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Reusing Models of Actors and Services in Smart Homecare to Improve Sustainability

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Abstract: Industrial countries are faced with a growing elderly population. Homecare systems with assistive smart house technology enable elderly to live independently at home. Development of such smart home care systems is complex and expensive and there is no common reference model that can facilitate service reuse. This paper proposes reusable actor and service models based on a model-driven development process where end user organizations and domain healthcare experts from four European countries have been involved. The models, specified using UML can be reused actively as assets in the system design and development process and can reduce development costs, and improve interoperability and sustainability of systems. The models are being evaluated in the European IST project MPOWER.

Keywords: Homecare, Smart house, Service Oriented Architecture, System architecture, UML, Model-driven software development, standardisation, HL7

Introduction

Home care is a concept where new technological solutions allow the elderly to live independently at home. The consumers, typically elderly, chronically ill and cognitive disabled are empowered by state-of the art information and technology in their homes to achieve the overall goal of aging in place[1-3].

The technological advances are being deployed into the homecare domain, and many projects are working on *smart house* technology [4, 5] for homecare. This concept needs, in addition to technical devices, to be supported by a team of actors including family members, healthcare personnel and non-healthcare services organizations. A smart homecare system is both complex and expensive to build. Efficient development of complex systems should seek to *reuse* components and services through abstraction to "*manage complexity and guarantee continuity*"[6]. Krueger states that *"in order to reuse artefacts, software developers must either be familiar with the abstractions a priori or must take time to study and understand the abstractions."[7].* The importance of understanding the domain concepts is emphasized by Beyer et al in [8] where they state that *"to reduce the effort for system evolution it is highly desirable to incorporate generic components, that can be reused in different contexts"*.

Lenz, Beyer and Kuhn elaborate on this in [9] and argues for a separation of domain concepts and system implementation: *"in order to cope with domain evolution, modelling of domain concepts should be separated from IT system implementation. IT systems should be implemented by IT experts and medical knowledge should be modelled and maintained by domain experts."* A reusable reference model for *smart homecare* can form the basis for more efficient development of smart homecare systems and reuse of its services[8, 10-12]. This article presents the work done in the MPOWER project [13] where a model of the core business process actors and services in smart homecare systems has been specified. Two research questions are addressed:

- *Which actors (persons and systems) are involved in the teamwork treatment of smart homecare service consumers?*
- *Which information services are needed to support the (treatment) processes?*

The focus of the work is on actors and information service support for elderly and cognitive disabled. The project result is a formal representation of actors and services that enable service reuse and increase the understanding of actor-service dependencies.

The remainder of the paper is organized as follows: First the methods and materials for specifying the actor and service models are described. Next, the core of these models is presented before the implications they may have on the development of sustainable healthcare systems are discussed.

1. Methods and Materials

Domain experts and user groups for elderly and cognitive disabled in four European countries were involved in the requirements process; Austria, Poland, the Netherlands and Norway [14]. The process produced the "User Scenario Specification" describing the problems experienced by the target groups and the planned assistive smart homecare services. Figure 1 shows the overall iterative approach for the work.

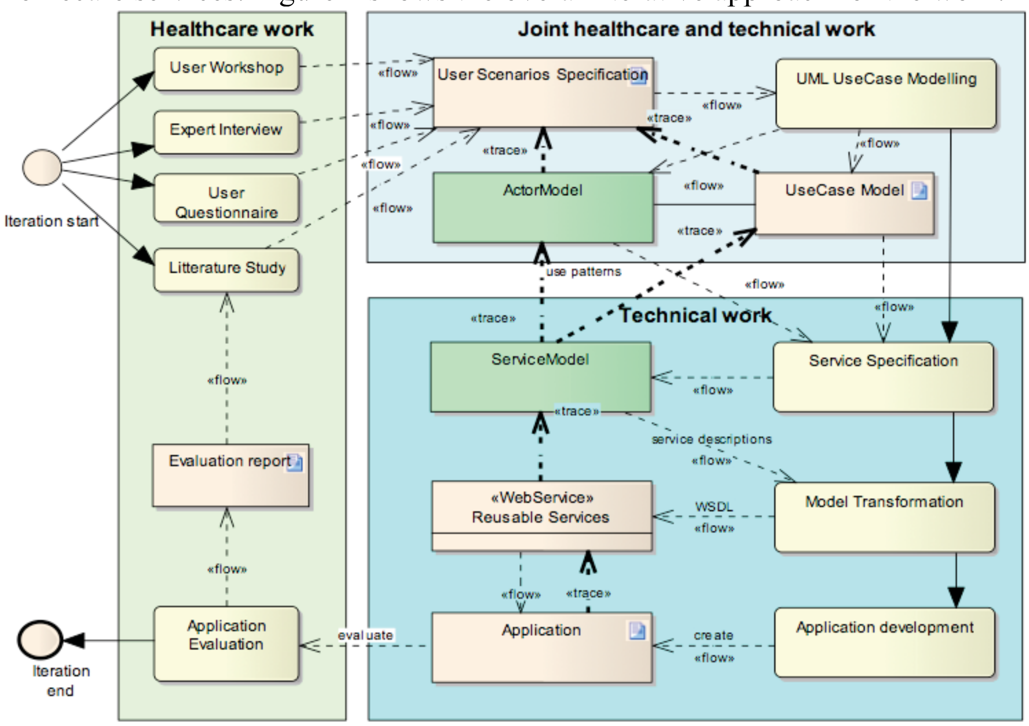

Figure 1: The iterative model-driven development process used to identify actors and services. Artefacts are shown as rectangles whereas the activities are denoted as rectangles with rounded corners.

This user requirements document was used as the basis for UML [15] UseCase Modelling activity that produced the UML Actor and UseCase Models. The modelling work was a joint effort by healthcare personnel and system architects, as recommended by Lenz et al in [9]. The Service Specification activity uses the Actor and UseCase models as input to create the Service Model which is used in the Model Transformation [16-18] activity for creating Reusable Services (Web Services). Finally, the Reusable Services are used by application developers to implement applications that will be evaluated by healthcare personnel. The evaluation report (from Application Evaluation activity) is used as input for the succeeding iteration. The bold arrows in Figure 1 highlight traceability links between artefacts [19].

The Use Case Model, Actor Model and Service Model were developed using Unified Modelling Language (UML) with the IBM Profiles for Software Services [20] according to Service Oriented Architecture (SOA) [21]concepts. The services in the Service Model were identified according to best practice SOA in general [21], and for healthcare especially [22, 23].

2. Results

In this paper, only a selection of the most important elements from these models is presented in detail. Full specifications are accessible on the MPOWER Website [13]. The use case and service modelling activities resulted in three UML models: the Actor Model, the Service Model, and the Use Case model that relates the two first.

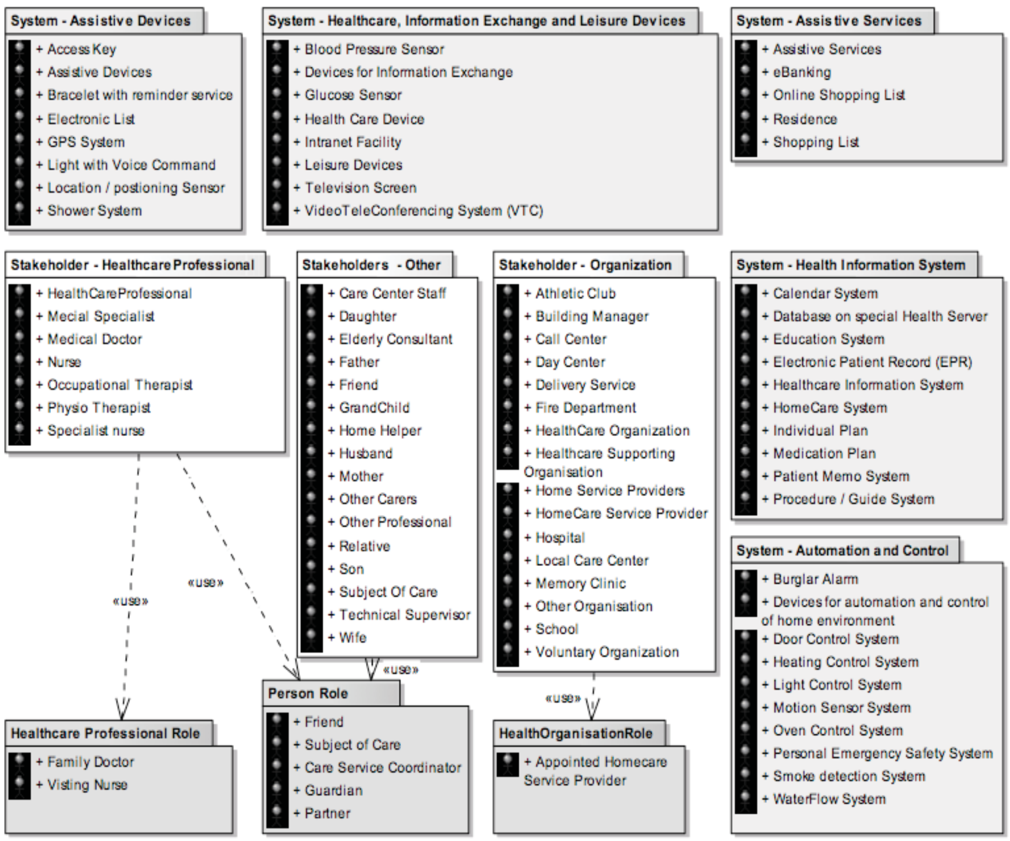

Figure 2: The ActorModel showing the elements of the system, stakeholder and role parts.

The Actor Model (Figure 2) has three main parts: System (light grey), Stakeholders (white) and Roles (dark grey). The stakeholders can have different roles as shown in Figure 3. The roles that the stakeholders can take are modelled as a dependency link, e.g., only a Nurse or a Specialist Nurse can have the role as a Visiting Nurse. All Healthcare Professionals can be a patient themselves (role Subject of Care).

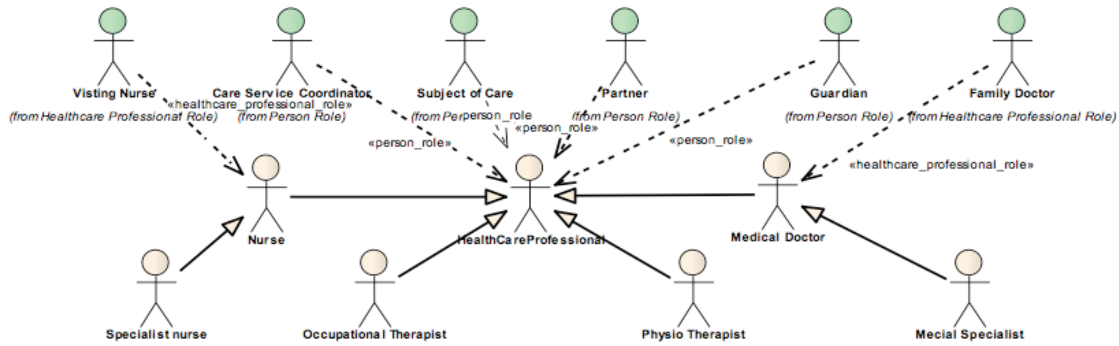

Figure 3: The relationships between healthcare professional actors and roles as defined in the ActorModel

The UseCase model defines activities that the actors (and roles) participate in. These activities are the link to the services in the ServiceModel. Figure 4 shows a use case diagram for calendar management activities involving systems, stakeholders and roles.

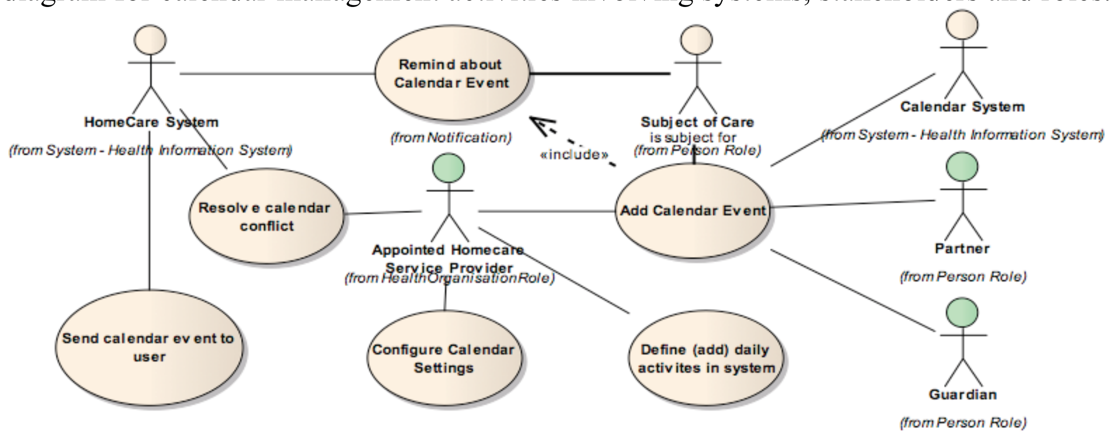

Figure 4: Actors, Roles and Use cases in the usecase diagram for Calendar Management services

From the scenarios and use cases five categories of services were specified (Figure 5) using the service identification principles described in [23].

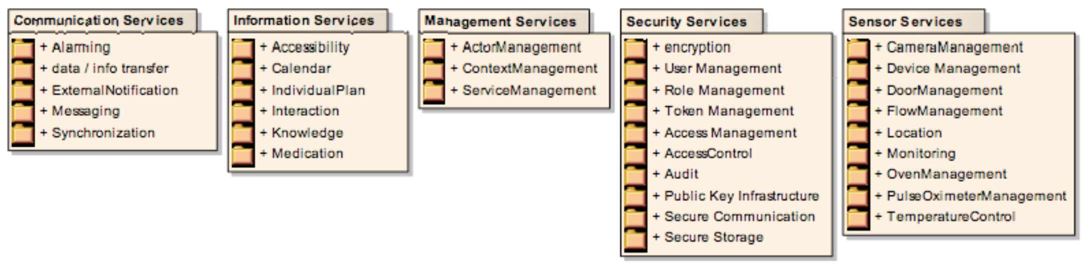

Figure 5: The service categories in the ServiceModel. The elements of each category are resuable services

3. Discussion

The Actor Model specified from the User Services Specification includes formal actor and role specifications in UML that allows for reuse across functional domains such as medication management and home automation services. A common and formally specified Actor Model means that 1) Actor-System (service) interaction can be precisely specified, 2) access control for services can be derived from use cases with actor interaction, 3) Actor-System dependencies can be traced through trace links, and 4) Systems and services can be compared to each other.

The elements of the Actor Model were agreed by all four countries participating in the specification process, and it is conform to the CEN TC251 CONTSYS [24] standard and compatible with those actors described in [25] and [5]. An important finding when modelling the Actor Model was the feasibility of using *roles* in use case modelling. In many cases, it is not the *actor* itself that interacts with the system, rather an actor taking a certain role. Using this concept, the constraints will be put on which *actor* that can take a *role* instead of modelling use cases for different actors in different contexts. Figure 4 shows an example where the *Appointed Homecare Service Provider, Partner* and *Guardian* roles are used to interact with the add calendar event activity.

The services identified for the Service Model are being implemented and used in two proof-of-concept applications in the MPOWER project [13]. The applications communicate with the services through HL7 messages, and all underlying complexity is handled by the services. The results from these developments will evaluate the services' reusability in the domain. Preliminary development results show that:

- Applications can be developed more rapidly by reusing high-quality services [8].
- Functionality can be reused across applications and organisations and nations, e.g., sending SMS, PKI, calendar management, medication list management.
- Clearly defined actors will improve the validity of the system services being developed and improve sustainability[6, 26]
- The gap between business processes and supporting information systems can be shortened by applying the Service Oriented Architecture concepts [10, 21-23]
- Aligning service and actor descriptions with national and international standards will promote standardisation and facilitate reuse of services and components across organisations and nations, thus improving interoperability[27]

Reuse of software and design is not trivial. Krüger states that *"for a software reuse technique to be effective, it must reduce the cognitive distance between the initial concept of a system and its final executable implementation."* The Actor and Service models presented herein are the results of a formal process to reduce this distance.

The results presented herein are generalisations, and may not be directly applicable to all domains without prior local adaptations. The actor and service models can serve as reference models from which nation and organization specific models can be developed in accordance with the prevailing ways of organizing care and legislations. The specification of reference models must be supported by standards developing organisations such as CEN TC251 and HL7 [28]. The proposed models being implemented and evaluated in the MPOWER Project [13], and will be presented for the HSSP project [29] and national standardisation bodies in Europe.

4. References

[1] Magnusson, L.H., E.; Borg, M, *A literature review study of information and communication technology as a support for frail older people living at home and their family carers.* Technology and disability, 2004. **16**(4).

[2] Wacanta, J.e.a., *Number of dementia sufferers in Europe between the years 2000 and 2050.* European Psychiatry, 2003. **18**: p. 306-313.

[3] Demiris, G., et al., *Older adults attitudes towards and perceptions of smart home technologies: a pilot study*. Medical Informatics and the Internet in Medicine, 2004. **29**: p. 87-94.

[4] Helal, S.C., *The Gator Tech Smart House: A Programmable Pervasive Space*. Computer, 2005. **38**(3): p. 50.

[5] Stefanov, D.H., Z. Bien, and W.-C. Bang, *The smart house for older persons and persons with physical disabilities: structure, technology arrangements, and perspectives*. IEEE transactions on neural systems and rehabilitation engineering, 2004. **12**(2): p. 228-50.

[6] Shaw, M., *Abstraction techniques in modern programming languages*. IEEE Software, 1984. **1**(4): p. 10-26.

[7] Krueger, C.W., *Software reuse*. ACM Computing Surveys (CSUR), 1992. **24**(2): p. 131-183.

[8] Beyer, M., et al., *Towards a flexible, process-oriented IT architecture for an integrated healthcare network*, in *Proceedings of the 2004 ACM symposium on Applied computing*. 2004, ACM Press: Nicosia, Cyprus.

[9] Lenz, R., M. Beyer, and K.A. Kuhn, *Semantic integration in healthcare networks*. International journal of medical informatics, 2007. **76**(2-3): p. 201-207.

[10] Kawamoto, K. and D.F. Lobach, *Proposal for Fulfilling Strategic Objectives of the U.S. Roadmap for National Action on Decision Support through a Service-oriented Architecture Leveraging HL7 Services*. Journal of the American Medical Informatics Association, 2007. **14**(2): p. 146-155.

[11] Lenz, R., M. Beyer, and K.A. Kuhn, *Semantic integration in healthcare networks*. International journal of medical informatics, 2006.

[12] Lenz, R. and K.A. Kuhn, *Towards a continuous evolution and adaptation of information systems in healthcare*. International journal of medical informatics, 2004. **73**(1): p. 75-89.

[13] The MPOWER Consoritum. *MPOWER Website*. 2007 [cited 2007 June 15]; Available from: http://www.mpower-project.eu.

[14] Prazak, B., et al. *User Requirements as Crucial Determinants for the Development of New Technological Solutions for Elderly Care - Exemplified in an European Project*. in *AAATE*. 2007. San Sebastian, Spain: IOSPress

[15] Object Management Group (OMG), UML 2.0 Superstructure FTF Rose model containing the UML 2 metamodel, Object Management Group (OMG), 2005, http://www.omg.org/cgi-bin/apps/doc?ptc/04-10-05.zip

[16] Frankel, D., *The MDA Journal: Model Driven Architecture Straight from the Masters*. 1st ed. 2004, Tampa, Florida, USA: Meghan-Kiffer Press. 219.

[17] Mellor, S.J., *MDA Distilled: Principles of Model-Driven Architecture*. 2004.

[18] Miller, J. and J. Mukerji, MDA Guide Version 1.0.1, Object Management Group (OMG), 2003-06-13, 2003, http://www.omg.org/docs/omg/03-06-01.pdf

[19] Walderhaug, S., et al., *Traceability in Model-Driven Software Development*, in *Designing Software-Intensive Systems: Methods and Principles*, P. Tiako, Editor. 2008, IDEA Group: Langston.

[20] Johnston, S. *UML 2.0 Profile for Software Services*. 2005 [cited 2007 June 15]; Available from: http://www.ibm.com/developerworks/rational/library/05/419_soa/.

[21] Erl, T., *Service-Oriented Architecture Concepts, Technology, and Design*. The Prentice Hall Service-Oriented Computing Series ed. T. Erl. 2006, Crawfordswille, Indiana, USA: Prentice Hall.

[22] Honey, A., et al., SOA4HL7 Architecture Document, Health Level Seven, August 16, 2006,

[23] Honey, A. and B. Lund, Service Oriented Architecture and HL7 v3: Methodology, HL7 Service Oriented Architecture Special Interest Group (SOA SIG), November 10, 2006, 2006,

[24] CEN TC251, EN 13940-1: Health Informatics - System of Concepts to Support Continuity of Care - Part 1: Basic Consepts, European Committee for Standardization, September 26, 2006,

[25] Toivanen, M., et al., *Gathering, Structuring and Describing Information Needs in Home Care: A Method for Requirements Exploration in a "Gray Area"*. MEDINFO 2004: Building High Performance Health Care Organizations, 2004: p. 7-11.

[26] Coiera, E. and E.J. Shovenga, *Building a Sustainable Health System*, in *IMIA Yearbook of Medical Informatics 2007: Biomedical Informatics for Sustainable Health Systems*, A. Geissbuhler, R. Haux, and C. Kulikowski, Editors. 2007, Schattauer Publishers. p. 250.

[27] Mykkeänen, J., *Specification of Resuable Integration Solutions in Health Information Systems*. Department of Computer Science. Vol. Doctoral Dissertation. 2007, Kuopio, Finland: Kuopio University Publications, Finland 133.

[28] Blobel, B., *Authorisation and access control for electronic health record systems*. International Journal of Medical Informatics, 2004. **73**(3): p. 251-257.

[29] HSSP Project, The HSSP Roadmap: HSSP, Version 1.0, Joint HL7-OMG Healthcare Services Specification Project, October 10, 2007, 2007,