DESIGN AND EVOLUTION OF HOME-CARE WORKFLOWS USING ONTOLOGIES AND MODEL TRANSFORMATIONS

Sabrina Zefouni[1,2], Elyes Lamine[1,2], Rémi Bastide[1] and Hervé Pingaud[1]
[1]*ISIS - CUFR J.F. Champollion, Campus Universitaire, Rue Firmin Oulès, Castres, France*
[2]*EMAC, Centre de Génie Industriel, Jarlard, Route de Teillet, Albi, France*

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Abstract: This paper investigates the use of workflows to automate the delivery, coordination and monitoring of home-care processes. Workflow models of these processes need to be customized, resilient to change, collaborative and also need to account for the temporal aspects of care (treatment duration, frequency of a medical acts, etc.). To this end, an approach based on ontologies (home-care ontology and BPMN ontology), rules and patient's profile is proposed for the construction of workflows supporting the coordination and continuity of home-care processes.

1 INTRODUCTION

Home-care presents two majors problems, namely coordination and continuity of care. These problems have been highlighted by the document MIN/DHOS-/DSS-CNAMT/2002/n°610, and several others (Arundel et al, 2001) (Bricon-Souf et al., 2005) and (Woodward et al., 2001). From our studies in the home-care area, these drawbacks are still valid. 1) Lack of inter-organizational communication or coordination of care: there are several associations, organizations, stakeholders that manage employees to work at the patient's home. However, there is no well-established means of communication between these different stakeholders (Arundel et al., 2001) and (Helleso et al., 2005). Indeed, the only means used by many home-care organizations to enable this communication, is the so-called "liaison logbook" i.e. a physical notebook, usually unstructured and kept at the patient's home (Bastide et al., 2010) and (Lamine et al., 2010). 2) Problem of care continuity: in the literature, there are a multitude of definitions for continuity of care like (Woodward et al., 2004) and (Shortell, 1976). In homecare, the need for continuity stands at two levels: the intervention level where the stakeholders must ensure continuity and consistency of care provided. But also, over time, during different steps of patient treatment: moving from one institution to another.

To ensure the coordination and continuity of home-care, workflow management systems appear to be appropriate. WfMC (Workflow Management Coalition) (Hollingsworth, 1995) has defined workflow. The role of a workflow management system, in home-care, is to coordinate the work involved by transmitting the necessary information and tasks, with different stakeholders, depending on the condition of the patient's intervention plan and the role of the interveners. For example, the nurses' day-to-day tasks vary according to the patients' intervention plan, and the storage and exchange of the relevant information would improve the continuity of care.

However, the specific characteristics of processes involved in homecare make the design of their workflow a challenge. The use of ontology to help in the design and evolution of these workflows is proposed in this paper

In section 2 we discuss the need for workflow in automating the home-care processes and we point out the challenges for this. Section 3 is focused on the presentation of proposal approach to design a workflow for home-care. We discuss the related work and our objectives on the section 4. Finally, we conclude with a summary and outlook.

2 PROCESSES IN HOME-CARE

The activity of home-care gives rise to communication and coordination problems. To ensure the coordination and continuity of care, and to improve its quality, the caregivers involved on

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home-care are mandated to: 1) ensure the accuracy of information, by automating the transmission of information and by avoiding several transcriptions for the same information; 2) Guarantee the timely transmission of information to the appropriate stakeholders, be it information about the patient's condition or other logistical information; 3) Ensure the transmission of information about the actual medical or paramedical interventions performed by the caregivers; 4) Ensure the storage of information about the evolution of patient's health conditions.

2.1 Home-care Processes

In the literature, there are many research works about home-care processes and particularly on medical home-care (Jebalia, 2008), (Ben Bachouch et al., 2009), (Lunn et al., 2003), (Hamek, 2005) and (FNEHAD, 2009). In (FNEHAD 2009) the "National federation of institutions hospitalization at home" (FNEHAD) provides a mapping process for patients under medical home-care, considering that computer support is still underdeveloped in institutions of medical homecare. This work aims to structure information systems for home-care and stands as a reference in this area, as it encompasses all processes presented in other works. Figure 1 shows the main processes involved in home-care, following ISO 9000: 2000 (ISO, 2000) which classifies processes into three types: management, operational (management of patient) and support (Human resources, purchasing and logistics...).

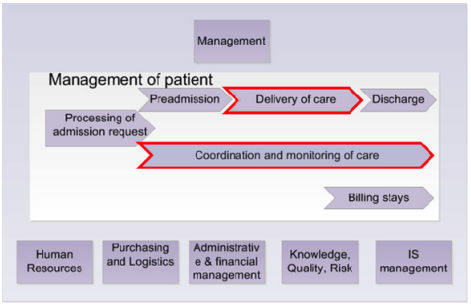

Figure 1: Home-care mapping processes.

2.2 Workflow in Home-care

To cope with the drawbacks addressed above, we suggest the automation of some processes of patient management. In this paper, we focus on the delivery, coordination and monitoring of care.

We distinguish two sets of processes: The first set includes the "*admission request", "preadmission", "billing stays"* and *"discharge"* processes, which are prone to be automated by a classical workflow management system. The second set of processes includes "*delivery of care*" and "*coordination and monitoring of care*" that are the main topic of the present paper. The characteristics of these processes make the design of workflows for their automation a difficult task. This set of processes has the following characteristics: 1) High degree of customization (Dadam et al., 2000), (Dazzil et al., 1997) and (Quaglinia et al., 2001): each patient is a specific case due to particular health conditions, social networking, geographic location, etc. 2) Collaborative nature: (Arbaoui, 2008) and (Cunin, 2000). The homecare processes present a strong human component. Such a process is usually long-running, distributed among several actors with various levels of autonomy, and subject to dynamic change (Liu et al., 2008). This collaborative process is made of the assembly of distributed business processes in partner organizations. Its behaviour is related to the effective contributions of partners, implemented jointly to achieve a common goal. 3) Dynamicity: (Dadam et al., 2000) according to the changing health of the patient and his environment. In general, the process it required to quickly and easily adapt to a changing environment. 4) Temporal aspects: (Dadam et al., 2000) the tasks in homecare have frequency and duration which are inconvenient to represent in conventional workflow models.

3 PROPOSITION

3.1 Context

A workflow to deliver, monitor and coordinate home-care is a *sequence of interventions*, as shown in figure 2. This workflow depends on the *intervention plan* defined by the professionals that manage home-care institutions, and depends on the profile of patient: diseases of patient, the presence of family caregiver, etc.

Figure 2 shows - using BPMN (Business Process Management Notation) - the sequence of interventions performed within a two-days' timeframe for a specific patient (Mrs Bissière that has peritonitis vesicular, the case study detailed on section 4), with the distribution of interventions amongst stakeholders (nurse, physiotherapist, etc.). The intervention plan defines the list of provisional care to be performed, including actions and treatment, prescribed or not, as well as the frequency and schedules, and specify the appropriate takeholders (nurse, cleaning agent, etc.) to perform each actions.

Figure 2 shows one pool representing the patient's home, containing four lines representing four different categories of actors involved in the home-care of a specific patient: Nurse, Cleaning agent, care aid and Physiotherapist. The first day features five interventions: In the morning, the Nurse has to perform perfusion, alimentation via parenteral route, vacuum assisted closure, preparation of pill box and blood drawing. In the evening, she performs perfusion and alimentation via parenteral route. Cleaning agent performs cleaning room, Care aid performs help with dressing and bathing and changes the cover, and Physiotherapist performs physiotherapy. Second day features the same five interventions but a difference appears at tasks level of nurse in the morning, when she performs only three tasks that are perfusion, alimentation via parenteral route and vacuum assisted closure. Each of these interventions is done at a specific moment, e.g. the intervention of *cleaning agent* must be performed in the morning and be followed by the intervention of *nurse.*

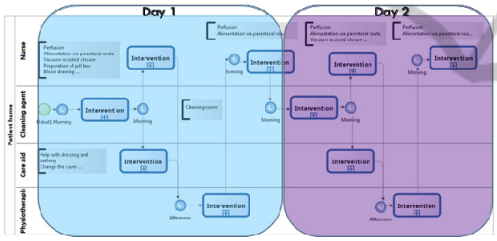

Figure 2: Home-care Workflow.

An intervention is a sequence of three actions, namely: 1) *consult transmissions*: consist in consulting eventual transmissions (remarks, alert, etc.) noted by a precedent stakeholder. 2*) Inform on performed acts*: display the acts to be performed during this intervention. It is the dynamic and adaptable part of the intervention. It changes each day, and for each stakeholder. 3) *Transmit information and alerts to other stakeholders*: consist in writing information about patient to inform or alert others stakeholders about any change on patient's state or environment.

3.2 Proposed Approach to Design Home-care Workflows

In recent years the concept of ontology has been largely studied in computer science. Ontologies allow for the sharing of knowledge to solve problems of semantic heterogeneity. There are several definitions of the concept ontology amongst which we choose "ontology is a formal, explicit specification of a shared conceptualization" (Thomas, 1993).

The works we mostly refer to is that of (Valls et al, 2001). The authors propose ontologies for medical home-care. The design of these ontologies is based on a model of home healthcare defined by a European consortium of professional homecare, European project K4Care.

Figure 3 shows the position of our proposal within the reference architecture of workflow management systems proposed by the WfMC (Hollingsworth, 1995). This architecture consists of five interfaces with the following components: 1) process definition tools: tools for graphical modelling of the process to automate and deploy.2) Workflow client applications: any applications to communicate to-do lists, messages, etc. to actors. There are applications that interact with the user. 3) Invoked applications: any application: DBMS, web service, etc. called or invoked during the deployment process automatically without intervention or interaction of a user. 4) Other workflow enactment services: any other workflow management system able to communicate with the workflow management system. This ensures the interoperability between different workflows management systems on the market. 5) Administrative and monitoring tools: provides access to admin tasks, such as suspension of a task, stopping a process, etc.

Based on this reference architecture for workflow management systems, we propose the use of ontologies at level 1 and 3: 1) in the process definition tool, the goal is to help the construction of patient personalized care workflow. 2) At the invoked applications, the goal is to guaranty interoperability and flexibility of workflow at run time.

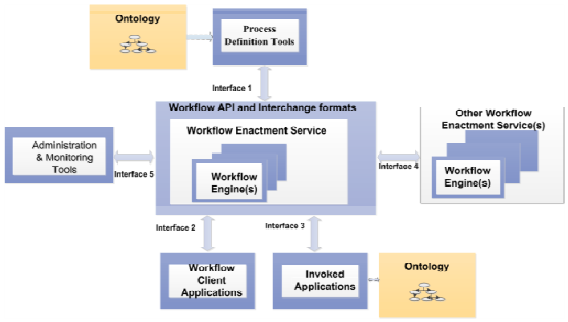

Figure 3: Position of our proposition in the reference architecture for workflows systems.

In this paper, we discuss workflow design. The idea is to use ontologies for help designing the workflow models for delivery, monitoring and

coordination of homecare. The definition of an intervention plan maps to the definition of a workflow model. They both define the distribution of tasks (care intervention) to actors (homecare stakeholders) in order to achieve the specific goal to improve the quality of home-care. But an intervention plan defines frequency of intervention and their duration over the treatment period.

Transformation Process. Figure 4 shows the steps to design customized BPMN process models for each patient. The resulting process models will be executed on workflow system.

We use these components: 1) a knowledge base is a fusion of the home-care ontology (presented in the next sub-section) and the BPMN ontology (Ghidini et al., 2011). This knowledge base contains patients' profiles and rules about actors and actions involved in treatment of a specific disease. 2) A Java application is based on OWLAPI. OWLAPI is a java API and reference implementation for creating, manipulating and serializing OWL Ontologies. This application queries the knowledge base about an intervention plan of specific patient. The output of this application is an XML file. The XML file defines an intervention plan of specific patient as a BPMN process model. 3) Tools are used for model-transformation. The XML file resulted in the last step must be transformed in a format suitable to be interpreted by a workflow engine. Tools such as ATL or XSLT are well suited, and allow transforming the XML file into a standard BPMN 2.0 file.

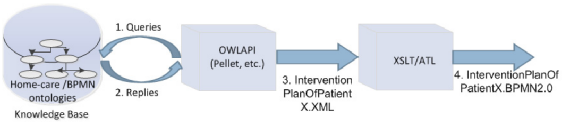

Figure 4: Methodology for customized workflow design.

Embryo of Ontology for Home-care. Little ontologies have been built in the home-care area, we present here two projects: ABAH: An Agent-Based Architecture for a Cooperative Information System (Zarour et al., 2007), an Algerian project with the goal to ensure interoperability in a multi agent system. K4CARE European project (presented above) with their two ontologies APO: Actor Profile Ontology and CPO: Case Profile Ontology: CPO is for representing symptoms, diseases, syndromes, etc.

Based on these ontologies, and our own surveys of current practices in homecare, we propose a high level ontology of home-care. It is represented as the usual RDF triples where circle represent class (concepts of home-care domain) connected by relationship arrows (figure 5). For ease of reading we have not presented the inverse functions (relationship)

This ontology contains global information about a structure and organization of home-care (actors, roles, etc.) as well as profile of patients and the task and actors needed for each disease.

To build this ontology of the home-care domain, we followed a synthesis of different methodologies in literature such as the ones proposed in (Uschold and King, 1995), (Staab, 2001). The ontological engineering process for building the home-care ontology has been performed under four steps: 1) Step 1: this step consists in identifying the goal to define the ontology, the users of this ontology and scenarios of using this ontology.

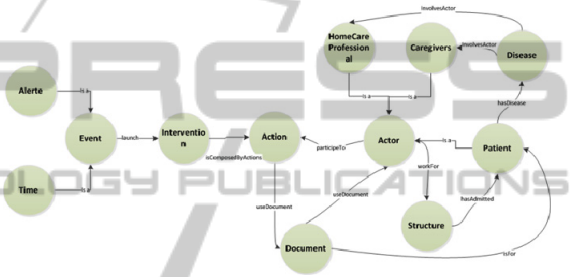

Figure 5: Main classes and relations of the ontology for home-care.

2) Step 2: based on the result of the first step, we define the basics concepts and relationships for this ontology. 3) Step 3: we choose a tool to design the ontology and start buiding frome the general concepts to the more specific. 4) Step 4 is an iterative step, consisting in maintiaining the the consistency of the ontology.

4 CASE STUDY

The proposition consists in indicating the profile of the patient: pathology, family caregiver, etc. The application, based on the ontology and the patient profile, proposes an intervention plan: set of actors involved in home-care, tasks, sequence of interventions and frequency of these interventions. The solution is based on populating the ontology by information of patient.

The case study concerns Mrs Bissière. She is 72 years old and has a Peritonitis Vesicular.

In the knowledge base we have this information.

Data that the professional introduces on the Knowledge base

- `MrsBissière hasDisease PeritonitisVesicular`

Data that models general domain knowledge:

- `PeritonitisVesicular InvolvesActor: Nurse, CleaningAgent, CareAid,and PhysicalTherapist`

We distinguish between two kinds of rules (expressed in SWRL): 1) rules that relate to concepts of home-care ontologies. 2) Rules that make a mapping between the two ontologies (home-care ontology and BPMN ontology).

These two types of rules are illustrated by the example below: the first rule indicates that, if patient X has a disease Y and disease Y involves the intervention of actor Z, then we deduct actor Z. The second rule indicates that, if there is an actor X then there is a lane X (*actor* that is a concept from the home-care ontology, mapped to the equivalent concept of *lane* in the BPMN ontology).

- `Patient(?x),hasDisease(?x,?y),InvolvesActor(?y,?z)->Actor(?z)`
- `Actor (?x)-> Lane (?x)`

We request the knowledge base to include the BPMN concepts to generate the home-care processes. An example of query is presented below

Query: `lane and (Actor and isInvolvedToCareDisease some (Disease and (isDiseaseOfPatient value MrsBissière)))`

Results: `Nurse, CleaningAgent,CareAid and PhysicalTherapist`

In this case study, the knowledge base includes the details of the patient profile: Mrs Bissière has vesicular peritonitis. Then, we query the knowledge base about the concepts of BPMN (lane) involved in the process of home-care of Mrs Bissière. It is possible to answer to this query based on knowledge and rules contained in the knowledge base.

5 RELATED WORK

There are several studies on the use of workflow in health-care, especially at the hospital. In the study of (Dadam et al., 2000), the authors discuss the challenges to elaborate workflow on clinical domains. They point out the critical role of workflows in the clinical area. Like Song and al (Song et al, 2006) where the authors note that improving healthcare workflows is very important for improving healthcare quality and efficiency. The authors of (Quaglinia et al., 2001) propose to design of a flexible workflow for the management of a stroke at hospitalization. This work is focused on a specific problem (stroke case) whereas in the case of home-care, each patient may suffer from various diseases including stroke. In addition, the issues of home-care differ from those encountered in the care in the hospital, where all stakeholders work within the same organization and use the same information system, with the ability to see to discuss the status of patients.

Many authors use ontologies combined with workflow in order to enhance flexibility or agility. In (Bouzguenda et al., 2008) the authors are interested to a collaborative environment to implement the WIO (Workflow Inter-Organizational). The authors propose a solution based on multi-agents systems for the execution of flexible web services to facilitate partner search and ontologies for searching and selecting the partners. In (Vieira et al., 2004) the authors suggest use of ontologies to achieve flexible execution of workflow. In our work, we are interested in the design of customized workflow models for each home-care patient. In our knowledge there are no others works with the same goals.

6 CONCLUSIONS

In order to improve communication and continuity in home-care, we propose system architecture based on a workflow engine to distribute tasks among home-care stakeholders. However, the characteristics of home-care processes make the design and enactment of home-care workflow a challenge. The goal of this architecture is to respect the reference architecture for workflow management systems while relying on ontologies to overcome these identified obstacles. We propose an approach using two ontologies (home-care ontology and BPMN ontology) to help designing home-care workflows. Our on-going work consists in completing the transformation pipeline in order to generate process model suited to be interpreted by a workflow engine.

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