Institute of Architecture of Application Systems

Informal Process Essentials

C. Timurhan Sungur, Tobias Binz, Uwe Breitenbücher, and Frank Leymann

Institute of Architecture of Application Systems
University of Stuttgart
Universitätsstraße 38, 70569 Stuttgart, Germany
http://www.iaas.uni-stuttgart.de

in: Proceedings of the 18th IEEE Enterprise Distributed Object Conference (EDOC 2014).
See also BibTeX entry below.

BibTeX:

```
@inproceedings {INPROC-2014-72,
    author = {C. Timurhan Sungur and Tobias Binz and Uwe Breitenb{\"u}cher and Frank Leymann},
    title = {{Informal Process Essentials}},
    booktitle = {Proceedings of the 18th IEEE Enterprise Distributed Object Conference (EDOC 2014)},
    address = {Ulm},
    publisher = {IEEE Computer Society},
    institution = {University of Stuttgart, Faculty of Computer Science, Electrical Engineering, and Information Te
    pages = {200--209},
    type = {Conference Paper},
    month = {September},
    year = {2014},
    language = {English},
    cr-category = {H.4.1 Office Automation,
                   K.1 The Computer Industry,
                   H.1 Models and Principles},
    department = {University of Stuttgart, Institute of Architecture of Application Systems},
    abstract = {Human-centric processes are part of most organizations and their execution
      steps are typically not known initially. Consequently, standard business
      process modeling approaches are not suitable for modeling informal processes
      because they typically concentrate on the explicit modeling of the execution
      steps. In this work, we analyze properties of informal processes and
      requirements for supporting their correct enactment. We review existing
      approaches and evaluate their suitability in terms of modeling informal
      processes. Based on these results, we present a resource-centric approach by
      employing the concept of Informal Process Essentials which is used to create
      executable informal process models with dynamically changing interrelated
      resources.},
    url = {http://www2.informatik.uni-stuttgart.de/cgi-bin/NCSTRL/NCSTRL_view.pl?id=INPROC-2014-72&engl=1}
}
```


Universität Stuttgart
Germany

Informal Process Essentials

C. Timurhan Sungur, Tobias Binz, Uwe Breitenbücher, and Frank Leymann
Institute of Architecture of Application Systems
Universtity of Stuttgart, Germany
lastname@iaas.uni-stuttgart.de

***Abstract*—Human-centric processes are part of most organizations and their execution steps are typically not known initially. Consequently, standard business process modeling approaches are not suitable for modeling informal processes because they typically concentrate on the explicit modeling of the execution steps. In this work, we analyze properties of informal processes and requirements for supporting their correct enactment. We review existing approaches and evaluate their suitability in terms of modeling informal processes. Based on these results, we present a resource-centric approach by employing the concept of Informal Process Essentials which is used to create executable informal process models with dynamically changing interrelated resources.**

Keywords*—*informal processes, resource-centric processes, ad-hoc enactment, collaboration

I. Introduction

Business process models are used in many organizations to capture recurring activities and the structures (control flows, data flows, etc.) of business processes. For example, the workflow languages BPEL [1] and BPMN [2] are employed to capture recurring patterns of such activities in the form of executable workflow models that can be executed automatically [3]. Along with such well-defined business processes, there are informal processes which are typically enacted by human performers, i.e., the performers conduct the activities of informal processes [4]. This kind of processes are typically collaborative and ad-hoc, i.e., they are hard to model and predict beforehand. Informal processes are human-centric processes whose business logic, i.e., the set of activities and their structure, is not previously defined. However, there may exist informal definitions or guides of how to handle certain problems. But defining the business logic of informal processes is typically not done for the following reasons: (i) the activities or their structure are not known beforehand, (ii) the cost of creation of a well-defined process is too high, or (iii) the process changes too often [5]–[7]. Moreover, defining the business logic of informal processes can result in a restrained flexibility and an inefficient solution when (i) the performers are restricted by predefined activities and (ii) their creativity is decreased by having less autonomy [8]. Instead, human performers enact these processes based on their skills, experiences, social interactions, and intuition. Although there is no predefined business logic, the informal processes may contain best-practices and recurring activities, which can be used to support their enactments [4]. Additionally, during execution, interrelated human performers use other resources to conclude the corresponding informal processes. Briefly, social computing units (SCU) [9], i.e., socially networked humans with computing power, are often used for accomplishing specific goals without describing *how* corresponding SCUs are going to reach these goals [10].

To support the enactment and modeling of informal processes, activity-oriented process modeling approaches can be employed. These approaches define processes based on the involved activities. As these approaches fit best for the situations where the deviation from process logic is least expected, they are not suitable for the cases of informal processes which change typically frequently. To handle these deviations and to provide more flexibility, there are different approaches proposed, e.g., data-driven [11], declarative [12], adaptive [13], workflows. However, a prerequisite for these approaches is an existing definition of the business logic, which typically does not exist in case of informal processes. As a result, the existing approaches fail to represent informal processes by focusing on their previously unknown business logic. By not explicitly representing the informal processes, the knowledge about their correct enactment is not reused or shared in the organization and, additionally, is lost when the human performers who possess this knowledge leave the corresponding organization.

In this work, we tackle these issues by defining a new paradigm for modeling informal processes. Business logic of informal processes is based on decisions of human performers, i.e., these performers conduct activities during enactment based on their decisions. Consequently, by defining roles and capabilities of involved humans, i.e., by describing the corresponding decision makers, we implicitly design the business logic of an informal process. Therefore, we present the concept of *Informal Process Essentials*, which defines a meta-model to specify all information required to enact informal processes except their actual business logic. This information include: (i) context and intentions of the informal process, (ii) all resources which have an impact on the process, (iii) corresponding resource relationships, and (iv) resource organizers. The development of the meta-model is based on an explicit analysis of (i) typical informal process properties and (ii) requirements to support their correct enactment. We additionally conducted a detailed literature review on the modeling of informal processes to analyze possible features of other approaches that can support our concept. The contributions of this work are fourfold and can be categorized as follows:

- Analysis of informal process properties and requirements for supporting their enactments (Section IV)
- Literature review and evaluation of related work for modeling informal processes (Section V)
- Concept of Informal Process Essentials (Section VII)
- Case Study of Informal Process Essentials (Section VIII)

In the following section, we describe a scenario to introduce our motivation and present fundamentals in Section III to explain underlying terms and concepts of this work.

II. Motivating Scenario

We have selected a motivating scenario concerning a software product supplier. However, one can observe similar human-centric scenarios in numerous domains. Other examples can be found in Dustdar [14]. Our motivating scenario considers an informal process of maintaining an email client application. The product is not further developed but rather maintained based on a strategic decision of the company. The email client is included in a product ecosystem. Consequently, there are inter-dependencies with other products in the system. Moreover, the email client uses a common software component developed by another department. A maintenance request is issued whenever (i) a bug has been reported or (ii) product dependencies have been updated. There is one responsible employee for the product. In most cases, two additional people with certain skills, roles, and availability are recruited for each maintenance request from other projects in the enterprise. Moreover, these two additional people preferably have worked previously together or know other teammates so that they can build up an effective team. Product team members collaborate using a version control service, a task management system, and a project wiki for knowledge sharing. The development environment of the product is a custom Linux distribution with a client for the version control service and a custom Java Development Kit (JDK). Whenever advanced expertise is required to satisfy the corresponding maintenance request, they add new external experts to the team to satisfy the request. To recruit an external expert, a specific form is filled out and submitted to the human resources department. The steps of the expert recruitment is noted down in a text file. After the external expert is recruited, he is given access to collaboration services. Moreover, a development host is created containing the same Linux environment with the client for the version control service and the custom JDK for each contributing team member. Because of enterprise policies, such experts have limited access to product related data, e.g., financial records cannot be accessed. To finalize a maintenance request, there are quality assessment tests, which are executed automatically using a well-defined workflow. After running the tests, created test data is analyzed manually by the maintenance team.

When we analyze the aforementioned motivating scenario, we can observe that people with certain skills and roles are the solution for a certain type of problem in a particular enterprise. We do not model the steps that they need to follow to satisfy corresponding requests because each request may require ad-hoc solution steps, which can't be defined in advance. Consequently, one cannot predict the tasks and the order of tasks in this scenario is based mainly on ad-hoc human decisions. They use resources in the form of tools to collaborate with each other and to reach a specific goal. Moreover, they use the existing explicit knowledge in the system such as documentation related to the product to establish a common understanding of the product. Another important point to mention is that the software resources or the human resources involved in the informal process can be changed during the enactment of the informal process, e.g., a new external expert is added on-demand. In our motivating scenario, the obvious reusable information is the set of performers and respective IT resources related to the product development including resourceful product documentation and development tools, i.e., resources of the informal process. The complexity to provide different resources in this scenario varies. For instance, a web-page in the project wiki has a URL to access it, whereas the test data has to follow a certain workflow to access it.

III. Fundamentals

In this section, we provide fundamental information required to understand the presented approach. We first clarify the notion of informal processes. Informal processes involve a set of activities, similar to predefined explicitly modeled business processes. However, activities in informal processes are not defined beforehand, rather they are conducted in an ad-hoc fashion during enactment of an informal process based on the decisions of human performers. Informal processes can be carried out in the context of a previously defined business process or they can be executed independently. They are human-centric processes. During their enactments, human performers use the available knowledge in the corresponding organization. This knowledge can be distinguished between implicit (tacit) and explicit knowledge [8]. The implicit knowledge is contained in individuals, i.e., know-how, and not represented to the outside world explicitly. Because human performers have limited capabilities, complex problems require networked human performers with computing power [15], i.e., social computing units (SCU). The experienced human performers, i.e., the human performers who have enacted the corresponding process or a similar one previously, can possess the knowledge of best practices. Systems involving such human performers can be modeled using an agent-based approach, i.e, by defining systems based on individual, autonomous agents. Some of the important properties of agents are autonomy, communication, reactivity, pro-activity, goals, and planning [15]. Agents can have various roles including the coordinator roles in the processes. The processes can be defined using different approaches such as decision-oriented and activity-oriented approaches [6].

Traditional workflows are based on activity-oriented process models and executed based on these models. The business logic of these models is predefined by a set of (structured) activities. Each business process has one or more goals (sub-goals) [16], similar to collaborations which target achievements of collective goals [17]. The business processes specify work items which are assigned to resources that are capable of doing work [18]. In the context of our work, the definition of resources refers not only to the resources that are capable of doing work but rather to all resources that have an impact on the outcome of the process, e.g., employed tools. Resources are addressed by IT resources (which) and organization (who) dimensions of business processes whereas the business logic (what) dimension addresses activities and their structures [5]. Business processes can be modeled in three levels: (i) descriptive, (ii) analytical, and (iii) executable modeling. The first two levels of modeling are used for documentation purposes, whereas at the level of executable modeling, we have executive business process models [3], which can be deployed on a workflow engine to be executed in an automated fashion. Processes can be declaratively or imperatively defined [12]. Declarative processes focus on *what* needs to be done without stating *how* it needs to be done. For example, recruit a new expert is a declarative process. Recruit a new expert by contacting the human resources department is a more imperative process because it provides also information about how the corresponding process needs to be executed.

IV. Analysis of Informal Processes

In this section, we first analyze properties of informal processes. Thereafter, we describe the requirements we derived for supporting informal processes. In the vision work of Sungur et al. [7], an overview of generic requirements was given and a proper explanation has been left as future work. The following properties and detailed requirements are defined based on the existing research and the motivating scenario introduced in Section II. Moreover, in the field of the human resources in transformable factories [19], i.e., the factories that can be transformed to meet changing requirements, we have conducted four semi-structured interviews containing open-ended questions with experts in four different international companies [20]. The information collected during these interviews supports the following properties and requirements. By focusing on the resource dimension, e.g., IT and organization resources, of informal processes instead of focusing on the business logic dimension, the presented properties and requirements can be considered as a resource-oriented subset of a larger set.

A. Properties of Informal Processes

The following paragraphs highlight the characteristic informal process properties, which are not addressed by existing approaches comprehensively.

Property 1 (P1): *Implicit Business Logic*. The business logic of informal processes is not defined explicitly before the enactment. The reasons for this are their collaborative, unpredictable nature with unknown number of participants and the high cost of predefining them [5]–[7]. Rather, this kind of logic is created in an ad-hoc fashion based on human decisions during the actual enactment. In our motivating scenario, the human performers act based on the content of the maintenance request. The actual business logic cannot be foreseen as it depends completely on the request itself and the software to be maintained. Thus, details of such kind of logic is unpredictable in general. This means, that the only information that can be described in advance are the resources that may contribute to the request, i.e., people with certain qualifications and other resources needed to support reaching the desired goals.

Property 2 (P2): *Different Relationships Among Resources*. Due to having limited capabilities as individuals, *interrelated* sets of individuals are used to accomplish more complex goals [15]. These goals are reached by a collaborative knowledge sharing process between the interrelated individuals [8], [17]. For example, in our motivating scenario, we have a product team, i.e., human resources, with certain skills and relationships between each other, who collaboratively satisfy a maintenance request. Moreover, relationships between the resources are not only limited to human performers but rather also exist among other resources, e.g., software tools or physical hardware such as laptops. In the motivating scenario, there is a restriction between financial records and an external expert, i.e., there is a relationship between a human resource and a data resource. Similarly, the email client depends on a common software component developed by another department, i.e., there are interrelated software resources. Thus, there are various relationships between different resources depending on the context, in which a resource is considered.

Property 3 (P3): *Resource Participation in Multiple Informal Processes*. To overcome complex problems, teams are built up [15] and they use numerous resources, e.g., a custom JDK, a custom Linux distribution, etc. Each team member can typically participate in more than one team with different roles and each of these teams can be associated with different resources [17], [21]. Moreover, each of these resources can collaborate with multiple resources. In the motivating scenario, two additional people for each request are allocated from other informal processes, i.e., from other projects in the enterprise.

Property 4 (P4): *Changing Resources*. Matthews et al. [17], [21] mention the notion of dynamic teams, i.e., changing team structures based on changing needs. Similarly, the set of human resources of informal processes can change after initialization. Moreover, the change is not limited to the human resources of an informal process. Due to changing requirements, new resources, e.g., new software tools, new deliverables, etc., can be required during enactment. For example, in our motivating scenario, an external expert, i.e., a new human performer, can be hired from an external company to react to changed requirements.

B. Requirements for Supporting Informal Process Enactment

Supporting informal processes involves preserving and making use of the aforementioned properties. In the following, we describe the requirements we have derived from these properties and from the literature study we have conducted.

Requirement 1 (R1): *Enactable Informal Process Representation*. The business process life-cycle of Weske [22] starts with modeling and identifying processes so that one can reuse the available information for the execution of business processes and make improvements on existing process models. Similarly, informal processes need to be first represented so that they can be executed and improved afterwards based on the corresponding representations. As the business logic does not exist in advance in informal processes (P1), the executable modeling of an informal process requires bringing together the resources which are capable of deriving and executing the corresponding business logic. For example, in the motivating scenario, we execute the informal process of satisfying a maintenance request by bringing together the human performers with certain profiles, development environments, and collaboration environments. By providing the needed resources, the desired business logic of an informal process can be reproduced in each enactment [10]. Therefore, an executable representation of an informal processes requires: (i) no predefined business logic, rather an informal definition of the aim of the process and (ii) means of *providing* the resources, i.e., making human performers and all the other resources ready for enactment. For example, in our motivating scenario, the workflow for quality assessment is the organizer of the resource *test data*.

Requirement 2 (R2): *Resource Relationships Definition*. In an informal process, each resource can have relations with other resources (P2). For example, a software developer has a "requires" relationship to a software tool to execute the maintenance task. Therefore, we need a means to define custom as well as generic relationships between the resources of an informal process. As a result, one can describe not only the individual resources but also their complex interrelations

for more precise definitions of the solution elements of specific problems. This requirement is a generic version of "Organizational Allocation" [18], i.e., allocating interrelated performers for work items, because in the context of our work, resources do not only refer to performers of tasks but also to other participating resources, e.g., a custom Linux distribution, a client for version control service, etc.

Requirement 3 (R3): *Resource Visibility Definition*. Informal processes involve multiple resources which have impact on the result, e.g., human performers, custom Linux distributions, etc. Moreover, each of these resources can participate in more than one informal process (P3) and in each informal process, there can be different relationships between other resources (P2). To create businesslike representations (R1), we need a means to provide *visibility* of resources (i) for the whole process, i.e., all resources of an informal process can be made visible in the process representation, and (ii) for each resource, i.e., related resources to a resource can be made visible.

Requirement 4 (R4): *Support for Dynamically Changing Resources*. Due to emerging or changing requirements during process enactment, new resources need to be added or old ones need to be removed from informal processes at any time (P4). Therefore, we need a means to add and remove resources at modeling time and even dynamically at runtime from the corresponding informal process representations. This requirement is similar to the "Additional resources" pattern described by Russell et al. [18] but not limited to that because this requirement involves also removal of resources throughout the lifetime of a process. As a result, one can react dynamically to changing requirements in informal processes, e.g., in the motivating scenario, based on the changing requirements, the maintenance team may hire external experts.

V. Literature Review and Evaluation of Related Work

In this section, we present existing approaches in the literature and evaluate them based on the requirements described in Section IV-B. We first elaborate the activity-oriented process definitions which are typically used to describe ad-hoc, collaborative, administrative, or production workflows and then we continue with more flexible approaches such as an information-centric approach [23], a decision-oriented approach [16], and activity-centric computing [24].

Process models are defined using different modeling paradigms, e.g., activity-oriented and decision-oriented [6]. Activity-oriented approaches describe the process based on its activities whereas decision-oriented models focus on the goals of processes. Conventional workflows follow typically an activity-oriented approach. Process models, e.g., BPMN [2], BPEL [1], petri-nets [25], etc., are used to capture recurring activities of particular processes [5]. However, they fail to meet requirement R1 because the enactment is typically based on explicitly predefined business logic. To handle changing requirements during enactment of these predefined processes, the adaptive workflow approaches have been proposed [13], [26], where deviations from a predefined process model are possible. However, as these adaptive approaches are still based on predefined process models, they are equivalent to conventional workflows regarding our requirements. In the context of traditional workflows, resources are referred as capable of doing work, i.e., performers of an activity [18]. Similarly, relations of the resources are limited to only the relations of the activity performers as indicated by the Organizational Allocation pattern, which refers to assigning tasks to *interrelated* sets of performers [18]. As the concept of resource relations is indirectly and partially addressed, requirement R2 is partially met by these approaches. Traditional workflows do not focus on the visibility of the resources in a process, rather they focus on the visibility of individual work items contained in a process [18]. Consequently, each work item is executed in an isolated fashion. However, certain situations may require awareness of related work items in a process. The case handling paradigm tackles this problem by enabling allocation of such related work items to the same resource [11]. Nevertheless, case handling does not address the resource visibility of the whole process by increasing process awareness based on the related work items. Thus, these approaches fail to meet requirement R3. Dynamically changing resources (R4) are typically not supported by traditional workflow management systems and their variants, e.g., case handling [18].

Involvement of humans in business processes is an intensively researched topic. Caramba [27] has aimed to provide a process-aware collaboration platform, which links together the organizational aspects, processes, and data. Moreover, Caramba enables initiating ad-hoc processes, which are initialized with empty process models. Both ad-hoc and predefined processes in Caramba require modeling of activities before their enactments. As a result, the corresponding business logic is defined before their executions at a finer level of abstraction and the approach fails to meet requirement R1. The concepts introduced by Caramba provide definitions based on a limited set of resources, i.e., persons, roles, groups, skills, units, organization, tasks, documents, processes, workcases and database tables. As a result, one cannot represent, for example, the custom Linux distribution from the motivating scenario. Caramba's resource types are related by either default relationships or relationships with named identifiers. As a consequence, requirement R2 is satisfied. Caramba's "Object Center" enables project team members to view relationships between activities, artifacts, documents and organizational constructs [27]. This activity-oriented visibility with limited resources satisfies requirement R3 only partially. Human performers of an activity can be changed after its initialization. However, changing other resources of an informal process dynamically (R4) is not directly addressed by the approach. New resources can be associated only indirectly by defining new tasks with new resources and by instantiating the created tasks.

To integrate activities executed by people in BPEL processes, a BPEL extension called BPEL4People [28] has been proposed. Human tasks (activities) in these processes are described using the WS-HumanTask specification [29]. These tasks are created before their enactments during process modeling or execution. Thus, the business logic needs to be modeled beforehand and requirement R1 is violated. The WS-HumanTask specification defines performers, ad-hoc attachments, and comments. The ad-hoc attachments are used to associate arbitrary task data. These attachments describe how the attached data is accessed, which is similar to the concept of making the data ready as in R1. The specification mentions notion of supporting applications for human tasks. However, how they are associated with the

tasks, is not detailed. One can define people assignments using expressions, in which interrelated performers can be described. As there is no generic, rather limited, relation concept, this approach meets R2 only partially. Each task is associated with a set of performers, ad-hoc attachments, and comments. As a result, visibility is at the level of activities, not at the level of process. Due to addressing resource relations only partially, the visibility of relevant resources is also only partially addressed. Consequently, the approach fulfills R3 only partially. Performers can be changed after they are initialized by creating ad-hoc composite tasks or delegating the corresponding task. Moreover, the ad-hoc attachments or comments can be added and removed dynamically. As a result, the approach meets requirement R4.

To provide more flexibility to the process models, a declarative approach is proposed by van Groundelle and Gülpers by exploiting pre and post conditions of activities [30]. One describes a process using a set of activities which are connected using pre and post conditions. As we need to specify the activities, i.e., business logic, before their enactment, this approach fails to meet R1. Pre and post conditions can be artifacts, data objects, decisions, people involved in processes, and time limits. Moreover, pre and post conditions are used to describe the associated resources in a process. As there are no relationships between resources, the approach does not satisfy R2. The limited set of resources constrains the visibility of the relevant resources in a process representation. Consequently, R3 is only partially satisfied. R4 is not met by this approach because changing the pre and post conditions (resources) dynamically is not addressed by the approach.

As opposed to activity-oriented business modeling approaches, the concept of decision-oriented approach has been proposed by Nurcan [16]. Decision-oriented business process modeling starts with describing goals (intentions) of an organization. After defining generic goals, the goals are refined based on sub-goals or based on operational terms, e.g., an activity-based process model. As a result, the business definitions created by the approach do not contain the activities or their structure, i.e., business logic. However, as it does not enable executable representations, i.e., it does not provide means to represent informal process resources and a description how to provide these resources, it satisfies requirement R1 only partially. Nurcan [16] proposes a linguistic approach to formulate an intention: An intention starts with a verb followed by an entity affected by the intention, e.g., satisfy (verb) customer request (entity). However, such an approach is not sufficient to describe resources and their relationships comprehensively. Consequently, this approach fails to meet R2, R3, and R4.

BPM4People [31]–[34] is an effort to socialize business process management. They aim for exploitation of weak ties and implicit knowledge, transparency, participation, activity and decision distribution, social feedback, and knowledge sharing. They provide extensions for BPMN to reach these objectives. As the approach is bound to a predefined process definition, it violates R1. Seeing that the introduced concepts do not involve new concepts for modeling of relationships between resources, it meets R2 only partially similar to the conventional workflows. The social publication pattern defined in Brambilla et al. [33] adds a context information to artifacts of a process. This provides the visibility for the socially published artifacts. The requirement R3 is not satisfied because such an approach ignores all other resources that participate in an informal process and their visibility. New people can contribute to social tasks. However, these new contributors are not defined in models and adding new definitions or removing old ones is not addressed by this approach. Consequently, it fails to meet R4.

For modeling of collaborative processes, Papageorgiou et al. [35] have proposed a pattern-based approach. Pattern-based modeling of collaborations requires defining certain patterns of activities beforehand, which is similar to business process modeling regarding the requirements. Moreover, the patterns are represented using BPMN [35]. Consequently, by requiring the explicit modeling of business logic, the approach does not satisfy requirement R1. Collaboration patterns involve roles which can observe the associated data with a collaboration pattern, i.e., input / output documents and data. However, roles are not interrelated to other roles and there are no additional explicit relationship structures. As a result, requirement R2 is only partially satisfied similar to traditional workflows. Due to having a limited set of resource representations, requirement R3 is only partially satisfied. The approach does not address dynamically changing resources (R4).

Another approach is defining the collaborative processes based on context-aware state transitions where each state has a corresponding context and in each context there are interrelated collaboration artifacts [23]. These models are information-centric because state transitions are based on the states of collaboration artifacts, i.e., information. As a predefined information-centric business logic is assumed, the approach fails to meet requirement R1. Each state is associated with a collaboration context, and each collaboration context contains collaboration artifacts and their relations with their neighborhoods, e.g., other relevant artifacts or performers. There are predefined and dynamic relations among the resources, i.e., collaboration artifacts. By using the relations, temporal and structural relationships can be defined. Consequently, requirement R2 is satisfied. As the resource concept introduced by this approach focuses only on the collaboration artifacts and their neighborhoods, e.g., the performers, R3 is partially satisfied, Depending on the relationships of the resources, dynamic resource assignments are possible. However, requirement R4 addresses adding and removing resources dynamically, not assigning them. Thus, this approach fails to meet R4.

To avoid predefined process business logic, activity-centric computing (ACC) has been proposed [4], [24], [36], [37]. The approach is centered around a shared concept of an activity (Moran [24] uses the metaphor of “shared checklists”), which evolves based on the actual activity. ACC provides means of associating a predetermined list of resources, i.e., the type of resources that can be associated are fixed, to activities without predefining the set of activities to be executed. As the approach does not address creation of executable models, i.e., making the resources ready for the execution, it meets R1 partially. An activity can have certain actors, tools, artifacts, descriptions, states, models, and may contain other activities [24]. These provided concepts are not related to each other. Thus, R2 is violated. As the approach provides only a limited set of resources, the visibility is also limited. Moreover, the missing resource relations avoids the visibility of relevant resources. As a result, it satisfies R3 only partially. The approach meets R4, as one can associate activity resources and remove old ones during

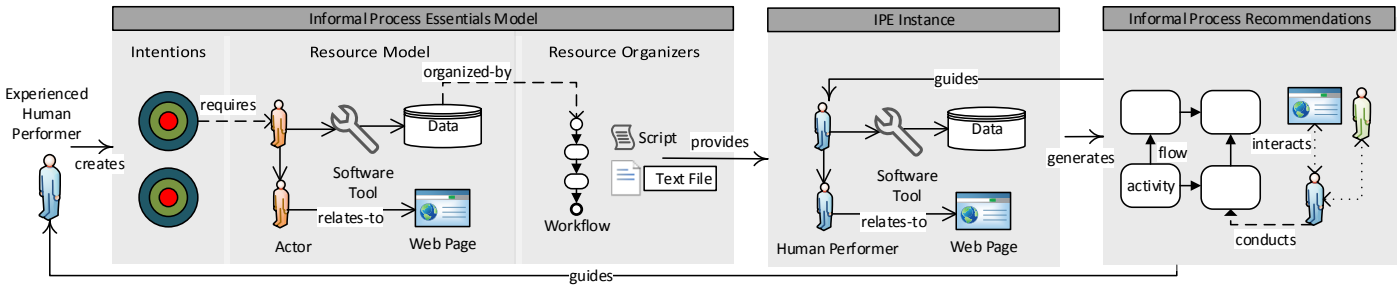

Figure 1. Overview of the Informal Process Support Model

activity enactment. The Adaptive Case Management (ACM) [38], [39] concepts follow a similar approach to activity-centric computing. Cases in the ACM, analogous to activities in the ACC, can be started without predefining any business logic. During enactment, business logic of a case evolves reactively. The ACM presents the same results regarding our requirements.

Most of the approaches focus on the business logic of business processes and neglect the underlying interactions with other resources, e.g., software tools. To overcome such problems, ArchiMate [40] provides an integrated modeling approach. Using ArchiMate, one can describe processes based on both activities, i.e., business processes, and based on competencies, knowledge, and resources, i.e., business functions. Business functions can be used to describe processes without predefining their business logic. As the created models are not executable, this approach partially satisfies requirement R1. The approach provides three levels of modeling, i.e., business, application, and technology, with refinements. At the business level one can describe the business actors, e.g., human resources, and in the next level the related resources that are used during the process enactment. As resources are related using custom and predefined relationships, R2 is satisfied. Because of providing both visibility of the whole process and relevant resources, the approach satisfies R3. The changing resources is not addressed by this approach as the runtime details are not described. Thus, requirement R4 is not addressed.

The result of this review is that the currently available approaches do not meet all the requirements derived in Section IV-B. Therefore, we present in this paper an approach that enables modeling Informal Process Essentials, which fulfills all the requirements. We first present an overview of our abstract framework we developed in Sungur et al. [7] and present the new meta-model in Section VII. In Section IX, we evaluate the presented approach compared to the existing approaches to show the enabled advantages.

VI. Informal Process Support Model

In Sungur et al. [7], an overview of generic requirements for supporting informal processes was given and a proper explanation has been left as future work. To satisfy these requirements, the concepts of *Informal Process Support Model* (*IPSM*), *Informal Process Essentials* (*IPE*), and *Informal Process Recommendations* (*IPR*) have been introduced. In this work, we have detailed a resource-oriented subset of all requirements for supporting informal processes. Additionally, to satisfy these requirements and to provide building blocks

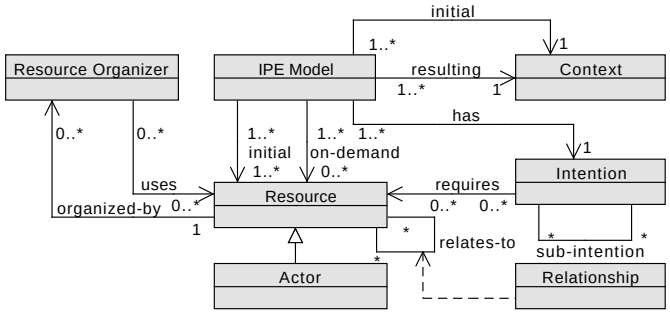

Figure 2. Conceptual Informal Process Essentials Meta-model

of modeling informal processes, we detail the concept of IPE, which was only abstractly defined previously.

The concepts of IPSM are introduced to make use of existing knowledge of human performers. As illustrated by Fig. 1, the initial creators of these models are experienced human performers. Based on their experience, they add the relevant resources of an informal process, e.g., human performers, collaboration services, etc.. Each of these resources is managed, e.g., listing the resources, acquiring the resources for use or releasing the resources after use, by a resource organizer. After initialization of informal processes using resource organizers, provisioned social computing units, i.e., socially networked humans with computing power, enact instances of the informal process based on their experience. The recurring activities generated by human performers in informal processes create the IPR models. IPSM is an evolutionary model, i.e., each enactment of an informal process provides a feedback loop for the next execution using an IPR model. Thus, after each enactment the model converges to the real world representation of an informal process automatically. The IPR models are generated at runtime based on the interactions and activities of the corresponding human performers.

VII. Informal Process Essentials

The conceptual meta-model of IPE is depicted in Fig. 2. IPE models describe a set of interrelated resources which work together to achieve a collective goal. The concept of IPE provides an agent-based approach [15], i.e., human performers are considered as agents who execute the processes autonomously. Moreover, by defining our business models based on goals, we provide an goal-oriented approach [16]. IPE

models are created by experienced human performers and, thus, reflect already the existing knowledge of the respective creators, i.e., they already represent the possible best practices.

As indicated in the fundamentals section (Section III), both processes and collaborations aim for achievement of goals. Similarly, an informal process targets for accomplishment of a goal. The goals can be referred as intentions and each informal process can be associated with an *IPE Intention*. IPE Intentions can be associated with IPE Resources, which are typically needed and used to achieve the corresponding intentions. IPE Intentions can be refined by defining sub-intentions, which can be defined recursively as independent informal processes. An IPE Intention in the motivating scenario (Section II) is to satisfy the maintenance request. An example sub-intention is to complete the corresponding maintenance request without producing any new bugs, for which an automated quality assessment test has to be run. The IPE models are also used to define execution constraints of informal processes, e.g., all quality assessment tests must be passed to satisfy a maintenance request. This intention-based approach enables describing processes declaratively, i.e., without describing *how* the intention is achieved, and providing only information about *what* has to be achieved. Thus, we can avoid predefined business logic in the representations of informal processes.

Each informal process starts from an initial context, i.e., *IPE Context* and aims to achieve a goal, i.e., an IPE Intention. After reaching a goal, there is a resulting IPE Context. In the motivating scenario, the existence of a maintenance request is the problem IPE Context and the resulting IPE Context is the resolved maintenance request. The resulting IPE Context is reached when the goal is reached. The initial and resulting IPE Contexts can be used to link IPE models.

The concept of IPE contains *IPE Resources* which are used to carry out the corresponding informal process. The IPE Resources contained in an IPE Model can be categorized into two classes: (i) the initial IPE Resources, i.e., the resources acquired at the initialization of the process, and (ii) the on-demand IPE Resources, i.e., the resources acquired / accessed during the process execution. Initial IPE Resources are the resources which have been foreseen needed at the beginning of an informal process, e.g., performers who carry out an informal process. To initialize informal processes, the initial IPE Resources need to be made ready for the process enactment. Thereafter, other associated resources can be used on-demand anytime during enactment. Each IPE Resource can be related to another IPE Resource in the context of an informal process using predefined or custom *IPE Relationship*s. Example of IPE Resources could be an online documentation or a human performer. How they are defined is out of scope of this work and there are various definitions of different resources in different domains. The IPE Resource concept does not only refer to the data required to start a process or an output data of a process but also all the resources that impact the outcome of an informal process, e.g., task management services, the custom JDK, and the wiki documentation of the presented motivating scenario (Section II). The concept of IPE Resource contains IT resources (which) and organizational resources (who) used in an informal process but the concept is not limited to them, i.e., one can also describe material resources. A more specific type of resource is the type *IPE Actor*, which typically refers to human performers who autonomously and collaboratively conclude an informal process using other available IPE Resources. However, the concept of IPE Actor is not limited to human performers and in certain settings one can represent, for instance, a workflow engine as an actor next to other human performers. Each resource can have an associated *IPE Resource Organizer* because the focus is making the resources ready for enactment, which involves not only the description of *what* resources we need, but also *how* these resources are managed, e.g., the means of listing, acquiring, releasing the associated resources for process modeling and enactment. IPE Resource Organizers can be simple textual descriptions, e.g., the expert recruitment description contained in a text file, a URI, e.g., a link to an online document in the project wiki, or could be more complex workflows, e.g., the workflow to make the test data ready in the motivating scenario. IPE Resource Organizers can also use another resource to manage its associated resources, e.g., the client for version control service in the motivating scenario is used to manage another resource. An IPE Resource without an IPE Resource Organizer represents only an abstract resource, i.e., a resource which is not directly managed. IPE Resource Organizers enable modeling executable informal processes, i.e., we can use IPE Resource Organizers to bring together the relevant interrelated resources, which will work to achieve the corresponding goals. Additionally, the concept of IPE Resource Organizers adds a layer of abstraction on top of domain specific resources, e.g., material, IT, or human resources, which enables a unified way of organization of these resources.

We claim that this approach is the right one because by using the IPE meta-model, informal processes are modeled in an as-is fashion, i.e., the focus is not on business logic as it is not defined previously, rather the focus is on the other dimensions, e.g., resources. The non-existence of business logic results in a *resources-centric* approach and facilitates more autonomy for human performers and enables establishment of best practices.

VIII. Case Study on Informal Process Essentials

In this section, we present a case study of the IPE concept using existing Cloud Computing and Social Network technologies. By exploiting the on-demand self-service property of Cloud Computing [41], we can provision IT resources of IPE models on-demand in a Cloud infrastructure. Due to popularity of Cloud Computing, there was a need of standardization and an open standard, The Topology and Orchestration Specification for Cloud Applications (TOSCA) [42], has been proposed. TOSCA can be used to model the structure of an application, i.e., all nodes and the relations among them. TOSCA nodes and relationships can be considered as equivalent of IPE Resources and Relationships in the domain of Cloud Computing. Moreover, in TOSCA, nodes can be associated with management plans which can be used by their respective IPE Resource Organizers to manage associated resources. Additionally, as the TOSCA specification allows any kind of extension in TOSCA models, the models can be extended to overcome unanticipated problems. TOSCA models can be managed using the open source modeling tool Winery [43] and can be deployed on the open source runtime environment for TOSCA-based applications OpenTOSCA [44]. The humans and their relationships in social networks can be considered as IPE Resources and Relationships. OpenSocial [45] is a standardization effort to provide a unified way of

operating with different social networks. To access available human resources, we are using an OpenSocial compliant back-end. The methods for finding matching human resources with certain relationships defined in an IPE model, i.e., sub-graphs in social graphs, is out of scope of this work and further information can be found in Skopik et al. [46].

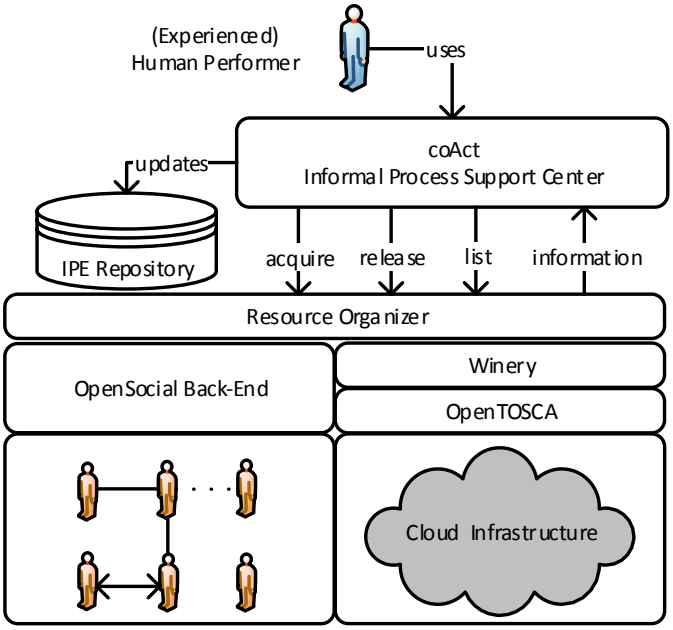

Figure 3. Architecture of the case study

The architecture of our case study is depicted in Fig. 3. We are currently developing an *Informal Process Support Center (coAct)* to enable intuitive management of IPE models. The Resource Organizer layer uses Winery to fetch available resources and OpenTOSCA to initialize these resources in the corresponding Cloud infrastructure. Desired human resources are found by using an OpenSocial complaint back-end. To automate the management of the human resources, we are defining a standard deployment plan for them: Human performers are communicated via the messaging API of OpenSocial. If they accept the participation in the corresponding informal process, they are considered as being deployed. One can define custom deployment plans for human nodes based on recruitment strategies of the corresponding organization. After deploying human performers, the software services used are configured accordingly. These configurations are described by relationships of the human nodes to the corresponding software nodes. Dynamic addition and removal of resources is an important aspect as described in R4. In general, changing resources may result in a re-initialization of the partial or the whole application topology, which is also aimed to be supported by our prototype.

The case study can be as well applied in the context of our motivating scenario: The IT resources of our case study are provisioned on demand and reside in a Cloud Computing infrastructure. These resources are described in TOSCA models which are stored in Winery and deployed in a OpenTOSCA container. CoAct fetches the available IT resources and human resources using Winery and the OpenSocial complaint back-end respectively. All resources are listed during creation of the IPE model for the corresponding maintenance process. During modeling, first a relevant context, e.g., "After product release" in case of product maintenance process, is selected or created. Hereafter, an IPE model is created by adding required IPE Resources, e.g., three human resources, custom JDK and Linux distribution, etc., and their corresponding IPE Relationships, e.g., is-a-friend-of, requires, etc. By using IPE Intentions, the goal and the constraints of the informal process is defined. On the receipt of an maintenance request, the IPE model is initialized by provisioning all initial IPE Resources. After accomplishment of the corresponding IPE Intentions, the human performers stop the instance of corresponding IPE model and Resource Organizer releases the previously acquired resources.

The case study can be extended by implementing necessary adapters to make use of an existing organizational database or a human-provided services registry, i.e., services provided by humans and profiles of the organizers are stored in this registry [47], [48]. The case study illustrates an integration point of the paradigms Cloud Computing and Crowdsourcing. Virtualization of IT resources enables the Cloud Computing paradigm and virtualization of human resources is a researched topic. Dustdar and Truong [14] have proposed a computing model for a unified way of virtualizing human and IT resources. Our case study provides a complementary approach as it provides the means to model human and IT resources in a unified way, i.e., in the same model, and their corresponding deployment plans.

IX. Evaluation

In this section, we evaluate the proposed concept of IPE and compare it with the literature review we conducted in Section V based on the presented requirements. A comparison of IPE with existing approaches is depicted in Table I. During the following evaluation, we summarize BPM4People [31], [33], collaboration patterns [35], adaptive workflows [13], [26], and BPEL4People [28] under the category of traditional business process modeling (activity-oriented approaches), as they do not present any differences regarding the requirements.

By modeling our business processes based on the resources and agents which work towards certain intentions, informal processes are modeled without predefining their business logic. By adding the resource organizers, we enable modeling executable models. Consequently, our approach meets requirement (R1). In contrast, activity-oriented approaches, pre and post condition-based process models, concepts introduced in Caramba [49], the information-centric modeling framework proposed by Liptchinsky et al. [23], and WS-HumanTask [29] fail to satisfy R1 because they are executed based on previously defined business logic. Decision-oriented approach [16], activity-centric [24], adaptive case management [38], and ArchiMate [40] enable defining models without describing the business logic but they do not provide means of creation of executable models. Thus, they meet the R1 only partially.

The IPE meta-model provides a generic means to model resources and their relations in the context of an informal process. Custom relationships can be created based on the domain of interest. Moreover, the same resources can have different relationships in different informal processes. Consequently, the concepts meet requirement R2. Similarly, ArchiMate [40] satisfies R2, as it provides a set of predefined relationships

Table I. EVALUATION OF THE APPROACH

Approach	Executable Informal Process Representation (R1)	Resource Relations (R2)	Resource Visibility (R3)	Changing Resources (R4)
Informal Process Essential	+ Resources are provided not just defined + Goal-oriented	+ Any type of relation	+ Any kind of resources	+ Addressed
Activity-Oriented	- No means of providing resources - Activity-oriented	~ Interrelated Performers	~ Performers	- Not addressed
Caramba	- No means of providing resources - Activity-oriented	+ Interrelated Caramba Objects	~ Visibility of Caramba Objects for activities	~ Indirectly
WS-HumanTask	~ Ad-hoc Attachments - Activity-oriented	~ Interrelated Performers	~ Performers, Ad-hoc Attachments, Comments	+ Addressed
Pre and Post Condition Based Modeling	- No means of providing resources - Activity-oriented	- Not addressed	~ Resources as pre and post conditions	- Not addressed
Strategy-Driven	- No means of providing resources + Goal-oriented	- Not addressed	- Verbally described resources	- Not addressed
Information-Centric	- No means of providing resources - Prescribed execution states	+ Predefined or Dynamic	~ Collaboration artifacts and their neighborhood	- Not addressed
Activity-Centric *Adaptive Case Management*	- No means of providing resources + From goal-oriented to activity-oriented	- Not addressed	~ Limited resources	+ Addressed
ArchiMate	- No means of providing resources ~ Process / Function-oriented	+ Any type of relation	+ Any kind of resources	- Not addressed

and allows definitions of new relationships. By providing default relationships and relationships which are modeled with named identifiers, Caramba satisfies R2 [49]. The information-centric approach proposed by Liptchinsky et al. [23] provides predefined and dynamic relationships. Thus, it meets R2. In contrast, activity-oriented paradigms and WS-HumanTask [28] consider only relationships among the performers of an activity. Thus, R2 is only partially satisfied. Activity-centric [24], adaptive case management [38], decision-oriented [16], and pre and post condition-based [30] approaches do not consider resource relations. Thus, they fail to satisfy requirement R2.

The concepts of IPE enable defining new resource to reflect various participating resources of informal processes comprehensively. Each of the relevant resources of an informal process can be made visible in the IPE models and can be associated with intentions. These resources can be used to provide other resources which are visible in the IPE models. As the resources are provided with their relationships in an informal process, for each resource all the related resources are visible too. Thus, the concept of IPE meets the requirement R3. Similarly, ArchiMate [40] satisfies R3. Pre and post condition-based modeling [30], activity-centric computing [24], adaptive case management [38], Caramba [49], WS-HumanTask [28], and the information-centric approach [23] satisfy R3 partially. Activity-oriented and decision-oriented [16] approaches do not address the visibility issue.

One can change the set of resources (R4) in an IPE model during modeling or enactment of an informal process. As a result of certain relationships, e.g., dependencies, between resources, removal or addition of resources can affect the other resources naturally. For example, whenever a new expert is added in the motivating scenario (Section II), the collaborative resources need to be configured for the access by the new expert correspondingly, i.e., new permissions need to be granted for the new expert. Activity-centric [24], adaptive case management [38], and WS-HumanTask [28] satisfy R4 and Caramba [49] satisfies it partially. Other approaches do not address R4.

The presented concepts provide a *resource-centric* approach by focusing on the organization and IT resources dimensions of business processes. Consequently, the concepts provide the basic building blocks of informal processes which can be complemented with existing approaches which focus on the other requirements of informal processes, e.g., behavioral requirements [50]. IPE models will result in more effective collaborations because (i) one can define coherent teams by using social relationships and (ii) the collaborative software (groupware) [51] can be defined. This evaluation shows, that the analyzed requirements in Section IV-B are met completely only by the concept of IPE. Due to the complementary nature of our approach, IPE models can be combined with other approaches to benefit from strengths of multiple concepts.

X. CONCLUSION AND OUTLOOK

In this paper, we have analyzed properties of informal processes and derived requirements for supporting them. We have conducted a literature review and evaluated related work based on the derived requirements. To create executable informal process presentations with dynamically changing interrelated resources, we have presented the concept of Informal Process Essentials. Moreover, we have described a case study of the concepts of Informal Process Essentials by exploiting existing Cloud Computing and Social Networking technologies.

As the case study addresses human and IT resources, inclusion of other type resources, e.g., material resources, will be examined in the future work. Moreover, in the future work, we will investigate how the concept of Informal Process Essentials can be combined with the existing approaches, e.g., other approaches which focus on the behavioral aspects.

ACKNOWLEDGEMENT

This work is supported by Graduate School of Excellence advanced Manufacturing Engineering (GSaME)[1] and partially funded by the BMWi project CloudCycle (01MD11023).

[1] http://www.gsame.uni-stuttgart.de/

REFERENCES

[1] *Web Services Business Process Execution Language Version 2.0*, OASIS Std., 2007.

[2] Object Management Group, "Business process model and notation version (BPMN) version 2.0 specification," Object Management Group (OMG), Tech. Rep., 2011.

[3] B. Silver, *BPMN Method and Style, 2nd Edition, with BPMN Implementer's Guide: A Structured Approach for Business Process Modeling and Implementation Using BPMN 2.0*. Cody-Cassidy Press, 2011.

[4] P. Moody, D. Gruen, M. Muller, J. Tang, and T. Moran, "Business activity patterns: A new model for collaborative business applications," *IBM Systems Journal*, vol. 45, pp. 683–694, 2006.

[5] F. Leymann and D. Roller, *Production Work Flow: Concepts and Techniques*. Prentice Hall PTR, 2000.

[6] S. Nurcan, "A survey on the flexibility requirements related to business processes and modeling artifacts," in *HICSS–41*, 2008.

[7] C. T. Sungur, O. Kopp, and F. Leymann, "Supporting Informal Processes," in *ZEUS 2014*, 2014.

[8] I. Nonaka, "A dynamic theory of organizational knowledge creation," *Organization science*, vol. 5, no. 1, pp. 14–37, 1994.

[9] S. Dustdar and K. Bhattacharya, "The social compute unit," *Internet Computing, IEEE*, vol. 15, no. 3, pp. 64–69, 2011.

[10] F. Leymann, "Linked compute units and linked experiments: Using topology and orchestration technology for flexible support of scientific applications," in *Software Service and Application Engineering*. Springer-Verlag, 2012.

[11] W. van der Aalst, M. Weske, and D. Grünbauer, "Case handling: a new paradigm for business process support," *DKE*, vol. 53, no. 2, pp. 129–162, 2005.

[12] W. van der Aalst, M. Pesic, and H. Schonenberg, "Declarative workflows: Balancing between flexibility and support," *CSDR*, vol. 23, no. 2, pp. 99–113, 2009.

[13] P. Dadam and M. Reichert, "The ADEPT Project: A Decade of Research and Development for Robust and Flexible Process Support - Challenges and Achievements," *CSRD*, vol. 23, pp. 81–97, 2009.

[14] S. Dustdar and H. L. Truong, "Virtualizing Software and Humans for Elastic Processes in Multiple Clouds- a Service Management Perspective," *IJNGC*, vol. 3, pp. 109–126, 2012.

[15] S. Meyer, H. Simon, and M. Tilebein, "Applying agent-based modeling to integrate bounded rationality in organizational management research," in *HICSS'09*, 2009.

[16] S. Nurcan, A. Etien, R. Kaabi, I. Zoukar, and C. Rolland, "A strategy driven business process modelling approach," *BPMJ*, vol. 11, pp. 628–649, 2005.

[17] T. Matthews, S. Whittaker, T. Moran, and S. Yuen, "Collaboration personas: a new approach to designing workplace collaboration tools," in *SIGCHI*, 2011.

[18] N. Russell, A. H. Ter Hofstede, D. Edmond, and W. M. van der Aalst, *Workflow resource patterns*. Beta, Research School for Operations Management and Logistics, 2005.

[19] E. Westkämper, "Factory transformability: adapting the structures of manufacturing," in *Reconfigurable Manufacturing Systems and Transformable Factories*. Springer, 2006.

[20] B. DiCicco-Bloom and B. F. Crabtree, "The qualitative research interview," *Med. Educ.*, vol. 40, pp. 314–321, 2006.

[21] T. Matthews, S. Whittaker, T. P. Moran, S. Y. Helsley, and T. K. Judge, "Productive interrelationships between collaborative groups ease the challenges of dynamic and multi-teaming," *CSCW*, vol. 21, pp. 371–396, 2012.

[22] M. Weske, *Business Process Management: Concepts, Languages, Architectures*. Secaucus, NJ, USA: Springer New York, Inc., 2007.

[23] V. Liptchinsky, R. Khazankin, H.-L. Truong, and S. Dustdar, "A novel approach to modeling context-aware and social collaboration processes," in *CAiSE*. Springer Berlin Heidelberg, 2012.

[24] T. P. Moran, "Unified Activity Management: Explicitly Representing Activity in Work-Support Systems," in *ECSCW 2005*, 2005.

[25] W. van der Aalst, "The application of Petri nets to workflow management," *JCSC*, vol. 8, pp. 21–66, 1998.

[26] A. Marrella, A. Russo, and M. Mecella, "Planlets: Automatically recovering dynamic processes in yawl," in *On the Move to Meaningful Internet Systems: OTM 2012*. Springer Berlin Heidelberg, 2012.

[27] S. Dustdar, "Architecture and design of an internet-enabled integrated workflow and groupware system," *BPMJ*, vol. 11, pp. 275–290, 2005.

[28] *WS-BPEL Extension for People (BPEL4People) Specification Version 1.1*, OASIS Std.

[29] *Web Services Human Task (WS-HumanTask) Specification Version 1.1*, OASIS Std.

[30] J. C. van Grondelle and M. Gülpers, "Specifying flexible business processes using pre and post conditions," in *The Practice of Enterprise Modeling*. Springer, 2011.

[31] M. Brambilla, P. Fraternali, C. Vaca, and S. Butti, "Combining social web and BPM for improving enterprise performances: the BPM4People approach to social BPM," in *WWW 2012*, 2012.

[32] M. Brambilla, P. Fraternali, and C. Vaca, "BPMN and Design Patterns for Engineering Social BPM Solutions," in *BPM 2011*, 2012.

[33] ——, "A Notation for Supporting Social Business Process Modeling," in *BPMN*, 2011.

[34] P. Fraternali, M. Brambilla, and C. Vaca, "A Model-driven Approach to Social BPM Applications," *Social BPM*, 2011.

[35] N. Papageorgiou, Y. Verginadis, D. Apostolou, and G. Mentzas, "Event-driven adaptive collaboration using semantically-enriched patterns," *Expert Systems with Applications*, vol. 38, pp. 15 409–15 424, 2011.

[36] T. P. Moran, A. Cozzi, and S. P. Farrell, "Unified Activity Management: Supporting People in E-business," *Commun. ACM*, 2005.

[37] S. Yarosh, T. Matthews, T. Moran, and B. Smith, "What Is an Activity? Appropriating an Activity-Centric System," in *INTERACT 2009*. Springer Berlin Heidelberg, 2009.

[38] C. Herrmann and M. Kurz, "Adaptive Case Management: Supporting Knowledge Intensive Processes with IT Systems," in *S-BPM ONE - Learning by Doing - Doing by Learning*. Springer Berlin Heidelberg, 2011.

[39] H. Motahari-Nezhad, S. Spence, C. Bartolini, S. Graupner, C. Bess, M. Hickey, P. Joshi, R. Mirizzi, K. Ozonat, and M. Rahmouni, "Casebook: A Cloud-Based System of Engagement for Case Management," *Internet Comput., IEEE*, vol. 17, pp. 30–38, 2013.

[40] T. O. Group, *ArchiMate 2. 0 Specification*, The Open Group Std., 2012.

[41] P. Mell and T. Grance, "The NIST definition of cloud computing (draft)," *NIST special publication*, vol. 800, p. 7, 2011.

[42] T. Binz, U. Breitenbücher, O. Kopp, and F. Leymann, "TOSCA: Portable Automated Deployment and Management of Cloud Applications," in *Advanced Web Services*. Springer New York, 2014.

[43] O. Kopp, T. Binz, U. Breitenbücher, and F. Leymann, "Winery – Modeling Tool for TOSCA-based Cloud Applications," in *ICSOC'13*, 2013.

[44] T. Binz, U. Breitenbücher, F. Haupt, O. Kopp, F. Leymann, A. Nowak, and S. Wagner, "OpenTOSCA - A Runtime for TOSCA-based Cloud Applications," in *ICSOC'13*, 2013, Demonstration.

[45] M. Häsel, "OpenSocial: An Enabler for Social Applications on the Web," *Commun. ACM*, 2011.

[46] F. Skopik, D. Schall, and S. Dustdar, "Discovering and managing social compositions in collaborative enterprise crowdsourcing systems," *IJCIS*, vol. 21, pp. 297–341, 2012.

[47] D. Schall, H.-L. Truong, and S. Dustdar, "Unifying Human and Software Services in Web-Scale Collaborations," *Internet Comput., IEEE*, vol. 12, pp. 62–68, 2008.

[48] D. Schall, H. Truong, and S. Dustdar, "The Human-Provided Services Framework," in *EEE '08*, 2008.

[49] S. Dustdar, "Carambaa process-aware collaboration system supporting ad hoc and collaborative processes in virtual teams," *Distributed and Parallel Databases*, vol. 15, pp. 45–66, 2004.

[50] K. Swenson and J. Farris, "Human-centered business process management," *Fujitsu scientific and technical journal*, vol. 45, pp. 160–170, 2009.

[51] C. A. Ellis, S. J. Gibbs, and G. Rein, "Groupware: Some issues and experiences," *Commun. ACM*, vol. 34, pp. 39–58, 1991.

All links were followed on June 10, 2014.