centric user interface of a WFMS look like?
- How do experts evaluate the drafted HC-PAIS user interface?

The resolving of the stated issues calls for different research methods to be applied. A detailed description of the overall research methodology behind this work can be found in chapter 3.

1.3 Structure of the work

The master thesis is organized as follows: To start with the theoretical background for PAIS and WFMS is presented in chapter 2, which contains a detailed overview of their basics, functionalities and relevant characteristics as well as an outline of the most important terminology used in the field of these systems in order to create a common understanding for the further course of this work.

In chapter 3 the research strategy is illustrated that was applied in order to achieve the intended goals of this work. In the course of this also a detailed description of the different research methods is provided, that were deployed in the overall procedure.

Chapter 4 firstly contains an introduction to HC-PAIS. After explaining what human-orientation in PAIS stands for, criteria from the areas of Workflow patterns and HC-PAIS approach are prepared that are assumed to render the client application of a WFMS more human-centric. Based on these findings an evaluation scheme is created, which contains all the criteria that have been identified as useful for the realization of a HC-PAIS user interface.

In chapter 5 the analysis of three existing WFMS is presented that were chosen to be evaluated by means of the previously created evaluation scheme. Each of the selected systems is introduced shortly before it is outlined in detail to what extent the respective WFMS fulfils the requirements of a human-centric workflow client application. In the last

section the ratings of the analysis results are summarized and contrasted in an evaluation summary table and a comparison between the examined systems is drawn.

Chapter 6 comprises the centerpiece of the master thesis, which is the presentation of the HC-PAIS user interface mock-ups that were developed based on the previous findings of this work. By means of the created UI models the successful implementation of almost all features that were identified to qualify a workflow client application as human-centric could be demonstrated. In the last section of this chapter a comparison between the designed WFMS and the previously analyzed systems is drawn by contrasting their evaluation results in a comparison scheme.

Chapter 7 starts with the presentation of the evaluation approach that was used for assessing the created HC-PAIS user interface mock-ups with regard to their human-orientation. After that follows the illustration and interpretation of the evaluation results, as well as an outline of the lessons learned.

To conclude with, chapter 8 gives a summary of the conclusions of this work and provides an outlook on possible future research in the field of HC-PAIS.

2 Theoretical background

In the following sections the theoretical background for PAIS and WFMS is presented, in order to give a brief overview of their basics and functionalities. In particular, it will be defined what PAIS are and for what purposes they are deployed. After introducing the term process awareness and discussing the advantages of this characteristic, the typical PAIS lifecycle will be illustrated. Besides, a classification of the named systems will be given as the master thesis at hand only focuses on a certain type of PAIS. In the further course a typical kind of PAIS will be presented, namely workflow systems, which are the basic element of this work. After determining some definitions of terms that are important for a common understanding in the remainder of this thesis, it will be explained how WFMS are used and which functions they fulfill. Apart from the working routine also the systems' workflow client application will be described in detail as the focus of the following work lies primarily on this component. To conclude with, the strengths and weaknesses of WFMS will be discussed.

2.1 Process-aware information systems (PAIS)

Process-aware information systems (PAIS) are software systems that are used to support organizations in managing and automating their business processes involving people, applications and information sources [34].

2.1.1 Basics of PAIS

As the name suggests, a PAIS is a specific type of information system. Referring to [2], in [13, p. 5f] the definition of the term information system is given as follows: “*An information system is a particular type of work system that uses information technology to capture, transmit, store, retrieve, manipulate, or display information, thereby supporting one or more other work systems.*” In this denotation a work system is understood as system that enables humans to execute business processes applying information, technology and other resources in order to produce a certain output. By information technology, the author of [2] means the software and hardware that is used to process the data. In other words, an information system supplies users with computer support to perform certain tasks. It is responsible for allocating the required resources such as data, communication services or hardware devices to the users [13].

What differs a PAIS from an ordinary information system as described above is the fact that it is also process aware, meaning that it provides a link between information technology and business processes [13]. For a common understanding: A process can be described as a sequence of single tasks that are executed stepwise to achieve a defined business goal. A typical example of a business process would be an order fulfilment.

Process awareness denotes that a system includes information about the operational processes of an organization. This information is captured in form of explicit process models. PAIS manage and execute business processes on the basis of such explicit embedded process models, which serve for guiding and automating them. The models are typically represented in a visual language like Petri net-based notations for instance. [13]

Given these considerations, process awareness can be defined as the quality of a software system to be aware of the process as a whole and at the same time also having detailed knowledge about the single tasks that the process consists of and how to execute them. Thus, a text editor, for example, is not process aware as it performs a task without having any knowledge of the process that this task belongs to. Also a typical e-mail client is unaware of the process it is used in. This is because both applications just support tasks, not processes. [13]

2.1.2 PAIS lifecycle

Figure 1 shows the different phases of a typical PAIS lifecycle. The specification of the process models comes under the design phase, where the business processes are (re)designed according to the results of the diagnosis phase. In the configuration phase the designs are implemented by configuring a generic PAIS infrastructure [36]. After that, the process enactment phase starts, in which the processes are being executed. This is also the

phase where the HC-criteria presented later in this work will become effective. As stated in [13], process enactment is realized in PAIS by scheduling tasks corresponding to the predefined rules of the underlying process. They control the required routing of tasks, which determines their execution order, and are also responsible for the assignment of tasks to qualified users. Thus, users have to fulfil their jobs in a certain predetermined order.

In the diagnosis phase a requirements analysis is conducted in order to identify problems and aspects that need to be improved [36]. Summarizing it can be said that PAIS enable the specification, execution and control of business processes and allow organizations to manage their resources efficiently [13].

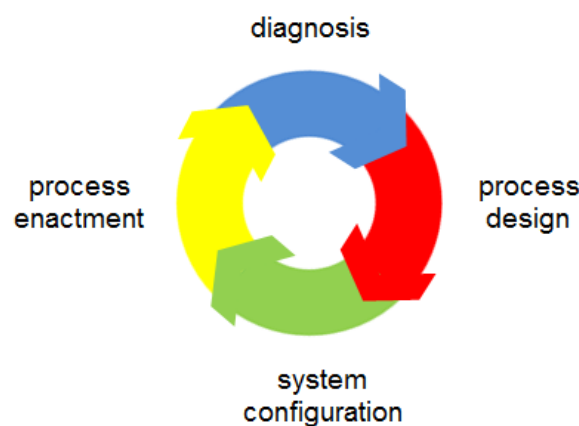


Figure 1: PAIS lifecycle (adopted from [36, p. 5])

The different phases of the PAIS lifecycle require different methods and types of tools for execution. Stated in [36] the focus of traditional WFMS as presented in section 2.2 lies on the lower half of the lifecycle. Thus, they are primarily geared towards the support of system configuration and process enactment and provide little assistance for the design and diagnosis phase. The authors of [36] remark that support in process design is mostly limited to only providing an editor, whereas tools for simulation, verification and validation of the designs are often missing. They also point out that most WFMS enable the logging of data on executed tasks and cases, but only few support techniques for the collection and interpretation or analysis of real-time data.

2.1.3 Advantages of process awareness

According to [13], process awareness is a very beneficial property for information systems as it comes with several advantages. First of all, the use of explicit process models supplies a means of communication between managers who define the structures of the processes and the employees from the IT department who provide the technical infrastructure for supporting

these. Further, the explicit representation of processes allows for their automated enactment [37], which may lead to an increased organizational efficiency. Through providing a global view on the operations of the information system it is also possible to avoid or reduce data redundancies. Additionally the use of explicit process models enables management support at the (re)design and control level. The former intends that process models enable support in the (re)design phase [28] as tools for automated verification or simulation might be applied to them, which facilitates the (re)designing itself and allows for the evaluation and improvement of existing processes. At the control level, generic process monitoring facilities can be used to prepare useful information about the processes and thereby improve the control of them.

As PAIS are driven by process models rather than code [35], business processes can be modified easily by simply changing the diagrammatic representation of the underlying model with the help of comfortable tools. Thus, there is no rewriting of existing source code necessary, which may lead to unexpected results or programming errors. This demonstrates a central principle of PAIS, which is the separation of process logic and application functionality, and thereby isolating the management of processes in a separate component [13].

Conclusive it should be mentioned that the focus in the area of information systems was not always on processes. As can be read in [13], in the time from the late 1970s to the early 1990s the majority of attention went to data-driven approaches. Storage, retrieval and presentation of information were of main interest. Thus, data models were mostly the starting point for the development of information systems, whereas the modelling of business processes was often omitted. During the 1990s a number of parallel management trends like the concept of business process reengineering (BPR) shifted the focus from data orientation to processes orientation and thereby provoked the emergence of an increasing number of process-aware information systems.

2.1.4 Classification of PAIS

The term PAIS can cover a variety of dissimilar facilities: According to [13] process-aware information systems can differ from each other in respect to the operational areas they are applied to, the types of processes they support, or the resources they involve - to name just a few. Therefore PAIS can be classified according to different orthogonal dimensions. In this subsection the separation concerning the nature of resources involved by PAIS is illustrated, as this dimension of classification is crucial for the further progress of the work presented. However, a more detailed classification can be found in [13].

One approach to classify PAIS is to distinguish them based on the type of participants they require to perform the process tasks, more precisely, whether these participants are

people or software applications. In this regard, PAIS can be separated into the categories system-oriented and human-oriented. Technically speaking, it can be differentiated between application-to-application (A2A), person-to-application (P2A) and person-to-person (P2P) processes. [13] The particular variants will be described in more detail below.

2.1.4.1 A2A processes

Processes that just involve entirely automated tasks performed by software applications without any human intervention are called A2A processes. They are typically deployed in the field of distributed computing, especially for distributed application integration. Application-to-application processes are supported by enterprise application integration (EAI) platforms and transaction processing systems, by way of example. As annotation, it should be remarked that the logic of A2A processes is not always captured by explicit process models – it can also be written down implicitly in the code of the programs that participate in the process. [13]

2.1.4.2 P2P processes

On the other hand, there are P2P processes, which primarily incorporate tasks that require the integration of human abilities and therefore cannot be executed fully automated by an application. Although the participants that perform the P2P process tasks are solely people, also applications are called into action, especially to support computer-mediated interactions like e-mail clients or video-conferencing tools for instance. Person-to-person processes are provided by job tracking and project management tools, among others. [13]

2.1.4.3 P2A processes

Finally, there also exists a hybrid of the two former process types, namely P2A processes. These involve manual tasks carried out by humans as well as automatically executed tasks performed by software applications and aim at making people and applications work in an integrated manner. As most of today's workflow systems are suited for interactions between both people and applications, they fall into the category of people-to-application systems. It should be remarked that since workflow technology as a whole is considered to be P2A, it can also be employed to support human-driven tasks as well as application-driven tasks only. [13]

The boundaries between the three categories presented are fluent. As stated in [13] some systems are placed in between of two classes, while others target two process types at the same time. The master thesis at hand will exclusively address processes that require human performers for processing because for the successful execution of the involved tasks a person's skills, knowledge and experiences are needed. Thus, it is about processes that

cannot be executed fully automated by software applications without the intervention of human users.

2.2 Workflow systems (WFS)

Typical examples for PAIS are workflow systems. They support P2A processes and target the improvement of interaction between people and applications. The initial aim of this master thesis is to analyse how human-centric user interfaces of existing workflow systems are. Therefore, as a first step the basic aspects from the field of workflow systems that are relevant for this work are presented in this section.

2.2.1 Definition of WFS

Workflow management is usually defined as the IT assistance or automation of business processes [18]. Its aim is the IT-supported execution of workflows on the basis of a process specification (or workflow schema), which describes a type of process and is used as a template for the execution of concrete workflow instances, as it consists of a coordinated set of activities to reach a specific goal. By controlling the routing of tasks and linking the persons to the required applications, workflow management ensures that the work is done efficiently at the right time, by the right person, with the right software tool. Thus, the focus lies on the structure of the work process, not on the contents of its individual tasks. [13]

Workflow management includes all tasks that are necessary for the modelling, specification, simulation, execution and control of workflows. The software for realizing the workflow management is called a Workflow-Management-System (WFMS). WFMS integrate the single tasks of a business process into an entire processing stream and arrange the allocation of different applications and required information to the respective user. Therefore all organizational aspects of a business process, like who is doing what at what time, are captured at design time by a process model and possibly also by an organizational model. [17] Based on these models the WFMS is able to coordinate the execution of tasks at run time by informing the respective people about upcoming jobs, providing relevant information and integrating the required tools for their processing.

2.2.1.1 Process model

WFMS are generic systems in that they do not include any professional functionality or information concerning the processes of a particular organization. Instead, the generic software product must be configured first in order to be able to utilize it productively. Initially a process model has to be defined that pictures the organization's business processes. This is done by means of a definition tool that makes use of a certain modelling language. The

range of languages for modelling process specifications reaches from textual languages in an algebraic or programming style to graphical notations. A distinction is made between vendor proprietary and standardized languages. [13]

The process model contains at least information about the tasks that need to be executed and the relationships between them, conditions for enabling tasks, as well as information about required resources that must be allocated to task instances and resource management rules. [13] There is also the possibility to lodge instructions for single work items in the process model that describe how the jobs have to be executed [17]. All this data is administered in a database, where also an organizational model including roles, skills and similar aspects might be stored [40].

The required resources indicate all kinds of objects that are necessary to perform the single tasks, like services and applications, but also employees that might be regarded as (human) resources. Some of them can be shared between multiple tasks while others are just available for exclusive use. Resource management rules are used to resolve conflicts that arise from concurrent access to resources by different task instances. [13]

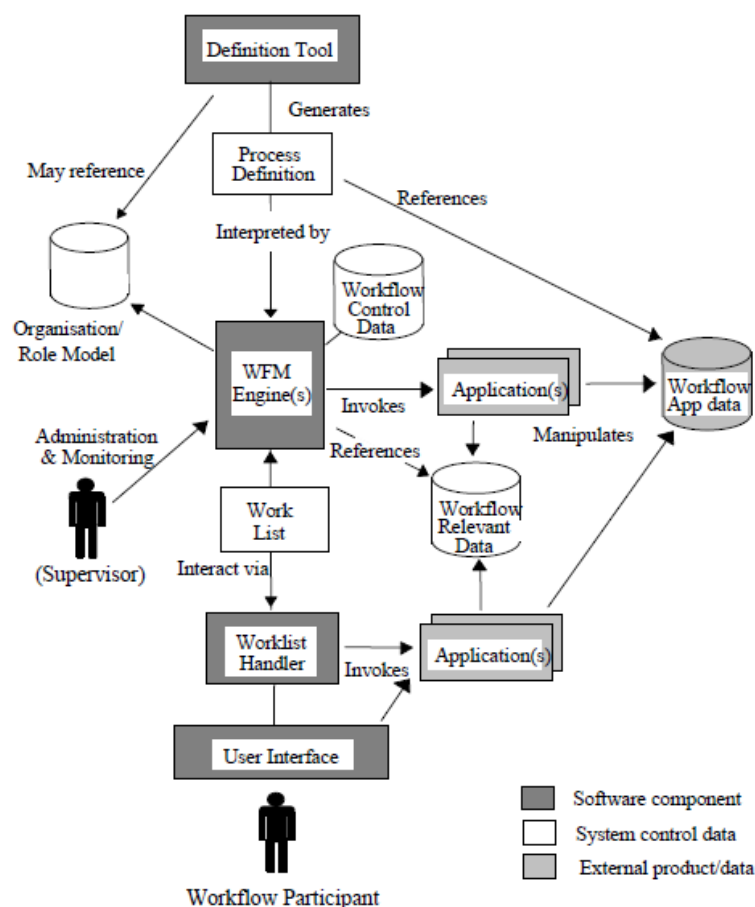


Figure 2: Generic structure of a WFMS [39, p. 39]

2.2.2 Working routine

The main components of a generic WFMS are illustrated in Figure 2. The shown structure will be explained briefly in order to give an initial overview of a WFMS' working routine: The central component which is responsible for interpreting and executing the modelled process definitions is called workflow engine. The workflow engine implements the workflow enactment service that is responsible for the generation of new instances of a process type. The engine works as follows: It autonomously interprets the occurrence of certain types of events (e.g., the arrival of an order) at runtime and reacts to it with triggering the execution of an instance of the appropriate process type. An executing instance of a workflow schema is called a workflow or also a process instance. [13]

Depending on how specified in the underlying process model, one or more tasks are being enabled by triggering a process instance. A task conforms to the work that constitutes a logical step in a process. It may comprise one or more single steps, called work items, which are routed to qualified persons or applications who / which accomplish them. [13] Items that require user interaction for execution are placed on the worklist for attention by the worklist handler, which is responsible for the interaction with the users [40]. The pending items on the worklist are then being processed from the workflow participants by means of the linked applications.

After completion of the actual task(s) the WFMS continues with dispatching the next one(s) according to the specification until the termination event is reached, which defines the end of the workflow execution. [13]

As a rule, the process specification describes the regular way of executing the process. However, under certain conditions, a workflow may deviate from the predefined schema, for instance if a required resource is not available or a deadline is missed. In case of such exceptional situations the WFMS should hold methods for systematic recovery, like predefined procedures that provide specific exception handling mechanisms for each exceptional condition (e.g., "resource A is not available") that might occur. [13]

The workflow engine also records the execution of workflows for the purpose of later analysis and also for legal reasons. Normally, several instances of the same process type are performed concurrently. [13]

2.2.3 Workflow client application

A workflow management system provides different interfaces to its comprised components. Thereof the workflow client application is the most relevant one for the further course of this master thesis, therefore it will be presented in this subsection.

The workflow client application is used to provide an interface to the users that are involved in the workflow execution. It's most important feature is the worklist, which exists for

every user. It contains the work items that currently need to be performed within the active instances and presents them to the respective workflow participants. Additionally it supplies the users with instance-specific information about the particular tasks, like how to execute a specific item. [13] Figure 3 shows the relationship between process definition, process instances and the worklist.

Beside the basic worklist function, the client application can contain various optional features depending on the particular WFMS. Some of these will be presented later in this work.

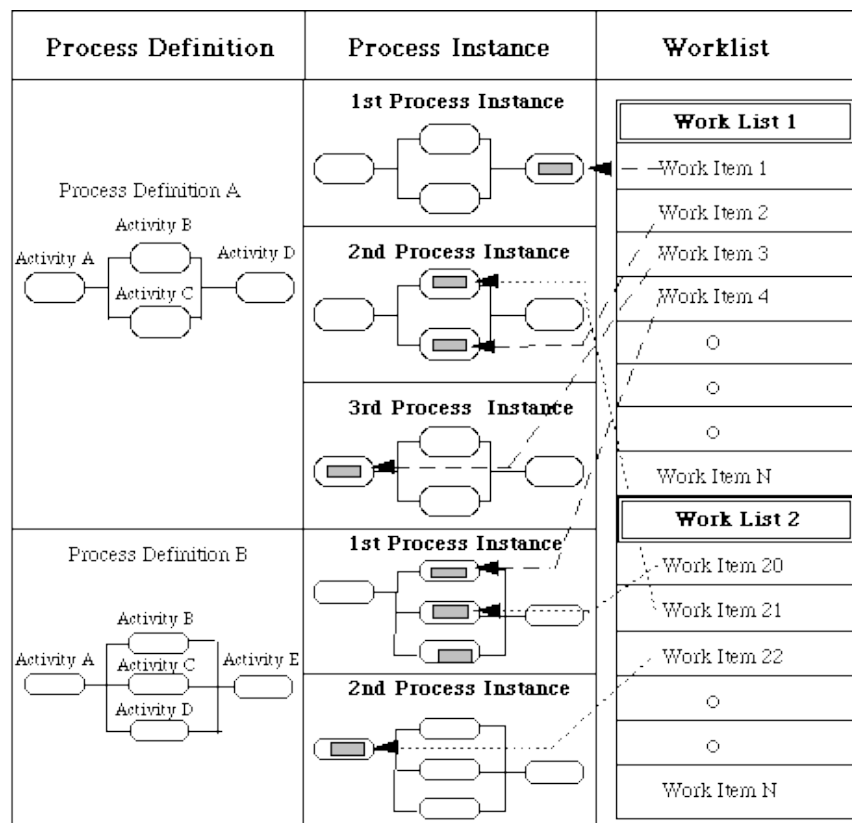


Figure 3: Relationship between process definition, instances and worklist [39, p. 22]

A worklist can either follow the pull or the push principle. The difference between the two variants is that in the pull-based case the workflow user himself does the scheduling, as he can select the tasks that he wants to perform from a list of pending tasks. He has to gather the required information and to choose the adequate applications for the task execution on his own. On the contrary, in push-based worklists the user does not have the choice, which tasks to execute. The workflow engine does the scheduling of tasks and assigns the work items together with the appropriate applications and necessary information to workflow participants that have the requisite capabilities. [13] In both cases an automatic escalation management can be proceeded: If a work item rests too long in an employee's

worklist, that is, a defined time limit is exceeded, the item is forwarded or a notification is sent to another user. [17]

The assignment of tasks to possible processors usually happens dynamically by means of roles. That is, the work items are assigned to predefined roles instead of human actors. An employee can have different roles, whereas a role is associated with certain capabilities and privileges that clarify the suitability for different types of work items. This form of task assignment increases the flexibility towards organizational changes, as employee transfers do not affect the underlying process model. In case of assigning tasks directly to the processors, changes in the organizational structure would make it necessary to also change the process definition. [17]

The execution of task usually involves the invocation of external application systems or Web services. External systems may be standardized office tools like a spreadsheet program on the one hand, but also specially developed software systems for certain business functions on the other. A distinction can be made between interactive and fully automated applications: Whilst the former implicates interactions with workflow users, like the completion of a form, the latter application type executes the tasks automatically without the assistance of a human hand. An example would be the search for data in a database. By contrast, Web services are software applications that are provided via the Internet or a network. They supply certain functionalities, e.g. for data access or validation, that can be used to support specific tasks to build a complete workflow. [13]

2.2.4 Strengths and weaknesses

Workflow management technology has become very popular and widespread since its beginnings in the early nineties. The great success of workflow management systems can be explained by the fact that its use provides a tremendous advantage for organizations. [33]

The coordination of work is assumed by the WFMS instead of human actors, which leads to less mistakes in work handoffs and thereby increases the efficiency of the work. Workflow management systems also allow a better insight into process execution and ensure that the process is executed according to the intended procedure, which results in a higher quality of service. Shorter lead times are another notable benefit of WFMS, as well as the fact that they facilitate the redesigning of a process, which makes the process more flexible. [29] According to [17], there arise potential savings up to 90% of the total processing time through the employment of workflow systems. All in all, the use of WFMS allows for a faster, more flexible and qualitatively better instance processing in organizations.

Without doubt, the use of workflow management systems leads to great changes in the way that professionals do their work. That is why, despite its success, WFMS have also received many criticism. The main argument against the use of workflow systems is that the

rigid structure of WFMS might be experienced as too restrictive by the employees and thereby may have a negative impact on their performance, motivation and satisfaction for want of self-responsibility. [33] As the employees have to do their jobs strictly according to the process definition enforced by the WFMS, they may perceive their work as more monotonous and similar to stringent assembly line work [24] because there is little room for individual user decisions and adjustments to user preferences. Through the given frame there is no possibility to integrate or promote human creativity and ideas for improvement of the processes. Also the treatment of humans as exchangeable resources with a certain function, which comes along with the mechanical approach of workflow systems, negatively effects the employee satisfaction and declines the acceptance to work with WFMS [33]. Furthermore, the monitoring function that is provided standardly by workflow systems makes it possible to assign every occurred workflow error to the particular person that is responsible for it, which additionally applies pressure on the employees.

Figure 4 shows a brief summary of the revealed strengths and weaknesses that are described above. As can be seen the weak points of a WFMS are all concerned with workflow participants and their human needs. The purpose of this master thesis is to overcome these negative effects in respect to the users of WFMS and to unfold potentialities that enable a better integration of humans and their demands into the workflows. Therefore criteria will be presented later in this work, which make the use of workflow systems more human-oriented and thereby increase employee's acceptance and motivation to work with such systems.

Strengths	Weaknesses
<ul style="list-style-type: none"> • Increased efficiency of work • Higher quality of service • Shorter lead times • Shorter processing times • Facilitation of process redesigning • More flexible instance processing 	<ul style="list-style-type: none"> • User's motivation and satisfaction is affected negatively through the WFMS' rigid structure • Treatment of humans as exchangeable resources • Increased pressure on employees • Monotonous work • No integration of employees' needs

Figure 4: Comparison of strengths and weaknesses

3 Research methodology

In this section the research design is presented that guided this thesis in order to realize the target aims that have been introduced in section 1.2. To start with Figure 5 gives an overview of the different research methods that were used within this work by graphically illustrating the deployed research strategy. As can be seen the procedure was divided into three phases that build on one another: In the first stage the design principles (DPs) were being acquired, on which the entire development of the HC-PAIS user interface mock-ups was based on. Therefor it may also be regarded as the preparation or planning phase. In the second stage the actual mock-up generation was realized, which constitutes the core of this work. By contrast, the final evaluation in Phase 3 can be seen as a kind of post-processing as it provides an implied feedback on all the previously taken steps.

In the following the overall research methodology applied in this work will be explained in detail.

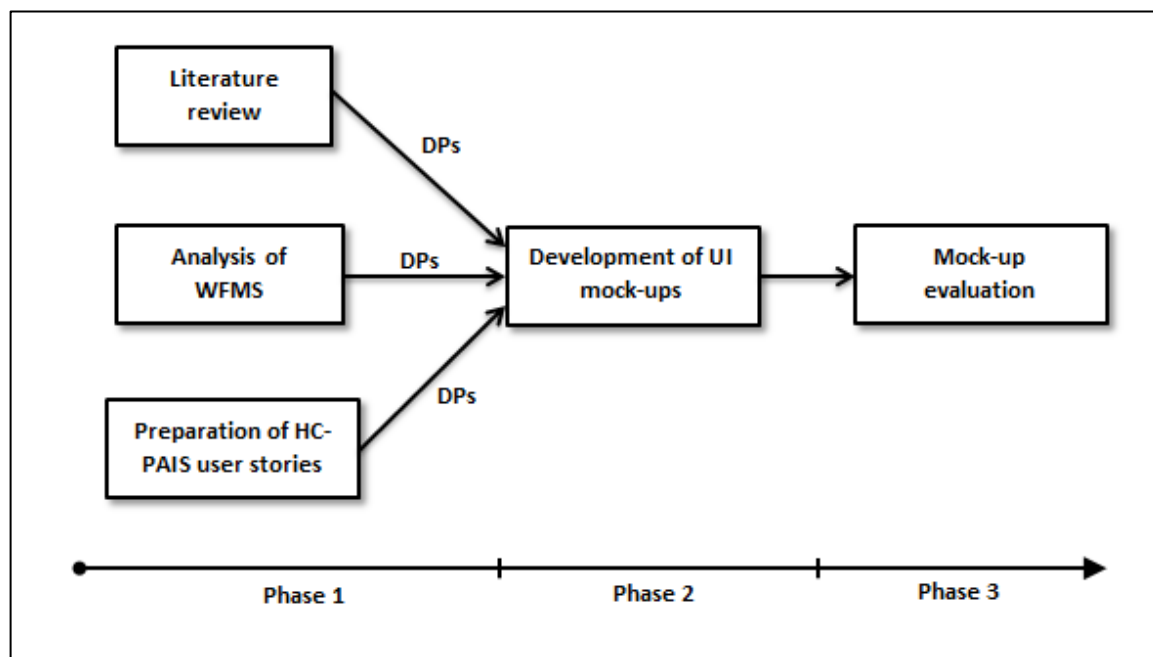


Figure 5: Research strategy

The starting point for the thesis at hand was a comprehensive literature review based on which the theoretical backbone presented in chapter 2 was prepared and also the criteria were derived that are assumed to qualify the workflow client application of a WFMS as human-centric. The thereby identified criteria were then recorded in an evaluation scheme, which can be seen as initial point for the subsequent research activities.

The next step was the conduct of an investigation into existing WFMS in order to get an overview of the current situation on the market. A summary table containing the most

popular products at present was created, from which three were chosen to be analyzed regarding the human-orientation of their workflow client applications. The analysis was conducted by means of the previously compiled evaluation scheme: It was examined if - and if yes to what extent - the listed criteria are implemented in the selected WFMS. Besides, attention was paid to whether the inspected products feature any additional qualities that contribute to rendering their workflow client applications more human-centric and have not been considered yet. In this case the detected criteria were added to the evaluation scheme afterwards and taken into account in the further course of the investigations. At the conclusion of the analysis the valuation results were outlined in an evaluation summary, so that a comparison between the analysed WFMS could be drawn.

In the following phase the construction of a human-centric PAIS user interface was addressed. This was realized by preparing some mock-ups of a workflow client application that covers selected features listed in the evaluation scheme. For the purpose of developing the UI models some user stories were drawn up that each relates to a specific process and describes a concrete usage scenario. These scenarios, in turn, were then simulated based on their underlying processes in a fictional WFMS, whereby for every simulation step at least one corresponding user interface screen was created. The total of the screen images prepared in this way constitute the intended HC-PAIS user interface mock-ups.

In a final step the created mock-ups were validated by means of a qualitative expert evaluation. Therefor qualified test persons were elected to be questioned in an open way about their opinion regarding the human-orientation of the developed workflow client application and possible improvement activities.

4 Human-centric PAIS

Recent research [21] suggests the development of human-centric concepts that support human integration in PAIS in a way that provably increases users' motivation and satisfaction working with the system and as a consequence positively influences the performance of users executing the process tasks. The intended implementations that address human-orientation in PAIS are referred to as Human-Centric Process-Aware Information Systems (HC-PAIS). In this context human-orientation stands for the integration of people's skills, competencies, knowledge, ideas, wishes, needs and also goals into PAIS, which will lead to a more efficient performance at the execution of human tasks in an organization's processes. Accordingly, the focus of such systems lies on the process participants, meaning the employees working with the PAIS. For the realization of a HC-PAIS it is important that these

people accept the deployed technology, otherwise, if this precondition is not met, the objectives intended by the human-centric system cannot be reached. [21]

According to this definition a HC-PAIS is rather qualifying than defining an information system. It concerns the behavioural perspective on human-system-interaction facilitated by a PAIS. [21] However, the integration of the people perspective into PAIS is very sophisticated because processes that require human capabilities are often complex, semi-structured and dynamically changing. As an increasingly large number of humans have to work with PAIS technology these days, it is nevertheless important to focus on the sociotechnical issues within these systems, which place the emphasis on the interacting individuals. [15]

Section 2.2 has given a survey on a specific kind of PAIS, namely workflow management systems. As already mentioned, these systems deal with processes that also involve manual tasks that have to be performed by human actors and therefore a fully automated process execution is not practicable. Thus, the workflow participants play a central role in PAIS as they are essential for processes that require human competencies and knowledge for a successful completion. Since the integration of humans in WFMS is necessary, these systems should be customized in a human-oriented way by better responding to employees' needs at the execution of tasks because this will lead to an increase in process performance.

The thesis at hand aims at providing a concept for a HC-PAIS user interface that focuses on the end-users of WFMS and their wants in respect of carrying out their work. To achieve this goal it is necessary to overcome the shortcomings of workflow systems regarding their users. Accordingly, criteria have to be identified that qualify the interface they are working with, i.e. the workflow client application, more human-centric. In a further step, the collected criteria will be recorded in an evaluation scheme based on which the mock-ups for a HC user interface will be realized.

4.1 Criteria for HC-PAIS

In the remainder of this subsection the question will be answered how the client application of a WFMS has to look like and which functionalities it should contain in order to be regarded as a human-centric user interface. Therefor different approaches will be determined that seem to be most useful for the realization of a human-oriented UI approach.

The areas considered are:

- **Workflow patterns**

In this section proven solutions to resource allocation problems, called resource allocation patterns, and policies that can be used to guide task assignment and synchronisation decisions are presented.

- **HC-PAIS approach**

This approach explores additional features that can be implemented to render a PAIS more human-centric. It primarily gears towards the integration of people's skills, work experiences and goals into the system, but also concerns the communication between employees and their support.

In the following the mentioned perspectives are presented in more detail. The thereof resulting frame of reference defines the scope of research for HC criteria concerning a WFMS user interface and constitutes the theoretical background for the development of the evaluation scheme in 4.2.

4.1.1 Workflow patterns

A workflow pattern is understood as a proven solution to a common problem in the field of workflow application development. The usage of the pattern concept allows to economize the process of development and to simplify maintenance.

Workflow patterns can concern different perspectives, like control-flow, data, resources, exception handling or presentation [30]. In this work the scope of patterns is limited to resource patterns, as introduced in [30], which capture various ways of how resources are represented and utilized in workflows and how they interact with a PAIS. As already indicated before, a distinction is made between human and non-human resources, whereas the focus of this master thesis lies on the human ones. Additionally the assignment and synchronization policies suggested in [41] will be regarded, in order to top the pattern concept off. Whereas the former concern the work allocation strategy that is used to assign pending tasks to the shared worklist of potential performers, the latter determine how the work items on a shared worklist can be accessed by individual users [41]. Below chosen patterns and policies from the mentioned reference works and also some new modifications of them are presented, that can be adopted to render the workflow client application of a WFMS more user-friendly and are therefore identified as criteria for a HC-PAIS user interface.

4.1.1.1 Work item distribution

Of particular interest from the resource perspective is the way in which work items are offered and ultimately allocated to specific process participants for execution. The framework proposed at hand assumes a workflow client application that maintains two kinds of worklists – a shared and a private one. The former shows all the tasks that are offered to a person, while the latter only shows these that have already been allocated to a person. To each item in the list a description can be displayed that includes information about the task execution and the thereto necessary applications, as well as the presumed workload in hours and the requirements that must be fulfilled from a user to be able to complete the task successfully [1]. Additionally every task is provided with a deadline and a priority level, which can be *critical*, *high*, *medium* or *low*. The priority of a work item depends on various factors, such as the complexity or difficulty of a task, the significance of the customer and of course the deadline date ¹.

The creation patterns presented in [30] and also the assignment policies introduced in [41] determine to which persons newly created tasks are offered, i.e. whom these tasks are put on the shared worklist. The way of how the workflow enactment service prioritizes pending work items and notifies candidate performers of it is dependent on the chosen work allocation strategy. The role-based distribution is probably the most common approach to work item distribution within PAIS. Thereby the created tasks are offered to one or more roles, which are specified in an associated organizational model. The role concept serves as a grouping mechanism for employees with equal characteristics in respect of the field of duties, responsibilities, privileges and capabilities. Note that a human resource can be assigned to different roles.

The capability-based distribution strategy is similar: The newly available tasks are offered to employees that possess the indicated capabilities, which are also recorded for every individual person in the organizational model. Capabilities can be captured in form of skills, qualifications or work experience, what will be explained in more detail later. Since the previous execution history is taken into account here too, also the pattern of history-based distribution is applied at the same time. Beside the described strategies a new innovative type shall be introduced at this point, namely priority-based distribution, which can be applied to make the work item distribution in WFMS more human-oriented. In this approach, every person in the organization can assign personal priorities in his / her profile, e.g. one can define a certain task type that he wants to be offered in preference or a favoured skill type so that he is increasingly offered work items that require this defined skill. It must be considered that the employee profile is not equal to the organizational model, as the profile is private and

¹ The illustration of a mathematical function that can be used to calculate the task priority level is beyond the scope of this work.

individual for every person and changes can be made in it on one's own. Which features the skill profile additionally supports and how it will be realized in practice is illustrated later in this work.

For the implementation of a human-centric PAIS concept, a combination of the three mentioned distribution strategies is proposed, that is, newly created tasks are put on the shared worklist of people with an appropriate role, suitable capabilities or a relevant priority. According to that, the resource selection happens indirectly by means of so-called proxy constructs as stated in [41]. The assignment is static to the effect that it does not alter with different workflow instances and thus is not dependent of specific properties of the current instance. Illustrated by an example, the combined distribution mechanism behaves as follows: If the combined distribution policy is adapted to the information given in Figure 6, the task *perform operation* would be offered to Tina because she has the adequate role, to Fred because he has set a corresponding priority, and also to John since he possesses the suitable capabilities to perform the task. Accordingly, the assignment of work items to possible processors happens dynamically by means of the afore-remarked characteristics. That is, upon availability of new work items, they are put on the shared worklists of qualified persons by the workflow enactment service, but are not directly allocated to the human resources by the system. In this way the WFMS does justice to the capabilities and wishes of the people that are working with it.

At the same time the combined distribution strategy creates an implicit substitute relationship between multiple performers that are qualified for the execution of the same work items. Thereby a delegation function, as outlined in [41], is not necessary, which is a good thing because from a security perspective the ultimate passing on of tasks from one workflow performer to another delegate one entails many risks. By way of example this way of substitution would be common during the absence of employees. Wainer et al. have outlined the security problems of revocation and delegation in WFMS in their technical report [38]. However, the additional use of a pull instead of a push strategy at the allocation of public work items to users' private worklists in combination with a processing deadline – as proposed later in this work - makes a delegation function unnecessary anyway. This will be explained in more detail below.

Task: Perform operation				
Offered to:				
<u>Role:</u> Surgeon				
<u>Capabilities:</u> Doctor's degree, 2 years consultant competence surgery				
	Tina	Fred	John	Alice
Role	Surgeon	Surgeon in Training	Chief Physician	Nurse
Capabilities	- Doctor's degree	- Doctor's degree	- Doctor's degree - 2 years consultant competence surgery	- taking blood samples
Priority	Heart surgery	Perform operation	Discharge patients	Organisation of care measures

Figure 6: Available information for work item distribution

At the realization of a human-centric workflow client application also the retain-familiar pattern proposed in [30] should be regarded, as it may contribute to users' motivation and satisfaction. It is defined as the ability to allocate a work item within a given case directly to the same resource that undertook a preceding item. As this employee is already familiar with the case, the performance at executing a successive task will be better. Additionally the execution itself will be expedited, what is a further advantage. For the processor it may be motivating that he is entitled to perform the whole interrelated thread and that he is preferred at the task allocation of the respective case. As a result he will deal with the case more extensively. Taking account of this pattern at the composition of our framework, the assignment mechanism of the proposed WFMS would not be entirely static any more, as for the retain-familiar mechanism, data from the current workflow instance has to be incorporated in order to identify the same processor that has executed the previous task of a specific case. Since considering a human-oriented client application, the user has of course the freedom to refuse the tasks that are assigned to his private worklist in this way. In [41] this feature is referred to as participant autonomy. In case of refusing an automatically allocated task, the combined work item distribution strategy that was described above is applied, thus meaning the item is put on a shared worklist.

4.1.1.2 Task assignment and execution

Once a work item is available on a shared worklist, the employees that have access to it can chose which tasks they want to perform and allocate them to their private worklist at a convenient time. This approach is called pull strategy and conforms to a partially automated allocation mechanism, where the WFMS suggests qualified performers, but is not responsible for the ultimate assignment of tasks to final recipients. By allocating an item to a

person's private worklist, it is simultaneously removed from the shared worklist and thus no longer available for other potential processors. That is, each task can only be selected by a single resource for execution. The allocation mechanism follows the first-come, first-serve (FCFS) principle, which implies that the requests of users are attended to in the order that they arrive.

Nevertheless, for a human-centric PAIS approach it is necessary to impose some restrictions on the FCFS service policy in order to organise the work item distribution in a fair and efficient way. Therefore it is recommended to implement some authorization rules to ensure an evenly distributed task allocation among the employees. An example would be a rule that concerns the quantity of allocated items in the private worklist. For instance a limitation to a maximum number of five tasks could be specified, so that if one has already five items in his list, he cannot obtain new jobs from the shared worklist and other employees with less than five allocated items are yielded precedence. Thereby the workflow participants should be restrained from randomly piling work items on their private worklist. Another example would be a rule, that processors cannot have concurrent execution of work items, i.e. users are not allowed to start additional work items while another previously started item is still being executed and not yet completed. This may reduce the time needed for the execution of a task and thus contribute to a more efficient performance, as the user is forced to concentrate on the one work item that is currently started and is not distracted by other tasks.

The aim of such authorization rules like the above-named is to keep the workload between users in balance, what may contribute to their personal satisfaction and to a good work climate in an organization. Which rules to apply concretely depends on the respective organization and the nature of their processes and individual tasks. Therefore the rules illustrated above may only be regarded as suggestions, which are not generally applicable in every domain.

Work items that are allocated to a private worklist need not be executed compulsorily by the respective user. It is still possible to deallocate items and return them to the shared worklist, for instance if it is not feasible for the user to complete the task in time due to a recent problem that has occurred. The same applies to tasks that have already been started: Users can abort the execution of a work item at any point of time and deallocate it from their private worklist. The task is then available again for other potential processors who can allocate it to their list and start the execution from new. If an employee wants to make use of the deallocation mechanism, he has to report it to his direct supervisor before and cite the reason why he intends to give back the work item. Thereby it should be avoided to misuse the ability of returning tasks to the shared worklist.

It is also possible to use assistance if a problem occurs at task execution. There are various ways to get help: One can view the task-specific support material that is provided for such cases in the *Support area* or ask other users for assistance via the forum. In addition there is the possibility to contact a mentor, who helps to solve the problem. In this way processors should be enabled to complete the work item successfully without having to make use of the deallocation feature if it is not indispensable.

As soon as a work item is allocated to a user's private worklist, he can decide on his own when to start the execution of the task. This could happen immediately upon allocation or at a later point in time. A prerequisite is, however, that the task is completed until a given deadline, which each item is provided with. If a work item rests too long in an employee's worklist, the user will get a reminder in form of a system notification in due time before expiry of the deadline, in order to call to mind that the completion of the task instance is still outstanding. If the deadline is passed regardless, the system will deallocate the respective item from the private worklist and offer it to other available persons again. Also in this case the supervisor of the employee gets informed about the escalation, what should encourage the process participants to adhere to the given deadlines and to assume the responsibility that is granted them.

After starting the execution of an allocated work item, there is the possibility to suspend the processing and to resume it at a later point of time. Upon finishing a task, the user has to confirm its completion in order to terminate the process properly and to clear the item off his worklist.

The employees can determine a desired display format for the items listed in their private worklist. The work queue can be arranged according to various task attributes such as deadline dates or priority levels. At processing users have selection autonomy, meaning that the items need not be executed in sequence, but can be selected for execution based on the processor's preferences. The only exception to this are work items with priority level *Critical*, which must be executed first before any other task with a lower priority can be chosen for execution. In [41] this kind of item queuing is referred to as pool-type distribution. It enables human performers to determine the priority of the pending tasks on their private worklists on their own. Accordingly, the employees can do their work autonomously since they are allowed to make their own decisions and to schedule and organize their work on their own. This leaves a lot of "elbow room" for the users, what conforms to the requirements of a human-centric PAIS.

4.1.1.3 Work item lifecycle

The selected workflow patterns and policies presented above are identified as practical for the realization of a human-centric PAIS user interface. Resulting from these assumptions the work item lifecycle illustrated in Figure 7 arose for the framework proposed in this work. The lifecycle is expressed in the form of a state-transition diagram - referring to [30, p. 9] - which shows the proceedings from a work item's creation through to its final completion. Each edge label in the graph is prefixed with either an S or an HR, indicating whether the underlying transition is triggered by the workflow system or a respective human resource. In the following the work item lifecycle is explained briefly in order to provide a clearly laid out summary of the main points again.

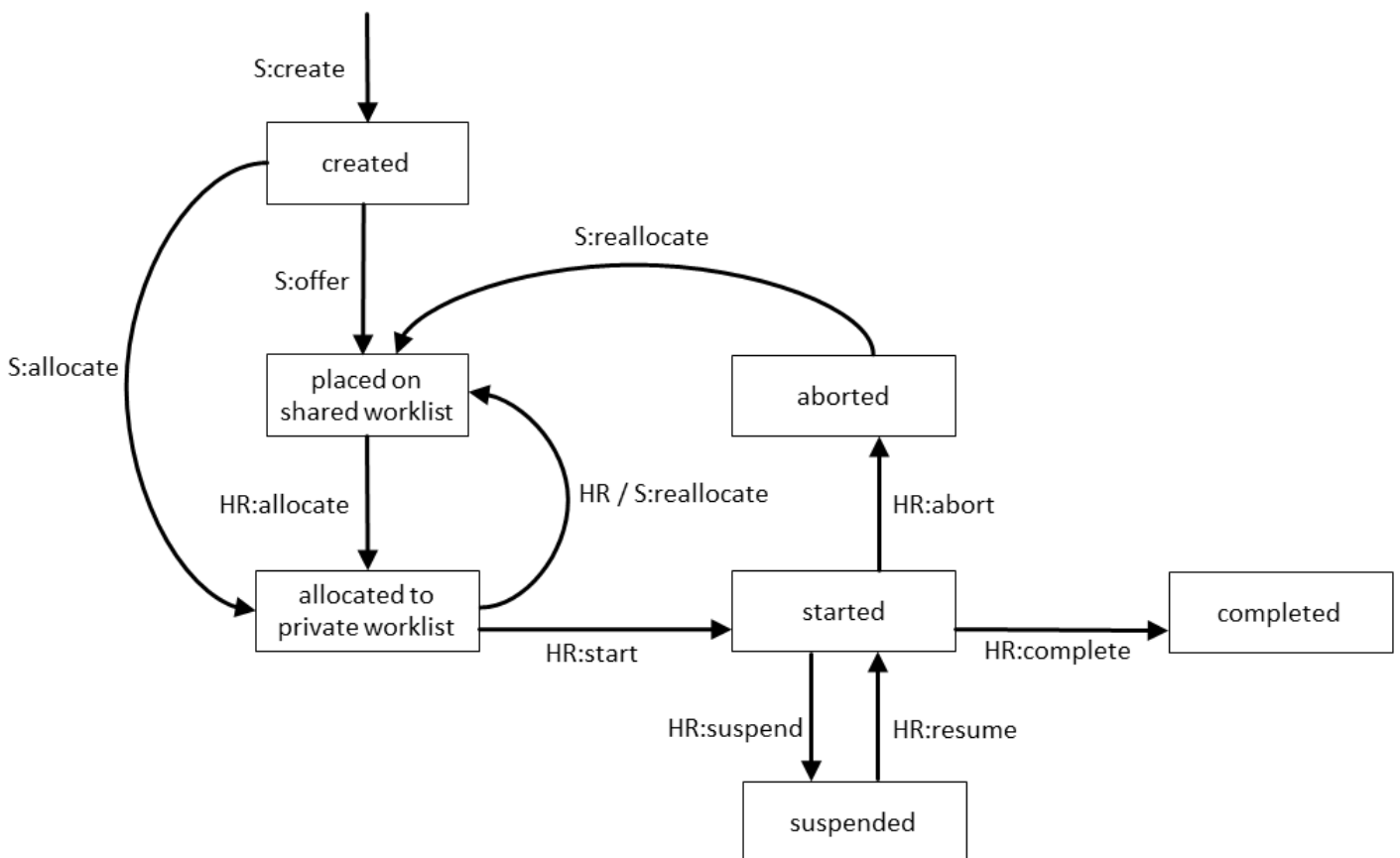


Figure 7: Work item lifecycle (adapted from [30, p. 9])

As can be seen in Figure 7, a work item comes into existence in the *created* state, which is enforced by the workflow enactment service. Once a workflow activity is capable of being executed, there are two distinct ways of making human resources aware of pending tasks. In the general case, the system offers newly created work items to multiple performers by placing the tasks on a shared worklist that can be accessed by qualified users. The

determination of possible candidate performers is based on the combined distribution strategy and thus conforms to a static and indirect type of assignment. After this step the work item is in a state called *placed on shared worklist*. At that point the users that can view the list have the possibility to allocate tasks from it to their private worklist in a pull manner, meaning that the allocation is undertaken voluntarily by the workflow participant and not by the system. The access sequence of users is basically scheduled by the first-come, first-serve principle, though it may underlie certain restrictions caused by customized authorization rules. By assigning a work item to the private worklist of a designated performer, it gets concurrently removed from the shared worklist and comes into the state *allocated to private worklist*.

The unusual case of informing workflow participants about the availability of pending work items would be the dynamic assignment by the *retain familiar* strategy. Contrary to the general method, the task is directly allocated to the private worklist of a single resource based on information from the current workflow instance. However, the thereof resulting work item state is the same like in the other path, namely *allocated to private worklist*.

Once a task is allocated to a private worklist, there are two possible ways of further processing. The work item can either be started by the performer or deallocated from the list again. Depending on whether a reached deadline or a human decision is responsible for the reallocation, the mechanism is triggered by the system or by the user himself. In any case, after this step the item is in the state *placed on shared worklist* again.

If the user decides to commence the execution of the activity, it comes into the state *started*. Subsequent states in the lifecycle model are *suspended*, which indicates that the workflow participant has chosen to pause the execution of the task for a period, but does intend to resume it at a later point in time, and *aborted*, which denotes that the user has stopped the execution and does not want to continue working on the respective activity. In this instance the workflow enactment service deallocated the aborted work item and places it on a shared worklist of qualified people again. If the execution of a work item is finished, the user has to confirm its completion in order to change the state from *started* to *completed*.

4.1.2 HC-PAIS approach

Besides the above mentioned criteria that were identified as useful for the realization of a human-oriented PAIS user interface, there are some additional features that can be applied to render the workflow client application of a WFMS more human-oriented and user-friendly. The detected functions do not fall into the category of workflow patterns or AS policies, and are therefore aggregated under the term HC-PAIS approach. These features are particularly geared towards the integration of people's skills, work experiences and goals into a WFMS, but also concern the communication and exchange of experiences between employees. The

single functions that are partly based on existing literature and partly extracted from already existing WFMS implementations in combination with some self-conceived modifications are described in detail below.

4.1.2.1 Experience breeding

The largest point regarding the HC-PAIS approach concerns the integration of work experiences into PAIS. In this work the term *work experience* is meant as a specification of capabilities, which can be collected through working in processes with a PAIS [22]. In [20] a concept called experience breeding is presented, which is very beneficial for employees as it allows them to define experience development goals [22] that they want to reach and also to track their development proceedings in a so-called skill profile [1], what has already been broached before in section 4.1.1.1. Thereby an experience-based task allocation is enabled, which is part of the capability-based work item distribution strategy [22]. As there are strong indications that the experience breeding concept qualifies a PAIS towards a human-centric PAIS, most parts from it are adopted for the realization of the HC-PAIS user interface provided in this master thesis. In the following the concept from [20] is presented with some adaptations made for the purpose of the work at hand.

For the realization of a human-centric PAIS the implementation of a skill profile for every employee working with the WFMS is proposed. In the profile a user's roles, skills [1, 14] and current work experiences are captured. This information is static in that sense that it cannot be changed from the user, as it is adopted from the underlying organizational model. Additionally employees have the possibility to quote themselves their individual experience breeding goals and task priorities (see 4.1.1.1 – priority-based distribution) in the profile. User preferences set in this way have a relevant effect on the work item distribution as they act as a driver for the alignment of tasks to human resources. Therefore this distribution strategy is also referred to as human-centric allocation [22]. It is assumed that the perception of a person's work may be positively influenced by the named allocation strategy, as workflow participants have the opportunity to co-determine which tasks they get offered for execution. In turn, how work is experienced from the users affects personal and organizational outcomes. [22, 27]

An example of a skill profile as outlined above is shown in Figure 8:

Skill profile:

USER: Martin

Role(s): Customer Consultant

Skills: MS Excel

Work experience: <ul style="list-style-type: none"> - E1: Calculating Offers - E2: Describing Offer Details - E4: Dealing with Customers 	Level: <div> Specialist <div> <div></div> <div>82%</div> </div> </div> <div> Valuable <div> <div></div> <div>45%</div> </div> </div> <div> Newbie <div> <div></div> <div>67%</div> </div> </div>
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Experiene goals:

- Remain "Specialist" at "E1: Calculating Offers"
- Become "Valuable" at "E5: Designing Landscapes"
- Neglect "E9: Working with Large Machinery"

Priorities:

- Task "T3: Draw up landscape plan"
- Skill "MS Project"

Figure 8: Skill profile

The experience breeding goals are self-set goals, like performing goals or learning goals, and express the users' wishes how they want to shape their work experiences as employees of a company. For example, users can state whether they want to learn something new in a specific area or whether they only want to maintain their current experience levels. It is assumed that the option to enter self-defined goals into the system on their own increases users' motivation. Moreover if a task is perceived as relevant for achieving such a goal, this task will be executed with a better performance. [20] This assumption is also applied to the possibility of specifying personal task priorities in the skill profile.

Experience goals can be entered by means of predefined goal patterns [20]. Whereas in [20] five different patterns are presented, three variant forms of them are proposed in this work for the realization of a HC-PAIS user interface, as these already cover all eventualities that are an issue in the field of experience goal setting. Before the suggested goal patterns are introduced, it is explained how work experience can be gathered by the employees in order to achieve their set goals. In this work it is supposed that the execution of a task activates one or more experiences [20]. Thus, work experience can be maintained or increased through the successful completion of tasks. The better the task performance, the

greater is the positive impact on the corresponding experience types. Note that the repeated execution of similar tasks that activate the same experience(s) can increase employees' performance [26]. However, on the contrary, a poor performance or a failed task execution will have adverse effects on a user's work experiences. Aside from that, the level of an experience also decreases if it is not activated over an extended period, as the gathered acquirements become obsolete over time².

In Figure 9 an example of an abstract process is represented: It shows the tasks (T1-T8) that the process consists of and also the experiences (E1-E9), which are activated by the tasks of this process, are listed top right. The connection between a task and its related experience(s) is illustrated by means of blue arrows, which point from the tasks to the respective experience(s). [20]

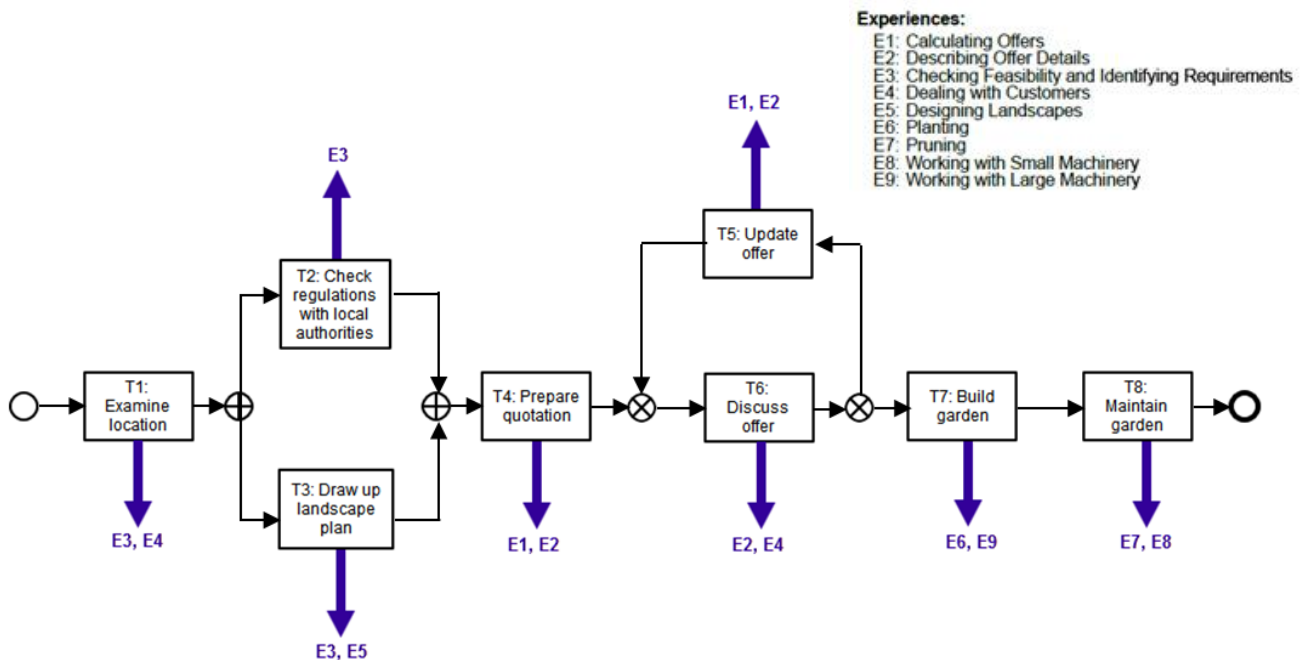


Figure 9: Abstract process 'Garden landscaping' (adapted from [20, p. 9])

If a task provokes more than just a single experience, it must be defined in the task description how much percent of the task is occupied by which experience [20]. Besides the activated work experiences, also the required criteria are listed in this description, which must be fulfilled from the workflow participants in order to be offered that task as they are prerequisite to handle the task successfully. These requirements generally include certain roles, as well as skills and work experiences at a predefined level, whereas the specified level is dependent on the priority of the underlying task. While critical tasks must be

² The provision of a mathematical function for reproducing the experience aging process is not part of this thesis but could be an issue of future HC-PAIS research.

performed from experienced employees, tasks with a low priority can be executed from unversed users. Tasks that are prioritized as high or medium require a processor of at least a mean experience level.

The work item that contains a defined task is only offered to users who meet all the required conditions that are listed in the description. An example of a task description is illustrated in Figure 10. As one can see, in the upper right of the description the overall process is pictured, whereas the task relevant to the presented description is highlighted. This serves to give the workflow participants an overview of the entire process and to illustrate, where the respective task is located in the process. The stated feature is assumed to be extremely valuable in the regard that users do their job more efficiently if they know what purpose their executed tasks accomplish and where they are embedded in the overall process [14].

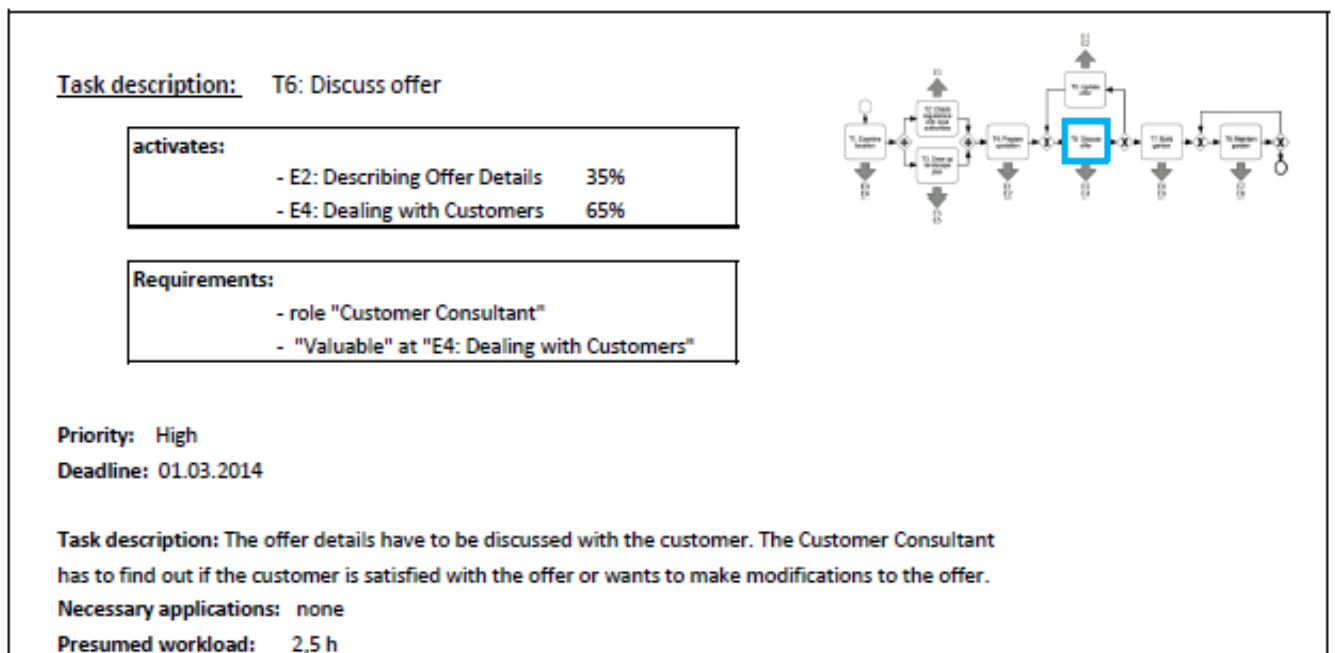


Figure 10: Task description

In the following the experience goal patterns that are proposed for the realization of a HC-PAIS approach are presented:

- *Pattern 1: Collect / maintain experience level.*

On the one hand a user can formulate his aim to breed a particular experience to a desired level until a defined date with *pattern 1* by entering the command:

Become [LEVEL] at [EXPERIENCE] (optional [UNTIL])

On the other hand this pattern can be used to specify that the employee wants to keep the current level of a certain experience by the command:

Remain [LEVEL] at [EXPERIENCE]

By setting a goal of type *pattern 1* the user is primarily offered work items that activate the specified experience.

Explanation: Experiences can be expressed at different levels [22], which are used to incorporate goal-based motivation [20]. Levels are distinguished based on their labelling: For the HC-PAIS approach proposed in this work, three levels are used, namely *Newbie* (lowest level), *Valuable* (mean level) and *Specialist* (top level). Which level to use as entry level for new users is left to the discretion of the respective company. It is suggested to rank newcomers tentatively as *Newbie* or *Valuable* depending on the competencies stated in their job profile or application documents. Through working with the system the initially assigned level will adapt itself accordingly anyway.

As can be seen in Figure 8, a user's work experience levels are displayed in his skill profile. The current status within a level is presented by means of progress bars. After reaching 100% the indicated level switches to the next higher one except the user is already *Specialist*, then the maximum is achieved. In the other direction, if the progress rate decreases to 0%, the level changes to the next lower one unless the employee is at the level *Newbie*, then the experience will disappear from the profile as the user does not dispose of it any more.

The particular experience rates are calculated by means of the experience measurement rule presented in [20]. This rule describes a mathematical function that combines quantitative and qualitative task performance aspects in order to achieve a single value that affects a user's current experience level either in a positive or a negative way. For the demonstration of the HC-PAIS user interface mock-ups within this work it is not crucial how the applied experience breeding rule works in detail, as primarily the visible outcomes for the users are relevant at this stage. Therefore only the essentials of the used measurement concept are explained in the following, whereas more detailed information concerning its functioning can be looked up in [20].

In [20] the stated rule is referred to as "*Generic Experience Breeding Rule for HC-PAIS*" [20, p. 8]. Generic on that score because the function is formulated in very general terms to be broadly applicable in various domains and businesses. Thus, the individual fine-tuning of the final formula specification and its single parameters is in the responsibility of the respective company. However, in general, the named function

combines four measured values, which are *Count*, *Duration*, *Importance* and *Quality*, that may be weighted differently depending on the respective experience and task type. While the first two are quantitative factors, the latter two are of qualitative nature and thus, are highly context sensitive and have to be defined individually according to the particular requirements of a company or branch. For the envisaged HC-PAIS approach the following applies: Apart from the suggested composition in [20], the *Importance* is additionally dependent on the priority of a task. The *Quality* value is affected from various task-related factors [20] as well as from certain circumstances concerning the task execution (successful completion / abort / deallocation / escalation of a task, necessity of a help request, behaviour in case of a help request).

An important point is the frequency with which the measurement rule is performed [20]. If the rule is executed only every six months, the employees see the effects of their work on their experience levels not until after half a year. For the HC-PAIS approach presented, it is suggested to perform the measurement rule after every task execution. In this way it is possible to keep the work experience display in a user's skill profile always up-to-date and to provide the user a transparent evaluation of each of his task performances (cf. Figure 63). Besides, this approach is necessary to ensure a correct distribution of work items according to the users' latest progress.

The data acquired from the measurement rule will be recorded on a monthly basis in an appropriate database and aggregated by experience types. At the end of the month the aggregated work experience values will be pushed to another database, in which the data about previous work experiences is stored [22]. In this way it is possible to give the user an overview of his monthly work experience progress (cf. Figure 37) and its percentage composition (cf. Figure 39). It is assumed that this method contributes to a better traceability of a WFMS' functioning and in turn increases user's satisfaction when working with the system.

- *Pattern 2: Neglect an experience.*

Workflow participants also have the possibility to define experience neglect goals with the command:

Neglect [EXPERIENCE]

In this way a user indicates that he is not interested in further breeding or maintaining the specified experience and thus, that he does not want to be offered tasks that activate this experience. This implies that the stated experience may decrease to the

lowest level over time. Nevertheless the employee's satisfaction and motivation to work with the HC-PAIS will increase, if tasks that include the particular experience are offered less often to him. [20]

- *Pattern 3: Breed experience for a role.*

With *pattern 3* the user has the possibility to set a goal for collecting experiences of a certain role by entering the command:

Collect experience for [ROLE]

As roles have associated tasks, which in turn activate specific experiences, this goal refers to all tasks, and thus experiences, that are ascribed to the defined role. This kind of goal is designed for employees that intend to attain an additional or another role than the role they are currently holding. By setting a goal of the type of *pattern 3* the user is still offered work items that are ascribed to his current role(s), but in addition tasks that are assigned to the role specified in the experience goal are increasingly offered to him. [20]

As already mentioned before, besides experience breeding goals users can also set task priorities in their skill profiles. They can specify certain task types that they want to be offered primarily and / or chose specific skills that they apply with preference. In the latter case the employees will be mainly offered work items that require the defined skills.

Unlike work experiences, skills are not expressed at different levels in our HC-PAIS approach³. Either an employee possesses a certain skill or he does not. Whereas experiences are collected by users during the task execution, new skills are being acquired in dedicated training units [32]. These can be external classes or internal training settings. The latter is realized by offering instructor-led courses that employees can attend after prior registration. Upcoming course dates as well as additional support material and learning aids such as tutorials with written instructions and how-to-videos can be found in a specifically provided *Support area*, which will be outlined in detail in section 6.2.2.

Different from work experiences, which are updated in a user's skill profile after every task execution according to a defined measurement rule, skills are actualised in the profile once they are attested and recorded in the underlying organizational model.

³ Note that also skills could be expressed at different levels. The same concept that is applied to work experiences would also be suitable for this purpose.

Conclusive it must be said that it is in users' option whether they make use of the experience breeding functions or not. They can decide on their own if they want to perform the same tasks all the time or if they want new challenges and more sophisticated task for execution. By defining experience breeding goals and task priorities, employees have the chance to pursue their individual experience building strategy, like reaching a particular generalization or specialization level. This self-determined way of working will increase not only users' work experience, but also their job satisfaction and task performance, what in turn has a positive impact on the overall process performance, which is essential for an organizations' competitiveness. [22]

Also from the manager's point of view it is a beneficial feature that users have the possibility to state their preferences as these data is ideally suited for analysis purposes. Decision-makers can get an idea of the current situation and job satisfaction in the company and find out where there are problems that have to be solved.

4.1.2.2 Experience and task history

Another feature that is believed to render the workflow client application of a WFMS more human-centric is called task history. It is primarily used to offer every user an individual overview of the work items that he has completed at some time in the past. In the history view the employee can declare whether he wants to see all his past tasks, which is the standard setting, or only the tasks of a certain time period, which can be specified by entering a start and end date. By default, all completed items are listed, meaning successfully completed tasks as well as aborted and escalated ones, but the user has also the possibility to hide certain kinds of tasks and to limit the display in this way.

The listing of the chosen tasks is ordered descending by the date of completion. Each listed work item is provided with the time required, that is captured during task execution [14] from the system by recording the user's actions while he is performing the respective task (that is when he activates *start*, *suspend*, *resume*, *abort*, *finish*). To each task the associated task description can be invoked in order to recall what the respective task was about. It is also possible to restrict the displayed work items to a certain task type, so that only completed tasks of this specified kind are listed. By doing so, the employee can make comparisons between his performances rendered, e.g. time comparisons.

In addition there is a separate experience history, in which the proceedings and changes concerning a user's work experience are evident [22]. It shows the current experience levels for the end of every month, so that the user can track where he has improved or get worse over time. All in all, the introduced history features serve for providing the employees a review of their performances and work experiences, what is assumed to

contribute to users' satisfaction to work with a PAIS and to increase their motivation to pursue their self-set experience goals.

All the information that is captured in a user's skill profile and history can be used to draw up a portfolio. Thereby employees have the possibility to extract their individual track record and use it as a proof of experiences in case of applying for a new role or job. On the other side a portfolio, in which a user's work experiences and progress over time are registered, enables the managers of an enterprise to identify and select suitable users for roles or special cases (e.g. as mentors) in an objective way. [20] It also allows them to take account of users' experience goals at the allocation of positions, what might result in an increase of employees' job satisfaction.

4.1.2.3 Communication and exchange

To conclude with, another function should be introduced, which is used for the purpose of communication and exchange of information between employees and also for tracing the progress of work within a process. This feature is designed as a discussion forum or message board with the enhancement that all working steps of the process execution are logged automatically from the system, thus meaning it is recorded who does what and when. As an example:

Alice started task "**T5: Update offer**". [Yesterday at 2:40 pm]

Martin aborted task "**T5: Update offer**". [Yesterday at 9:16 am]

John finished task "**T4: Prepare quotation**". [Oct 23 at 3:16 pm]

It is distinguished between process-related and task-related forums. In a forum of the former kind all employees are involved, who perform any task of a certain process. Therefore, in our case there would be a process-related forum for the abstract process '*Garden landscaping*' (see Figure 9), where all users participate that perform at least one of the tasks (T1-T8) of this process. By contrast a task-related forum only involves those users, who perform a certain task type. In our example, there would be a separate forum for each of the eight process tasks T1-T8. E.g. in the forum for T1, only employees participate that perform this type of task.

Apart from the different user group, both kinds of forums serve the same purpose: Employees are enabled to leave comments [14] and inform their colleagues about the current state of their progress in order to keep them up-to-date. Thereby users can keep track of the whole process easily. The forum provides users the facility to exchange views about certain tasks and to give each other feedback for work done or proposals for improvement [19]. Additionally one can ask for help or request for assistance via the message board if a problem occurs at the task execution. All forum entries are equipped with

date and time and are ordered chronologically. A reply function is made available for every posting so that employees can support their colleagues, answer their questions or comment their progress. In a user's private worklist the latest updates of all forums, where he is involved, are listed in order to keep him up-to-date of all his topics at a glance.

It is believed that the forum function encourages and facilitates the communication between workflow participants and thus qualifies a WFMS towards a HC-PAIS, as it contributes to users' motivation and satisfaction working with the system.

4.2 Evaluation scheme

On the basis of the above an evaluation scheme is created, which contains all criteria that have been identified as useful for the realization of a human-centric PAIS user interface. More detailed descriptions to the single criteria can be looked up in the sections 4.1.1 and 4.1.2. With the aid of the presented scheme the envisaged HC-PAIS user interface mock-ups will be constructed later in this work.

Evaluation scheme	
Area: <i>Workflow patterns</i>	
Criterion	Fulfilled
Work item description	
Separation shared / private worklist	
Work item distribution strategy (role-based / capability-based / priority-based)	
Indirect participant selection	
Retain familiar strategy	
Participant autonomy regarding the refusal of task	
Pull strategy (FCFS)	
Authorization rules	
Deallocation of work items from private worklist	
Freedom at task execution	
Timekeeping at task execution	
Reminder before exceeding a deadline	
Work list display format	
Selection autonomy regarding the execution order	

Area: HC-PAIS approach	
Criterion	Fulfilled
Skill profile	
Experience goals	
Task priorities (task type / skill)	
Mentor / Support	
Task history (completed tasks / work experience proceedings)	
Portfolio	
Forum	

Note again that the criteria proposed only concern the human-orientation of the workflow client application, namely the user interface for the workflow participants and its client functions. Everything else, like how the process tasks must be composed to meet human needs, is beyond the scope of this thesis.

5 Analysis of selected workflow systems

In the context of this work a research was conducted, which has shown that there are more than one hundred WFMS from different vendors at the moment. Most of them are commercial products, but also a considerable number of open-source software exists in this area. In order to get a better oversight, an overview of the most popular WFMS and its vendors was created, which is illustrated in Figure 11. In the table also the respective license model is annotated. After examining the listed software products based on the available information on the corresponding websites, three out of the thirty were selected to be analysed regarding the human-orientation of their workflow client applications. The criteria that were decisive for the selection were the free disposability or access to the WFMS, as well as to its belonging product documentation or manual. A crucial prerequisite was also an appealing and intuitive design of the system's user interface. The named selection factors arose as a result of the examination of the respective product websites.

The chosen WFMS are:

- **YAWL**
- **AristaFlow BPM Suite**
- **Bizagi BPM Suite**

System	Vendor	License model
1. Activiti	Alfresco	open-source
2. jBPM	JBoss	open-source
3. OpenWFE, now Ruote	SourceForge	open-source
4. Enhydra Shark	Together Teamsolutions	open-source
5. YAWL	YAWL Foundation	open-source
6. Bonita	ObjectWeb	open-source
7. Declare	Eindhoven University of Technology	open-source
8. FlowMind	BPM Advanced Technology Company	open-source
9. Taverna	myGridTeam	open-source
10. Imixs Office Workflow	Imixs	open-source
11. AristaFlow BPM Suite	AristaFlow	commercial
12. Staffware	TIBCO	commercial
13. FLOWer, now BPM one	Pallas Athena	commercial
14. COSA BPM	COSA	commercial
15. IBM Business Process Manager	IBM	commercial
16. iPlanet	Oracle	commercial
17. SAP Workflow	SAP	commercial
18. FileNet	IBM	commercial
19. Axxerion	Axxerion	commercial
20. @enterprise	Groiss Informatics	commercial
21. Oracle BPEL	Oracle	commercial
22. Kontinuum	Web and Flo	commercial
23. FlowConnenct	FlowConnect	commercial
24. OpenText BPM	OpenText	commercial
25. Pectra BPM Suite	Pectra Technology	commercial
26. BizAgi BPM Suite	BizAgi	commercial
27. NextFlow	Next Solution	commercial
28. APIM workflow solution	CSRbusiness	commercial
29. WorkflowXpert.NET™	Isonet	commercial
30. inubit Business Process Management	Bosch	commercial

Figure 11: Overview of WFMS and vendors

In the following sections the stated workflow systems are going to be analyzed by means of the evaluation scheme presented above. Prior to this each of the WFMS will be described shortly and it will be argued in detail again why they have been chosen for analysis. The ratings that are put into practice for the evaluation are the following: ‘+’ which indicates that the respective system provides the quoted criterion by default, ‘+/-’ which indicates that the

stated criterion is only provided with restrictions by the system, e.g. that an existing feature does not supply the full functionality as required or that there is an alternative function that serves the same purpose as the listed criterion, and '-' which indicates that the stated criterion is not provided by default by the WFMS. The ratings of the analysis results show up in the evaluation summary in section 5.4.

5.1 YAWL

YAWL (Yet Another Workflow Language) is a workflow language originally developed by Wil van der Aalst (Eindhoven University of Technology, the Netherlands) and Arthur ter Hofstede (Queensland University of Technology, Australia) in 2002 and now administered by a non-profit organisation, which is called the YAWL Foundation. The idea behind YAWL was to define a workflow language that supports all workflow patterns that were specified to date by the Workflow Patterns initiative (see www.workflowpatterns.com for further information). As Petri Nets were observed to support most of these patterns, the designers of YAWL decided to take the mathematical modelling language as a basis for the visual representation of their workflows. [31]

YAWL is supported by a software framework that consists of a workflow execution engine, a graphical workflow editor and a worklist handler. The WFMS is an open source product released under the GNU Lesser General Public License (LGPL). As far as known there is no existing BPM environment - neither commercial nor open source - that offers an as comprehensive support for workflow patterns, especially the control-flow and resource patterns, like the YAWL system. [31]

YAWL was chosen for the analysis because it is an open source environment, which is easy to install and use. On the YAWL Foundation homepage a detailed user manual and also a technical manual that contains detailed technical descriptions on the inner workings of the YAWL system are available. Additionally a lot of support material in form of tutorials, videos and examples, and even teaching resources are provided for the users. On the website there is also an own section, where it is described how the applied workflow patterns are realised in YAWL, what will be most helpful for the following analysis. All in all the YAWL system is very well documented and all the information required for the evaluation can be found online and is open to the public. If there would be any open questions left, there is also a forum on the homepage, where the outstanding issues can be discussed.

Apart from that YAWL was selected to be analysed due to the fact that founder Wil van der Aalst is a very popular, leading researcher in the domain of WFMS and well-known for his work on workflow patterns. Therefore it will be interesting to examine this WFMS regarding its human-orientation.

5.1.1. Analysis

In the YAWL system the allocation of tasks to users is managed by a custom service component named *Resource Manager*. Work items of a task are offered to a defined set of human resources, called the distribution set. This set may consist of any number of participants and/or roles, which means that YAWL supports direct as well as indirect resource selection. Additionally filters can be applied to the initial distribution set in order to further specify the potential recipients of a work item created from a task. Filtering can be performed by means of capabilities, certain job positions and/or organisational groups. [31] Thus, YAWL partly meets the requirements of the work item distribution strategy proposed in section 4.1.1.1, as it supports a role-based distribution extended by a capability-based filter mechanism.

Each human workflow participant has an individual worklist assigned to him, which contains four work queues, namely *Offered*, *Allocated*, *Started* and *Suspended*. The layout of all queues is similar (cf. for example Figure 12). They all include a list of work items that are currently existent in that queue. The items are sorted according to their age, with the oldest one at the top of the list. By default no other display format is provided by the system. Besides the work item list every queue contains some information fields that describe the currently selected work item. Among others its current status and expiry date are quoted. Via the documentation field descriptive text about the respective task instance can be displayed to the user. This field can be populated arbitrarily at design time, so it can be used to provide any information desired that should be made available for the performer at runtime. [31] That means also the work item description outlined in section 4.1.1.1 can be put into practice in all its aspects over the documentation field. Moreover, the documentation can be edited at runtime, so that messages regarding the work item can be exchanged between administrators and users [31].

Depending on the respective work queue, there are various actions that may be taken on a currently selected work item. These actions, which are connected to the set user privileges and task privileges, are represented by a set of buttons on the right area of each queue and will be explained in detail in the descriptions of the particular queues. [31]

Figure 12: The *Offered* work queue [31, p. 170]

When a work item is ready to be executed, it appears in the *Offered* work queue (cf. Figure 12) of those workflow participants, who are included in the distribution set of the associated task. In the general case the same work item is offered to a number of potential performers, who may choose to work on the respective item or not. If one of the users accepts the offered work item, it is removed from the *Offered* queues of all participants that it had been previously offered to and placed on his assigned *Allocated* queue. [31] This approach corresponds to the first-come-first-serve pull strategy proposed in 4.1.1.2. As the start interaction of offered work items can be defined as user-initiated, participants can decide on their own when to start the execution of accepted tasks. By clicking on the *Accept & Start* button, the work item will be started immediately and placed on the user's *Started* queue instead. [31]

In the *Offered* queue view users also have the possibility to *Chain* work items. This allows a participant to chain all eligible work items of the case of which the selected work item is part of. [31] Thus, the chaining feature corresponds to the retain-familiar strategy proposed in section 4.1.1.1. If chaining is enabled, each future work item that is offered to a user within the chosen case will be allocated automatically to his worklist and started immediately. The chaining functionality remains valid until the respective case completes or it is turned off by the user via the *Edit Profile* form. [31]

Figure 13: The *Allocated* work queue [31, p. 171]

The *Allocated* queue (cf. Figure 13) contains work items that have been allocated to a single user exclusively. Actions that may be taken on any listed work item of this queue are [31]:

- a) *Start* the execution of a work item at an arbitrary time, what will move the selected item to the performer's *Started* queue.
- b) *Deallocate* a work item, what results in removing the item from the user's *Allocated* queue and redistributing it again as defined in the distribution set with the exception that the original performer is now excluded from the set.
- c) *Delegate* the responsibility for a work item to a user's subordinate workflow participant, what will move the work item from the delegator's worklist to the *Allocated* queue of the subordinate instead.
- d) *Skip* the execution of a work item.
- e) *Pile* a work item. This means that the work item and all future instances of such work items created from a certain task description are allocated to a certain user and started immediately, independent from any distribution specification for the task. The piling functionality remains valid until it is turned off by the performer via the *Edit Profile* form.

As the listed work items in the *Allocated* queue need not be executed in sequence, but can be chosen to be started in an arbitrary order by the user, the HC-PAIS criterion of selection autonomy is fulfilled. Also the possibility for users to deallocate work items from their private worklists was considered in the evaluation scheme presented in 4.2. On the contrary a

function for delegating work items was not included there because every participant should be able to decide on his own which items get assigned to his *Allocated* queue. YAWL's piling function can be compared to the HC-feature of setting task priorities, as it allows a user to specify a certain task type that he wants to execute with preference.

In a user's *Started* queue all work items are listed that have been started by the participant himself and also those which have been automatically started for him by the system due to activating the chaining or piling function for a task before. In this view the processing of work items takes places. The execution of a single item can be done in a progressive manner, meaning that it must not be realized at one go, but can be interrupted in between via the *Suspend* button. By doing so, the respective work item is moved from the *Started* to the user's *Suspended* queue, from where it can be resumed at a later point in time by *Unsuspending* it, what will move the item back to the *Started* queue again. If a participant is finished with the processing of a work item, he has to confirm the termination via the *Complete* button in order to return his work results to the YAWL engine and to clear the item off his worklist. However, a prerequisite for the successful completion of a work item is that it is proceeded within a given time period. Every task instance is provided with a task timer, which gets activated when the work item is started and remains live until the specified expiry time for the item is reached. When the timer expires, the task instance will complete independent from its current status, what may effect that a work item is timed out while its execution is still running. [31] Thus, there are no prevention measures for the exceedance of deadlines provided in YAWL by default.

From the *Started* queue view users also have the possibility to *Reallocate* already started work items to their subordinates, what will move the respective work items from the reallocator's worklist to the *Started* queue of the subordinate instead. [31] That means that the execution of a work item cannot be aborted if a user has no subordinate stuff and that abort is only possible by reallocating the task to another user. This does not correspond to the human-centric approach presented in 4, as in this case the subordinate users would not be able to refuse work items that they get from their superiors. That is, the HC-criterion of participant autonomy regarding the refusal of automatically assigned tasks is not fulfilled. However, except for the abort of started work items YAWL provides all features that were identified in section 4.1.1.2 to ensure freedom at task execution for human workflow participants. Furthermore, the separation of work queues into an *Offered* one, which contains work items that are visible for a number of potential performers, and three other queues, that only comprise items that have already been allocated to a single user, conforms to the suggestion of providing a shared and a private worklist.

By means of the log predicates that are provided in the YAWL system, several additional features can be realized that might be useful to render the client application more

human-centric. A log predicate may be defined to be logged at the start and completion of a work item [31], thus it could for instance be used for enabling time keeping at task execution. Besides it may also contain embedded values that describe current data of an active work item [31]. An example for such a value would be the current status of a task that may be displayed during execution in the user interface.

Under the *Edit Profile* tab in YAWL's client application users can have a look at their profile. Personal data as well as lists of assigned roles, positions and capabilities are displayed there. All the information is read-only and can be modified only by the administrator, except the password can be changed by the participant himself. Additionally all tasks that are currently chained or piled to the participant are listed in this view and can be unpiled / unchained from there by the user. [31]

In respect of authorization rules YAWL offers a feature to deny concurrent execution of work items [31], as also proposed in section 4.1.1.2. Additionally some constraints regarding the distribution of work can be set, e.g. that work items can only be offered (or not offered) to users who have previously completed items of a specified task in the respective process instance [31]. All these rules may contribute to an increased efficiency of users' task execution.

Taken as a whole the YAWL system fulfills almost two-thirds of all criteria that were listed in the evaluation scheme in the area of workflow patterns. This result is not as good as might have been expected after mentioning that the WFMS offers the most comprehensive support for workflow patterns amongst all known BPM environments. Regarding the proposed HC-PAIS approach criteria, the analysed WFMS performed even worse. Indeed every workflow participant has a user profile, but it is not designed in a very human-oriented sense, as it may primarily be used for changing a user's password and displaying his personal data. Task priorities can be set by defining task types to be piled, but not by specifying skills that a user might want to apply with preference, while participants work experiences are not considered in any form at all. Thus, the proposed features that would include information about a user's experience proceedings are not available in YAWL. Additional functions like a discussion forum or supporting working documents for users are also not provided. However, in [31] it is explicitly stated that YAWL's Resource Service, which provides the default tool set for user interaction with the system, offers various interfaces that may be used from developers to override existing service components, and thereby modifying them according to their own wishes and needs. Moreover the Resource Service can be extended in many ways, thus developers may add completely new functionalities or features. Accordingly it is assumed that all criteria listed in the evaluation scheme could be realized easily in YAWL's

workflow client application by manual implementation, as the therefor necessary means are available.

5.2 AristaFlow BPM Suite

AristaFlow BPM Suite is a product of the AristaFlow GmbH and provides the most distinguished process management technology in respect of flexible process support. The AristaFlow technology is based on longtime research activities of the Institute of Databases and Information Systems (DBIS) of the University of Ulm within its flagship projects ADEPT1, ADEPT2 and AristaFlow, and also on experiences of industrial partners they have gathered in numerous workflow and software projects. [12]

The BPM Suite is a commercial WFMS consisting of several software components, but provided free of charge for research and educational purposes. It offers a flexible solution for the universal support of business processes, from the process definition and modeling via automation through to permanent optimization. A unique feature of the AristaFlow BPM Suite is the facility of intervening on already running processes, referred to as ad-hoc changes. Additionally it provides workflow clients for every kind of target system and an open API, which makes the WFMS freely expandable and allows an unproblematic embedding into an existing IT infrastructure. [3]

AristaFlow BPM Suite was selected for analysis because it is also used in the course Workflow Technologies at the University of Vienna. There is a portal called AristaFlow Forum (<http://www.uni-ulm.de/einrichtungen/aristaflow-forum.html>), which is maintained by the DBIS for the purpose of supporting AristaFlow users in research and education. On the website screencasts and video tutorials are provided to the public as supporting material for working with the AristaFlow BPM Suite. As a registered user one has also access to an internal area, where additional information and complementary material as well as a discussion forum are supplied. Posed questions concerning the functionality of the WFMS were answered immediately from the head of the institute personally. Thus, the AristaFlow Forum provides a very good support for its users.

5.2.1. Analysis

In AristaFlow the distribution of tasks to users is realized on the basis of staff assignment rules, which can be defined in the Process Template Editor. To each process step a rule can be assigned (cf. Figure 14), which may contain several conditions concerning the range of suitable employees. The selection of processors can take place according to certain AgentIDs, which corresponds to a direct participant selection, or according to specified roles, abilities, organizational units or positions, which constitutes the indirect selection variant

proposed in section 4.1.1.1. At the same time this indicates that a role-based as well as a capability-based work item distribution strategy are supported, as abilities in AristaFlow refer to a user's skills and qualifications [8]. Thus, AristaFlow partly meets the requirements of the distribution strategy proposed for a human-centric PAIS.

Moreover AristaFlow allows constraining the task allocation by means of dependent conditions. Thereby the selection of processors happens depending on whether who has executed a previous process step. For example an assignment rule can be defined that determines that the processor of a work item "b" must (not) be the same person or the superior of the person who has executed work item "a", or that the processor of "b" must (not) be from the same organizational unit as the processor of "a". [8] In this way it is possible to realize constraints like a four-eyes-principle or certain signature regulations. Thus, also the retain-familiar strategy proposed in section 4.1.1.1 can be implemented in AristaFlow by setting a corresponding staff assignment rule via dependent conditions.

Work items that are assigned only to a specific person in this manner can still be refused from the designated processor. This mechanism fulfills the criterion of supporting participant autonomy listed in the evaluation scheme. By default AristaFlow allows its workflow participants to delegate already assigned tasks to other users who belong to the same organizational unit [4], whether the allocation happens on the basis of dependent conditions or otherwise. Thus the default settings concerning the delegation function can also be changed manually, meaning that for every work item it can be specified separately to whom it may be delegated.

Once a task is executable, it is offered to all workflow participants that fulfill the specified conditions in its assigned staff assignment rule. AristaFlow BPM Suite offers a standard client that provides amongst others a feature for displaying pending tasks in form of a shared worklist to its potential processors [11]. Each listed work item is provided with a priority and a deadline. A work item description, as proposed in section 4.1.1.1, can be displayed for every task, which may contain additional descriptive text as well as the date of activation. AristaFlow also offers a feature to display an *instance view* of the overall process, which shows where the actual task is located in the process and in which state it currently is.

The worklist display format can be determined by the user, who may choose between arranging his work queue either in alphabetical order or according to priority levels or deadline dates. The listed items need not be executed in sequence, but are freely selectable for execution, thus the criterion of selection autonomy stated in 4.1.1.2 is also fulfilled.

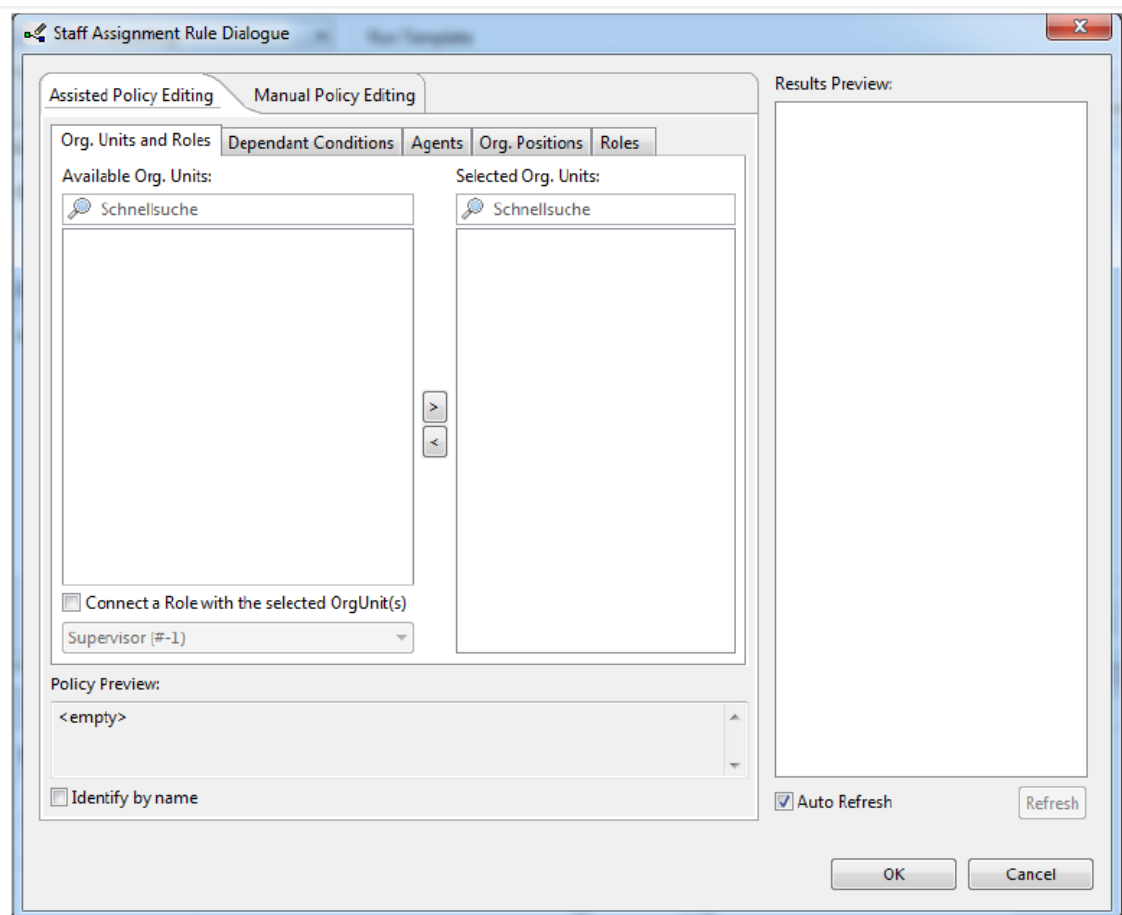


Figure 14: AristaFlow Process Template Editor – Staff Assignment Rule Dialogue

When a user selects an item from the worklist for execution, it is simultaneously removed from the worklist of the remaining employees. This method corresponds to the first-come-first-serve pull strategy proposed in 4.1.1.2. However, in AristaFlow users do not have a private worklist. This means they cannot reserve a work item for later execution by allocating it from the shared worklist to their private one. It is rather the case that tasks can only be started directly from the shared list: By selecting a work item from the list for execution, it gets automatically started by opening the mask necessary for its execution in the standard client. In addition the task it moved from the workspace section “tasks” to “running tasks”, where all work items are listed that are currently executed by the user.

Once a task is started, the user has the possibility to suspend its execution and resume it at a later point in time. The only prerequisite is that the processing of the work item is completed until a given deadline. Supportive, AristaFlow offers several escalation mechanisms for preventing the exceedance of deadlines, which may be adjusted as required [4]. It is possible to configure a multi-step escalation with any number of escalation points and measures [4]. Examples would be an increase of the task priority or the dispatch of a reminder email to the responsible user at an approaching deadline. Also an automatic

delegation of the work item to a predefined user at exceedance of the given deadline may be configured. As the escalation methods in AristaFlow are freely adjustable and arbitrarily expandable through any plugins, the criterion concerning deadline handling proposed in 4.1.1.2 is definitely fulfilled.

AristaFlow also allows its users to abort the execution of running work items by using the function *fail and discard*. By default, this leads to the suspension of the underlying process instance. Further proceeding steps may be defined manually as error treatment processes in the activity repository. Thus, an activity template may be implemented that causes the deallocation of a work item from the actual processor on abandonment and its reallocation to the worklist, so that the respective task is available again for other users. In order that the abort of running tasks remains exceptional, the AristaFlow BPM platform enables its users to make a targeted consultation via the system, meaning that if there are obscurities regarding the processing of a task, users may state their questions to a skilful person or their superior and ask them for help [4]. This function is quite similar to the proposal in section 4.1.1.2 to provide a mentor or a discussion forum for the users, which can be used for the exchange of information concerning the process execution.

When a user has executed all steps that are necessary for the accomplishment of a task, he has to confirm the completion via the dedicated button in the user form. Thereby the respective work item disappears from the processor's list of "running tasks" and is moved to the workspace section "completed tasks", which offers the user an individual overview of all his previously finished tasks. Thereby the terminated work items still remain comprehensible for the user after execution. However, this function only partly meets the requirements of the task history suggested in section 4.1.2.2, as it does not include the capturing of work experience proceedings which is due to the fact that user's work experiences are not incorporated at all in the AristaFlow BPM Suite.

By default the work items listed in "completed tasks" are not provided with the time that was needed until their termination although a feature for time keeping at task execution is provided by the AristaFlow process monitor. Thus, a time indication may be implemented manually in the standard client by means of the log data that is captured during process execution with the monitor component [10].

In respect of authorization rules AristaFlow does not provide any default features. That is there are no functions that enable the realization of an evenly distributed task allocation among the workflow participants, as a limitation concerning the number of running tasks per user at a time or the like. However, as AristaFlow BPM Suite offers an open API for all system functions [9], the WFMS is freely expandable meaning that additional functions can be integrated arbitrarily via the API. Accordingly it is assumed that the unavailable

characteristics mentioned above may be implemented manually in order to render the system more human-centric.

The open API also allows the linking of any customized client or user interface since it is possible to incorporate single BPM modules of AristaFlow in the client interface of an existing standard application. The masks of the existent software application are invoked directly from the AristaFlow platform and enable the interaction with the AristaFlow processes. [5] An example would be the linkage of a MS Outlook client by means of the Outlook-add-in, which allows users to manage their worklist and execute their tasks directly via MS Outlook.

To sum up, it can be said that AristaFlow BPM Suite nearly fulfills all criteria that were listed in the evaluation scheme in the area of workflow patterns. What should be particularly emphasized in this regard are the various escalations mechanisms that this system offers. Another positive feature is the search function that is integrated standardly in the worklist. This function will be included as a new criterion in the evaluation scheme as it is assumed that it contributes to the facilitation of a workflow participant's work and thus renders a PAIS user interface more human-centric. With respect to the proposed HC-PAIS approach criteria, AristaFlow BPM Suite does not come off as well. A major shortcoming of the analysed system is that processors do not have an individual user profile, where they may access all data relating to them, like their assigned roles, abilities, organizational units or projects. In section 4.1.2.1 it is stated that users have the possibility to quote their experience goals and task priorities in their skill profiles. These features are also not provided by AristaFlow either by means of a user profile or elsewhere. However, as already described above the WFMS is freely expandable via its open API. As the data required for the realization of the mentioned HC-PAIS criteria is stored as an organizational model in a relational database, it would indeed be possible to implement a corresponding section in AristaFlow's workflow client application or to link a customized client that fulfils the requirements stated in the evaluation scheme. Also the already existing HC-PAIS features, namely the possibility to state queries during task execution and the provided task history function, may be extended or modified by means of the API in a way that they exactly suit the termed needs. For example the "completed task" section could be enhanced by a mechanism that allows the drawing up of a portfolio, as suggested in section 4.1.2.2. Of course also the features listed in the area of workflow patterns that are not provided by default in AristaFlow can be realized or adjusted in that way. As a consequence it is assumed that all criteria of the evaluation scheme can be put into practice by manual implementation, as the therefor necessary means are very well supplied by the WFMS.

5.3 Bizagi BPM Suite

The company Bizagi provides a commercial Business Process Management solution consisting of two complementary products, a Process Modeler and a BPM Suite. The modeler is a freeware application, which can be used to visually diagram, document and simulate business processes in the industry standard format BPMN (Business Process Model and Notation). The BPM Suite enables the building of process applications, as well as their execution and automation. It contains two tools, Bizagi Studio, which is the construction module and Bizagi BPM Server for executing the process applications built with the Studio. For using the BPM Suite a license must be acquired. [7]

The analysis that will be performed based on the prepared evaluation scheme exclusively addresses the BPM Suite, as this component supplies the user interface for the end users - called Work Portal – to carry out their daily activities. Thus the Work Portal conforms to the workflow client application. Additionally business rules for process routing and user assignment, as well as the work allocation strategy can be defined here [7], which are important factors to render a WFMS human-centric.

Bizagi BPM Suite was chosen for analysis because also a pure commercial product should be regarded in the course of this evaluation. The BPM Suite is very well documented, has an attractive design and therefore seems very appealing and intuitive to use at first glance. But what was most crucial for the selection is the fact that unlike the most vendors of commercial WFMS, Bizagi provides support materials on its website that are open to the public: A detailed user guide, video tutorials and e-learning courses are available at free disposal for visitors of the company homepage.

5.3.1. Analysis

Bizagi BPM Suite provides a client application called *Work Portal* (cf. Figure 16) for the workflow participants, which can be accessed simply via a browser. Registered users can log in there and interact with the system, for example create new cases or conduct process analysis. In the *Work Portal* users can also access pending activities that were allocated to them by means of specified allocation rules via the inbox function. [7] The *Inbox* is the counterpart to the shared worklist outlined in section 4.1.1.1, as it contains all tasks that are offered to an individual user. However, a private worklist is not maintained by Bizagi.

In the *Main Area* of the *Work Portal* a search function is provided for the users, which allows to search cases by their case number and to get all available information about it [7]. As detected just recently, this feature may be very useful for workflow participants upon doing their daily work.

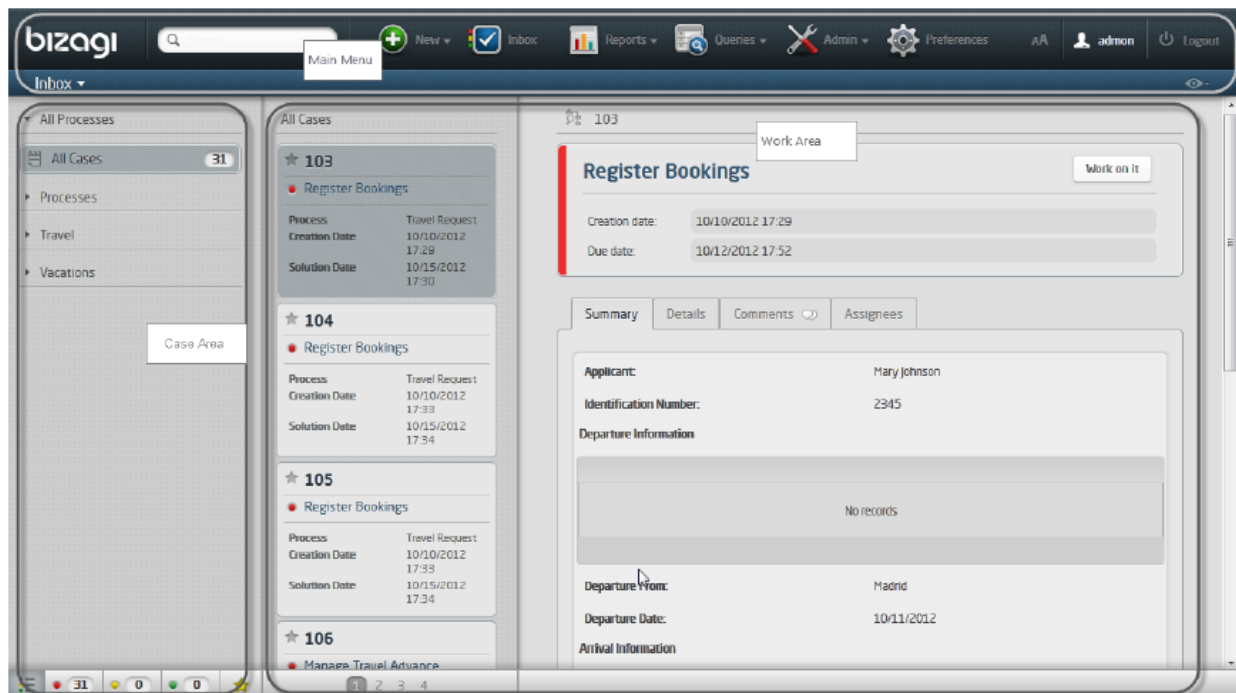


Figure 15: Bizagi's Work Portal [7, p. 158]

The *Case Area* shows the user the total number of cases that are currently available for execution in his inbox and also the distribution of cases sorted by their state. On the left side of the *Work Area* all pending cases are listed, whereas each task is provided with its associated main information, such as creation number, creation and expiration date or task state. [7] Users can determine the worklist display format on their own and configure themselves according to which property the listing should be sorted. Additionally a detailed task description is available for every case in order to provide some further information for the potential processors [7]. By clicking on a particular case listed as pending, its summary information and assignees log is displayed in the *Work Area* at the right, as can be seen in Figure 16. Since the summary form can be designed individually, it may include all the information proposed for the work item description in section 4.1.1.1. Besides, Bizagi's Work Portal offers a feature to graphically view the path followed by the actual case through the respective process as well as its current state [7].

As already mentioned work allocation in Bizagi is realized by use of predefined allocation mechanisms. The BMP Suite allows the implementation of various distribution strategies based on three different types of conditions, namely Allocation Rules, Assignment Methods and Preconditions. In any case every task must be provided with assignment conditions that allow the system to select the correct users as potential processors of the pending work items. [7]

Allocation Rules can be used to define specific users that an activity should be offered to in their inbox. This is realized by determining user properties that a workflow participant must have in order to qualify for the performance of a specific task. The properties are stated in a user's profile and can concern characteristics like certain user IDs, roles, skills or even task priorities. [7] Thus, the BPM Suite enables direct as well as indirect participant selection. As user properties can be configured individually according to one's business needs [7], Bizagi is fairly unrestricted in terms of the configuration of work allocation methods. The work item distribution strategies proposed in section 4.1.1.1 can be realized therewith in any case.

In addition to Allocation Rules, one out of four different Assignment Methods can be selected to determine how Bizagi distributes the pending tasks amongst qualified processors. By default the method "Everyone" is applied: A work item is offered to all users that meet the related assignment conditions, thus the item may be displayed in the inboxes of several adequate processors. The first person that chooses the task for execution (by clicking the belonging *Work on it*-button) will carry it out. Accordingly the task will no longer be available for the remaining users and disappear from their inboxes. [7] This mechanism corresponds to the FCFS pull strategy proposed in section 4.1.1.2.

Besides, Bizagi offers some other Assignment Methods which contribute to rendering the WFMS more human-centric and to increase productivity. There are options that ensure an evenly distribution of work items among employees, which is realized by allocating upcoming tasks to the user with the lightest workload or the least jobs pending. [7] Thereby the workload between the workflow participants can be kept in balance and also time is saved. These variants fulfill the requirements of authorization rules presented in section 4.1.1.2, which aim at arranging the work item distribution in a fair way. In addition Bizagi provides an Assignment Method that allows allocating a task to the same user every time it is initiated, thus if a task is instantiated several times, it will be assigned to the same user that was allocated the first instance [7]. This feature may lead to an increase in performance at the execution of a task, as the user is already experienced and familiar with the case. From there this method may be compared to the retain familiar strategy proposed in 4.1.1.1.

The last-named Assignment Methods imply a definite task allocation to a specific workflow participant driven by the WFMS. However, users have the possibility to refuse tasks that are automatically assigned to them in this way by reassigning the cases from their Work Portal [7], whereby the work item distribution strategy still remains human-oriented. Despite, it must be noted that - unlike suggested in section 4.1.1.1 – such tasks can only be reassigned directly to other qualified users and will not be allocated anew according to the default Assignment Method.

Now that Bizagi's work allocation mechanisms have been examined, the task execution itself should be considered. As already mentioned, a user's pending cases are presented in form of a list in the *Inbox* (cf. Figure 16 – left-hand side of the work area), where workflow participants can navigate the tasks offered to them and chose any arbitrary work item for execution [7]. Thus, the criterion of selection autonomy regarding the execution order is given in Bizagi. As the BPM Suite does not supply a private worklist for its users, tasks are being started directly from the shared list in the *Inbox*. To start the execution of a pending work item, either the *Work on it*-button or the access link in the *State* column of the respective case have to be pressed [7]. By doing so, the associated *Activity Form* will be displayed in the *Work Portal* (cf. [7, p. 1691]) that allows the processor to view and enter the required information and to perform all steps that are necessary to accomplish the activity [7].

Users have the possibility to suspend the processing of a task and to resume it at a later point in time. Information that has been entered for the activity so far can be cached by activating the *Save* button [7]. However, here too the prerequisite must be fulfilled, that a case is completed until its associated expiration date. In order to support users at meeting their deadlines, the WFMS provides a tool to generate email notifications that are sent to defined participants either if a running case is about to expire, expires or has expired. The thereby triggered warning message informs the recipients about the current status of a task and thereby prompts the necessary actions that must be taken to complete the case successfully yet. The configuration of the alarms is flexible in regards to recipients: Messages may be sent only to the current processor or also to his boss or another specified person like the case creator. [7]

If operational problems or the like arise at task execution, also the abort of already started tasks is possible by making use of the reassignment mechanism that was described above. However, this means that the cancelation of a running task is only feasible when another qualified processor is available that the work item can be allocated to. Additionally users can pose their questions or seek assistance if they have problems at performance of a task in the *Comments* tab of the *Case Details* area, which serves as a discussion forum. A thread can be started there by posting a case comment and anyone with permissions to view or work on the case may reply and give instructions, advice or relevant information in order to aid participants to take proper actions [7]. As comments are visible for all employees that have access to a case and are displayed throughout the case's life-cycle in its *Comments* tab, this function can also be used to simply provide or share complementary information that may be relevant to all users working the case and which may increase the performance and understanding. Besides the single threads may be assigned with a category that allows classifying them according to their relevance or topic and enables users to filter the displayed comments as needed. [7]

After completing the execution of a case, the user has to store the entered information for the last time. By clicking the *Next* button, the completion of the task gets confirmed: The current task will be closed and removed from the worklist, simultaneously the following case will become pending for the respective users. Noteworthy in this regard is the fact that Bizagi provides inline validation for predefined controls or business rules: If the set conditions are not met, an error will occur and it will not be possible to close the case until it is patched. [7]

Under the *Preferences* menu in the Work Portal, users can access their profiles and view or update the provided information. The displayed information is given by the user properties that are defined as “*manageable by the user*” in Bizagi Studio. As already explained above these properties can be configured individually, meaning that additional user characteristics can be created in order to fulfill one’s business requirements. [7] In section 4.1.2.1 it is suggested to provide a skill profile, which captures a user’s roles, skills and work experiences. This is also feasible in Bizagi, where roles and skills are supplied as user properties by default and work experiences can be implemented additively by hand. According to the proposal of the HC-PAIS approach it should also be possible to quote experience breeding goals and task priorities in the skill profile. These features can be realized in Bizagi as well by defining corresponding user properties and configuring them as “*available for assignation*”. The named option indicates that a property is enabled to be used as condition in an Allocation Rule [7]. Thus, it may be possible to determine allocation conditions which effect that a case is assigned to users that have quoted certain task types as preference in their user profile or stated specific skills and work experiences that they want to improve. However, Bizagi does not provide any features by default which enable workflow participants the acquisition of new skills, like supplying additional support material in form of tutorials or dedicated persons who act as mentors.

A task history in the form as described in the HC-PAIS approach is not available in the analyzed BPM Suite. Instead Bizagi supports a feature called *State log*, which allows displaying the case history. Thereby users with corresponding access are enabled to see detailed information about the respective case up to the time of the query. Among others the *State log* shows the users that are involved in the case, the information they modified and the activities they executed, as well as their final value and solution or modification date. [7] The viewed information can also be filtered, e.g. by user, so that only the case history with relation to a certain processor is displayed, which comes close to the suggested task history in section 4.1.2.2.

Moreover Bizagi allows consulting information pertaining to cases through customized queries that are realized by means of special query forms. Queries can be used to perform

searches that meet certain case criteria, which are defined in the underlying query form. [7] Thus, it may be possible to create a query form that returns the same data as suggested to be viewed in the task history. For example it could be defined that the query result shows all cases of a certain processor, as well as the associated case states and solution dates for a certain time period. Additionally there is the possibility to save a performed query and to reuse its results at a later point in time [7]. This feature can be compared to the portfolio function presented in section 4.1.2.2, as users have the possibility to extract any available information required from the system by defining an adequate query and use it for the drawing up of their personal portfolio.

Another useful feature are the performance reports that the BPM Suite offers. Among others, Bizagi provides an analysis tool for performance monitoring of historical information called *Analytics Report*. The tool can be used to present a graphical summary of closed cases by means of diagrams or tables for a given time period. Additionally filters can be applied to restrict the displayed results, e.g. in order to view only the cases of a certain processor and not all cases of all users as configured by default. There are different types of reports for distinct purposes. For example reports can be created that show the number of closed cases for a chosen process by average duration, expected duration, standard deviation and also the number of cases completed on time and overdue. Another report is used to display the number of cases created, the number of successfully completed and aborted cases during the time period selected. Some of the reports also allow comparisons between expected and real execution times and efficiency measurements. [7] Thus, the described report function may also be used from users to manually create their individual task history. The analysis results may be exported to Excel [7] where they can be used for further evaluations or other purposes.

Taken as a whole it can be said that Bizagi BPM Suite comes off very well in respect of the criteria that constitute a human-centric PAIS user interface, as it fulfils almost all requirements listed in the evaluation scheme. Indeed some features are not provided exactly in that way as described in the subsections of 4.1, but instead the WFMS offers some very good alternatives that nearly serve the same purpose. An example are the functions that Bizagi offers in place of the suggested task history. What should be additionally emphasized is the fact that the WFMS is fairly unrestricted in terms of the configuration of work item distribution strategies. The system provides extensive possibilities to define customized work allocation mechanisms in order to satisfy any given business requirement. Besides it allows for workload balancing and the realization of specific authorization rules. Another positive feature is the inline validation function that is applied at the processing of a task. It is supposed that forms that comprise this feature are easier and more comfortable to process

for the participants as they become aware of mistakes or empty mandatory fields immediately upon data entry. As a consequence users may be able to complete their tasks successfully in less time because they do not have to reread the entire form before submitting, as errors are resolved right away when processing. Based on that, the inline validation function will be added as a new criterion in the evaluation scheme.

One of Bizagi's few shortcomings is the fact that it does not provide a private worklist for its users. In this regard it must be referred to the system's flexible and powerful integration layer, which supports multiple integration possibilities for the entire BPM corporate solution [7]. Among other things the BPM Suite allows for invoking external or custom code by means of APIs or connectors, through which it is possible to include any custom component [7]. Thus, the WFMS can be extended or modified as required by manual implementation in order to fulfill any of the criteria listed in the evaluation scheme. Also the features that are not realized exactly that way as described in section 4.1 may be adapted as requested by making use of the provided API. Besides, details concerning the Work Portal itself - like the columns displayed in the *Inbox* - that are not set by default in Bizagi can be customized easily via Bizagi Studio. Concluding, as for the other analyzed systems as well, it is assumed here too that it is possible to realize all criteria of the evaluation scheme by manual implementation, as the therefor necessary means are available.

5.4 Comparison of analysis results

In a next step a comparison between the three analyzed WFMS will be drawn on the basis of the above. In the evaluation scheme below the ratings of the analysis results are registered. What is recognizable at first glance is the fact that Bizagi comes off best in both areas, namely workflow patterns and HC-PAIS approach, followed from AristaFlow BPM Suite, which performs also well in respect of the workflow patterns, but supports hardly any of the HC criteria. YAWL brings up the rear in both of the examined areas, especially in regard to the human-centric approach it provides only few of the proposed features. However, it must be noted that YAWL is the only open-source product out of the three selected and for this circumstance its analysis results are still pretty good.

YAWL provides a very simple and clearly arranged user interface, which is easy and intuitive to use for the workflow participants. Though, it only includes the standard features that are necessary for task processing within a WFMS and does not support any additional functions which may contribute to render the workflow client application more human-centric. In contrast, the standard client of the AristaFlow BPM Suite appears more complex and sophisticated. The design of the user forms itself looks more professional, although it is still clear arranged and easy to use. Regarding the configuration options AristaFlow is much

more flexible than YAWL and it provides plenty of features that were identified as valuable for the integration of participant's wants in respect of carrying out their work. To conclude with, one must say that Bizagi BPM Suite is already on very high level, as its examination has shown that the WFMS has hardly any shortcomings regarding human-orientation. Bizagi offers a very professional product that supplies the workflow participants with various efficient features that facilitate and assist their daily work. Besides it enables workload balancing between users and provides a comprehensive set of reports for the purpose of process analysis and monitoring what may bring out some useful information for the processors. The only criticism that is to be made is the fact that - as a result of the many functions that Bizagi includes - its *Work Portal* user interface may appear a bit overloaded for the end users. At least a longer training period will be necessary in order to become familiar with the system and to handle its many features and options.

<i>Evaluation summary</i>			
Area: <i>Workflow patterns</i>			
Criterion	Product		
	YAWL	AristaFlow	Bizagi
Work item description	+	+	+
Separation shared / private worklist	+	-	-
Work item distribution strategy (role-based / capability-based / priority-based)	+/-	+/-	+
Indirect participant selection	+	+	+
Retain familiar strategy	+	+	+/-
Participant autonomy regarding the refusal of tasks	-	+	+
Pull strategy (FCFS)	+	+	+
Authorization rules	+	-	+/-
Deallocation of work items from private worklist	+	-	-
Freedom at task execution	+/-	+/-	+
Timekeeping at task execution	+	+	+
Reminder before exceeding a deadline	-	+	+
Work list display format	-	+	+
Selection autonomy regarding the execution order	+	+	+

Search function in worklist	-	+	+
Inline validation at task processing	+	+	+
Area: HC-PAIS approach			
Criterion	Product		
	YAWL	AristaFlow	Bizagi
Skill profile	+	-	+
Experience goals	-	-	+
Task priorities (task type / skill)	+/-	-	+
Mentor / Support	-	+/-	-
Task history (completed tasks / work experience proceedings)	-	+/-	+/-
Portfolio	-	-	+/-
Forum	-	+/-	+

6 HC-PAIS user interface mock-ups

The analysis of the selected WFMS has shown that many of the criteria listed in the evaluation scheme are already implemented standardly in present systems. This applies particularly to the functionalities that are recorded in the area of workflow patterns. Hence, the focus at the development of the HC-PAIS user interface mock-ups will lie on those features, which are not or only available to a limited extent in these systems yet.

Besides it will be ensured that primarily such criteria are demonstrated in the mock-ups that truly contribute to placing workflow participants and their wants at the centre, which is especially realized by integrating user's skills, work experiences, wishes and goals into the WFMS. As first of all the criteria listed in the area of the HC-PAIS approach fulfil these requirements, main attention will be paid to them at the preparation of the human-centric UI mock-ups. Of course also most features from the area of workflow patterns will be realized in the workflow client application to be created, but they will not be referred to specifically as they are regarded as basic prerequisites for a HC-PAIS user interface.

Which of the particular criteria listed in the evaluation scheme have finally been implemented in the HC-PAIS user interface mock-ups and which have not can be looked up in the detailed overview in section 6.3.

Now that the selection of criterions to be incorporated into the following mock-ups is clarified, the procedure for developing the HC-PAIS user interface is going to be presented: First of all some adequate user stories will be prepared that cover the selected features. Each story will be assigned to a concrete process that will be illustrated explicitly with its associated actors and relevant properties. In order to give a better understanding of the specified user stories they will be described in more detail by means of usage scenarios, which indicate exactly the steps and actions that a user has to perform during the interaction with the workflow client application. The respective scenarios will then be simulated on the basis of their underlying processes in a fictional WFMS called *Mercury4*, which was initiated especially for the upcoming demonstration purposes. For every step of the scenario at least one corresponding user interface screen will be created. The total of the screen images prepared in this way constitute the HC-PAIS user interface mock-ups, which are the envisaged goal of this master thesis. In the following subsections two of these mock-ups will be created according to the procedure described above.

6.1 Mock-up I

In order to keep the presentation of the mock-up clear and structured, first of all the general framework for its development will be introduced in section 6.1.1. and subordinates, before the graphical user interface screens will be illustrated in 6.1.2.

6.1.1 Framework conditions

In the following subsections it will be initially explained how the process looks like, which the entire mock-up creation is based on. After outlining the most important process features, two workflow participants will be introduced explicitly as they play an active role in the simulation of the user story, which is also delineated subsequently. At last the usage scenario will be outlined that is gone through in the fictional WFMS *Mercury4* in section 6.1.2.

6.1.1.1 Process

The simulation of the first user story is based on the fictitious process '*Garden landscaping*' (see Figure 19), which was already presented in section 4.1.2.1. The process consists of eight tasks (T1-T8) that active the following experiences:

- E1: Calculating Offers
- E2: Describing Offer Details
- E3: Checking Feasibility and Identifying Requirements
- E4: Dealing with Customers
- E5: Designing Landscapes

- E6: Planting
- E7: Pruning
- E8: Working with Small Machinery
- E9: Working with Large Machinery

Which concrete experiences are activated by the single tasks is illustrated by means of the blue arrows in Figure 19.

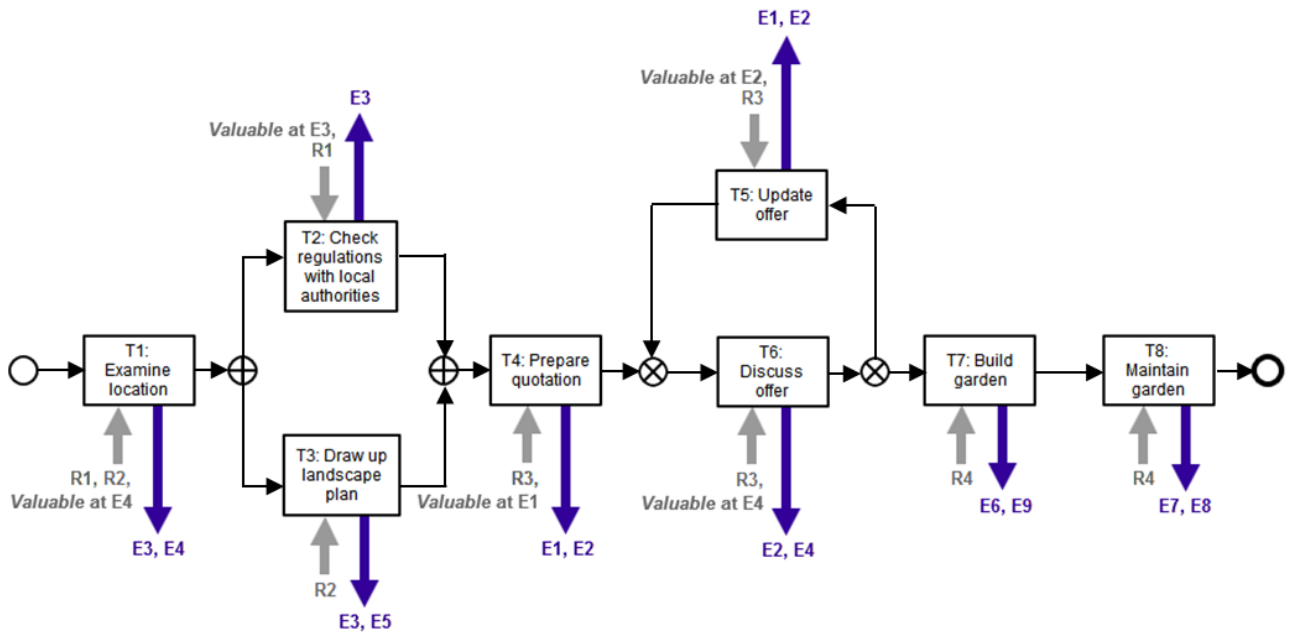


Figure 16: Process 'Garden landscaping' (adapted from [20, p. 9])

There are four roles to perform the given tasks, namely

- Project Manager (R1)
- Landscape Designer (R2)
- Customer Consultant (R3) and
- Gardener (R4).

According to the combined distribution strategy proposed in the evaluation scheme a task is assigned to workflow participants who have either an appropriate role, suitable capabilities or who set a relevant priority in their skill profile. In the present process this strategy is also applied: For being offered a certain task, a user must possess either the specified roles or experience levels, which are indicated in Figure 19 in form of the grey

arrows that point to the single tasks⁴, or he must have defined a corresponding task priority in his profile.

For the following simulation purposes two notional process participants of ‘*Garden landscaping*’ are being introduced explicitly, namely Martin, who is *Customer Consultant* and Tom, a *Project Manager*. Both of them are described in more detail by outlining their skill profiles below in Figure 20. The user story for the process at hand will be delineated from Martin’s point of view.

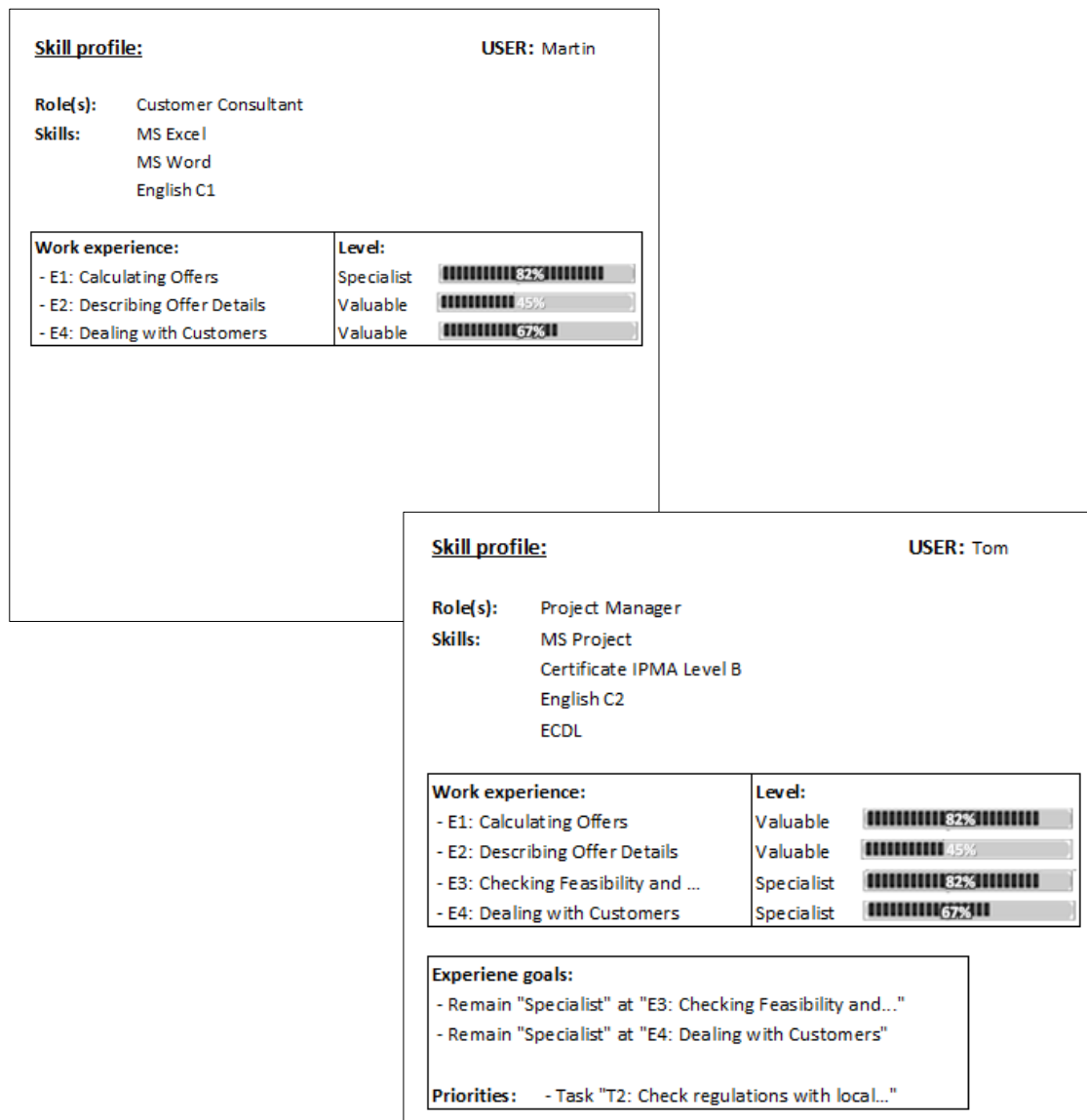


Figure 17: ‘Garden landscaping’ – key players

⁴ As the focus of the following mock-up simulation is mainly on work experiences and experience breeding, skill requirements or activations have not been considered at this point. Therefore, and also for reasons of clarity, they are not included in the process illustration.

The same applies to mock-up II.

6.1.1.2 User story

According to the information in his skill profile, *Customer Consultant* Martin is only offered tasks that are ascribed to his role (R3) at the moment, which are T4, T5 and T6. He is not satisfied any more with his field of duties because his current jobs have become a little monotonous for him in the meantime. Thus, Martin wants to develop and learn something new, so he decides:

“As a *Customer Consultant* I want to collect experience for the role *Project Manager* so that I can apply for that position after a period of six months.“

In order to realize his intention Martin just has to quote an appropriate experience goal in his skill profile. Therefor he will make use of the experience goal pattern that aims at collecting experience for a certain role (cf. Pattern 3 in section 4.1.2.1). By setting a goal of this type Martin will still be offered tasks that are assigned to his current role, but additionally he will be offered work items of tasks that are ascribed to his target role from now on. If he does no longer want to perform tasks that are integrated with his original role, he also has the possibility to define some corresponding experience neglection goals so that no work items are offered to him anymore that activate the stated experiences.

6.1.1.3 Usage scenario

1. Martin is logged on to the WFMS and his individual start page is displayed.
2. Martin switches to his skill profile.
3. Martin states his experience goals in his skill profile.
4. Martin switches to his shared worklist.
5. Martin choses a work item for execution.
 - 5.a. Martin inspects the associated task description.
 - 5.b. Martin starts the execution of the chosen task.
6. Martin performs the chosen task.
 - 6.a. Martin fills in the task editing form.
 - 6.b. Martin states a forum update about his current progress.
 - 6.c. Martin finishes the task execution.

After a period of three months performing primarily tasks that are ascribed to the role Project Manager:

7. Martin checks his work experience proceedings in the *History* menu.
 - 7.a. Martin inspects the *Progress Details* regarding experience type E3.

6.1.2 Simulation

Notice: The experience rates used within the mock-up simulations presented in this work are approximate values for demonstration purposes only, and not based on precise calculations.

Martin is logged on to the WFMS *Mercury4* and his individual start page is displayed:

The screenshot displays the Mercury4 Workflow Client interface. The top navigation bar includes 'My Work', 'Profile', 'History', 'Forums', and 'Support'. The 'My Work' tab is active, showing a 'Working on (4)' section with a table of tasks. The left sidebar shows 'Recent updates' for 'Garden landscaping' with messages from Stella and Michael. The bottom left shows 'Updates' for 'Garden landscaping' with a message from Alice.

Task	Process	Priority	Expiration date	Ref. No.	State	Last update
1. T6: Discuss offer	Garden landscaping	High	5/17/2014	103	Executing	5/15/2014
2. T5: Update offer	Garden landscaping	Medium	5/18/2014	110	Started	5/15/2014
3. T5: Update offer	Garden landscaping	Low	5/24/2014	115	Suspended	5/14/2014
4. T4: Prepare quotation	Garden landscaping	Low	5/24/2014	118	Suspended	5/13/2014

Figure 18: *Mercury4* - private worklist

The first thing that is displayed upon logging on to the workflow client of *Mercury4* is the *My Work* menu that contains a user's worklists. The tab "Working on", which is currently opened, represents the private worklist and thus shows the work items that are allocated to the user at present. Note that there is an authorization rule which limits the number of tasks allocated to this worklist to a maximum of five items in order to ensure an evenly work distribution among the workflow participants.

From the above shown view the execution of tasks can be started, continued or resumed, but also the deallocation of work items might be initiated here. For every task in the list the respective task description may be invoked by clicking the loupe button on the right of each line. The listed items can be sorted arbitrarily by means of the little arrows next to the task property headers.

On the left side of the window the latest forum updates are listed that relate to the respective workflow participant.

Martin switches to his skill profile by clicking the *Profile* Menu button and selecting the “Skill profile” tab. The following screen appears:

The screenshot shows the Mercury4 Workflow Client interface. The top navigation bar includes 'My Work', 'Profile', 'History', 'Forums', and 'Support'. The 'Profile' tab is selected, and the 'Skill profile' sub-tab is active. The profile for 'Martin' is displayed, showing his role as 'Customer Consultant' and skills in 'MS Excel', 'MS Word', and 'English (Level C1)'. A 'Work experience' section contains a table with three rows: 'E1: Calculating Offers' at 'Specialist' level (82%), 'E2: Describing Offer Details' at 'Valuable' level (45%), and 'E4: Dealing with Customers' at 'Valuable' level (67%). The 'Preferences' section shows 'Experience goals' and 'Task priorities' as 'No experience goals set' and 'No task priorities set' respectively, with 'Set new...' links. A 'Save' button is located at the bottom right of the preferences section.

Type of experience	Current level
- E1: Calculating Offers	Specialist 82 %
- E2: Describing Offer Details	Valuable 45 %
- E4: Dealing with Customers	Valuable 67 %

Figure 19: Mercury4 - skill profile

In the *Profile* menu a user has access to his personal info, where he can edit his personal data like name, address, email, password or profile picture, and also to his skill profile, where he can see his actual role(s), skills and work experiences levels. Additionally the currently set experience goals and task priorities are displayed in this view under *Preferences*. This is also where users can edit their preferences, i.e. define some new ones or delete existing ones.

As one can see Martin has not stated any preferences in his skill profile yet. Based on his decision to develop and gather a new role, Martin sets a corresponding experience goal in his profile in order to be able to realize his aim. By clicking the “*Set new...*”-link in the respective section a pop-up shows up that initiates the goal setting process:

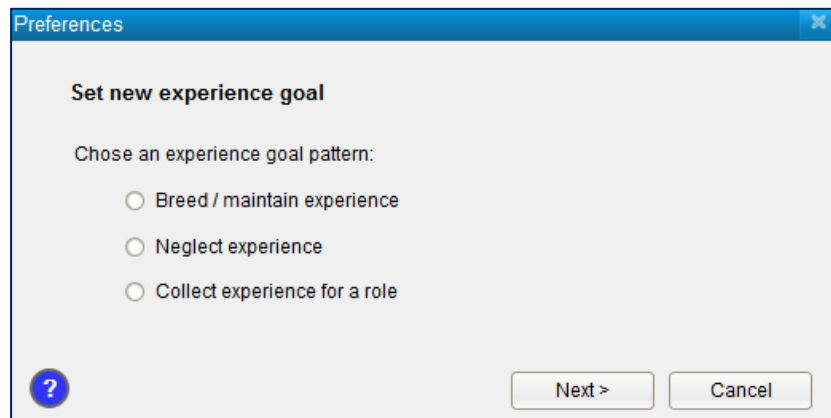


Figure 20: Experience goal wizard - Step 1

Martin ticks the third out of the three experience goal patterns (cf. Patterns 1-3 introduced in section 4.1.2.1) that are offered as eligible options in this step, as he wants to collect experience for the role *Project Manager*. After clicking the “Next”-Button the second step of the goal setting wizard appears. Now Martin just has to set the combo box to the appropriate role “R1: Project Manager” and complete the process by pressing “Finish”:

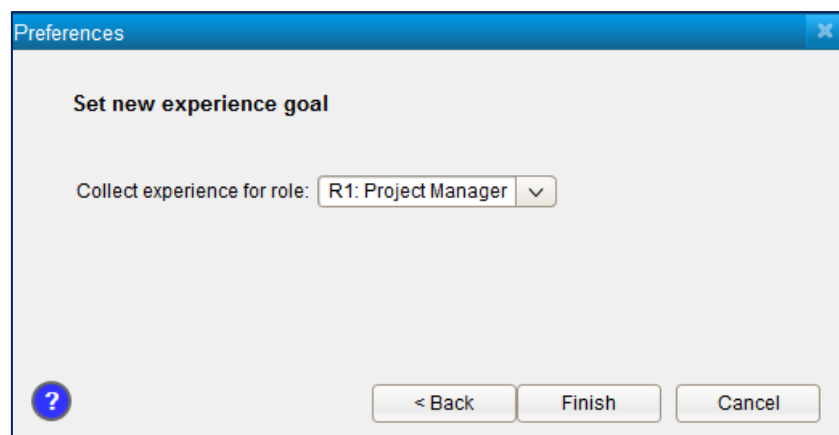


Figure 21: Experience goal wizard - Step 2 (Option 3)

The defined experience goal is now visible in Martin's skill profile in the *Preferences* area:

The screenshot shows the 'Workflow Client' interface for user 'Martin'. The 'Profile' tab is active, displaying 'Personal Info' and 'Skill profile' sections. The 'Skill profile' section shows Martin's role as 'Customer Consultant' and his skills: 'MS Excel', 'MS Word', and 'English (Level C1)'. Below this, the 'Work experience' section contains a table with three rows of experience types and their current levels. To the right, the 'Preferences' section shows 'Experience goals' with one goal: 'Collect experience for "R1: Project Manager"', and 'Task priorities' with the text 'No task priorities set.' and a 'Set new...' button. A 'Save' button is located at the bottom right of the 'Preferences' section.

Type of experience	Current level
- E1: Calculating Offers	Specialist 82 %
- E2: Describing Offer Details	Valuable 45 %
- E4: Dealing with Customers	Valuable 67 %

Figure 22: Skill profile after first update

In addition to his previous tasks, Martin will be offered work items that are assigned to role *R1* from now on. As a result also different experience types than the original will be activated.

However, Martin also does not want to abandon his *Specialist* level at "E1: Calculating Offers". Therefore he decides to set another experience goal. This time Martin picks option 1 in the first step of the experience goal setting wizard, as he wants to define an experience maintaining goal:

The screenshot shows a 'Preferences' dialog box titled 'Set new experience goal'. It prompts the user to 'Choose an experience goal pattern:' and provides three radio button options: 'Breed / maintain experience' (selected), 'Neglect experience', and 'Collect experience for a role'. At the bottom, there is a question mark icon, a 'Next >' button, and a 'Cancel' button.

Figure 23: Experience goal wizard - Step 1

Next he has to set the dedicated combo boxes to the proper action, the required experience level and experience type:

Preferences

Set new experience goal

Please select the required attributes:

Remain ▾ Specialist ▾ at E1: Calculating Offers ▾

? < Back Finish Cancel

Figure 24: Experience goal wizard - Step 2 (Option 1)

After activating the “Finish”-Button the new experience goal is displayed in the skill profile:

Workflow Client

MERCURY4

Martin Log out

My Work Profile History Forums Support

Search

Personal Info Skill profile

Martin

Role(s): Customer Consultant

Skills:

- MS Excel
- MS Word
- English (Level C1)

Work experience

Type of experience	Current level
- E1: Calculating Offers	Specialist 82 %
- E2: Describing Offer Details	Valuable 45 %
- E4: Dealing with Customers	Valuable 67 %

Preferences

Experience goals:

- Collect experience for "R1: Project Manager"
- Remain "Specialist" at "E1: Calculating Offers"

+ Set new...

Task priorities:

No task priorities set.

+ Set new...

Save

Figure 25: Skill profile after final update

Now Martin is eager to perform one of the tasks that are ascribed to his newly intended role. He switches to the *My Work* menu to check if he is already offered a new type of task in his shared worklist, which can be found under the “Offered items”-tab:

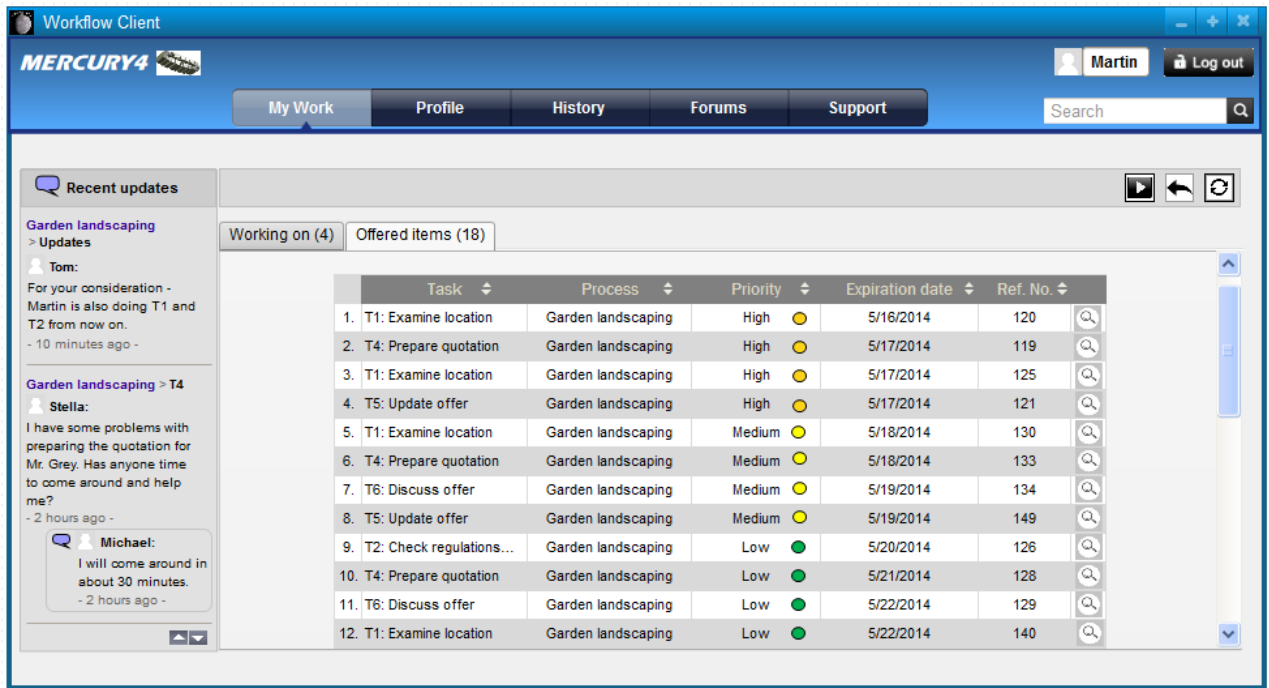


Figure 26: Mercury4 – shared worklist

The structure of this view is very similar to the one of the private worklist, with the difference that the list displayed here shows a user all the tasks that are offered to him based on the specified work item distribution strategy. From here the workflow participants can choose which items they want to execute and allocate them to their private worklist for later execution, but there is also the possibility to start the tasks directly out of this view. Note that the items listed under this tab may also be displayed in the shared worklists of other users. Therefore it must be mentioned at this point that the allocation mechanism described above follows the first-come, first-serve principle.

Back to Martin's case, one can see that he is already offered some additional work items in his shared worklist. Not only the number of items has increased, but also new task types (T1, T2) are available for execution now. In addition it is visible in the update section that project manager Tom has already informed the other employees about Martin's new field of duties. Martin inspects his worklist and decides to perform a work item of type T1 with medium priority. Before he starts the execution he takes a look at the corresponding task description that pops up by clicking the loupe button in the respective line:

Task description

Task: **T1: Examine location**

Task description:

The location for the garden has to be examined on-site at the customer. A groundplan of the location has to be obtained and size and type of the desired garden have to be inquired.

Further it must be determined if a terrace, a pond arrangement, a fence, a carport or a conservatory are required. If yes it must be inquired how the customer wants these things to be arranged - use the provided checklist for this purpose.

Necessary applications: None

Presumed workload: 6 h

Priority: Medium

Expiration date: 5/18/2014

Ref. No.: 130

Primary contact:

Tom

View support material

Work on it

T1: Examine location

T2: Check no customer address

T3: Check no customer address

T4: Prepare application

T5: Update app

T6: Discuss app

T7: Build garden

T8: Main garden

Process: Garden landscaping

Activated experiences

- E3: Checking Feasibility and Identifying Requirements 30%
- E4: Dealing with Customers 70%

Requirements

- R1: Project Manager
- R2: Landscape Designer
- "Valuable" at "E4: Dealing with Customers"

Figure 27: Task description of task T1

Now that Martin knows how to perform the task he directly starts the execution by clicking the "Work on it"-Button in the task description. Thereby the following view is opened in the *My Work* menu:

Workflow Client

MERCURY4

Martin

Log out

My Work

Profile

History

Forums

Support

Search

Task T1

Examine location

Process: Garden landscaping

Priority: Medium

Expiration date: 5/18/2014

Ref. No.: 130

Status: Started

Primary contact:

Tom

Forum update

View support

Help request

Examine location

Please fill in the required data after consultation with the customer.

Select customer:

Facts & requirements

Garden size:

Upload groundplan

Type of garden desired: Chose type...

Terrace desired: Yes, Chose substrate... No

Pond arrangement: Yes, Chose type... No

Confirm

Suspend

Reset

Cancel & Discard

Figure 28: Execution of task T1 (1)

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In the main area of this page an editing form is displayed that the user has to fill in to complete the task successfully. At the bottom there are buttons for suspending the processing of a task and for resetting the current form entries. Additionally there is the option to cancel and discard the actual task execution, which effects that the underlying work item is deallocated from the user's worklist. The "Confirm"-Button is disabled until the editing form is not completely filled, as processing cannot be finished before then.

In the left section of the page the basic information concerning the opened task is displayed, including amongst others the primary contact person. Below there are quick links for entering a status update in the appropriate forum, for viewing the corresponding support material of his task and for requesting the help of a mentor.

Martin enters all the required data into the editing form:

The screenshot displays the 'Workflow Client' application window. The title bar reads 'Workflow Client' and the logo 'MERCURY4' is visible. The user 'Martin' is logged in, with a 'Log out' button. The navigation menu includes 'My Work', 'Profile', 'History', 'Forums', and 'Support'. A search bar is present. The main content area is titled 'Task T1' and 'Examine location'. It contains a form with the following fields: 'Process: Garden landscaping', 'Priority: Medium', 'Expiration date: 5/18/2014', 'Ref. No.: 130', 'Status: Executing', and 'Primary contact: Tom'. Below these are links for 'Forum update', 'View support', and 'Help request'. The main form area is titled 'Examine location' and includes a note: 'Please fill in the required data after consultation with the customer.' It has a 'Select customer:' dropdown menu with 'Jane Taylor' selected. Below this is a 'Facts & requirements' section with radio buttons for 'Fence construction' (Yes, No) and 'Carport construction' (Yes, No). There is also a 'Conservatory desired' section with radio buttons (Yes, No). A 'Supplementary notes' text area contains the text: 'The design of a separate dog area with a kennel is also required.' At the bottom of the form are buttons for 'Confirm', 'Suspend', 'Reset', and 'Cancel & Discard'.

Figure 29: Execution of task T1 (2)

Thereafter the "Confirm"-Button is enabled. Martin decides to state a forum update before he finally finishes the task in order to inform his colleagues about the current process status and also to request some feedback for his work on the new task type. Thus he clicks the "Forum update"-link, which redirects him directly to the appropriate tab of the 'Garden landscaping' forum:

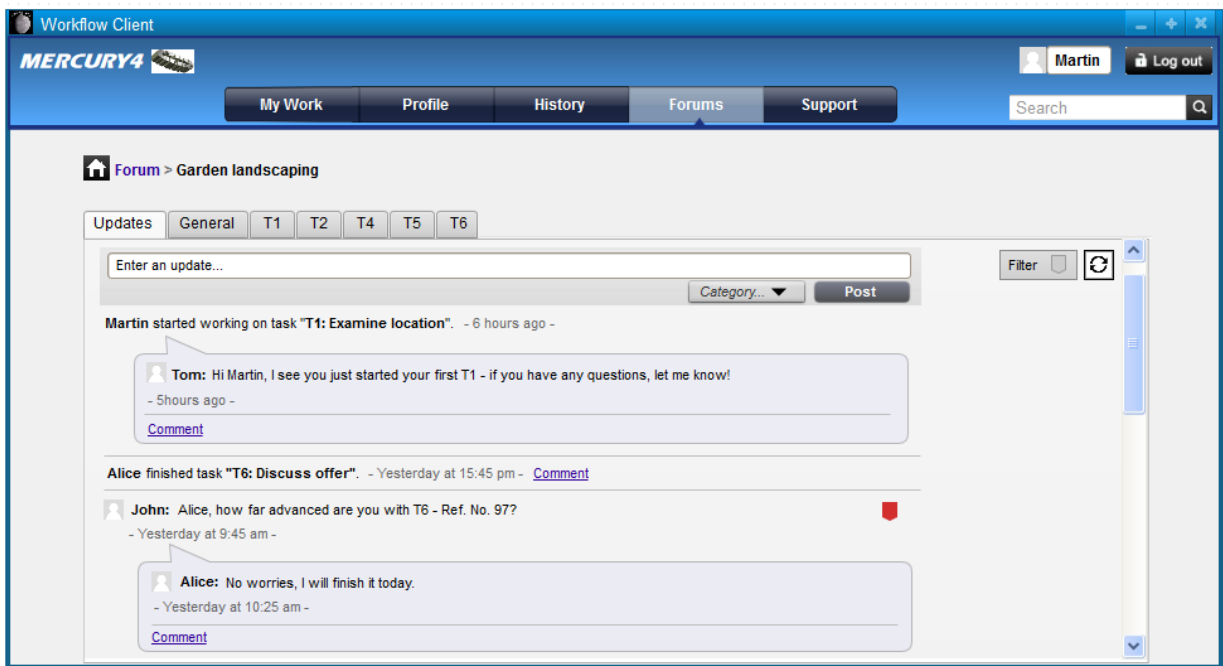


Figure 30: 'Garden landscaping' forum – section 'Updates'

For every process that is managed via *Mercury4* a separate forum is provided, which is divided into various sections that serve a specific purpose. Firstly there is a subforum for status updates concerning the actual process, which is primarily intended for informing the other users about one's current progress or actual developments in order to keep each other up to date. Additionally the single execution steps of all process participants are logged in this section, which allows users to keep track of the whole process flow. Supplementary there are subforums for the process in general and for every task that it includes. These areas are mainly designed for stating questions regarding the particular topic and assisting each other in case of problems at task execution.

Each subforum works the same way: Users can post comments, which have to be provided with a specific category (like update, request, advice, instruction, etc.), or reply to existing entries. The assignment of categories enables the filtering of comments: If no filter is set, all types of postings are displayed. If the filter is set to a specific category, only entries of this category are shown.

Martin enters his update and provides it with category *Update*:

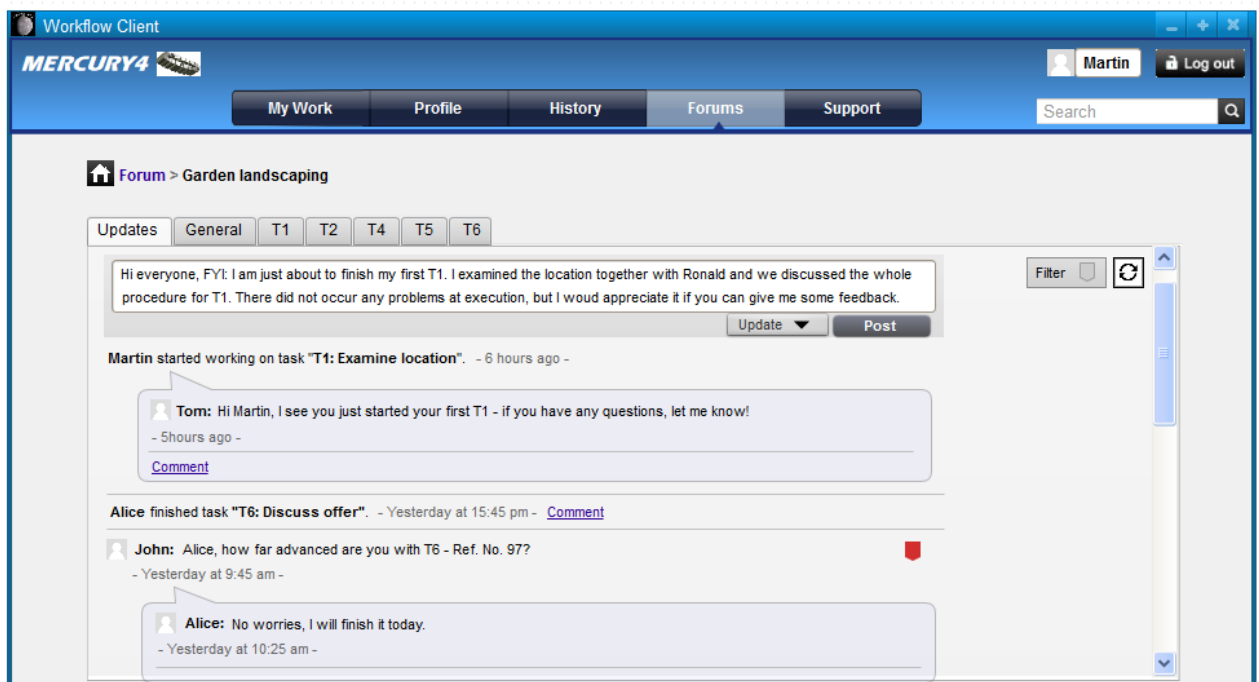


Figure 31: 'Garden landscaping' forum – entering new update

Then he posts his comment so that it is visible for all other process participants:

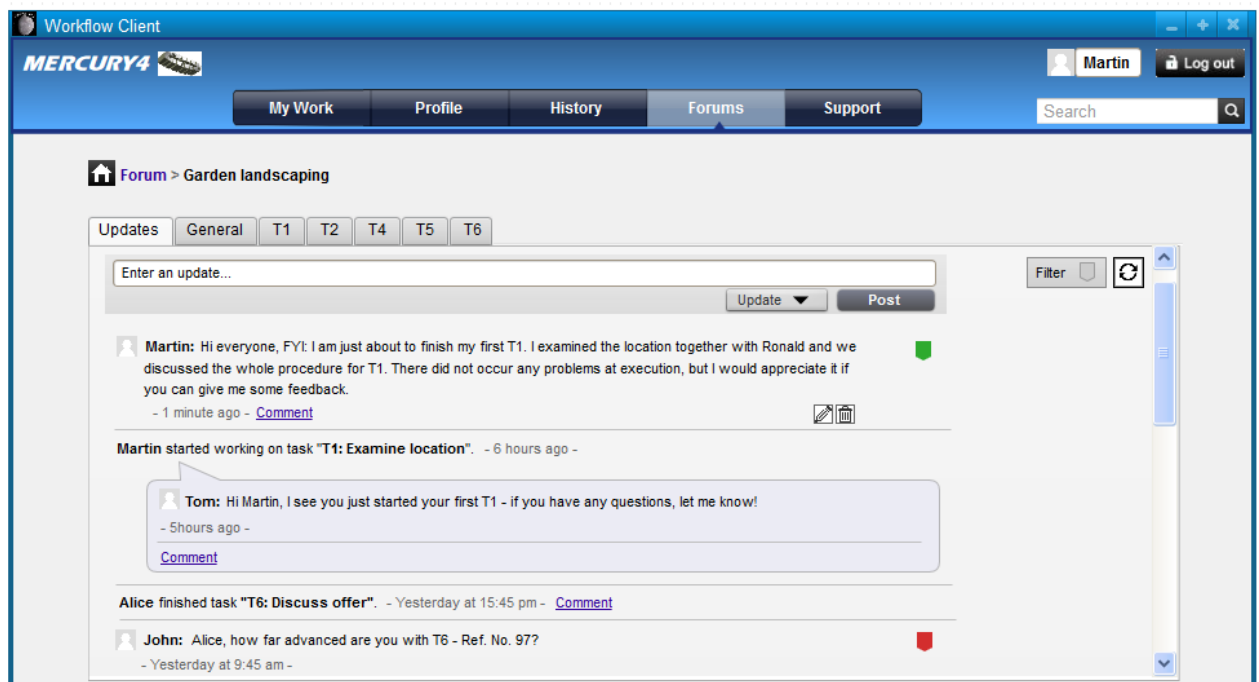


Figure 32: 'Garden landscaping' forum – new update posted

Afterwards Martin switches back to the *My Work* menu again, where the execution form for task T1 is still opened. He confirms the task completion by pressing the dedicated button and thus gets redirected to his shared worklist:

The screenshot shows the 'Workflow Client' interface for 'MERCURY4'. The user 'Martin' is logged in. The 'My Work' menu is active. On the left, there are 'Recent updates' for 'Garden landscaping' from users Stella and Tom. The main area shows a table of tasks under the 'Garden landscaping' process.

	Task	Process	Priority	Expiration date	Ref. No.	
1.	T1: Examine location	Garden landscaping	High	5/17/2014	125	
2.	T5: Update offer	Garden landscaping	High	5/17/2014	121	
3.	T4: Prepare quotation	Garden landscaping	Medium	5/18/2014	133	
4.	T6: Discuss offer	Garden landscaping	Medium	5/19/2014	134	
5.	T5: Update offer	Garden landscaping	Medium	5/19/2014	149	
6.	T1: Examine location	Garden landscaping	Medium	5/19/2014	154	
7.	T2: Check regulations...	Garden landscaping	Low	5/20/2014	156	
8.	T2: Check regulations...	Garden landscaping	Low	5/20/2014	126	
9.	T4: Prepare quotation	Garden landscaping	Low	5/21/2014	128	
10.	T6: Discuss offer	Garden landscaping	Low	5/22/2014	129	
11.	T1: Examine location	Garden landscaping	Low	5/22/2014	140	
12.	T2: Check regulations...	Garden landscaping	Low	5/24/2014	141	

Figure 33: Updated shared worklist

It can be seen that the corresponding item is not available any more in the worklist after successfully finishing task T1. In the meanwhile also some other tasks were removed from the shared list and new ones have been offered.

After a period of six months during which Martin has performed plenty of tasks that were ascribed to his intended role *Project Manager*, he wants to check his latest work experience proceedings and therefore switches to the *History* menu:

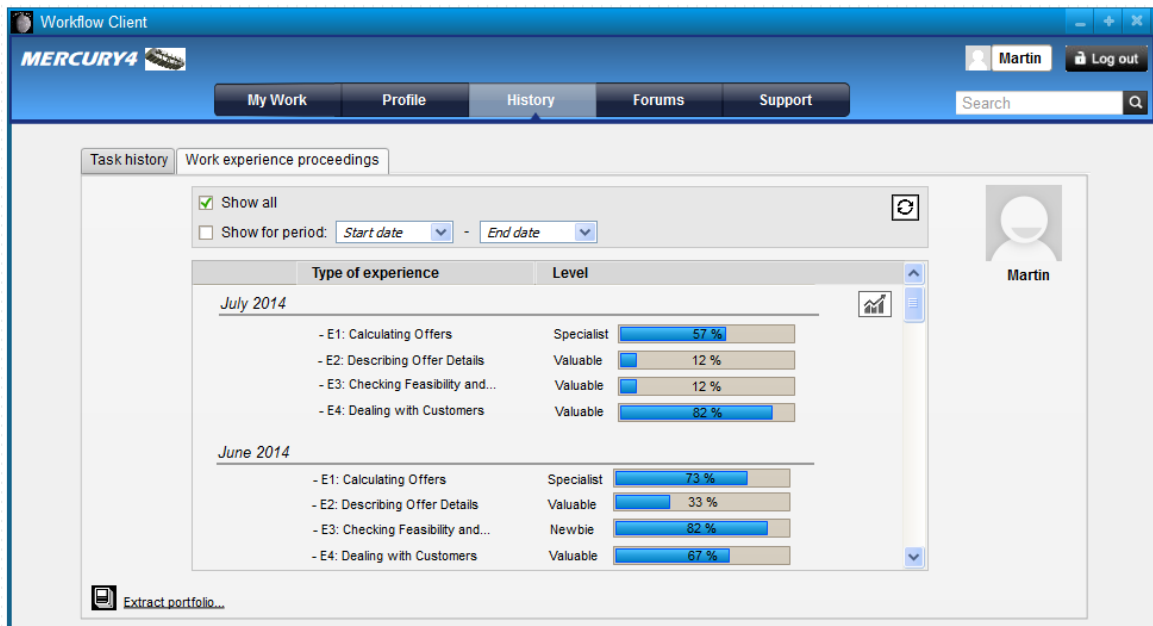


Figure 34: Mercury4 - work experience history

The *History* menu is divided into “Task history” and “Work experience proceedings”. Under the former tab a user can see his individual overview of all work items that he has completed up to now (cf. Figure 62), whereas every entry is provided with some additional information concerning the execution, like the time required or the final state. The latter tab shows the progress of a user’s work experiences by illustrating the current experience levels for the end of every month. This is realized by collecting and aggregating the experience values that arise over the month in an *Experience Breeding* database and pushing the aggregated data to the *Experience Record* database at the end of the month, in which information about previous work experience is stored [22].

By default the latest states of all months, i.e. from the time the user joined the company until now, are displayed in descending order. However, the period for which the work experience progress is outlined can also be restricted by entering a desired start and end date in the dedicated combo boxes. This is especially useful if a user wants to control which developments he made in a certain time span or at specific checkpoints. The selected information can also be represented graphically by means of a line diagram. By clicking the graph-icon on the upper right of the data display, the associated experience chart appears. In Martin’s case this chart would look like this:

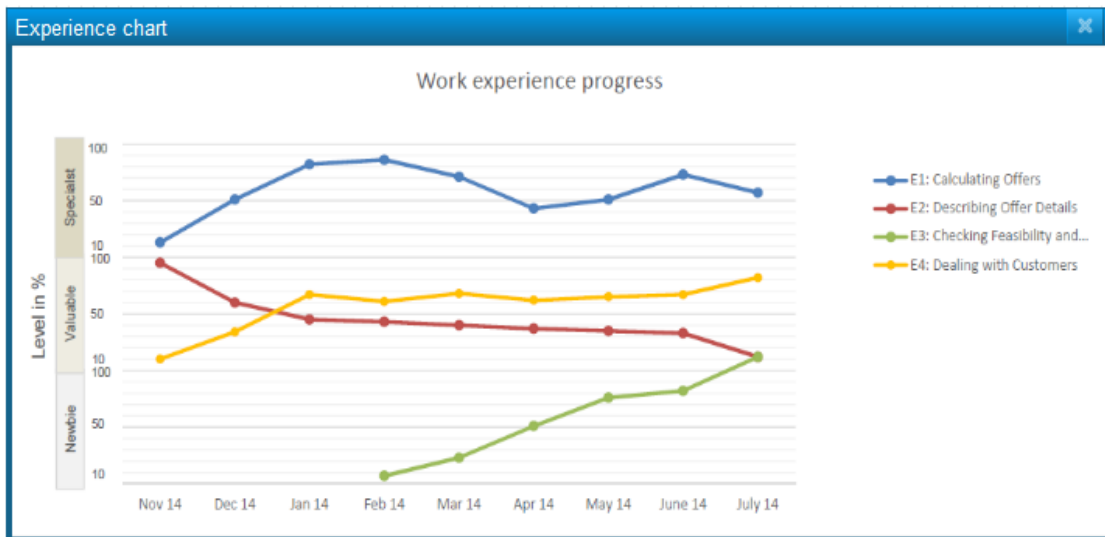


Figure 35: Work experience chart

In both sections of the *History* menu it is possible to extract a portfolio of all the information that is currently displayed on the respective site and to save it in a desired file format. This is done via the “*Extract portfolio...*”-link at the bottom left.

It can be seen that Martin has already reached level *Valuable* at both experience types that are decisive for the role *Project Manager*, namely E3 and E4. Thus, the first step towards gathering experience for the intended role has been successfully taken.

In order to get some more detailed information about his recent experience progress regarding experience type E3, Martin clicks the corresponding progress bar in his work experience history. The following pop-up appears:

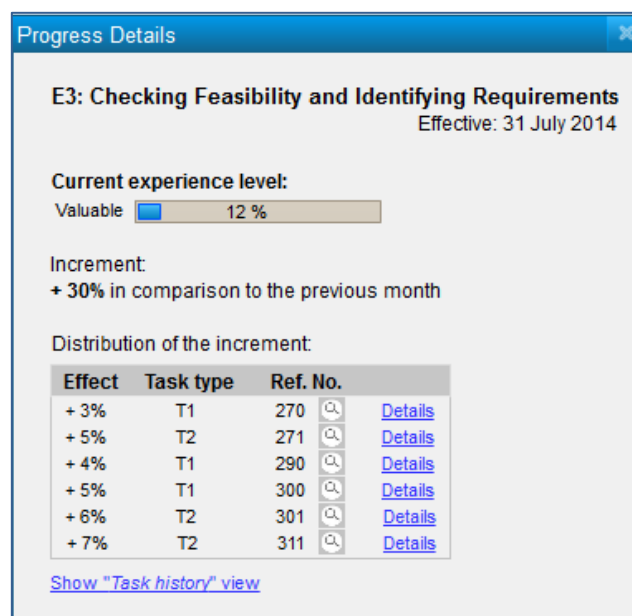


Figure 36: Work experience history – progress details

For every progress status listed in the “Work experience proceedings” the *Progress Details* for the respective experience type can be displayed, which are captured over the entire month in the *Experience Breeding* database. In the details view the percentage change (increment or decrement) in comparison to the end of the previous month as well as the percentage composition of this aggregated value and its allocation to individual tasks is illustrated. For reasons of better transparency and traceability each of the listed tasks is provided with a reference number and a link to the corresponding task description (via the loupe button). Further, there is the possibility to inspect the detail analysis (cf. Figure 63) of the underlying task execution by clicking the respective “*Details*”-link. Thereby it should be made understandable for the users, how the calculated effects came about.

By clicking the “*Show “Task history” view*”-link the shown data is represented in the task view. In the present case this would mean that all tasks of type T1 and T2 that were executed in the period of July 2014 are displayed in the “Task history”. This may be useful in order to make a comparison between the particular task performances or to draw up a portfolio that summarizes the selected tasks.

After inspecting the progress details, Martin closes the pop-up window and faces his work experience history (cf. Figure 37) again. Now he can draw up a portfolio of his latest work experiences by restricting the shown period to the last six months and clicking the “*Extract portfolio...*”-link. Martin may use the extracted track record as a proof of experiences when talking to the human resources manager about his goal of becoming *Project Manager*.

6.2 Mock-up II

Mock-up II was created in the context of the ADVENTURE FP7-ICT project (<http://www.fp7-adventure.eu/>). **AD**aptive **VI**rtual **EN**terprise Manufac**TU**ring **EN**vironment (Adventure) is Small or Medium-Scale Focused Research Project (STREP) funded by the *European Seventh Framework Programme* in Virtual Factories and Enterprises.

The structure for the preparation of the following mock-up is the same as for the previous one: At first the general framework for its development will be introduced in 6.2.1. and subordinate sections, before the corresponding user interface views will be illustrated in 6.2.2.

6.2.1 Framework conditions

In the following subsections first of all the process will be described, which the second mock-up is based on. After explaining the process details that are most relevant in the further course of this chapter, two workflow participants will be introduced explicitly as they will be the key players in the simulation of the user story that is presented thereafter. Finally the usage scenario will be outlined that is gone through once more in the fictional WFMS *Mercury4* in section 6.2.2.

6.2.1.1 Process

The preparation of the second mock-up is based on a simplified part of a business process of the manufacturing company AZEVEDOS, which shows its manufacturing process. In Figure 40 it can be seen that the process consists of ten tasks (T1-T10), which activate the following experiences:

- E1: Guiding user interfaces' development
- E2: Operating small machinery
- E3: Executing surface treatment into steel parts
- E4: Reading and interpreting mechanical diagrams / drawings
- E5: Reading pneumatic diagrams
- E6: Performing quality control and evaluation
- E7: Conceiving electrical diagrams
- E8: Performing quality evaluations and tests
- E9: Reviewing suppliers' offers

The blue arrows in Figure 40 below indicate which experiences are activated by which tasks.

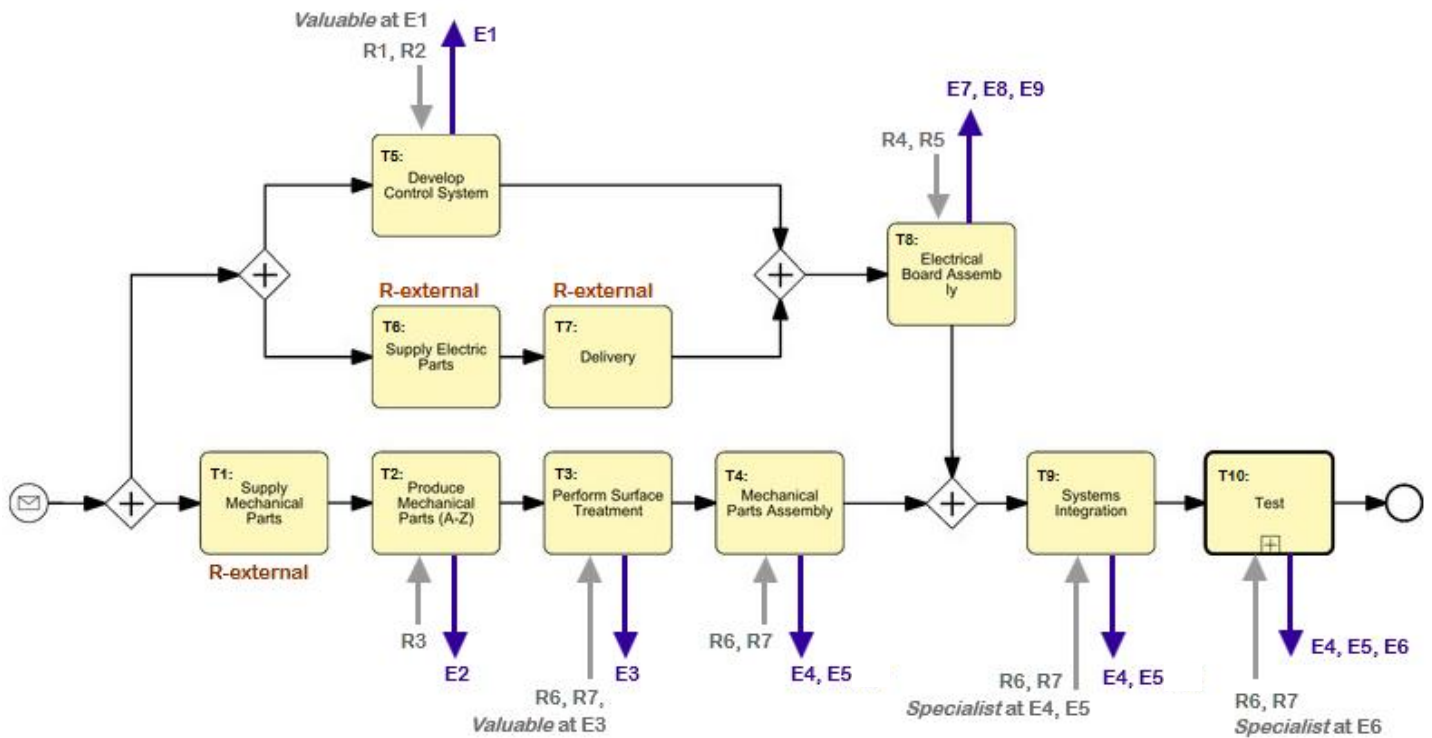


Figure 37: Manufacturing process

There are eight different roles to execute the particular tasks of the manufacturing process illustrated above, which are:

- Software Engineer (R1)
- Automation Expert (R2)
- Machine's Operator (R3)
- Electrical Engineer (R4)
- (Experienced) Electrician (R5)
- (Experienced) Operator (R6)
- (Experienced) Technician (R7)
- OEM supplier (R-external)

The last mentioned role differs from the other ones in that respect that it is occupied with external staff, which is not provided from the manufacturing company itself.

Also in this process a combined work item distribution strategy is applied. Again, the workflow participants must possess either the specified roles or experience levels⁵ that are indicated in Figure 40 by means of the grey arrows, or must have defined a corresponding

⁵ It must be noted that the indicated task requirements are only assumptions that were derived from the available information about the AZEVEDOS process for the upcoming simulation purposes and make no claims to being accurate, complete or current.

task priority in their skill profile in order for being offered a certain task. The exceptions to this are the jobs that must be executed from role *R-external* as they are not assigned to the manufacturing company's internal employees via the WFMS. Therefore these tasks are not provided with details about experience activations or requirements in Figure 40.

For the simulation of the user story that is presented in the subsequent section two fictive employees of the manufacturing company are being introduced, namely John, who is an *Experienced Technician* and Alice, an *Experienced Operator*. Both of them participate in the manufacturing process that is illustrated above and will be main actors in the following user story. Therefore the two of them are characterized in more detail by sketching their skill profiles below in Figure 41. Note that in the further course of this work especially user John will play a central role, as the user story will be described from his point of view.

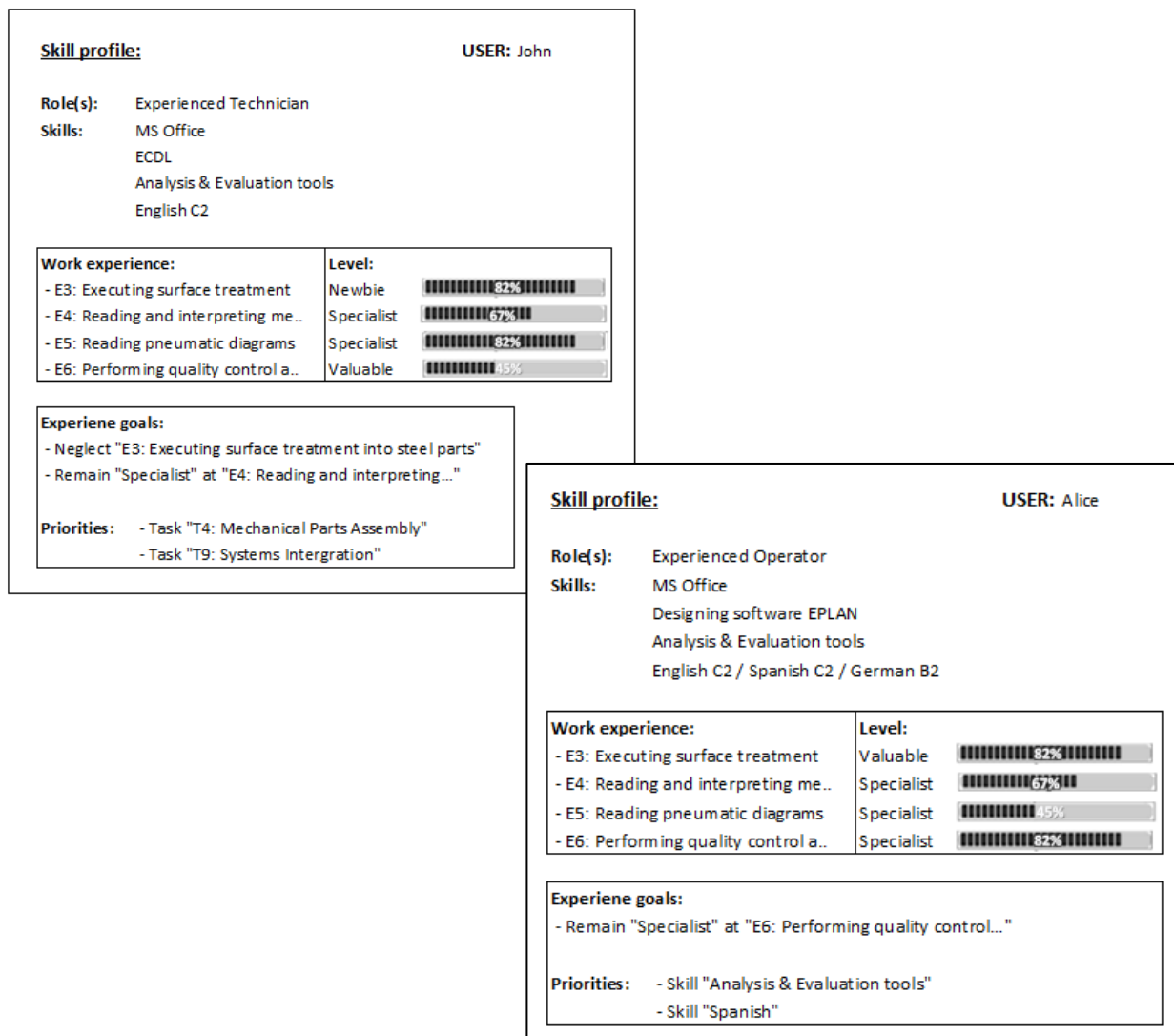


Figure 38: Manufacturing process - key players

6.2.1.2 User story

John is an *Experienced Technician* who has been working in the manufacturing company for many years now. Although he fulfills all requirements that are necessary to perform the whole range of tasks that are ascribed to his role (R7), John has avoided the execution of task T3 and T10 so far, what is also reflected in the stated experience goals and priorities in his skill profile. The reason for his behavior was simply the fact that it was more comfortable for him to do the same jobs again and again and that he just was not interested in breaking up his routine. But now John does not want to leave his capabilities and broad knowledge unused any longer and decides to pass it on to other *Technicians* so that they can breed their experiences within the scope of R7 to a higher level:

“As an *Experienced Technician* I want to gain high competence in all tasks that are ascribed to my role in order to be qualified to act as a mentor for less experienced users.”

Excursus: In this work a person qualifies as mentor for a specific task, if he has the work experience level *Specialist* in all experiences that are covered in the respective task. However, just because someone qualifies for such a function, this does not mean that he compulsorily has to carry it out. The decision if one wants to adopt a mentoring position or not is left up to oneself.

Concretely, John aims at supporting users that want to develop from ordinary *Technicians* to *Experienced* ones. The difference between these two types of role R7 is easily explained: *Technicians* are merely competent in performing task T3 as they do not have enough experience in E4, E5, E6 for executing T4, T9 and T10, which are reserved for *Experienced Technicians* only.

In order to be qualified for mentoring less experienced users in their development, John firstly has to achieve level *Specialist* in all the experience types that are crucial for becoming an *Experienced Technician*. As can be seen in his skill profile, he has already reached the highest standards in E4 and E5. Thus, John has to focus on improving his experience in E6 now, which can only be realized by intensifying the execution of task type T10. For this reason he has to adapt the currently set experience goals and priorities in his skill profile according to his needs.

6.2.1.3 Usage scenario

1. John is logged on to the WFMS and his skill profile is displayed.
2. John adapts his experience goals and priorities in the skill profile to his current needs.
3. John switches to his shared worklist.
4. John chooses a work item for execution.
5. John switches to the *Support* menu.
6. John inspects the available support material for the chosen task.
7. John performs the chosen task.
 - 7.a. John starts the execution of the chosen task.
 - 7.b. John fills in the task editing form.

During the processing of the editing form an error gets reported.
8. John submits a help request.
 - 8.a. Alice reacts to the request and contacts John.
 - 8.b. John remedies the error with Alice's help.
 - 8.c. Alice finishes the troubleshooting by completing the required error report.
9. John completes the task execution.
 - 9.a. John fills the remaining fields of the task editing form.
 - 9.b. John confirms his entries.
10. John checks his task history in the *History* menu.
 - 10.a. John inspects the detail analysis of the previously executed task.

6.2.2 Simulation

Notice:

- Some of the views shown below will not be outlined again in this section as they have already been explained in detail in 6.1.2.
- The persons, data and task-related information mentioned in the following simulation are fictitious, and do not rely on real data of the company AZEVEDOS.

John is logged on to the WFMS *Mercury4* and his skill profile is displayed:

Workflow Client
MERCURY4

John Log out

My Work Profile History Forums Support

Search

Personal Info Skill profile

John

Role(s): Experienced Technician

Skills:

- MS Office
- ECDL
- Analysis & evaluation tools
- English (Level C2)

Work experience

Type of experience	Current level
- E3: Executing surface treatm...	Newbie 82 %
- E4: Reading and interpreting...	Specialist 67 %
- E5: Reading pneumatic diag...	Specialist 82 %
- E6: Performing quality contro...	Valuable 45 %

Preferences

Experience goals:

- Neglect "E3: Executing surface treatment into..."
- Remain "Specialist" at "E4: Reading and inter..."

+ Set new...

Task priorities:

- Task type "T4: Mechanical Parts Assembly"
- Task type "T9: Systems integration"

+ Set new...

Save

Figure 39: *Mercury4* – skill profile

Based on his decision to become a mentor for less experienced *Technicians*, John has to gain high competence in all tasks that are crucial for exercising this position, namely T4, T9 and T10. Due to his role he already possesses the thereto necessary skills, but additionally he must have the required work experience in E4, E5 and E6.

According to his skill profile, John is *Specialist* in E4 and E5 at the present time. In order to realize his aim he has to maintain these standards, and in addition he also has to reach the highest experience level in E6. Thus, John has to adapt the preferences in his skill profile to his current needs.

First of all John deletes the set experience goals and task priorities that do no longer correspond to his immediate intent. This is done by clicking the “*Trash*”-icon next to the respective preference. Depending on whether the object to be deleted is an experience goal or a task priority one of the following windows pops up:

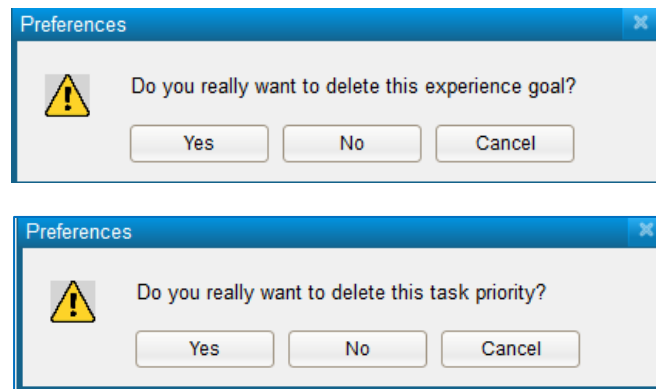


Figure 40: Preference deletion wizards

By clicking the “Yes”-Button the selected preference will be deleted and thus disappears from a user’s skill profile.

After deletion of the obsolete preferences John’s skill profile looks as follows:

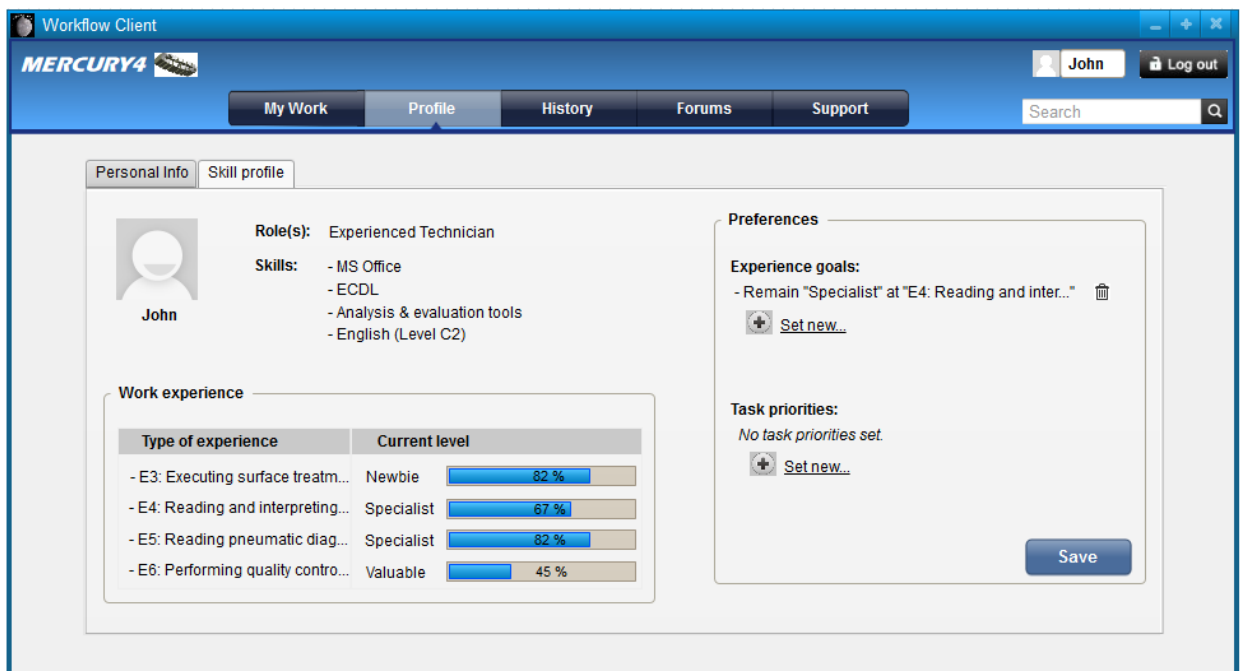


Figure 41: Skill profile after preference deletion

As can be seen one of the former set experience goals is still present because it conforms to John’s intended aim up to date. Now, John is ready to set some new preferences that reflect his current needs. Initially he wants to set an experience goal for maintaining his current experience level in E5. Thus, he clicks the “Set new...”-link in the respective section in order to initiate the goal setting process:

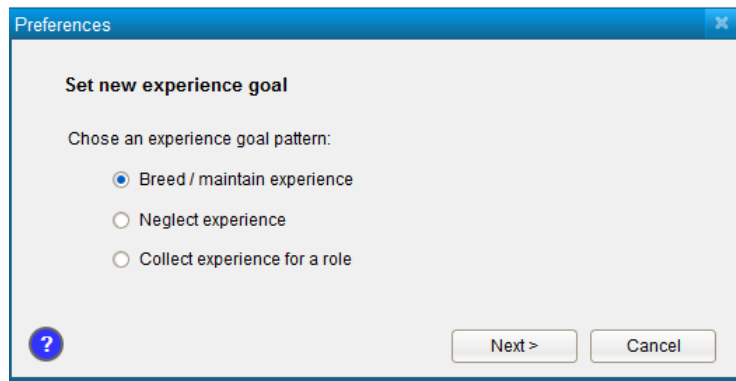


Figure 42: Experience goal wizard - Step 1

John ticks the first out of the three options, as he wants to set an experience maintaining goal. After clicking the “Next”-Button John sets the dedicated combo boxes to the proper action, the required experience level and experience type:

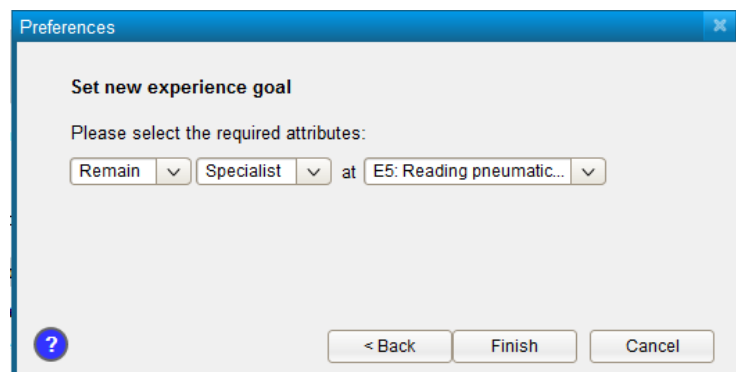


Figure 43: Experience goal wizard - Step 2 (Option 1)

Afterwards he completes the goal setting process by activating the “Finish”-Button. By applying the same procedure again, John also defines the following experience breeding goal:

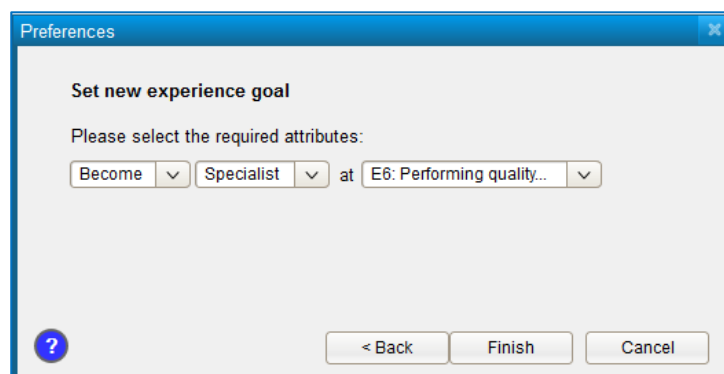


Figure 44: Experience goal wizard - Step 2 (Option 1)

As John primarily has to intensify the execution of task type T10 for achieving his objective of becoming a mentor, he decides to set another preference in order to additionally enhance the effect of being offered the focused task type. For this reason he wants to define an appropriate task priority, so he clicks the “*Set new...*”-link in the *Task priorities* section. Thereupon a window appears that initiates the priority setting process, where John just has to tick the desired priority type and to select his favored task type from the combo box:

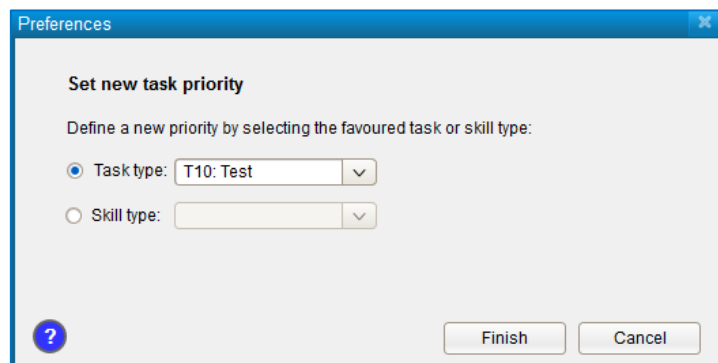


Figure 45: Task priority wizard

After stating his intended task priority, John clicks the “*Finish*”-Button to determine the process. Now that John has defined all preferences, which he assumes will contribute to achieving his aim, they can be found in the *Preferences* area of his skill profile:

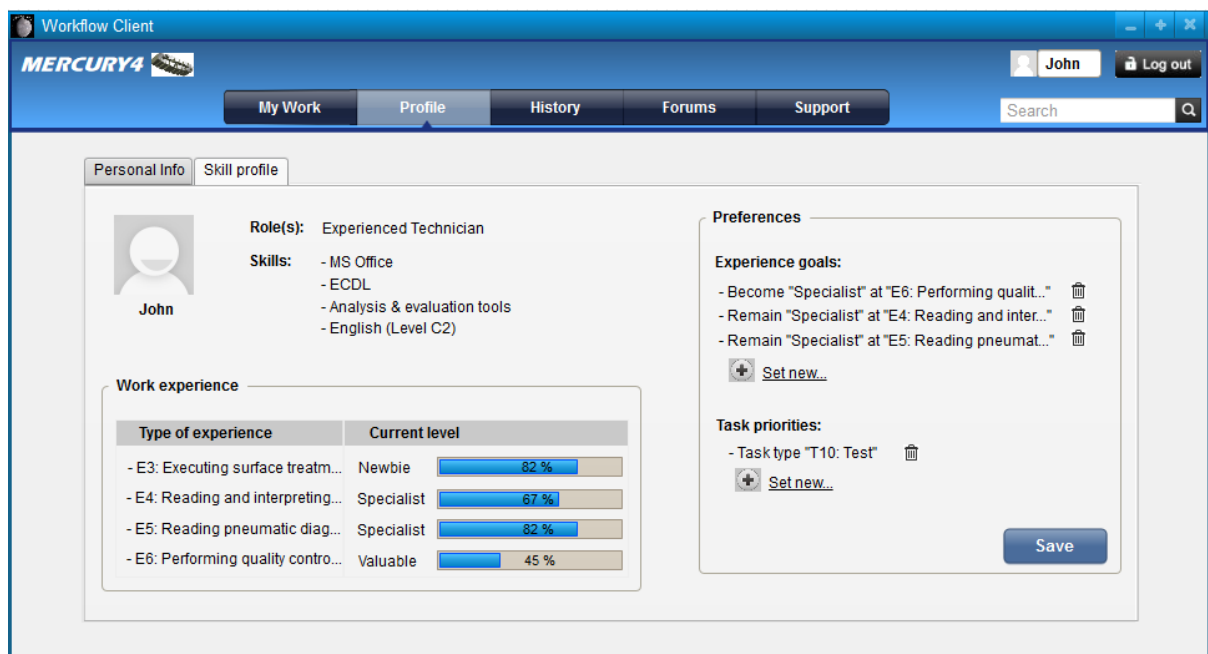


Figure 46: Updated skill profile

John wants to tackle his new objective immediately, therefore he switches to his shared worklist in the *My Work* menu in order to look for a task of type T10 that is ready for execution:

Task	Process	Priority	Expiration date	Ref. No.
1. T10: Test	Manufacturing	High	6/04/2014	301
2. T10: Test	Manufacturing	High	6/10/2014	311
3. T4: Mechanical Parts As...	Manufacturing	High	6/10/2014	319
4. T10: Test	Manufacturing	High	6/11/2014	321
5. T9: Systems Integration	Manufacturing	Medium	6/08/2014	310
6. T4: Mechanical Parts As...	Manufacturing	Medium	6/06/2014	318
7. T10: Test	Manufacturing	Medium	6/13/2014	331
8. T10: Test	Manufacturing	Medium	6/14/2014	332
9. T3: Perform Surface Tre...	Manufacturing	Low	6/11/2014	331
10. T4: Mechanical Parts As...	Manufacturing	Low	6/13/2014	340
11. T10: Test	Manufacturing	Low	6/18/2014	333
12. T3: Perform Surface Tre...	Manufacturing	Low	6/12/2014	339

Figure 47: Mercury4 - shared worklist

As one can see more than half of all tasks that are offered to John via his shared worklist are of type T10, what can be attributed to the previously set experience goals and task priorities as they have great influence on the work item distribution. John inspects the worklist and choses to perform a work item of "T10: Test" with medium priority, so that he has enough time for execution. Due to the fact that he has avoided the execution of the chosen task type for quite some time now, John has to admit that he is a little out of practice concerning its performance. Accordingly, John switches to the *Support* menu in order to inspect the available support material for the chosen task:

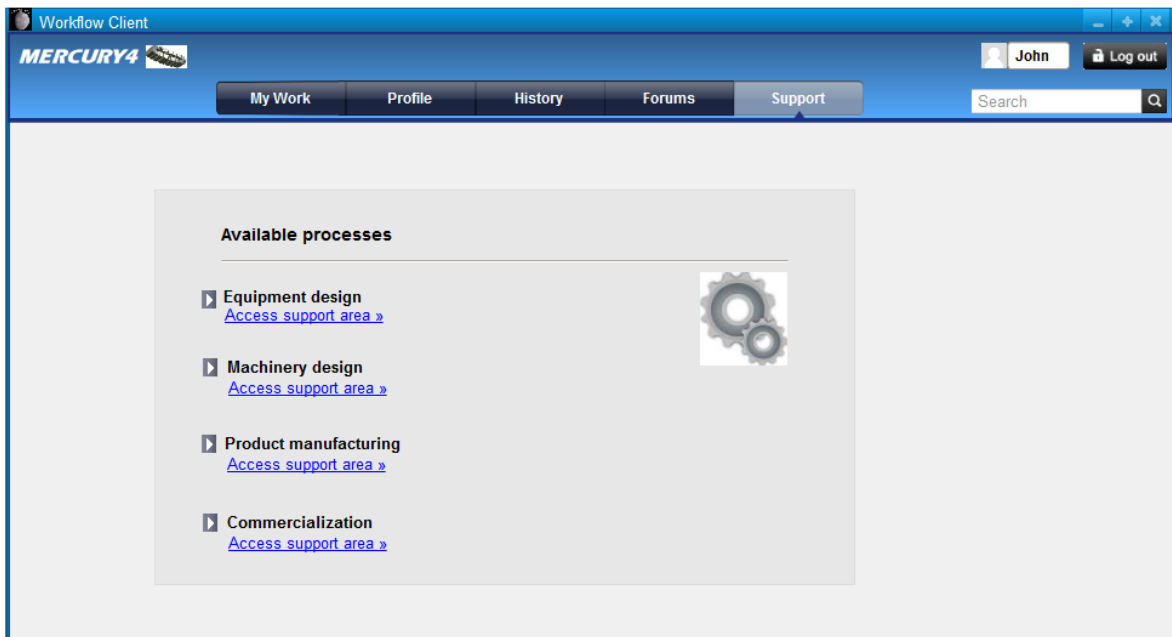


Figure 48: *Support* menu

In the *Support* menu various training and support materials are provided for the users, on which they can draw on to in order to acquire (new) knowledge concerning the processing of a particular task.

The initial view upon accessing the *Support* menu shows an oversight of all processes, for which some kind of learning material is available. From there the workflow participants can choose to which support area they want to get redirected by clicking the link under the respective process.

As John is about to perform a task that belongs to the manufacturing process, he clicks the corresponding “*Access support area*”-link under the list item *Product manufacturing*. The following view is opened:

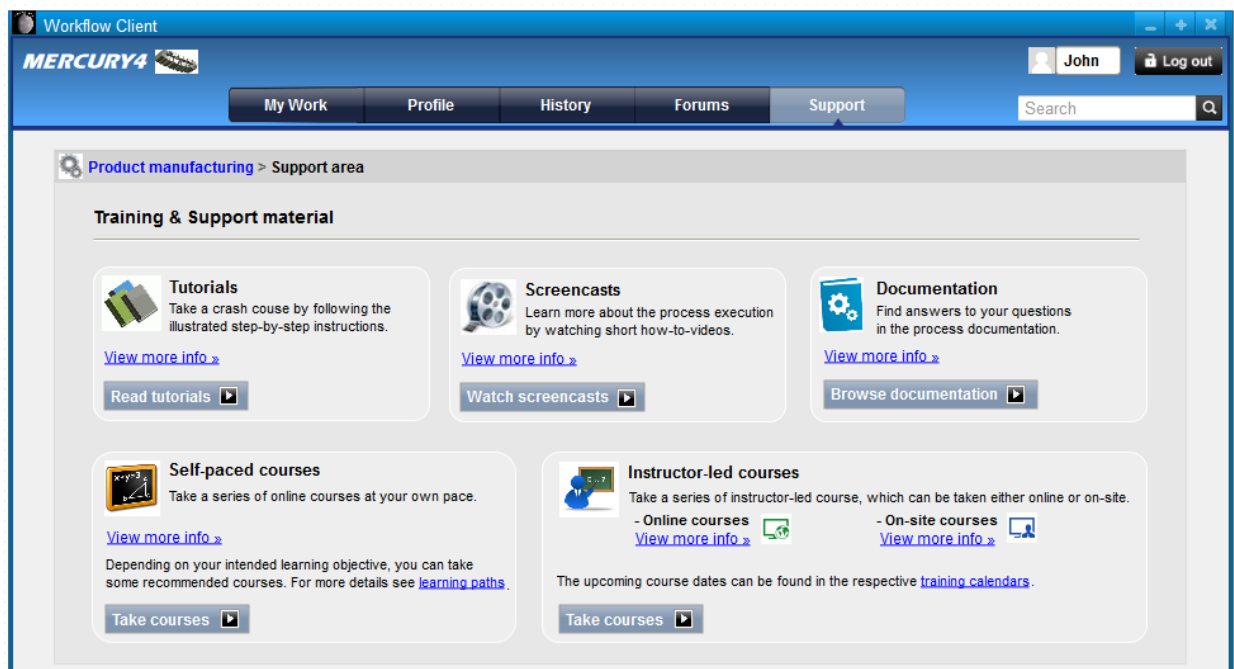


Figure 49: Process-specific support area

In the particular support areas the available support materials for the respective processes are presented. It must be noted that there are also task-specific support areas, which contain only learning aids that are relevant for a specific type of task. This kind of contextualized support areas can be accessed directly by clicking the “*View support*”-link in the respective task description or from the editing view of a task (cf. Figure 30 / Figure 55, bottom left). Thereby users do not have to search manually for appropriate materials, but get automatically redirected to it.

It can be seen that in the case of the manufacturing process there are various types of learning aids, which serve for different purposes. The tutorials and screencasts typically contain step-by-step instructions for the successful processing of a specific task, whereas the documentation serves as all-embracing reference book for the whole process. On the other hand several courses are offered that may be taken in order to achieve certain learning objectives. It is distinguished between self-paced courses that users can attend online at their own pace and instructor-led courses, which can be taken either online using a web conferencing platform or on-site. For the former some proper learning paths are supplied, which indicate the users the recommended steps to be taken to reach a specified educational goal. By contrast, instructor-led courses are assisted by a mentor as their name already suggests. They are held on fixed dates, which can be looked up in the provided training calendar, where users also have the possibility to register for the announced courses.

Each of the learning materials presented in the support area is equipped with a link that says “*View more info*”. By clicking on it a list of all obtainable resources of the respective learning aid will be displayed, each item including a detailed description of its contents. The button containing the play icon that is also available for every means redirects the user to the site map of the respective support material, from where the particular resources can be accessed and employed.

John decides to refresh his knowledge about the execution of task T10 by watching a short video tutorial. After clicking the “*Watch screencasts*”-Button in the *Screencasts* section he gets redirected to the screencast library, where he selects the desired tutorial from the video list for playing:

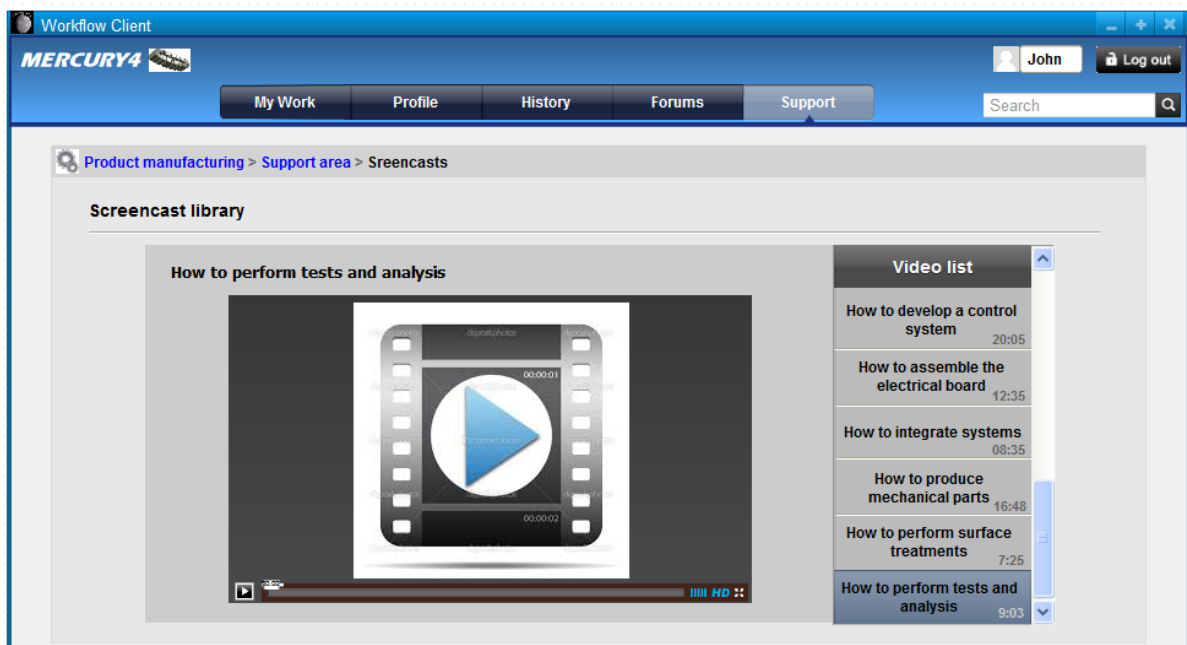


Figure 50: Screencast library

Now that John has been reminded by the video tutorial of how the execution of task “T10: Test” works, he switches back to his shared worklist in order to start the execution of the previously selected work item. This is realized by marking the respective list item and clicking the “*Play*”-Button top left in the worklist area:

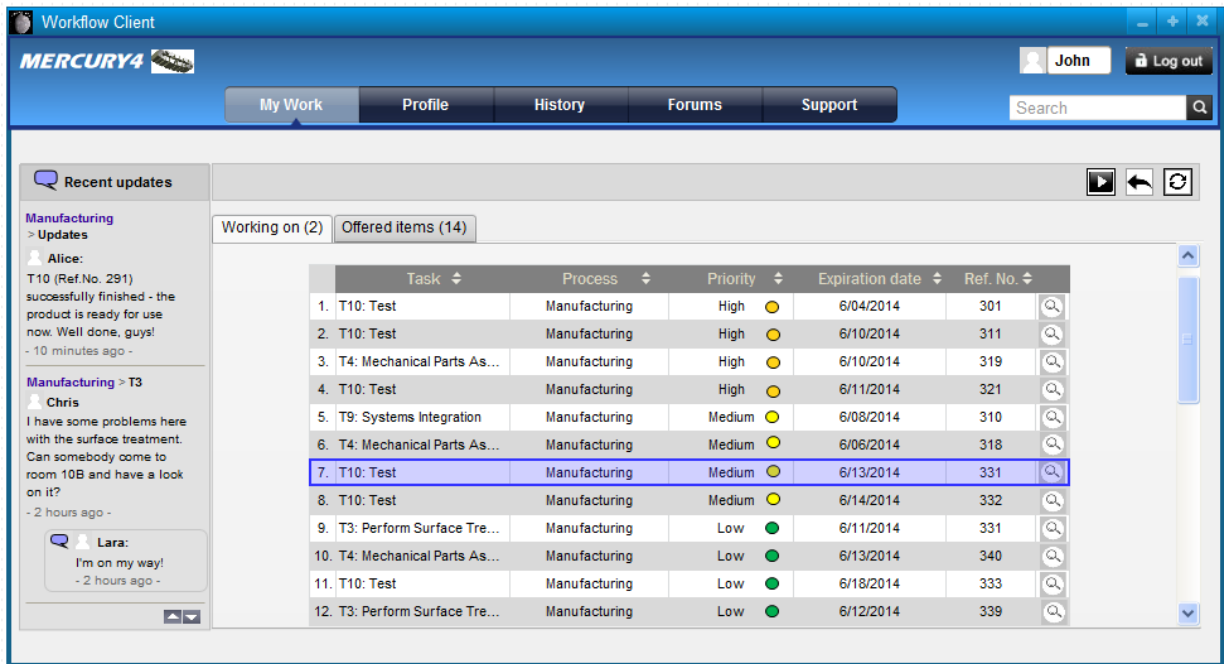


Figure 51: Shared worklist - work item selection

As a result the associated task editing form for the chosen work item is opened in the *My Work* menu:

Workflow Client
MERCURY4
 John | Log out
 My Work | Profile | History | Forums | Support | Search

Task T10
 Test

Process: Manufacturing
 Priority: Medium
 Expiration date: 6/13/2014
 Ref. No.: 331
 Status: Started

Primary contact:
 Alice

Forum update
 View support
 Help request

Test

Please fill in the required data:

Tested product:
 Serial number:

Quality control & evaluation results

Requirement 1 fulfilled? ☐ Yes ☐ No
 Requirement 2 fulfilled? ☐ Yes ☐ No
 Requirement 3 fulfilled? ☐ Yes ☐ No

Upload requirements specification

Functionality given as specified? ☐ Yes ☐ No:

Confirm Suspend Reset Cancel & Discard

Figure 52: Execution of task T10

John starts entering the required data into the editing form until suddenly an input error gets reported:

The screenshot shows the 'Workflow Client' window for 'Mercury4'. The user 'John' is logged in. The main menu includes 'My Work', 'Profile', 'History', 'Forums', and 'Support'. A search bar is present. On the left, the 'Task T10' details are shown: Process: Manufacturing, Priority: Medium, Expiration date: 6/13/2014, Ref. No.: 331, Status: Executing, and Primary contact: Alice. The main area is titled 'Test' and contains a form for entering data. The form includes fields for 'Tested product' (CAP-200) and 'Serial number' (08XD4E). Below these is a section for 'Quality control & evaluation results' with 'Measured values'. 'Key figure 1' is 25, and 'Key figure 2' is 307. A red error message is displayed next to 'Key figure 2': 'Error: Key figure 2 must be a number between 100 and 170!'. At the bottom of the form, there are radio buttons for 'Test successful?' (Yes/No) and a text area for 'List errors or problems that need to be fixed here...'. Buttons for 'Confirm', 'Suspend', 'Reset', and 'Cancel & Discard' are at the bottom.

Figure 53: Inline validation - error detection

The task editing forms in *Mercury4* support real-time inline validation for required controls or business rules that must be met. If a user fills an input field with inadequate data he gets immediately alerted through an error message next to it that indicates how the entry has to look like in order to be valid. The given error must be fixed according to the suggested feedback otherwise the execution of the task cannot be completed.

As John does not know how to solve the problem on his own, he decides to submit a help request. This is accomplished by clicking the “*Help request*”-link at the bottom of the task details section on the left of the current view, whereby the responsible contact person gets notified about the issue. In the present case this person is Alice, so the following notification pop-up appears on her screen:

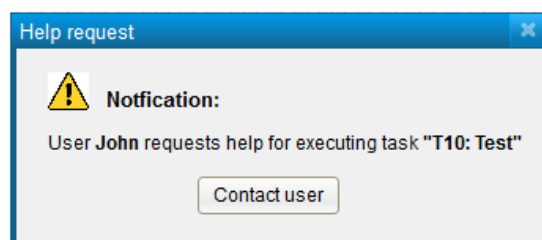


Figure 54: Help request notification

Alice reacts to the help request by clicking the “*Contact user*”-Button. Thereby she gets immediately redirected to the internal instant messenger *IMe*, where a conversation with the enquiring user is automatically initiated for the purpose of troubleshooting:

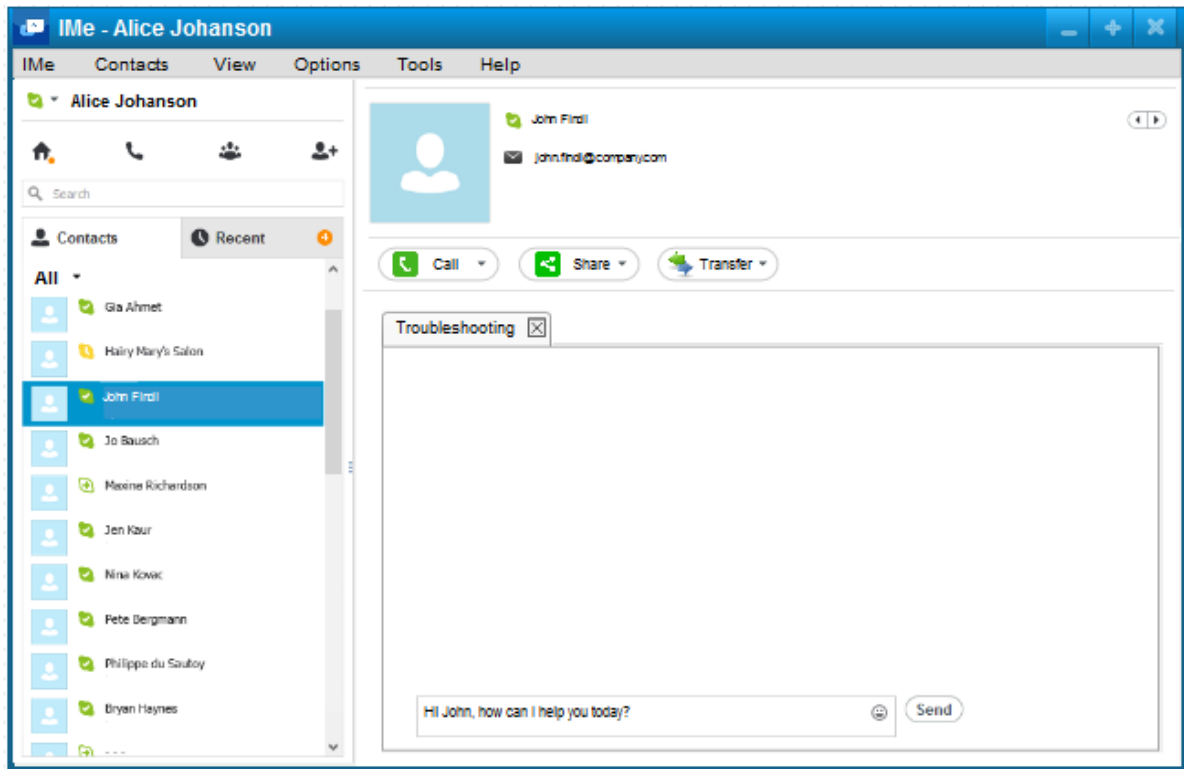


Figure 55: Internal instant messenger *IMe*

The internal messaging application *IMe* offers the functionality of a standard instant messenger extended by some additional features. First of all it allows user to communicate with each other in real-time via the chat function. The messenger also provides a contact list, where users can see which of their individual contacts are currently available and thus, ready for a conversation. Note that if Alice's status would not have been “Available” at the moment when John submitted his help request another competent mentor would have been notified about the issue on behalf of her.

Additionally *IMe* enables users to hold audio- or video conferences via the “*Call*”-function and allows for data exchange via the transfer of files. Another useful feature is the “*Share*”-option, which supports screen, desktop and application sharing. By making use of this feasibility users can view anything that their counterparts have currently displayed on their screens and trace the actions they are taking. Beyond it is even possible to activate remote desktop control in order to allow other users or mentors to manipulate one's own client.

Alice types her message into the dedicated text field and clicks the „Send“-Button. In this way the dialogue with John gets started, thus, a chat window pops up at his screen, where he can enter his response message:

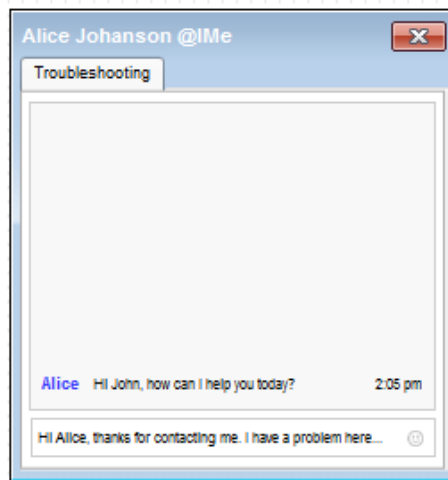


Figure 56: iMe pop-up chat window

Now John and Alice can discuss the problem via the messaging service. After some time of fault tracing John manages to fix the error with Alice's help and the error message in the task editing form finally disappears. In order to finish the troubleshooting process properly Alice has to fill in the troubleshooting report that appears upon closing the conversation on her part for the purpose of internal record-keeping:

Troubleshooting report

Please fill in the required information:

Reason for help request:

Origin of the problem:

Was the support area examined before stating the help request?

☐ Yes ☐ No

Can the solution for the problem be found in the support area?

☐ Yes ☐ No

How did the user handle the troubleshooting situation?

Submit

Figure 57: Troubleshooting report

By means of the troubleshooting report the reason for the help request and the origin of the error are ascertained. Further it is recorded if the user has taken the right actions to solve the problem and how he handled the whole troubleshooting situation, e.g. if he acted competent or rather clumsy, if he contributed anything constructive to resolving the problem and the like.

The thereby collected data may serve for different purposes. On the one hand it can be used as reference in the next performance review or may be the trigger for adding some new materials to the support area, if the recent problem has not been addressed there yet. On the other hand some information might also have direct consequences for the user, like a positive or negative impact on his work experiences or the revocation of a certain task type due to the fact that he is not competent to do it for now. The latter would mean not being offered work items of this task type any more until the user has not attended a task-specific course, acquired an essential skill or improved an experience to a required level.

After completing the report Alice just has to click the “*Submit*”-Button, whereby the case will be definitely closed.

Now that the error has been remedied successfully, John can continue with the execution of task T10. He fills in the remaining fields of the task editing form:

Figure 58: Execution completion of task T10

After completing the editing form, John confirms his entries by clicking the “*Confirm*”-Button, which is now enabled. Thereby the execution of the task is completed and the editing view gets closed. Afterwards John switches to the *History* menu to take a look at his task history, where the work item that he has just finished a moment ago is already listed:

Task	Ref. No.	Priority	Completion date	Execution time	Resting time	State
1. T10: Test	331	Medium	6/11/2014	07:32:14	00:00:00	Completed
2. T4: Mechanical Parts As...	230	High	6/10/2014	05:33:04	00:15:35	Completed
3. T4: Mechanical Parts As...	230	Critical	6/08/2014	02:10:45	00:00:00	Completed
4. T9: Systems Integration	285	High	6/07/2014	06:53:14	00:00:00	Completed
5. T9: Systems Integration	275	High	6/06/2014	09:45:08	02:30:22	Escalated
6. T4: Mechanical Parts As...	270	Medium	6/05/2014	03:15:40	01:20:22	Completed
7. T9: Systems Integration	275	Low	6/03/2014	10:59:31	03:14:49	Completed
8. T4: Mechanical Parts As...	260	Critical	6/02/2014	02:13:12	00:00:00	Completed

Figure 59: Mercury4 - task history

As already explained before the *History* menu is divided into the areas “Task history” and “Work experience proceedings”, whereas under the former the user can see his individual overview of all work items that he has completed at some time in the past. By default all tasks are listed that have been executed so far, i.e. from the time the user joined the company until now, but there is also the possibility to restrict the displayed items to a certain time period by entering a desired start and end date into the dedicated combo boxes. Besides the data shown may be further limited by making use of the additional display options that are outlined top right in the present view, which allow the user to restrict the displayed items to particular kinds of task, so that only completed tasks of the stated type(s) are shown, or to exclude specific items from the listing dependent on their final state. These possibilities may be useful if a user wants to compare his previous performances in respect of a particular aspect or also to draw up a portfolio with certain characteristics.

Each entry in the history is provided with some information concerning the underlying task execution. Of particular interest are the time records and the completion state, which may be completed (meaning successfully completed), aborted or escalated. The execution time indicates the time required from actually starting the processing of a task until its completion, whereas the resting time describes the period in which a work item dwells untreated in a user’s private worklist, e.g. because it is currently suspended or has not been started yet. If one wants to show good performance it is suggested to keep the latter one as short as possible since it implies ambition and diligence.

Additionally every listed task is provided with a loupe button, which allows the user to inspect the corresponding task description, and a “Details”-link, which leads to the detail analysis of an executed task.

The listing of the tasks is standardly ordered descending according to the completion date, but it may also be arranged after another depicted task property. In order to have a better oversight the number of work items that are currently displayed in the list is specially displayed above it.

In order to learn more precise details about his performance concerning the execution of the previously completed task T10, John clicks the “Details”-link on the right of the respective line. The following pop-up appears:

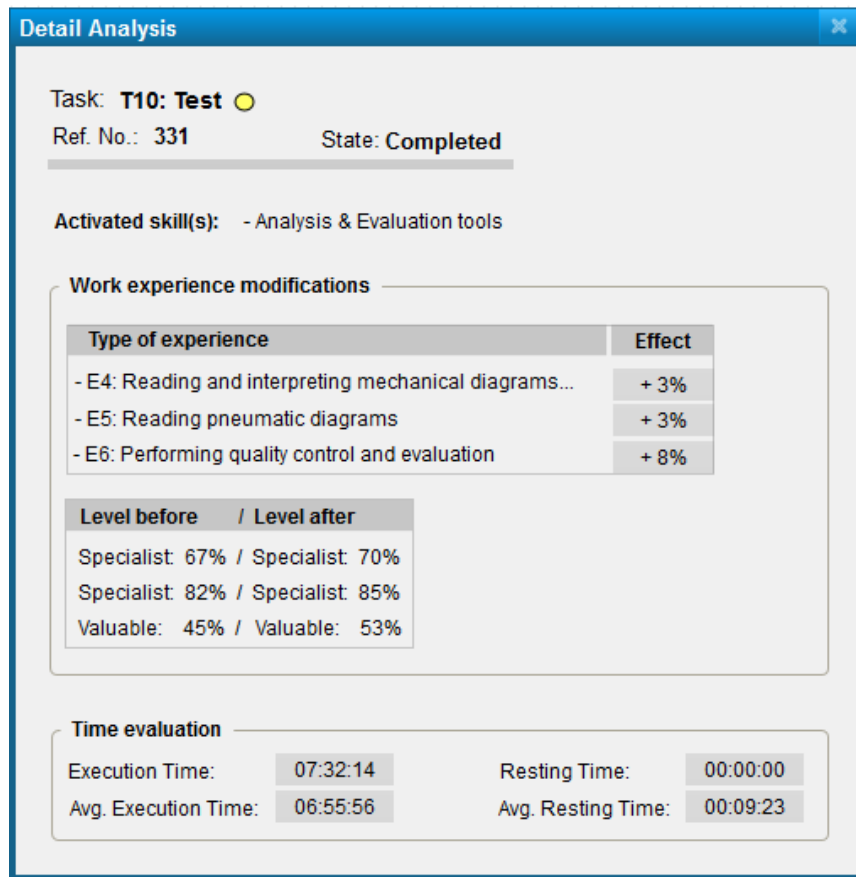


Figure 60: Detail analysis of an executed task

For every executed task a *Detail Analysis* is available, which can be inspected by the user in order to get an idea of his performance. First of all the analysis shows which skills and experience types were activated through the execution of the respective task. For reasons of transparency and traceability it is presented how and to what extent the execution affected the single experience types. In the interest of clarity also the corresponding experience levels before and after execution are indicated.

Further the analysis comprises a time evaluation of the executed task, which shows the required execution and resting time. In order to enable time comparisons also the average execution and resting time needed for this type of task are displayed, which are calculated based on historical data from previous task performances⁶. Self-evaluations concerning the required execution times can be carried out by means of the information displayed in the “Task history” view.

Through the exercise of all steps described above John got already far closer to his goal of becoming a mentor for less experienced *Technicians*. Now he just has to perform enough

⁶ Note that this kind of time comparison is only useful for standardized tasks.

tasks of type T10 in order to reach level “*Specialist*” at “E6: Performing quality control and evaluation” as soon as possible, so that he is authorized to officially support other users in their development.

6.3 Comparison fictional WFMS to present systems

After drawing up the HC-PAIS user interface mock-ups, their underlying WFMS *Mercury4* is going to be analyzed by means of the evaluation scheme created earlier in order to enable a comparison between the fictional WFMS and the evaluation results of the present systems that were analyzed in chapter 5. Therefore the evaluation summary from 5.4 will be adopted and expanded by a column for the new *Mercury4* system, where its ratings are additionally registered. The result can be seen in the comparison scheme below, which now contains the assessments of all products that have been reviewed in this work so far.

Comparison scheme				
Area: <i>Workflow patterns</i>				
Criterion	Product			
	YAWL	AristaFlow	Bizagi	Mercury4
Work item description	+	+	+	+
Separation shared / private worklist	+	-	-	+
Work item distribution strategy (role-based / capability-based / priority-based)	+/-	+/-	+	+
Indirect participant selection	+	+	+	+
Retain familiar strategy	+	+	+/-	-
Participant autonomy regarding the refusal of tasks	-	+	+	-
Pull strategy (FCFS)	+	+	+	+
Authorization rules	+	-	+/-	+
Deallocation of work items from private worklist	+	-	-	+
Freedom at task execution	+/-	+/-	+	+
Timekeeping at task execution	+	+	+	+
Reminder before exceeding a deadline	-	+	+	+
Work list display format	-	+	+	+

Selection autonomy regarding the execution order	+	+	+	+
Search function in worklist	-	+	+	+
Inline validation at task processing	+	+	+	+
Area: <i>HC-PAIS approach</i>				
Criterion	Product			
	YAWL	AristaFlow	Bizagi	Mercury4
Skill profile	+	-	+	+
Experience goals	-	-	+	+
Task priorities (task type / skill)	+/-	-	+	+
Mentor / Support	-	+/-	-	+
Task history (completed tasks / work experience proceedings)	-	+/-	+/-	+
Portfolio	-	-	+/-	+
Forum	-	+/-	+	+

As can be seen at first glance the fictional WFMS *Mercury4* that has been presented in the mock-ups above exceeds all existing products that have been analyzed in the previous course of this work. It fulfills all criteria that have been identified as useful for the realization of a human-centric PAIS user interface with the exception of the retain familiar strategy that has not been considered at its preparation, as this function does not relate directly to the workflow client application itself and therefore was not specially included.

Particularly noteworthy is the fact that all features listed in the area of the HC-PAIS approach could be realized effectively in the mock-ups, since the focus at their preparation was placed on them. Accordingly, it can be said that the goal of developing a HC-PAIS user interface has been achieved successfully with the creation of the *Mercury4* workflow client application, which is also reflected in the ratings of the analysis results in the scheme above. It now remains to be seen if the experts that were consulted in the context of the qualitative evaluation come to the same conclusion and assess the developed WFMS user interface as human-centric.

7 Mock-up evaluation

The developed HC-PAIS user interface mock-ups have been evaluated by means of a qualitative expert validation, which was composed of a mock-up presentation, followed by an expert interview. The presentation was conducted in the form of a cognitive walkthrough in combination with a variant of the usability inspection method called think-aloud. This means the experts were asked to express their opinion while walking through the presented simulation scenarios, in order to obtain feedback on the showcased workflow client application regarding its human-orientation and practicability. The subsequent expert interview was based on a structured guideline comprising 7 openly formulated questions that primarily should give information about the validity and eligibility of the developed UI mock-ups.

The main goal of the performed evaluation was to find out if the developed HC-PAIS user interface mock-ups are assessed as human-centric by the consulted experts. Based on their long-term experience and in-depth knowledge the interviewees could give useful information on the validity of the presented UI approach and provide some notable suggestions for improvement. A short introduction of the persons consulted can be found in the following subsection, where also the basic conditions of the evaluation are outlined, including the questionnaire that was used for guiding the expert interviews. The outcomes and lessons learned from the performed valuations are outlined in section 7.2 respectively 7.3.

7.1 Evaluation design and sample

Two experts (one female, one male) with a solid IT background were willing to assess the developed HC-PAIS user interface mock-ups within the framework of the qualitative evaluation process presented above. Respondent 1 (R1) is part of the research group *Workflow Systems and Technology* at the Faculty of Computer Science, University of Vienna, which focuses on research in the area of business process management and workflow systems. He has been dealing with the automation of workflows for the last 19 years now and also contributed to the exploration of the topic HC-PAIS [20] in the recent past. Respondent 2 (R2) is Managing Director / Head of Research at an Austrian research and consulting company. Before that, she also acted as a researcher in the field of *Workflow Systems and Technology* at the University of Vienna. Her central theme was human-orientation in PAIS, on which she worked for 4 years [20, 21, 22]. The whole issue of HC-PAIS was taken up on her initiative in the stated research group and it was also she, who developed the cornerstones for the definition of HC-PAIS.

Based on their many years' experience, both of the consulted persons possess an in-depth, domain-specific knowledge of HC-PAIS and thus, are recognized as experts in this field. While R1 has a quite technical background and hence, evaluated the shown mock-ups from a rather technical viewpoint, R2 focused on human-orientation / human factors instead. Consequently, both perspectives were well covered at the mock-up validation.

The expert evaluations were conducted in July and August 2014. The average duration of each was 1.5 hours. The intended evaluation concept made it necessary to use a face-to-face approach in order to be able to present the mock-ups properly and to provide the possibility to give more explanation where needed. During the guided expert interviews the respondents were asked

- what they understand by human-orientation in PAIS and what they think qualifies a PAIS as human-centric.
- if they would declare the shown mock-ups as human-centric and why / why not.
- which effects the deployment of such a workflow client application could have on its users.
- if they would be personally interested in working with the user interface presented in the mock-ups and why / why not.
- which advantages / disadvantages they think could arise for the company through the use of such a workflow client application.
- which difficulties / challenges could appear at the implementation of the mock-ups.
- if they have any ideas or improvement suggestions what can be additionally done to better integrate users into the system.

The interview results as well as the feedback that was provided by the experts within the mock-up presentations were documented and afterwards analyzed by means of a qualitative content analysis. The outcomes of this evaluation can be found below in 7.2.

7.2 Results

The evaluation found that the created mock-ups are rated as human-centric by the consulted experts and thus, the requirements to achieve the goal of this work have been fulfilled. Both experts stated that these were the first HC-PAIS user interface mock-ups that they have ever seen. They found it interesting to see how a human-oriented workflow client application could look like and in particular, how the human-centric details were put into practice.

The design of the user interface was perceived as very appealing and user-friendly, as it is clearly structured and intuitive to use. Also the contents were found to be prepared in a clear and comprehensible way. Besides, the presented UI approach meets the conditions that, in opinion of the experts, qualify a PAIS as human-oriented. On the one hand employees are integrated into the system in a way that allows them to improve themselves and to pursue their self-set development goals. They can co-determine which tasks they are offered and decide on their own which of them to execute. On the other hand the system is transparent and comprehensible for the users since it illustrates, which work experiences and skills are activated by the particular tasks and how their execution affects their experience progress.

What was especially welcomed by the experts were the features that are designated for supporting users in their work and development, like the possibility to access the contextualized support material or to state a direct help request to their assigned mentor if a problem occurs during task execution. The concept for defining self-set experience goals was found to be very well implemented in the mock-ups, as its functionality was prepared in a user-centric way and presented clearly. Also the tools that serve for promoting the exchange between employees, namely forums and internal messenger, were considered as useful for the realization of a HC-PAIS.

The interviewees agreed that the deployment of a workflow client application as shown in the mock-ups would have positive impacts on the users. Employees would be encouraged to reflect upon what goals they have in working life and how to achieve them. Knowing that their performances may contribute towards reaching their own aims, tasks would be chosen and executed much more consciously by the users. Additionally it was deemed helpful that the experience progress over time is visually represented and thus, employees have the possibility to track and control in which direction they are developing.

However, a drawback for the users is seen in the fact that the information recorded on their progress and working behavior remains permanently available in the system and may also be monitored from other persons that have access to this data, like managers or other people in authority. At the same time the experts stated that this constitutes a main advantage from a company perspective, as the presented system is ideally suited as an analysis tool. It provides an overview of the available pool of employees including their competencies, which makes it possible to identify gaps and positions that need to be refilled. Based on the employees' self-defined goals it can be determined if there are potential candidates in a company's own ranks that would be interested in filling the vacancies. Besides, the recorded information on users' performances and working behavior can be analyzed to determine which process tasks cause the most problems and thus, appropriate steps can be initiated to avoid them.

All in all, the experts assumed that the use of the presented workflow client application would be very beneficial for businesses as it reduces their administrative effort and facilitates the planning of personnel deployment and also development. Indeed, the introduction of the shown system would be associated with some effort on the part of the companies, as plenty of groundwork is necessary for its realization. By way of example, for every process appropriate roles, experiences and skills have to be defined and assigned to the single employees. Additionally the correlations between the named properties and the particular tasks have to be determined in great detail. According to the interviewees, the most demanding issue would probably be the customization of the experience measurement rule so that it meets the requirements of the respective company.

However, by way of conclusion, the experts pointed out that there is an important prerequisite for the success of the presented application. It must deliver what it promises for the users otherwise, meaning if the recorded user data is not used properly e.g. for corresponding task allocation purposes, this may lead to great frustration among the employees.

To sum it up, the consulted experts found the created mock-ups to be very well-made and were satisfied with the outcome of this master thesis. Nevertheless, it was also indicated that they would still have a few extension suggestions in order to enrich the shown user interface with even more human-centric details. What the interviewees were especially missing in the presented mock-ups are features that enable self-evaluation and peer reviews, as these are considered to be important aspects of HC-PAIS. Another expert proposal to render the showcased client application more human-centric was to establish a wiki, which enables users to exchange views on their experiences with certain process tasks by providing reports or critical reviews about it.

7.3 Lessons learned

For the successful implementation of a human-centric PAIS it is an important factor that the system is transparent for the users. The processes within the system (especially those with direct relevance to the workflow participants) must be clear and comprehensible for them. Therefore a user manual should be on hand, which provides all the necessary information about its operation and functionality.

In order to state appropriate experience goals, employees have to be informed of how to achieve their aims and must be aware of the relationships between experiences and goals. It is in the interests of the users to indicate how the completion of a particular task contributed to the achievement of an objective and affected their experiences (cf. Figure 63). In the course of this, it would also be conducive to give an explanation of whereon these

effects are attributable. A feature that enables the display of such information is not yet included in the presented mock-ups, but should be considered in future work to render the shown client application even more human-centric.

Another detail that is not yet available in the showcased HC-PAIS user interface concerns the work experience history (cf. Figure 37), which might be expanded by the set experience goals and task priorities. By illustrating the experience proceedings in combination with the stated preferences, the (chronological) context between the two can be presented clearly and comprehensibly for the users – especially from the diagram view (cf. Figure 38). In addition, the employees would thus have a good overview of the progress towards achieving their set goals, as they see all the necessary information at a glance.

8 Conclusion

In this work a HC-PAIS user interface mock-up was presented that integrates users' skills, experiences, preferences, goals and needs into the WFMS in a way that supports them in their everyday work with the system and in their personal development. For the realization of this aim it was necessary to detect appropriate means that can be used to shape the client application of a WFMS in a human-centric way. The particular criterions that were assumed to be useful for this intent were presented in chapter 4. Based on these findings an evaluation scheme was evolved (see section 4.2) that served as a basis and starting point for the development of the presented HC-PAIS user interface mock-ups. The named scheme was also used for the system analysis carried out in chapter 5, where three existing WFMS were evaluated regarding their human-orientation in order to get an impression of the current situation on the market.

During the implementation of the mock-ups, it was attempted to overcome the negative effects on human users that conventional WFMS cause due to their rigid structure (cf. section 1.1 and 2.2.4). On the one hand, this could be achieved by adjusting the system configurations according to the employees' demands and needs, what was realized with the inclusion of proven workflow patterns (see section 4.1.1). On the other hand, the drafted client application was equipped with some useful, partly innovative features, which facilitate user's daily work with the WFMS and allow them to set their individual experience goals and task preferences (see section 4.1.2). The named measures contribute towards loosening the rigidity of the concerned systems as they enable users to co-determine the distribution of work items by stating their own preferences and give them plenty of freedom at the task selection and execution. Moreover, the employees are encouraged to take their own decisions and to achieve their professional ambitions. Therefore the actions described above

are thought to make the work with the WFMS more satisfactory for the employees and thus, positively affect their motivation.

The realization of the described mock-ups was presented in chapter 6 based on the simulation of predefined usage scenarios in a fictional WFMS, what may be considered as a form of practical evaluation as well. Additionally, the designed system was contrasted to the previously analyzed WFMS in order to see how it performs in comparison to existing ones (see section 6.3). Besides, the contribution of this work also included a qualitative expert validation of the created models, which gave useful information about their validity and practicability, as illustrated in chapter 7.

To conclude, this work can be seen as an initial step towards the development of a human-centric WFMS that is tailored to the demands and needs of its users. By means of the created user interface models it was demonstrated what a human-oriented workflow client application might look like and how the features that were identified to qualify it as such may be implemented. The findings of the conducted expert evaluation confirmed that the developed mock-ups meet the requirements for a HC-PAIS.

As the literature review preceding this work revealed, the integration of humans has not received much attention within the area of PAIS research so far, since there are only few scattered works that address this topic at present. What is more, the analysis of existent WFMS found that hardly any of the research results from this field have made their way to presents systems yet. It is in the interest of this thesis to encourage an in-depth discussion of HC-PAIS and the inclusion of humans and their needs in future research and studies. Opportunities for future work include above all the actual implementation of previous research findings and their validation in practice in order to learn what effects the suggested concepts and solutions have on the PAIS users. In line with this, it seems worthwhile to implement a complete prototype of the HC-PAIS approach presented in this work, including the belonging data structures and appropriate measurement rules, and to perform a practical evaluation of the system to verify the effectiveness of the introduced concept. In order to achieve meaningful results, it would be recommended to conduct a simulation with real workflow participants in a realistic setting. By this means it would also be possible to ascertain if and how working with the developed HC-PAIS influences users' motivation and job satisfaction. The proposed investigation could be realized by means of a quantitative survey using a standardized questionnaire. Otherwise, future research activities could also address the development and introduction of a satisfaction measurement rule that can be used for quantifying the effects of human-centric system features on users' satisfaction to work with the WFMS.

Moreover, future works could also deal with the extension of the presented HC-PAIS user interface mock-up with additional human-centric functions and details. Some suggestions for improvements have already been outlined in chapter 7.2. Particularly interesting in this regard would be the implementation of the proposed features that enable self-evaluation and peer-reviews of completed tasks for the purpose of quality assurance. The former would be intended as a kind of self-reflection about the task execution and the therefore required effort, also including an evaluation of one's own performance. On the other hand, the peer review procedure is used to objectively assess the quality of someone else's work. This form of external evaluation could be carried out anonymously either by mentors or other experienced users, but also independently from a person's position, e.g. the processor of a task reviews the output of the related predecessor task. It is important to note that the given feedback has to refer to the deliverable rendered and not the person who executed the task. It is assumed that the employment of the envisaged quality assurance measures is most efficient and fruitful when adapting it to selected tasks that are a) of high complexity and require innovative thought, creativity and individual action for a successful completion or b) of great importance for the company, e.g. because they are attended with high profits or concern important customers. The analysis of the data obtained through the described methods involves a great deal of time and effort, as a standardized evaluation is not possible here. Therefore it is recommended to carry out the named measures only during certain, predefined periods or else at random points in time - according to the needs of the respective business.

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Appendix A: Abstract

A.1 English

Process-aware information systems (PAIS), such as workflow management systems (WFMS), support organizations in managing and automating their processes involving people, applications and information sources. Their major benefit lies in the fact that they allow for process optimization by enhancing flexibility and efficiency at processing. On the downside, the adherence to the rigid schedule that these systems imply is often experienced as too restrictive by the employees, what may have a negative impact on their motivation and satisfaction to work. The overcoming of these adverse effects on the users has not been paid much attention to in research so far. However, human orientation in PAIS constitutes a critical factor for high performance and business success.

The contribution of this work is to provide a concept of a workflow client application that focuses on the users and their wants in respect of carrying out their work by integrating their skills, experiences, preferences and goals into the system. An essential aspect for the realization of this aim is the disclosure of potentials and features that can be used to render the user interface of a WFMS and its operating more human-centric. The presentation of the identified criteria for human-orientation in PAIS constitutes a major part of this thesis, as these are reviewed theoretically and summarized into an evaluation scheme, but also demonstrated by means of user interface mock-ups, which show how the inclusion of humans may be realized in practice. Another focal point of this work lies in the analysis of selected WFMS. Existing products as well as the developed UI models have been evaluated regarding the human-orientation of their workflow client applications. The evaluation results are presented together with possible suggestions for improvement.

A.2 German

Process-Aware Information Systems (PAIS), wie zum Beispiel Workflow Management Systeme (WFMS), unterstützen Unternehmen bei der Verwaltung und Automatisierung ihrer Prozesse unter Einbeziehung von Menschen, Anwendungen und Informationsquellen. Ihr größter Vorteil besteht darin, dass sie durch Erhöhung der Flexibilität und Effizienz bei der Bearbeitung eine Optimierung der Prozesse ermöglichen. Andererseits implizieren diese Systeme die Einhaltung von starren Arbeitsabläufen, was von den Mitarbeitern oft als zu restriktiv betrachtet wird und daher negative Auswirkungen auf deren Motivation und Arbeitszufriedenheit haben kann. Der Bewältigung dieser negativen Effekte auf die Benutzer wurde in der Forschung bisher nur wenig Beachtung geschenkt, obwohl eine bessere Integration der Menschen und ihrer Bedürfnisse in PAIS wesentlich zur Leistungsfähigkeit und zum wirtschaftlichen Erfolg eines Unternehmens beitragen kann.

Mit der vorliegenden Arbeit wird ein Konzept für eine Workflow Client-Anwendung erstellt, welche die Benutzer und ihre Bedürfnisse hinsichtlich der Verrichtung ihrer Arbeit in den Mittelpunkt stellt, indem ihre Fähigkeiten, Erfahrungen, Präferenzen und Ziele in das System integriert werden. Ein wesentlicher Aspekt für die Realisierung dieses Vorhabens ist die Offenlegung von Potentialen und Funktionen, die dazu verwendet werden können, die Benutzeroberfläche eines WFMS und deren Bedienung mehr an die Anforderungen der Mitarbeiter anzupassen. Die Präsentation der identifizierten Kriterien macht einen Großteil dieser Arbeit aus, da diese theoretisch aufgearbeitet und in einem Evaluierungsschema zusammengefasst, aber auch anhand von User Interface Mock-Ups demonstriert werden, um zu veranschaulichen, wie die Einbeziehung von Personen in der Praxis umgesetzt werden kann. Ein anderer Schwerpunkt dieser Arbeit liegt auf der Analyse ausgewählter WFMS. Sowohl bestehende Produkte als auch die entwickelten UI Modelle wurden hinsichtlich der Benutzerorientiertheit ihrer Workflow Client-Anwendung untersucht. Neben den Ergebnissen dieser Evaluierungen werden auch mögliche Verbesserungsvorschläge präsentiert.

Appendix B: Curriculum vitae

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