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Personalized Service Creation by Non-technical Users in the Homecare Domain

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Abstract

One of the conditions for the successful introduction of ICT-based homecare services is to allow non-technical persons such as home nurses to personalize these services. We refer to this process of homecare service personalization as service tailoring. Service tailoring can be done by configuring and composing previously developed and deployed service building blocks. In this paper, we describe an approach that employs predefined information of care-receivers, called user profile, to hide most of the technical details from care-givers who do the service tailoring. First, we define the information to be included in a user profile and patterns that represent composition structures corresponding to common homecare tasks experienced in homecare. Then, we define how the service tailoring process can exploit information contained in the predefined user profiles. After that, we illustrate the approach with a tailoring scenario.

Keywords: Service oriented computing, service adaptation, user centric, personalization, service tailoring, user profile, e-health, homecare, user modeling, ambient assisted living

1. Introduction

In the near future, the industrialized world will face a situation where the population needing healthcare, namely elderly people, outnumbers the working population in healthcare [1]. Moreover, elderly people prefer to stay in their own home and live an independent life as much and as long as possible. Supporting independent living at home would be difficult because of the increasing gap between the number of elderly in need of care support and the number of available care-givers. Use of IT solutions is one of the means to close this gap. There are various IT services which are already available and can support elderly at home. However, most of them are designed without considering the individual preferences, needs and situations of care-receivers [2]. Services designed for the 'general' user may not be suitable for real users. This is particularly true for elderly at home, since they are subject to different bodily and mental limitations with respect to using services [3]. This calls for the provisioning of personalized services, according to the individual needs of each elderly.

Personalization of services based on dedicated design, implementation and deployment of software and hardware is not feasible because of the cost and time involved for doing so. Motivated by this, we introduced a service tailoring process in [4], which exploits the Service Oriented Architecture (SOA) paradigm [5] to create personalized composite services through configuration and composition of predefined service building blocks (SBB). The proposed service tailoring process guides caregivers to make configuration and composition choices based on their professional knowledge and with minimal assumptions on their technical knowledge and skills. The concept of SBB is used to denote the smallest manageable unit of service functionality from the point of view of care-givers. Each SBB represents a concrete service or alternative concrete services, abstracting from technical details that are not relevant to the service tailoring (i.e., to the care-giver). The outcome of a service tailoring process is a so called service plan, which represents a composite service tailored to the needs of a specific care-receiver as understood by the care-giver. A service

plan contains enough information to allow automated derivation of a complete implementation on a target execution platform.

In this paper, we elaborate on one aspect of the service tailoring process, namely guiding care-givers to create a care-receiver specific service plan, based on their professional knowledge and with minimal assumptions on their technical knowledge. We propose a template, called user profile, for collecting information on the care-receiver. A user profile is typically filled in by a care-giver before the start of the service tailoring process. The information in a user profile helps to partially automate the generation of a service plan by suggesting and/or constraining certain choices. Specifically, the user profile of a care-receiver may suggest usability options of selected SBBs (for example prescribing that the user interface should be voice-based, since the user profile indicates that the care-receiver has a visual impairment) and decision rules with respect to alternative behavior (for example prescribing that voice messages should be played immediately unless company is present, since the user profile indicates that the care-receiver has a corresponding privacy preference). We discuss our motivation for the user profile structure and show how a user profile can be used in the service tailoring process. We also discuss the impact of this use on other information structures such as the service plan and the description of SBBs.

We believe that the presented work contributes to user-centric service creation in the homecare domain. Our approach envisions a care-giver who can use his/her professional knowledge to define, within a short time period (typically during a home visit), a composite personalized service to support independent living of an elderly.

The rest of the paper is structured as follows. In Section 2, we describe our understanding of a homecare service tailoring platform and present a scenario to motivate the need of it. In Section 3, we explain the structure of a user profile and service plan. In Section 4, we apply constraints and preferences based on the user profile to the service plan. In Section 5, we demonstrate our approach by an example. In Section 6, we discuss related work and compare them with our approach. Finally, in Section 7, we discuss our findings and present future research directions and in Section 8, we conclude our paper.

2. Homecare Service Tailoring

We present a scenario to demonstrate the need for tailored homecare services, to describe our understanding of a homecare service tailoring system, and also to motivate the work presented in this paper. Let us assume:

Jan and Linda are 74 and 72 years old, respectively. They live together in a special home for elderly. They have different needs with respect to care support. Therefore, Nancy, as their care-giver should create different services to assist them. Jan has a hearing problem and uses a hearing aid and also he cannot speak clearly and understandably, whereas Linda cannot see well and so she must use glasses. Moreover, Jan suffers from Alzheimers disease and may not remember what to do, and Linda suffers from Parkinson disease and she cannot move around easily so she uses a wheelchair. Jan and Linda are prescribed to take certain medicines at certain times.

Nancy, uses existing SBBs to create service plans to assist Jan and Linda in taking their medicines at the right times. The service tailoring platform contains predefined user profiles of Jan and Linda.

As an example, consider the following SBBs:

Reminder: To notify care-receiver to do something. Other services can register to it for sending reminder.
Alarm: To inform the care-giver if there is a hazard situation.
Dispenser: To help care-receiver to take the correct dosage of the right medicines.

Fig. 1 depicts a simple version of homecare service tailoring and provisioning platform including their users and components. In this paper, we focus only on using information contained in user profile, to build and configure the service plan using the tailoring platform of the homecare system. We see in the example scenario that *Jan* and *Linda* have individual requirements and preferences, and *Nancy* must create different service plans for them by tailoring existing services. Creating such a service plan requires both domain knowledge and IT knowledge. Since the care-givers generally do not have deep IT knowledge, technical details of the service tailoring process should be abstracted as much as possible.

We aim at achieving such an abstraction by using the concept of service building block (SBB). Each SBB is the representative of one or possibly several concrete services (CS). SBBs abstract the technical details of CSs and provide a generic service specification like interface to be used by care-givers in the creation of a service plan. Each SBB has configuration parameters for specifying behavior constraints. Among these configuration parameters, in this

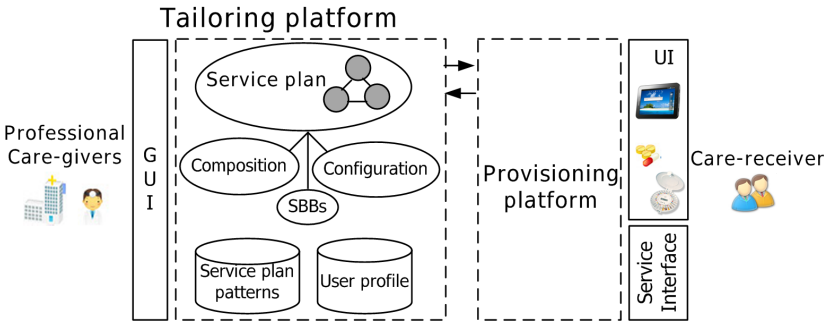

Figure 1: Homecare Service Tailoring and Provisioning Platform

paper we focus on usage requirements and context-aware parameters. Usage requirements stipulate the abilities which the care-receiver needs to interact or use the service; however, context-aware parameters are those parameters which evolve around the desire of the care-receiver in different situations. For instance, a reminder SBB represents several concrete reminder services in the real world care environment that remind the care-receiver differently, for example, via showing a text, playing a sound or vibrating a device connected to the care-receiver. At runtime, each SBB in the service plan will be substituted by one of its possible alternative CSs based on the abilities of the care-receiver that uses the service.

To simplify the creation of the service plan, we propose the use of service plan patterns, where a pattern can be provided by the service tailoring platform based on a selection of applicable homecare task from a menu with a list of common homecare tasks (for example, monitoring medication taking task). A service plan pattern, which is composed of a set of SBBs, is a treatment pattern for a specific generic homecare task. To personalize the selected service plan pattern for a specific care-receiver, the service tailoring platform configures SBBs used in the service plan pattern using the predefined profile of that care-receiver. The care-giver can refine further the service plan until it satisfies the medical requirements of the care-receiver.

We identified several homecare common tasks and their corresponding treatment patterns through several interviews with professional care-givers working in a care institute. Due to brevity, we exclude the identification process and we use one of these tasks namely *monitoring medication taking* and its treatment pattern. As mentioned earlier, we do not discuss how the provisioning platform utilizes the annotation information to map the SBBs in the service plan to the CSs and to generate executable specification. For the detailed explanation, we refer the interested readers to our earlier work reported in [6]. In this paper, we specify the necessary structure of a user profile and how these information can be exploited to build a service plan and its influence on the configuration of the service plan. However, we do not specify how the user profile instances are created, i.e., how the care-receiver specific information is collected.

3. User profile and Service Plan Patterns

In this section, we explain user profiles and service plan patterns and their role in the tailoring process.

3.1. *User Profile*

We define the user profile as follows:

Definition 1: *A user profile is a structured representation of the user's personal data, needs, and preferences that is used by the tailoring platform to configure SBBs of a service plan.*

We identify three necessary items which should be contained in a user profile.

a. **Personal Information:** Represents the personal information of the care-receiver such as name, age, weight, gender and language. In some scenarios, this information can affect the configuration of SBBs, for example assuming that *Jan* speaks Dutch language, the output message of reminder service should be in Dutch. We identify five parameters for personal information, but this can be extended if we deem other parameters necessary. The schema of the personal information is the following:
$U_I = (Name : String, Age : Int, Weight : Int, Gender : String, Language : String)$
For example, for *Jan*: $u_I = (Jan, 74, 84, Male, Dutch)$

b. **Abilities:** Represents the information about the care-receiver's physical and mental (dis)abilities. For example, if the care-receiver cannot hear well, he or she will not be able to use any services or devices which utilize sound as a means to convey messages to him/her. This information can be generalized based on the international classification of functioning, disability and health (ICF) [7] to: hearing, seeing, touching, mobility, speaking and memorizing. However, this can be extended if we deem other parameters necessary. Abilities are stored as Boolean variables where 0 means absent.
$U_A = (Hearing, Seeing, Touching, Mobility, Speaking, Sensing, Memorizing)$
For example, for *Jan*: $u_A = (0, 1, 1, 1, 0, 1, 0)$ means that he cannot hear but he can see and so on.
Instead of using either 0 or 1 as the value of an ability, we could use more general form of these abilities. For example, one can completely be blind 0, or he might have perfect seeing ability 1 or something in between. In that case we could assign a value in the range [0,1] to the ability parameters and adapt the service provisioning with regards to the value of the abilities (e.g., lower the value of seeing ability, larger the font size or lower the value of hearing ability parameter, louder the voice of the devices). Without loss of generality, in this paper we use only the values 0 or 1 but these can be easily extended to range values.

c. **Preferences:** Indicates how the care-receiver wants the desired services to be delivered to him/her in different situations. For example, the care-receiver may want to be reminded through vibration on the cellphone instead of receiving a voice message when he/she has company. Preferences usually are defined as a strict partial order such as *"I like A better than B"* [8]. Based on Dey's definition of context ("Context is any information that can be used to characterize the situation of an entity") [9], we add context information (such as location, time) to define preferences, i.e., *"I like A better than B in situation C"*. So, we define preferences as follows:
Definition 2: *User preferences are rules and conditions set by the user to characterize his/her desire in each context situation.*
A user preference consists of two parts. The first part is the condition part in which the situation is specified and the second part is the desired action for the situation specified in the first part. The conditional part includes three parameters namely: *Location, Time, People around*. However, these parameters can be extended if we deem other context information necessary. The possible values of the parameters are determined in consultancy with the care-givers. The second part is relates to user abilities. Here are some examples of user preferences:

- *If* (-, -, People around > 0) *Then* u_P =(x, 0, x, x, x, x, x)

Where "0", "1" and "x" denote "not desire", "desire" and "do not care" respectively. This preference means that when there is someone around the care-receiver, he/she prefers non visual messages.

- *If* (Location= outside the house, -, -) *Then* u_P =(0, x, x, x, x, x, x)

This means that when the care-receiver is outside the house, he/she prefers non audio messages.

- *If* (-, -, -) *Then* u_P =(x, 1, x, x, x, x, x)

This means that the care-receiver always prefers visual messages.
If there is more than one preference, the care-receiver could specify their priorities maybe with the help of care-givers otherwise the system applies a random order of the preferences.

3.2. *Service Plan Pattern*

Service plan patterns are treatment patterns for specific generic homecare common tasks. One such a pattern is shown in Fig. 2. The service plan pattern is represented by a BPMN like notation in which an action represented by a rounded corner rectangle refers to the use of an SBB. The decision points are represented by diamonds. The service plan pattern shown in Fig. 2 is for reminding forgetful people of taking their medicines. It consists of three actions: *dispenser, reminder* and *alarm*. This service plan assists a care-receiver to take his/her medicine on time. If it is time for taking medicine, the *dispenser* is enabled and a *reminder* message is sent to the care-receiver. In case he/she ignores the reminder and does not take his/her medicine after t_2 min, the *reminder* service repeats sending the reminder message up to n times. If the care-receiver still does not take the medicine, finally an *alarm* message is sent to the care-giver indicating that the care-receiver did not take his/her medicine.

The target users of the SBBs are either care-receivers (specified by a "+" sign in upper right corner of an action) or care-givers (specified by a "-" sign in upper right corner of an action). The target user of each SBB is indicated in its specification. Later, in the tailoring process, the user profile information is added only to those SBBs targeted to care-receivers.

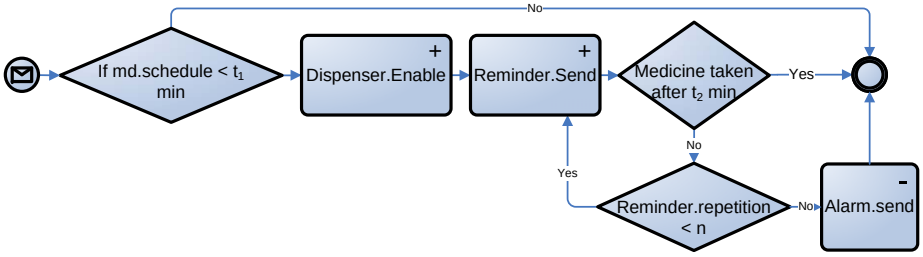

Figure 2: Service Plan Pattern for Monitoring Medication Taking Task

4. Creating a User-specific Service Plan

As already mentioned, there are already predefined service plan patterns for each care task in the tailoring platform. When a care-giver wants to make a specific service plan for a care-receiver he/she must specify the appropriate homecare task. Then, the tailoring platform adds the necessary information excerpted from the user profile to the service plan pattern. Hence, a detailed service plan is a pattern annotated with the information of a specific care-receiver.

The care-giver may make some amendment to the existing service plan generated automatically by the tailoring platform to adapt it to the situation of the care-receiver. The annotated information to the service plan can be of two types: hard constraints and soft constraints.

4.1. *Hard Constraints*

The ability information in the user profile is hard constrains which used to specify the service requirements (S_R) those requirements which must be met by the CSs. For example considering *Jan*'s profile, u_A = (0, 1, 1, 1, 0, 1, 0), all the SBBs in the service plan, with the care-receiver as the target user, will be annotated with the signature s_R = (0, x, x, x, 0, x, 0). This signature means that all those CSs of that SBB that do not need the first, fifth and the last abilities can be selected in the executable service plan. However, those services may or may not need the other abilities.

4.2. *Soft Constraints*

The second type of information which is added to service plans as soft constraints are user preferences. These constrains (S'_R) are those requirements which should be met by the CSs. For example, if we have the following user preference: If (-, -, People around > 0) Then u_P =(x, 0, x, x, x, x, x). We define an alternative signature: s'_R =(x, 0, x, x, x, x, x). After applying the hard constraints if there is more than one CS which satisfies all the requirements of the care-giver we apply the soft constraints one by one in the order already defend until either there is only one CS left or there is no more user preference. Applying the hard constraints before the soft constraints prevents selection of inappropriate services in case incompatible preferences are set with the abilities of a care-receiver.

5. Example

We use the scenario described in Section 2 to illustrate our approach. Based on *Jan*'s profile, a user specific service plan will be generated by the tailoring platform as shown in Fig. 3. As shown in the figure, the *reminder* and the *dispenser* are used by care-receiver where *alarm* SBB is used by the care-giver. Therefore, in the configured service plan only the *reminder* and *dispenser* SBBs have annotated information. Considering the abilities and preferences part of the user profile, we assume that *Jan*'s user profile has the following values:

$$\begin{cases} u_A = (0, 1, 1, 1, 0, 1, 0) \\ If(-, -, \text{People around} > 0)\ Then\ \mathrm{u}_P = (x, 0, x, x, x, x, x) \end{cases}$$

As mentioned in Section 3.1, we consider the abilities (Hearing, Seeing, Touching, Mobility, Speaking, Sensing, Memorizing). The above values then indicate that *Jan* has impairment with respect to hearing, speaking and memorizing, and that in case of company *Jan* prefers not to receive visual messages (e.g., no messages shown on the TV screen in the living room).

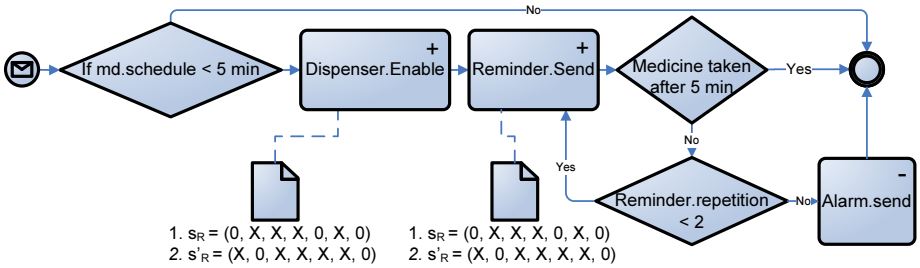

Figure 3: Service Plan for Jan, Automatically Generated Using Corresponding Pattern and Jan's Profile

The annotated information, represented as a data items, are attached to those SBBs used by *Jan* to guarantee their usability. For example, because *Jan* has hearing problem so the reminder SBB should match this disability of *Jan*, i.e., it should not use voice to convey its message. To do so, the appropriate signature (0, x, x, x, 0, x, 0) is connected to the reminder action. *Nancy* can further configure the created service plan for *Jan*, for example, by assigning values to t_1, t_2 and n as 5 min, 5 min and 2 times respectively.

As shown in Fig. 4, the service plan for Linda based on her profile is different:

$$\begin{cases} u_A = (1,0,0,0,1,1,1) \\ If(\text{Location= Outside the house, -, -})\ Then\ \mathrm{u}_P = (0,x,x,x,x,x,x) \end{cases}$$

Nancy can further configure the service plan for Linda by removing the *reminder* SBB and increasing waiting time after enabling *dispenser* from 5 to 15 min, as *Linda* does not forget the things and can not move fast. She just needs the assist of dispenser to take the right medicine.

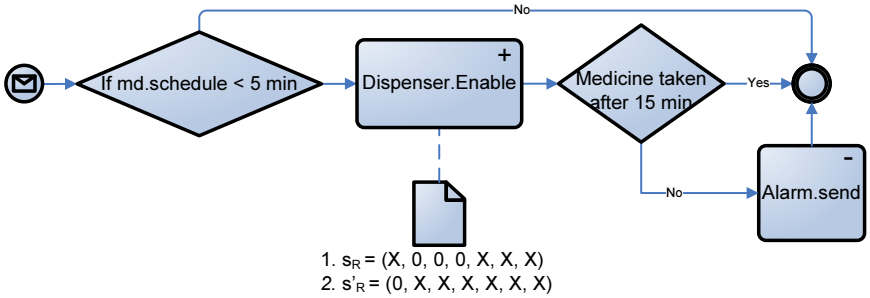

Figure 4: Service Plan for Linda Which is Configured by Nancy

In this way, the service tailoring platform generates the structure (i.e., the added date items), and any values that can be automatically derived from the user profile are filled in. The remaining values have to be provided by the care-giver in interaction through the service tailoring platform GUI.

6. Related Work

To decrease efforts required for personalization and to avoid manual development of business process models from scratch, the concept of *reference models* (patterns) and their configuration to satisfy the needs and preferences of target users seems as a promising approach [10]. To adapt a reference model to individual requirements, either additional information can be added to fine grain the reference model, or some of the existing elements can be eliminated from the reference model to coarse grain the reference model [10, 11, 12].

In our case, reference models are service plan patterns, which should be understood, altered and confirmed by the non-technical developers, such as care-givers. Therefore, we use coarse grained patterns which are automatically annotated based on the user profile and further refined by care-givers by adding extra information (see Fig. 3 and Fig. 4) and possibly removing information (see Fig. 4). Our service tailoring platform supports care-givers in adding/removing information.

Alternatively, flexibility and personalization of the process models may need to be supported at runtime. The exception handling approaches can be considered as one of the possibilities to achieve such flexibility [13]. This approach is not suitable in the homecare domain in which care-givers have to develop the service plans. We cannot expect care-givers to be well acquainted with these technologies and have enough technical knowledge for handling the service execution at runtime. In our approach, we abstract these technical details and allow care-givers to specify the personalization parameters at design-time.

User profiles have been used in the healthcare domain to provide some standards for sharing, managing and retrieving of care-receiver's physiological raw data (inter-operable electronic health records) among care-givers [14, 15, 16, 17]. Unlike our approach, these profiles are not used specifically for personalization of services. In other domains, user profiles and service catalogues have been used for personalized selection of services [18, 19, 20, 21], but such techniques are not applicable in the homecare domain as they do not take into account physical and mental constraints of users. User abilities are considered and defined in the ETSI user profile standard [22]. However, they are mainly providing some settings for deployment of ICT services, as opposed to specifically selecting services based on user profile information as proposed in our approach.

In other works, several approaches are proposed to support computer-based modeling of clinical guidelines and execution of these models [23]. Rule-based clinical guidelines like Arden Syntax for Medical Logic Modules (MLM), which is part of the Health Level Seven (HL7) standard [24], has been employed to facilitate knowledge sharing among care-givers (e.g., sharing knowledge for COPD [25] treatment). Workflow-based clinical guidelines (e.g., careflow [26, 27]) are proposed to define which task needs to be executed in which order while providing care to a care-receiver. Unlike in our approach, these works neither consider the use of workflow patterns nor the personalization aspects. The use of workflow patterns would allow non-technical care-givers create and personalize the service plan for a specific care-receiver. In [28], the implementation of an agent-based platform to execute clinical guidelines in an efficient way is proposed. In their work, the concept of user profile to provide patient-centered services is used. The user profile, however, is mainly used for specifying users preference parameters (e.g., on which or at what time care-receivers prefer to go to a clinical treatment). In our approach, we additionally considered care-receivers abilities in using services, which are important for selecting useful services.

Ageing well at home is a new paradigm. It provides elderly with higher degree of independence and dignity while guaranteeing higher quality of life for a longer time [29]. This is made possible with the assistance of IT services. There are several research projects [30, 31, 32] that aim at utilizing IT services in the homecare with an attempt to reduce the overall healthcare cost while increasing quality of life of care-receivers. However, the existing works do not consider the role of care-givers in tailoring the services or even allowing them to tailor the services, which is the main focus of our approach.

7. Discussion

This work is driven from problems in the homecare domain, namely cost-effective personalization of services to the needs of individual care-receivers. The tailoring platform has been designed for this particular domain, and certain criteria are specific to this domain. For example, care-receivers in the homecare domain can have limited abilities (physical or mental) in using the services. They may also suffer from a combination of diseases and these diseases also change (usually get worse) slowly during the time. Therefore, the services in the homecare domain should be tailored such that both care-receivers' long-term situation and short-term changes can be taken care of easily. However, a user-centric service tailoring approach, as we propose for homecare, is expected to be applicable in other domains as well.

We propose a semi-automatic approach for creating a service plan, which should then be approved, refined or configured by the care-giver. Since the proposed approach uses predefined treatment patterns and user profiles, one may think of a completely automatic approach, where a care-giver merely indicates the types of patterns and the profile of the care-receiver. However, an elderly usually suffer from a combination of diseases and hence, a care-giver who takes care of elderly can make better decisions about the type of configuration parameters based on his/her comprehensive knowledge about the care-receiver's situation. Moreover, accountability is an important factor in the homecare domain, which means that if something goes wrong, somebody should be responsible for the decisions that have been made while designing the user specific service plans. In addition, it has been found that completely relying on automated systems for elderly with several co-morbidities may have undesirable effects [33].

By introducing the notion of SBBs which can be mapped to concrete services, we separate the tailoring of the services from its provisioning. This separation gives a greater flexibility, i.e. the service plans are created without knowing which concrete services are available during runtime. The provisioning of the service plan is done without knowing how they are created, i.e. the provisioning platform only needs to execute the service plan. The configuration of service plans can be done at different levels of detail. For example, it could be the composition of building blocks or the configuration of each building block. At a lower level, it could be the provision of detailed technical information to enable mapping of building blocks used in the service plan to concrete services that can execute on the target platform. In this work, we do both, but we try to avoid dependency on the technical knowledge of the care-giver. Therefore, we use the concept of user profile to help refine a service plan pattern, and assume technical details to be handled by either the service tailoring platform or the service provisioning platform.

We have collected a list of common tasks that need to be performed in providing care to elderly. By interviewing professional care-givers, we identified that some of the tasks such as cleaning the room, washing the care-receiver and changing clothes of the care-receiver can not be automated. But there are some other tasks which can be automated such as reminding the care-receiver for doing certain activities and monitoring the health situation of the care-receiver. We are also defined, with the help of same care-givers, treatment patterns for those tasks which can benefit from the use of IT-based solutions. We are currently implementing a prototype of the proposed solution using the WebSphere Lombardi Edition[1]. We aim at validating our approach in a real life case in a care center that provides care services to elderly. Based on the validation results, we plan to improve and consider possible extensions of the proposed solution. One of the extensions is to represent user abilities in a more general form than just as Boolean parameters. For example, hearing and seeing can be represented by multi-value parameters, reflecting different degree of hearing/seeing (dis)abilities.

8. Conclusion

In this paper, we discuss a situation in which an elderly receives care at home. Unlike other domains, users of homecare services are subject to various impairments. This characteristic of elderly people is determinant in service usage. Hence, there should be a selection process of the services, not only based on user preferences, but also based on their health related situations.

For providing such services, we can use different approaches. For example, designing specific services for each particular user is an option. However, such a solution is not desirable because of the cost and time required in designing services for each and every elderly. Because of the high similarity of the care services at abstract level, we propose an approach to enable creation of a personalized homecare service based on SBBs which can be composed and configured easily by a care-giver. We can make a rich collection of homecare services using these SBBs. One could argue that configuring and composing already existing SBBs to make a service through tailoring is less expressive than developing the service from scratch. Indeed, some users may have very special needs or preferences which cannot be adopted in the properties of the SBBs nor in their composition. However, we still think that considering the cost aspect, a service tailoring approach such as ours is the best compromise.

Even though homecare services are similar at the abstract level, the usage requirements of their concrete services are different. To select proper services which are consistent with care-receiver abilities and preferences, we use an approach which adds information derived from the user profile to the service plan. We think that an appropriate user profile in the homecare domain should contain the care-receiver physical and mental abilities, and subsequently consider (dis)abilities in using services.

Acknowledgment

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