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Flexibility Requirements in Real-World Process Scenarios and Prototypical Realization in the Care Domain

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Abstract Flexibility is a key concern in business process management and mature solutions and systems have been developed during the last years. What can be observed is that the approaches mostly consider process instances that are executed based on a process schema reflecting a process type, e.g., an order process. The process instances might be adapted during runtime in an individual manner (ad-hoc changes) or the process schema evolves due to, for example, new regulations. We studied cases from four different domains for their requirements on flexibility. These use cases are characterized by long running, highly adaptive, and individual instances, i.e., instances that are not based on a common process schema, but develop during runtime based on context and process-relevant data. The requirements analysis shows that can only part of them can be met by existing approaches. To illustrate an initial solution meeting the identified requirements, a prototypical implementation of the care domain use case is demonstrated, followed by a discussion of lessons learned and a research agenda.

1 Introduction

Flexibility is a key topic in business process research [1–4]. Some business processes require a high degree of flexibility, but still follow a predefined schema, which can be repeatable reused for multiple instances [3]. A different set of processes describe situations that require a high degree of flexibility regarding the instance design. They are based on a standardized, but very minimalistic process skeleton, and adapted on-the-fly according to constantly changing requirements. Domain-specific solutions that support individually developed processes (plans) have been already developed in health care [5][1]. Another study from the logistics domain stating similar requirements was presented in [6]. Further business domains that are investigated in this paper are:

– **Care Planning:** The *ACaPlan* project[2], developed at the University of Vienna, aims at supporting nurses in care centers who are adapting therapy

[1] See Section 4 for a discussion.
[2] http://cs.univie.ac.at/project/acaplan

plans based on a patients symptoms. The inherent human-centered process structure requires a highly adaptive and individualisable approach.
- **Manufacturing:** *Azevedos*, which participated in the FP7 project[3], is one of the leading manufacturers of machines for cork transformation. They plan and produce machines which are tailored according to the demands of one specific customer, thus leading to a very adaptive and individual production process.
- **Software Development:** *Mesonic*[4] develops Electronic Resource Planing and Customer Relationship Management technology. Their *Support Net* is a central access point where support cases of retailers and customers are distributed to the support team. For each user there exists a highly adaptive process instance, containing each interaction with the system and all resulting consequences.
- **Hotel and Event Management:** Schlosspark Mauerbach[5] (SPM) is a seminar location and a hotel close to Vienna. Based on wishes, suggestions and complaints by hotel guests, customer specific process instances have to be adapted.

Although these four applications differ in their business area, they have one thing in common: All implement at least one type of long running process based on a minimalistic standardized process schema, which has to be continuously adapted according to individually changing requirements. These adaptations eventually lead to highly individual, customized, and long running process instances which have to be supported accordingly.

Though several generic approaches regarding process flexibility have already been discussed [1–4], the following challenges are not yet (fully) supported:

- **Adaptation and management of highly individual process instances:** This refers to the on-the-fly creation and adaptation of highly adaptive process instances. All relevant data related to the process instance, including the structure of the instance itself, have to be managed through the whole life cycle and made available to the person in charge when required.
- **Maintenance and support of changes to adapt highly individual process instances:** Since these highly adaptive and individual process instances are not based on a common schema, known similarity checks based on a process schema like [7] or classical process life cycle support [8] cannot be utilized for determining which situations are similar, and which are not. This circumstance leads to the utilization of other data sources describing the process instance and its environment. These data sources will be used for assessing and analyzing the current situation, and recommending suitable adaptations to the person in charge.
- **Support and application of data driven process changes:** Based on changes of certain data items - for example the body temperature of a pa-

[3] `http://fp7-adventure.eu`
[4] `http://www.mesonic.com/`
[5] `http://www.schlosspark.at/`

tient - new adaptations of a certain process instance can be triggered or recommended to the person in charge.

In order to address these above mentioned research gaps, the methodology depicted in Figure 1 is applied in this work.

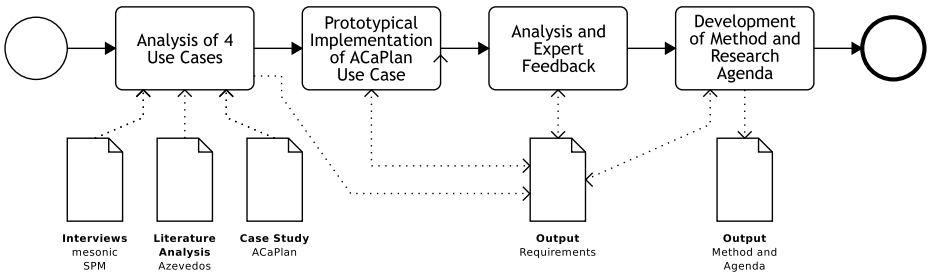

Figure 1. Research Methodology

1. We started with an analysis of the different use cases from distinct business domains, revealing the basic requirements. For the use cases of *Mesonic* and *Schlosspark Mauerbach* interviews with domain experts were conducted. The requirements of Azevedos have been analyzed based on documents from the ADVENTURE FP7 project. In cooperation with domain experts from two nursing centers in Lower Austria, we developed the basic concepts of the ACaPlan prototype, which also serves as a use case.
2. Based on our findings, we developed a first prototype of the ACaPlan Use Case. Since this prototype is a good representative for such a use case, we focused our efforts mostly on this project. During the implementation phase, we discovered additional requirements for such a system.
3. After the first version of the ACaPlan prototype has been finished, we analyzed the results with the domain experts and implemented their feedback to the requirements.
4. Based on this feedback round, we were able to define a certain set of requirements, as well as to develop a road-map for our future research.

The contribution of this paper is threefold: First, we define the basic requirements for highly adaptive, individual, long-running process instances. Second, we have developed a methodology to support users and data-driven process adaptation, which we name **APES** (**A**daptive **P**rocess **E**nvironment **S**upport). Third, by developing and enhancing our ACaPlan prototype, we provide a testing environment, where the results of this methodology can be demonstrated and tested.

The rest of this paper is organized as follows: Section 2 describes the setting of the process. After a short introduction into the ACaPlan prototype and

the three other use cases, a description of the general and data-source related requirements (Section 2.3) is given. Section 3 describes the overall approach for providing support in adaptive process environments. Based on our prototypical implementation of the nursing case study, necessary steps and required information are illustrated. The paper concludes with an overview over related work (Section 4), followed by our research agenda and conclusion (Section 5).

2 Requirements analysis

This section will exemplify the requirements analysis part of APES, utilizing the ACaPlan project as a starting point. We continue by introducing a set of scenarios from three other business domains, and show how the approach can be utilized to support adaptation of highly individual, long-running and adaptive process instances. The section concludes with a general requirements analysis, including an analysis of the required data sources containing exemplary elements for each of these scenarios.

2.1 ACaPlan

ACaPlan (Adaptive Care Planning) is an adaptive process application which aims at supporting nurses in geriatric nursing homes at their daily work. The ACaPlan project implements the central processes and data sources necessary for taking care of each patient in an optimal, individualized way. Based on the symptoms a patient shows and related data the nurse is supported in finding the correct diagnoses, and in further consequence in designing optimal therapy plans, which lead to a better situation for the patient as effectively as possible. This therapy plan is inserted into a patient-specific, long running, highly adaptive process instance, which includes all of his therapy plans.

Based on the data available about each patient and the environment, APES can provide decision support for nurses who have to set up a therapy plan for a patient: Starting with information about prior conditions and related therapies, therapy plans can be suggested or not. When it is unknown if a certain treatment may help a patient, the basic informations about the patient can be used for finding comparable ones which already had this kind of therapy, and suggest the therapies which proved being successful first.

2.2 Further Use Cases

This section illustrates three other scenarios, where APES can be used to provide support during the adaptation of a long running, highly adaptive and individual process instance.

Business Field Manufacturing - Scenario Azevedos: The company could profit from APES in the adaptation of the production and documentation process of its products. Based on informations about the requirements of customers, process

patterns which have been used for customers with comparable requirements can be suggested and reused. With the APES approach in place, if suppliers have bottlenecks, or Azevedos needs to optimize its production processes, adaptations to the processes can be carried out in standardized way.

Business Field Software Development - Scenario Mesonic: Information about how to solve problems of comparable users or of the same user in the past can be utilized to help the supporter to interact with one specific customer.

Business Field Hotel and Event Management - Scenario Schlosspark Mauerbach: At Schlosspark Mauerbach, the *Customer Process*, which encompasses all interactions with one specific customer, is the central process for incident management. Based on information about the customer and comparable guests, future events and stays at the hotel can be optimized.

2.3 General Requirements and required Data Sources

Based on our experiences from the ACaPlan prototype, we were able to conduct several general, and data-source related requirements for a supportive adaptive process environment. The general requirements are as follows:

- creation of general process stubs serving as a basis for later adaptations, which will individualize the process.
- on-the-fly adaptation of instances, based on information from multiple data sources
- supporting multiple process patterns as defined in [4] including insertion, deletion, moving and replacing.
- alerting persons in charge of adaptations when certain data sources change (e.g. a change in the patients body temperature can trigger certain adaptations)
- utilization of every data source available for assessing the current situation from multiple vantage points.

One of the key issues is to identify and analyze data sources, that (1) help in building and adapting the individual process instances which are not based on a common schema and (2) help in determining the similarity of the processes instances. The following list summarizes the data sources which are relevant for a comprehensive view on a single process instance:

- **Subject Data:** Who or what individual element is directly related to the process instance and thus affected by the adaptation?
- **Environmental Data:** Which other data elements, which are not directly related to the subject can be relevant for planning and executing an adaptation?
- **Goals:** What are possible goals which could be reached by an adaptation?

– **Trigger Conditions:** What are the events and data sets which make planning and executing an adaptation necessary? This includes requirements for optimization as well as any other data or event which makes an adaptation necessary.
– **Process Fragments:** What elements are provided for possible adaptations? This source contains the items APES can suggest for adapting the process instance.

These data elements are important for support during the adaptation of process instances, as they provide comprehensive information regarding the process instance and its environment. The more data about a process instance can be gained and categorized, the better the understanding of how the process in real life works is, thus leading to an improved support during adaptation.

Table 1 outlines exemplary allocations of the data sources in the four scenarios as described in Section 2.2.

Table 1. Data Source Allocation in the different Use Cases

	Care Planning	**Manufacturing**	**Software Dev**	**Hotel**
Subject Data	Patient	Product	Customer	Guest
Environmental Data	Nursing home information	supplier information, employee workload, factory information	employee workload, other projects	hotel information (occupied rooms etc.), upcoming events
Goals	cure the symptoms, make him happy	produce the machine, react to the customer	satisfy customer, solve bugs	satisfy guest
Trigger Conditions	new symptoms arise, the patient expresses desires	the customer has new requirements	the customer has a problem	the guest has a special wish for his next stay
Process Fragments	solutions for a diagnosis, as defined in the repository	work steps for planning and producing	tasks for the support / development / other teams	measures taken by the various hotel employees

3 The ACaPlan Prototypical Implementation

The approach for generating good recommendations for adaptations of a highly adaptive, long running process instance is divided into several distinct steps. The ACaPlan prototype, which is based on the *Cloud Processing Execution Engine*[6], is comprised of several REST web services, which can be called from multiple environments, allowing the development of custom interfaces. Over a web interface, which can be accessed by mobile devices and standard browsers, nurses use our approach for assessing which therapy is optimal for a patient given the environmental data, his basic data, current symptoms and goals.

The steps are:

1. Assess the situation: How can issues which have to be changed be described?
2. Find possible diagnoses which match the current symptoms.
3. Based on these diagnoses, generate a therapy plan and set the goals.
4. Adapt the process instance by inserting the new therapy plan and goals.

[6] `cpee.org`

The first step is covered by our nursing interface, a website which can be opened from multiple devices. Over an input mask as depicted in Figure 2, the nurse can describe the current symptoms of the patient.

The relevant nursing knowledge is described in a repository which is based on the nursing knowledge standards NANDA, NIC and NOC [9]. Here, each diagnosis is described in detail, including possible symptoms, risk factors, things that can be done to solve the issue (i.e., therapy steps) and possible outcomes.

Currently, the diagnoses are matched with the nurses inputs by using a simple pattern matching technique: If the words the nurses has typed in are found in the relevant sections of the diagnosis, the diagnosis is added. Additionally, each element which matches the search parameters can be supplied with a score, which will be added to the overall score of the diagnosis. The result of this step is shown to the nurse, who can now select relevant diagnoses (cf. Figure 3).

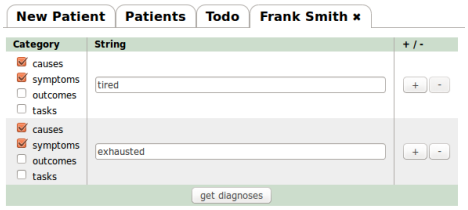

Figure 2. Input Screen for symptoms in ACaPlan

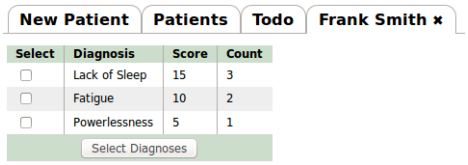

Figure 3. Selection Screen for diagnoses in ACaPlan

Each diagnosis includes the therapy tasks which can be executed and goals which can be achieved. Additionally, a set of possible solutions is defined for each diagnosis, including a predefined set of tasks and goals. These solutions are the process fragments, which in further consequence will be added into the specific therapy plan, as depicted in Figure 4. If no solution applies to the current situation, a new process fragment has to be generated. In similar situations, this new process fragment can be reused for the process instance.

This prototype utilizes the different data sources on a preliminary level. Given the inputs of a nurse, diagnoses are selected containing the possible adaptations, which are suggested to the user. In Section 5 we describe how this process can be enhanced.

4 Related Work

Due to constant changes in the process environment, process flexibility, i.e. adapting process instances as well as schemata, has emerged as a crucial challenge [10] [3].

The imperative approach of defining processes defines one explicit sequence of steps that solve the intention behind the business process [11], resulting in a

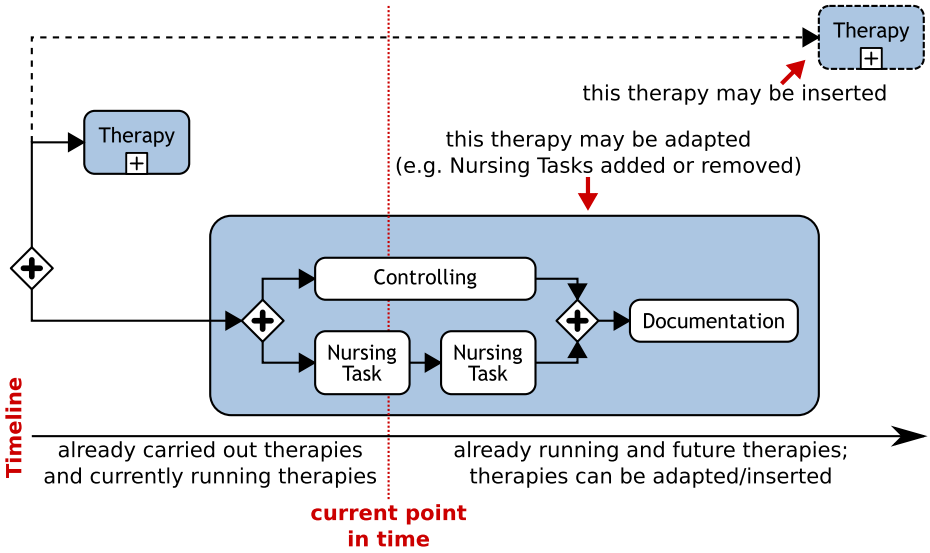

Figure 4. Exemplary Adaptive Process Instance

process model which is hard to understand for highly adaptive processes. During many years of research, powerful solutions at the technical level to develop changes on instance level and evolve process schemes have emerged [10]. However, except few approaches [12] [13], little attention has been spent on how to support users when defining and applying changes.

The declarative approach defines all relations between process steps [11] [14], thus allowing for multiple solutions to solve the intention behind the business process. Imagine an adaptive process containing all therapies for a patient in a care center: there is the potential to conduct hundreds of therapies with hundreds of thousands of steps in total. The sheer number of possibilities, with no explicit sequences but just dependencies is recognized to be very confusing for users of the system [11]. Thus the imperative approach is generally easier to comprehend for related personnel.

For a real-world process, data connected to the process as a whole, or to certain steps, plays a key role when executing the process. Standing in contrast to traditional workflow paradigms, data-driven processes aim at putting the control flow of the process in the background, and instead using data related to the process for the definition of the control flow at instance level. The process structure itself is only defined at a very coarse level, and the resulting skeletons evolve dynamically based on the data provided for the current instance [15].

Especially in the field of medicine, specialized solutions such as *K4Care* [5] have been developed. They utilize independent agents for the different tasks and users. In general, agent-based solutions are flexible, but the scalability of the solutions is questionable. The approach employs SDA* [16] models, where all possible *s*tates, *d*ecisions and *a*ctions have to be defined at the creation of a

therapy, including "follow-up actions in which the state of the patient is checked" [5]. Thus, it remains unclear what happens in case of unforeseen situations. As they are not included in any process model, the system cannot provide recommendations. Here, flexible process engines such as the CPEE provide the option to dynamically adapt the concerned process instances in order to resolve the exceptional situation.

Generating knowledge out of past experiences is a central feature necessary for providing recommendations for the user when adaptations become necessary. The purpose of Process Mining is to extract this information [17]. Generally, there are three ways of utilizing the results of log mining [18], i.e., process discovery, conformance checking, and model enhancement.

Log files, which are utilized for process mining can have a multitude of formats. A well known representative is MXML, which is based on XML and among others used by the process mining suite *ProM*. XES (*Extensible Event Stream*), which can be seen as a successor of MXML, impresses with a high degree of flexibility.

5 Research Agenda and Conclusion

Long running, highly adaptive and individual process instances occur in a variety of business fields. Since control flow related similarity checking algorithms cannot be utilized to find comparable process instances, other data sources have to be used for this task. Based on our experience from the ACaPlan project, such data sources are defined and evaluated with three other possible applications from different business domains. Secondly, the basic methodology of how we utilize the available information for providing adaptation support is outlined. Although the first ACaPlan prototype already illustrates basic functionality, the following concepts must be developed in order to close the above mentioned research gaps:

- **Support of Change Patterns:** In this stage of our prototype the adaptation of the therapy process only supports adding new therapies as a whole into the process instance. [4] defines several change patterns of process instances and schemata. In addition to the insertion deletion, updating and skipping therapies or parts of them would be desirable.
- **Utilization of the data sources for generating recommendations:** We can utilize the above mentioned data sources for analyzing the current situation and answering among others the following questions:
  - Do the symptoms the patient currently suffers from appear for the first time, or have they occurred before?
  - If they occurred before, which therapy has been used to treat them, and has it been successful?
  - Are there any other patients who had comparable symptoms before, and which therapies have been used on them successfully?
  - Have there been any situations before where the same goals should be reached?

– **Data driven process changes:** Based on certain changes in data, adaptations of the respective process instances have to be triggered and either carried out automatically, or recommended to the person in charge.

We focused our efforts on the realization of the ACaPlan prototype, but will continue to implement use cases from the other presented domains in the future. Thus, the general applicability of the proposed methodology will be evaluated.

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