# Research Challenges on Person-centric Flows*

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**Abstract** Research in the domain of Workflow Management focuses increasingly on service orchestrations. Often the fact is neglected that a huge part of the activities of business processes are performed by people. Especially, in the domain of pervasive computing processes are describing sequences of real world activities which are invariably performed by people. Therefore we consider the role of people participating in workflows from a new perspective. The basic idea of this work is to transfer the workflow metaphor to people processing their tasks. Therefore, we introduce the concept of a person-centric flow, which denotes such an implicit flow scheduled and executed by a single person. Secondly, we provide a list on research challenges on person-centric flows.

## 1 Introduction

Most research in business process management focuses on the aspects of service orchestration. The fact, that in certain types of businesses a business process consists of many manual activities, has not been recognized as a major research item, yet. Manual activities are carried out by people. We call those activities in the following tasks to differentiate them from the other types of activities, such as an invoke activity that requests the execution of a Web Service. For example, pervasive computing processes are typically describing sequences of activities which are performed by people. People are involved in many business processes at the same time, which requires appropriate support from the underlying IT infrastructure to help organize the work they need to carry out. Among many other functions such a infrastructure requires capabilities for work prioritization, context-sensitive assistance, or the capability of structuring a task by dividing the task into smaller tasks and ordering them as required by the user. Several specifications such as [1] and WS-Humantask [2] have been developed to address the integration of people into the world of services. We claim that those specifications only partially provide the required support and that additional capabilities must be provided by workflow management system to better integrate people in the execution of business processes.

* This work is partially funded by the ALLOW project. ALLOW (http://www.allow-project.eu/) is part of the EU 7th Framework Programme (contract no. FP7-213339).

Since the cognitive capabilities of people do not allow to carry out many tasks in parallel, people order the different tasks in a way that is convenient for them to process the different tasks. Current state of the art in workflow management typically provide the notion of work lists (cf. [3]), which the user can sort in any desired way using the properties that are associated with each task. Incidentally [4] shows that the efficiency of users highly depends on the capability for individual ordering of the work list. A disadvantage of larger work lists is the increased probability of missing the schedule for a task.

Studies have shown that people not only use the basic ordering of the work lists to select the next set of tasks, but also use some correlations or similar context information between the different tasks to select them [4]. This is similar to traditional workflow paradigm where the execution of the different activities is driven through the context that is associated with a process instance. We propose in this paper to order the individual tasks via process templates that are dynamically generated from the available tasks via the user preferences and automatically instantiated.

We introduce the concept of a person-centric flow, which denotes such an implicit flow scheduled and executed by a single person. Basically, a person-centric flow consists of the tasks on a person's worklist extended by additional ordering information. However, the knowledge about the existence of such a implicit person-centric flow cannot be utilized. Thus, making the person-centric flow explicitly visible and observable opens great opportunities to support people in doing their work. For example recommendations on the task ordering can be made which helps people e.g. to save resources or time. The goal of this work is to list research challenges on person-centric flows, their modeling, and execution. The aim of person-centric flows is not to prescribe people an ordering for performing their tasks. In fact, we want to support people e.g. by calling their attention to possible errors or to the fact, that the chosen ordering is prohibited. Another advantage of person-centric flows is the possibility to adapt the environment to needs of a future task. This is particularly useful in the case of actions that need time consuming preparation (cf. [5]) For example the filling of the bathtub can be started in time, as soon as it is known when a nurse will start washing a patient. For simplification reasons this work assumes that all tasks are generated by a Workflow Management System (WfMS).

The outline of this paper is as follows: Section 2 presents a scenario which is used to explain some issues of person-centric flows. A brief definition of person-centric flows is presented in Section 3. Section 4 lists the research challenges concerning person-centric flows and related approaches. Finally, Section 5 concludes the paper.

## 2 Scenario

Our scenario is situated in the domain of Healthcare (cf. [6]). Figure 1 shows simplified versions of the workflows executed each morning for each patient. All steps of the two workflows have to be done by a nurse and all steps of the

medication flow has to be done by the same nurse. Imagine there are two patients Frank and Tobias situated in two different rooms and one nurse Hanna. Imagine the situation where Hanna has executed the *prepare medicine* and *fetch medicine* task for both patients. As a consequence, Hanna has four tasks to perform which all appear on her worklist. Her person-centric flow could be first to medicate and wash Frank and afterwards to medicate and wash Tobias. In another situation she may decide to medicate both patients before washing them. This can be considered as an adaptation of her flow.

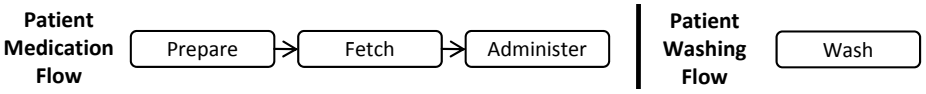


Figure 1: Secenario Flows

The scenario shows that a person-centric flow does not just follow a static flow model. It is highly dynamic due to context and changes of the worklist. Hanna implicitly forms her flow according to her actual situation. Her flow is not visible to the outside completely. Only the history of the flow is visible. Secondly, while executing a *prepare task* of an instance of the medication flow, by experience she schedules a fetch and a medication task even if these task are actually not on her worklist yet. By experience she knows that the a fetch medicine task is followed by a medication task. Hence, she considers the medication task right at the moment of scheduling her tasks, although only the fetch medication task is active.

## 3 Person-centric Flows

The aim of this section is to provide a first informal definition of the term and concept of person-centric flows. Later on the definition serves as foundation in order to identify research challenges. As mentioned before all tasks arise from flow instances executed by a WfMS which also provides a person's worklist. In the second part of this section we present the types of person-centric flows we identified during our research.

### 3.1 Definition

**Definition 1 (Person-centric flow).** *A person-centric flow defines a partial ordering over a set of tasks which have to be performed by one single person. Tasks of a person-centric flow can be classified in three tenses: past tasks, present tasks, and future tasks. Past tasks are completed either correct or incorrect and their ordering is known. Present tasks are tasks currently present at a person's worklist. Their ordering is planned by the person but can change dynamically. Future tasks are tasks which are assumed to be executed in the future. Both the set of future task as well as their ordering may change dynamically.*

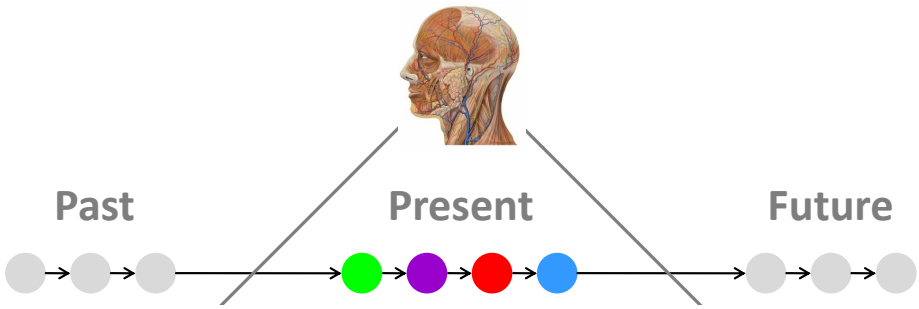


Figure 2: Person-centric Flow[1]

Figure 2 shows a simple graphical representation of a person-centric flow. Please note that present and future tasks can be mixed up within a person-centric flow. Only the actual executed task must be included in the set of present tasks. Since a person-centric flow is formed implicitly in a person's mind it must be predicted by the WfMS in order to utilize the ordering information. A person cannot be demanded to tell the WfMS its actual flow. Since tasks appear and disappear in a high frequency, this would be an additional stress factor. As a consequence predictions may be wrong. Furthermore, the person-centric flow paradigm is partly contrary to the existing workflow paradigm. For example a person-centric flow has no prescribed flow model since the set of tasks changes dynamically and consequently the ordering of the tasks. Many control patterns like loops are not needed in person-centric flows since each task is executed once. There also exists a single flow instance associated with exactly one person.

### 3.2 Classes of Person-centric Flows

During our research we recognized the following classes of person-centric flows:

**Predicted flow:** This is a predicted flow which corresponds to a person's flow with a high probability. Such flows are used for example to adapt the environment of a person. If washing a patient is supposed to be a nurse's next task the light in the shower could be switched on automatically. Regarding our scenario the knowledge of the nurse's flow helps to decide which patient will be washed first and consequently in which shower the light has to be switched on.

**Guidance flow:** A guidance flow is based on a predicted flow. However, a guidance flow may be extended by external ordering constraints. The aim of a guidance flow is to guide people actively through their flow. For example a constraint demands that a nurse must disinfect her hands between washing two patients. If she decides to perform both washing tasks without disinfecting her hands between, the constraint will be violated and the system will inform her.

[1] The figure uses an illustration by Patrick J. Lynch, medical illustrator and C. Carl Jaffe, MD, cardiologist.

**Enforcement flow:** An enforcement flow orders the tasks of a patient only based on external constraints. In this case the person-centric flow of a person is given by the environment. For example the fact that the medication must take place before washing can be enforced by an enforcement flow and the system can drive the person accordingly. A major disadvantage of this kind of person-centric flow is that it deprives people of the freedom to decide in which order they want to perform their tasks.

However, there is no clear distinction between the three classes of person-centric flows. A flow can comprise enforced as well as predicted as well as guided parts. Mostly, only a meaningful scenario-based combination of the three classes facilitates to reduce the cognitive load of a person necessary for scheduling task while retaining a high degree of freedom in scheduling tasks. Sometimes the characteristic of a person-centric flow may change over time. While a unexperienced nurse should be guided, with increasing experience the guidance should be reduced. As of that time the person-centric flow is only used for adapting the environment.

## 4 Research Challenges

In this section we present the identified research challenges on person-centric flows derived from the scenario analysis. The list is not exhaustive. Analyzing other scenarios may identify further issues.

**Relation between implicit and explicit flow:** As mentioned earlier a person-centric flow is implicit created by a person. In order to utilize the person-centric flow a explicit representation must be created. Like a hidden markov chain the observable behavior of the explicit flow may differ from the hidden implicit flow. Anyhow, the relation between these two flows must be described. The relation may be defined by describing the possible deviations of the predicted person-centric flow compared to the person-centric flow a person has in mind. Such an approach for modeling process variants is presented in [7]. Additionally, the predicted flow can be annotated with a maximum likelihood of its occurrence.

**Rethinking the notion of flow model and instance:** A person-centric flow has no predefined flow model. Since tasks emerge and disappear continuously, the person-centric flow has to be adapted very often. Thus, a language has to be defined that can deal with such a high degree of flexibility. Furthermore, the notion of an instance must be rethought. An instance of a common flow model has a defined beginning and a defined end. In contrast to traditional workflows a person-centric flow has no defined beginning and end. People are continuously performing tasks. Although there might be gaps in the flow where no tasks are performed.

**Imperative vs. declarative process modeling languages:** Basically, two types of workflow languages exist: imperative languages (cf. e.g. [3]) and declarative languages (cf. e.g. [8]). While imperative languages are assumed to be easier to understand, declarative languages promise a higher degree of flexibility. Furthermore, different orderings of the same set of tasks are hard to model

using imperative languages. In this work we use [9, 10] as starting points for our discussion on declarative and imperative workflow modeling languages, since the authors aim to contribute to a rigorous, theoretical discussion of this topic. Since high flexibility is a requirements for person-centric flows we decided to use a declarative language for the first attemp to describe person-centric flows (cf. [11]). The language is based upon the interval relations of Allen's interval algebra [12]. In contrast to existing declarative languages (cf. [8, 13, 14]) we extended the constraints of our language by time parameters to add support for temporal restrictions. To validate the consistency of the relation constraints we follow an approach similar to the one suggested in [15]. Also case handling [16] provides more flexibility in executing workflows. In case handling the control-flow related information does not drive the process but the state of the process, i.e. the existence of data objects. Since our approach focuses on the tasks themselves and not on the state of a data object, case-handling is inappropriate for modeling person-centric flows.

**Algorithms for prediction:** Since we are not able to capture the person-centric flow a person has in mind, we need to find algorithms to determine the task orderings. Especially history based algorithms are promising since people often have behavior patterns which can be detected by history-based algorithms. But also algorithms operating e.g. on task deadlines without considering the history (e.g. scheduling algorithms) seem to be useful in certain scenarios. There are many approaches which can be used as a starting point. In [17] the authors present an approach, which can be used for predicting a person's next steps based on the flow history. The recommendation in this approach is made for a single process instance and doesn't consider the interleaving of different process instances. In [18] scheduling algorithms are used to order worklists. Such an approach is suitable, if the person-centric flow should be enforced. [19] provides an approach which can be used for mining behavior patterns of people. Algorithms for predicting a person's next location are presented in [20]. The latter two approaches can be used, if there are recurring behavior patterns. However, they have to be adapted in order to operate on workflow histories.

**Granularity of tasks:** Tasks in business process are often modeled on a higher level than they will be actually executed by the people. Hence, people divide tasks in a set of subtasks. For example the washing of a patient is divided in several sub-tasks by a nurse. Algorithms for predicting person-centric flows also have to consider the fact that people re-structure their tasks. In [21] a case study is presented showing how people re-structure tasks.

**Parallelism of human actions:** It has to be discussed whether it is reasonable to allow parallelism in person-centric flows. Hence, granularity implies that if task are divided in sub-tasks which might be executed interleaving with subtasks of other tasks urge for parallelism capabilities.

**Visualization:** If person-centric flows are made explicit they should also be visualized in order to present them to a person, e.g. in the case that the personal flow is a guidance flow. However, meaningful representations must be found. For example, the person-centric flow of a nurse may be integrated within a map of

the hospital. Such a scenario may be realized based on an approach for workitem visualization as presented in [22]. In [23] a workflow visualization framework is presented, which enables a flexible business-oriented process visualization (e.g. using a gant chart). This approach can also serve as foundation for a visualization discussion on person-centric flows.

**Privacy:** Person-centric flows contain a lot information about the specific behavior of a person, which should be protected. Hence, discussing privacy is an important issue. [24] gives an overview on the effects of combining workflow systems and context-aware systems and to discuss its implications for workplace privacy and human-oriented design.

## 5 Conclusion

In this paper we introduce the concept of person-centric flows. Since person-centric flows are orthogonal to the existing workflow concept the two concepts complement each other. The main goal of person-centric flows is to support a person performing her tasks for example by reducing the cognitive load necessary for scheduling their tasks. However, person-centric flows can also be used to enforce external constraints. Initially, we will use the declarative workflow modeling language proposed in [11] to representing person-centric flows. In future work, we investigate and implement a prediction algorithm to predict person-centric flows prototypically. The aim of the prototype is to guide unskilled nurses. The prototype is also used to improve the accuracy of activity sensing and context recognition. In that case the person-centric flow reduces the search space of the activity recognition system since two activities having the same characteristics of sensor data may be distinguished according to their position in the person-centric flow.

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