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Ontology-based Workflow Design for the Coordination of Homecare Interventions

Elyes Lamine^{1,3}, Abdel-Rahman H. Tawil², Rémi Bastide³ and Hervé Pingaud³

¹ Université de Toulouse, Mines-Albi, CGI, Campus Jarlard, 81013 Albi Cedex 09, France
Elyes.lamine@mines-albi.fr

² University of East London, School of Architecture Computing and Engineering, Docklands Campus, University Way, London, E16 2RD, UK
A.R.Tawil@uel.ac.uk

³ Université de Toulouse, Plateforme e-Santé IRIT, CUFR J.F. Champollion, ISIS, Avenue George Pompidou, 81104 Castres, France
{remi.bastide,Herve.Pingaud}@univ-jfc.fr

Abstract. ICT are recognized as key opportunity to improve healthcare practices ,in the homecare domain particularly in relation to care interventions. However, despite all the advances accomplished in this field, a problem of coordination and continuity of personalized care remains. Given these needs, workflow management systems appear to be an appropriate tool for supporting the communication between the different stakeholders involved in the homecare ecosystem. Nevertheless, the specific characteristics of homecare processes make the design of such workflows a real challenge. In order to help with the conception of these workflows, we propose in this paper an approach based on ontology matching between homecare domain models and semantic representation of Business Process Modeling Notations (BPMN). This approach leads to the design of custom workflow coordinated interventions for a given patient according to his profile.

Keywords: Collaborative process, Homecare processes, Personalization, Workflow, Ontology, Model-Driven Engineering

1 Introduction

Homecare interventions are complex processes, which represents the chain of various activities achieved by several stakeholders trades (i.e., nurse, physician, professional caregivers, etc.) to follow patient's progression and needs at their homes. Interventions often represent collaborative or cooperative processes with strong human components involvement. Such processes are usually long termed, distributed among several participants and composed of heterogeneous elements with various levels of autonomy, but are subject to dynamic changes [1]. As outlined in several research works [1–3], the delivery of homecare interventions faces many challenges, mainly in terms of coordination and continuity of care. In both cases, the problem seems to be related to how care activities are distributed and managed among the different participants involved in such processes. As a result, there is a need to

improve the efficiency of the way in which information is exchanged and shared among care providers. One approach to overcome these challenges is to employ workflow systems, which appear to be appropriate tools for supporting the communication and coordination between the different stakeholders through managing a sequence of care workflow (careflow) activities. Indeed, the role of a workflow management system could be to coordinate the work to be done by transmitting the necessary information and tasks among different stakeholders, according to patient's needs and roles of the participants. For example, sending information about patient conditions to the right participant in real-time or notifying when a planned care activity is actually performed (or canceled) by a specified nurse.

The design of such intervention workflows is facing hurdles due to the complex characteristics of homecare processes, and this issue represents the framework of our research work presented in this paper. We present a new approach to assist in the conception of workflows apt to dynamically improve the coordination in homecare. The remainder of the paper is structured as follows. In Section 2, we give in the next section an overview of the coordination concerns in homecare, show how workflows can be used to tackle these concerns and point out some challenges for their design. Based on the latter, in the third section, we focus our endeavor on the presentation of our proposed approach to facilitate the design of personalized workflows that can be enacted to improve the coordination of homecare interventions. Our main contribution concerning this approach is described in this section. In Section 4 we discuss related work. Finally, we provide concluding remarks and future outlook.

2 Workflows-based Coordination Challenges for Homecare Interventions

Homecare interventions occur in a mobile and dynamic environment that is continuously evolving during its execution, as new stakeholders can be integrated while others may leave depending on the outcomes of successive actions. The set of relationships and dependencies across intervention episodes requires for actors to share knowledge, expertise and experiences. Accordingly, care coordination is an essential component for quality healthcare delivery. A purposely-broad definition of care coordination has been proposed by [4], as “The deliberate organization of patient care activities between two or more participants (including the patient) involved in a patient’s care to facilitate the appropriate delivery of health care services”. The focus is on organizing care by systemizing personnel and other resources needed to carry out required patient activities through managing the exchange of carried interventions among the different actors responsible for the diverse aspects of care.

Within the homecare environment care coordination is considered as both crucial and timely for the efficient delivery of provided care services. Indeed, the homecare process represents a collaborative process which is a set of potentially interdependent services carried at patients’ homes by different stakeholders in a cooperative way. For such process, the need for coordination stands at two levels:

- The **interventions level**: where different providers of social and healthcare participants have to organize the delivery of homecare activities and the exchange of

information with regards to performed interventions. This information is necessary to facilitate the appropriate delivery of health care services.

- The **transitions over time level**: where the stakeholders must ensure continuity and consistency of provided care during the transition of different episodes of care and across the full spectrum of patient's care. For instance when moving from one care institution to another arises the need for responsibility shifts.

As shown in Figure 1, the coordination of home-based interventions at the first level is generally focused on monitoring the proper enactment of patient care plans, which represents duly personalized statements of planned healthcare activities encompassing all health care provider activities to be performed by one or several healthcare professionals.

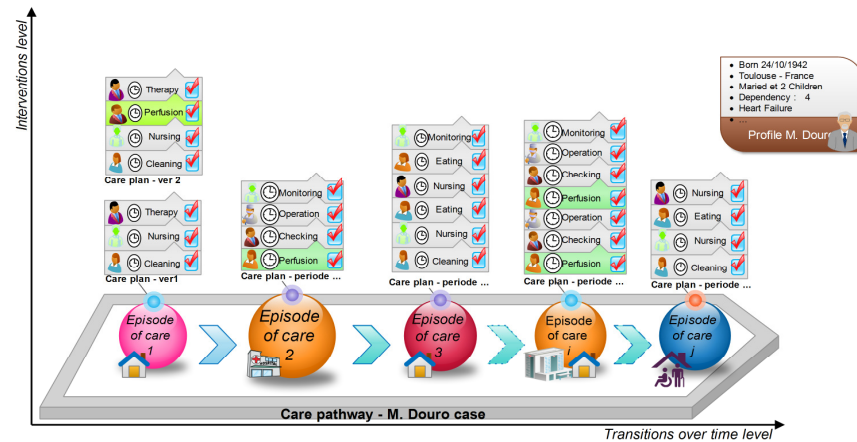


Fig. 1. Care coordination levels

The second level of coordination is mainly related the continuity of care over time through the integration, collaboration and sharing of information between different providers. Specifically, this level is focused on the anticipated care pathway, which is placed in an appropriate time frame, and agreed by a multidisciplinary team. In the home care domain, the coordination at this level simply consists of organizational shifting of care responsibilities and the transfer of current patient state condition and eventually the enactment of care history.

With regards to the above-mentioned levels we focus our endeavors on the first level of coordination since we consider it to be a fundamental step for homecare coordination. Given the needs at this level, workflow management systems appear to be an appropriate tool for supporting the communication and coordination between these different stakeholders through managing a sequence of care workflow activities.

2.1 Workflows Coordination for Homecare Process

Usually, workflow systems are process oriented, where a process represents a set of activities within a course-of-action that needs to be carried out in a prescribed sequence with the aim to achieve a determined outcome. In healthcare domain, such processes are known as care workflows (careflows), defined as the flow of care-related tasks to be carried out together with the timing and sequence of these tasks and the disciplines involved in completing them. Careflows tasks can either be diagnostic, therapeutic, administrative, or decision-making [5]. In the literature, there are several research works that have addressed the area of supporting healthcare process using workflow [6], mainly for the hospital domain.

However, fewer papers explore the design of workflow within the homecare domain. The mainstream of careflows in homecare context typically involves the coordinated provision of service care at patients' homes through monitoring sequences of interventions. Hence, these careflows, namely workflow coordination should be setup regarding a structured multidisciplinary care plans that detail essential tasks in the care for patients requiring specifically timed home services and offers structured means for developing and implementing local protocols of care based on planned clinical guidelines.

Fig. 2 shows a BPMN model process that represent a simple example of such a careflow in the homecare domain. It represents a sequence of interventions performed within a one-day timeframe for a specific patient, with the distribution of interventions amongst stakeholders (nurse, cleaning agent, etc.).

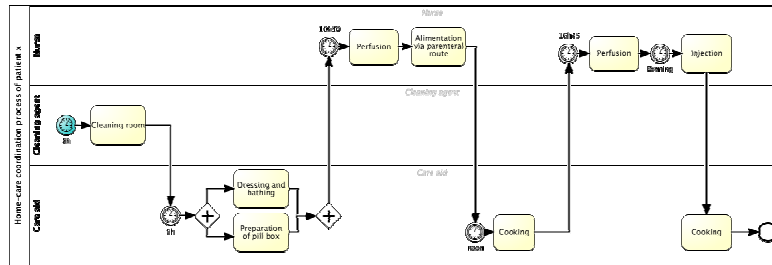


Fig. 2. An example of daily Home-care coordination workflow of a specific patient

This BPMN Model shows one pool representing a coordinated workflow, containing three lanes representing three different categories of actors involved in the homecare of a specific patient. In this case a cleaning agent should perform the first intervention at 8 o'clock, followed by two tasks (help with dressing and bathing and preparation of pill box) performed by a care aid agent. Followed by a third intervention that should be performed by a nurse at 10:30, etc.

In accordance with the patients' care plan, this careflow could be used to coordinate care interventions in real-time, thus allowing for the timely checking of planned care activities as to whether they were correctly executed by a specified actor or reported as cancelled. Notifications can be launched automatically by the system to advise when intervention is required, including the date and time of actions needed or

alternatively to alert coordinators for any delays or cancellations. In addition, stakeholders could rely on careflows for sharing information with regards to care progression and patients' conditions [7]. Accordingly, we have developed an ontology-based approach for the coordination of homecare interventions to fulfill the above-mentioned requirements. This approach is presented in the following section.

3 Ontology-based Careflow Design Approach

As noted in the previous section, a homecare plan can be considered as a rich temporal, process-centric, patient-specific representation of linked set of actions that need to be performed by several care providers at patient's home within agreed times. Based on the state-of-the-art, we have noticed that the knowledge management paradigm and more specifically the ontological approach are largely used in the field of medicine and health, especially to define careplans that are based on clinical guidelines. In addition they also seem to be a relevant means to cope with both flexibility and personalization needs.

Taking this into account and considering our goals, we propose to complement customized patient-centered workflows by using knowledge models. Specifically, according to the workflow architecture reference, ontologies are used to help in building workflow models in the design-time stage and to deal with the changing needs at run-time. In this work we have focused our endeavor on the design-time stage. Our approach consists of generating a "personalized care process" from a personalized careplan model. The resulting process model will be interpreted by a process definition tool in order to be enacted on a conventional workflow engine. This approach follows a Model-Driven Engineering approach, and is based on ontology matching between homecare domain conceptual models and a semantic representation of Business Process Modeling Notations. The result of the first step is an OWL model that conforms to a homecare ontology encompassing health objectives, subject of care profile, health and social conditions. Based on this intermediate personalized careplan model we generate a BPMN model by using the BPMN ontology [8] and SWRL (Semantic Web Rule Language) rules that define the mapping between the two ontologies. An important challenging step was to define a HomeCare Ontology (HCO).

3.1 Homecare Ontology: HCO

The use of ontologies has proven quite successful in the field of medicine and health in general, to describe diseases, their symptoms, and medical knowledge, e.g., CIM, UMLS and GALEN. A few ontologies have been built in the homecare area, however to our knowledge none is considered a standard in the field. Most ontologies of homecare remain at the stage of research projects, to address specific challenges of homecare [9–11].

In our work we adopted the APO (Actor Profile Ontology) and CPO (Case Profile Ontology) ontologies both implemented as part of the European K4Care project [2, 11]. APO deals with knowledge about actors and their skills involved in homecare domain and CPO is about illnesses and treatments. Though interesting, these ontologies on their own don't fit our needs. Therefore we had to rebuild a new ontology that we called HCO. To build this ontology of homecare domain, we followed a synthesis of different methodologies in literature such as the ones proposed in [12, 13]. HCO focuses on the concepts of homecare coordination. This ontology contains global information about a structure and organization of homecare (actors, roles, etc.) as well as the knowledge for capturing the profile of patients, tasks required and actors needed for each disease. Our knowledge model is based on the reuse of some concepts from both APO and CPO such as Interventions, Actors and Actions. We also had to modify some other concepts such as patient and homecare semantic representation. We also introduced new concepts too, such as the duration and the frequency interventions. The proposed HCO is sketched in Fig 3. We use different colors, as specified in the figure legend, to clarify the origin of the concept: CPO, APO or others.

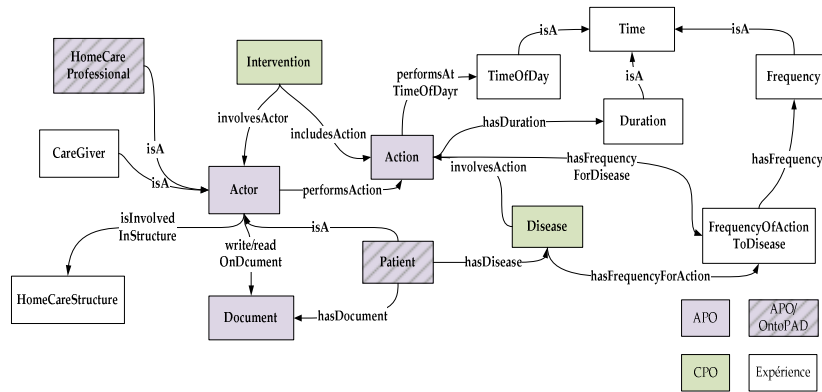


Fig. 3. Main classes and relations of HCO

This ontology could be queried to retrieve the elements that focus on which, when and by whom actions need to occur to treat a patient over a period of time.

With regard to the implementation of our approach, the software architecture is made of three main components: a knowledge base, an inference engine that is able to query the knowledge base and the BPMN generator module that allows for generating BPMN files to be interpreted by a workflow modeler Tool.

4 Related Work

Numerous research efforts have focused on implementing computerized care pathway systems. Alexandrou *et al.* [14] proposed a semantic approach that supports the execution of treatment schemes based on clinical pathways to efficiently handle the application of healthcare business processes. The developed SEMantic PATHways

(SEMPATH) system provisions for the constant monitoring of applied clinical pathways execution and automatically recognize any exceptional events. Abidi *et al.* [15] propose a patient care planning system that can automatically and proactively generates adaptive patient-specific healthcare procedures based on a semantic framework. They developed a careplan system that tries to combine heterogeneous healthcare knowledge sources with available patient information into personalized healthcare plans while utilizing the technology of web-services for the composition of integrated pathways. Yao *et al.* [16] propose a novel approach for integrating clinical pathways into clinical decision support systems. Their work acknowledges the frequent deviation that clinical pathways involves and the need for significant flexibility to build successful clinical decision applications. This is achieved based on a better understanding of clinical context through using ontologies, and associating with rules to provide the knowledge required to allow in deciding the correct activities execution.

Most of these research works develop electronic clones of existing paper-based care plan management methods with a focus that is mainly related to hospital care. Contrariwise, in homecare the collaboration is asynchronous where the interventions are distributed in space and time. Accordingly, these approaches gave little consideration for the explicit modeling of intervention outcomes and related temporal relationships when formally defining the coordination of homecare process models. In our work, we are interested in the design of customized patient profile careflow models and monitoring their execution to improve the coordination of homecare interventions. To our knowledge there are no other works with the same goals.

5 Conclusion

Homecare interventions give rise to coordination and continuity of care. To ensure such continuity and to improve its quality, we proposed an ontology-based workflow design approach for homecare coordination of interventions with focus on organizing tasks among the numerous involved stakeholders. Our work differs from classical workflow based methods in that we incorporate considerable domain in addition to organizational and temporal knowledge. The fundamental proposition of our approach is its ability to assess a patient case, evaluate and implement workflow models for personalized patients' care interventions. We rely on ontologies to overcome workflow flexibility as the major identified obstacle and allow for the dynamic construction of careflows. Next step in our work is to promote a human in the loop approach in our transformation process, as indeed all necessary knowledge is not present in our ontology and we still need to give the users the means to complete the missing items during the transformation process.

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