Key scenarios, Use Cases & Architecture of an E-health Homecare Instance

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ABSTRACT

This paper presents a key part of the design process of an e-health application for elderly patients in a home setting. It encompasses the key scenarios, use cases and the architecture consisting of system components, applications, and interfaces for supporting homecare of users with chronic health conditions. Care at home intends to provide health care at the same level and quality at the patient's home complementary to the work done in other health sectors. This paper presents a global overview of the design methodology in addition to depicting the different layers of the system and their components. This paper builds upon known requirements for homecare and serves as basis for the implementation of instances of such system.

CCS CONCEPTS

• **Requirements Engineering**; • **Internet of things**; • **Digital Health**;

KEYWORDS

Homecare, User Requirements, Key Scenarios, Use Cases, Architecture

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1 INTRODUCTION

The design of homecare systems requires the involvement of many stakeholders. The first step is the gathering of user requirements, e.g., through exploring their needs by interviews [1] [9] . The next steps are the definition of key scenarios and creation of use cases followed by the design of the system architecture. IT supported homecare depends strongly on the networking of physical devices, software, sensors, actuators, and network connectivity that enables these objects to collect and exchange health data in a standardized way. The homecare objects are sensed and/or controlled remotely across existing network infrastructures, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy, and economic benefit. Homecare devices, include IoT, in this context, patient's vital data can be collected in/from their home environment. These health monitoring devices can range from blood pressure and heart rate monitors to advanced devices such as electronic wristbands or advanced hearing aids [2] . Specialized sensors can also be equipped within living spaces to monitor the health and

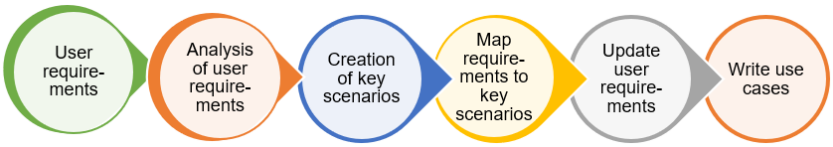

Figure 1: Human-centered design process

general well-being of older patients with chronic health conditions, while ensuring that proper treatment is being administered and assist people regain quality of life. More and more end-to-end health monitoring platforms are coming up for patients with chronic health conditions, helping in the care planning and managing of health vitals and recurring medication requirements. Such a homecare system is a complex distributed system involving different stakeholder, development platforms and teams and requires a sophisticated software engineering process with a reference architecture as a guide. The identification of a reference architecture can lead to a faster, more focused development and an exponential increase of homecare-related solutions [3] . This paper focuses on key scenarios and use cases, the system characteristics, and the system boundaries. The homecare system instance we are presenting here is CAREPATH, which is a Horizon 2020 funded project, proposing an ICT based solution for the optimization of clinical practice in the treatment and management of multimorbid older patients with Mild Cognitive Impairment (MCI) or mild dementia. To achieve this, CAREPATH designs and develops tools to support healthcare professionals of the caregiving process by administering care plans of their patients, any change in one or many plans will lead to a recalculation of the schedules allowing them to choose between alternative plans and finally to confirm the selected one. Again, the system will interface with existing tools, techniques, and processes. This paper presents the key scenarios, use cases and an architecture, which define the various application for the pilots of CAREPATH. These applications cover the following areas (the list is indicative but not exhaustive): Care Plan creation, Home / Health Monitoring, Data Analysis, Clinical Decision Support, Medication Management, Patient Empowerment, Appointment Management, Smart Reminders, etc. The presented scenarios and uses cases demonstrate the relevance of CAREPATH for the users' health. They show the envisioned context of use for patients and their informal caregivers as well as for healthcare professionals when using the CAREPATH system. The CAREPATH architecture is divided in several layers comprising the CAREPATH platform, which include from top to down, the presentation layer, the security layer, the application layer, the service layer, the knowledge layer, and the persistence layer. Additionally, the architecture contains links through dedicated connectors to external systems.

2 SCENARIOS AND USE CASES FOR INTEGRATED CARE

In the following sections, we will describe how key scenarios for the CAREPATH system were developed and report the results of these activities. The use cases will be utilized to build the CAREPATH architecture and define the technical specification of CAREPATH applications as shown in Figure 1: Use cases model requirements, they are highly dynamic in nature, and the more we examine a scenario, the more we learn, and the more use cases might change. To further complicate the issue, changes to one use case can lead to changes in the others [4] .

2.1 CAREPATH key scenarios

In CAREPATH, scenarios were captured in form of use scenarios, that describe key application use cases of the CAREPATH system. Therefore, they were called key scenarios. This methodology is particularly used in the beginning of a development project to provide a framework for the iterative requirements engineering phase. Key scenarios can also be used later in the project, as the basis for usability evaluations and to identify hazard-related use scenarios. They explicitly deal with the usage of a technical system, the context of use, and the allocation of functions between the technical system and human users. From an overall perspective they describe how a technical system may be used to fulfil its users' tasks and goals. Therefore, key scenarios describe end user activities as well as application functionalities, thus bridging the gap to the creation of use cases and the formulation of technical system requirements [5] [6] [7] . Scenario's development focusses on key application cases such as the CAREPATH Clinical Decision Support Module (CDSM) and its features, interaction with other components etc. In the following sections we provide a short description of the methodology used for creation of key scenarios and its results.

2.1.1 Methodology. Since domain knowledge is required to develop key scenarios for CAREPATH applications, an initial list of key scenarios considered crucial for development was compiled and clinical partners were asked to create the details of the listed key scenarios. For this purpose, a template providing instructions on how to compile the scenarios was provided (see section 2.1.2) and personas were created to ease scenario writing (see section 2.1.3). Once finalized, key scenarios were used to receive a common understanding on how the CAREPATH system shall behave towards the user, what functionalities and features are required, e.g., on the Patient Empowerment Platform (PEP) and the Adaptive Integrated Care Platform (AICP) for health professionals. As mentioned, key scenarios were also used to evaluate user requirements defined until now and see where they need to be refined, enhanced or new ones created.

2.1.2 Template for creation of scenarios. There are many formats on how to document scenarios, some suggest a story-like approach, others to conduct a task analysis, or elicit workflow descriptions etc. In CAREPATH, a combination of all formats was used with a short story-like description of the use scenario ('Scenario' in tab1), a list of user tasks describing the workflow ('User tasks' in Table 1) and in addition to that, clinical partners were asked to provide

Table 1: example template for definition of key scenarios

	Action
Scenario	Provide a short description of the use scenario, so workflow and context-of-use become alive for all partners
User roles involved	GP □ Geriatrician □ Nurse □ PT/OT □ Dietician □ Social worker □ Patient □ Informal caregiver □ Other (specify) □ . . ..
User tasks	List user tasks depicting the workflow
Design in-/output of CAREPATH services	Describe here whatever is important to mention in regard to how a CAREPATH service should be presented to users enabling them to fulfil their tasks. For example, if input is required from a user, how shall the system be designed to collect this input. If the system provides output such as an early warning or analysis of a patient's health measurements, how shall this information be presented to the user.

as much as possible their vision of how CAREPATH applications should be designed to support the user best in fulfilling their tasks and goals ('Design in-/output of CAREPATH services' in Table 1). This approach was considered most useful, because in the e-health domain, established processes are most often underlying the achievement of tasks involving several user roles, e.g., interaction between physician, nurses, and dietician. Therefore, it is crucial for development to understand each user role's tasks and needs as well foreseen workflows. So, as a result we were able to receive very valuable input from a design point of view and how issues could be accounted in the best way.

2.1.3 Personas. As mentioned above all clinical partners were asked to create key scenarios. In order to have a more coherent result, personas were created to be used as representatives of certain user roles. These made the scenarios also more lively and easier to understand. For this purpose, using personas is an established method in scenario writing. The following personas were created for CAREPATH key scenarios:

Carmen (patient): is a 72-year-old lady who has been living with type 2 diabetes for 10 years. Unfortunately, despite treatment, Carmen is not only developing a heart condition that might lead to heart failure. Even worse, she starts to show signs of memory loss and cognitive impairment leading to the fact that she forgets more and more often to, e.g., take her medication as prescribed and manage her appointments with health professionals. Note: in some key scenarios, Carmen is affected by co-other morbidities or living alone; this is done to illustrate better the purpose of the scenario.

John (informal caregiver): John is Carmen's 75-year-old husband. He used to own a small bakery where he sold together with Carmen fresh pastries. Since Carmen's health situation is deteriorating, he is helping her with keeping up with her tasks to-do to manage her health condition, e.g., making sure that she takes her medication on time and accompanies her to appointments with health professionals. John has access to Carmen's daily care plan on his tablet and this way can follow-up on tasks Carmen is expected to fulfil to manage her health condition. He has also the possibility to document symptoms Carmen is experiencing, e.g., after medication intake she often feels dizzy; therefore, her geriatrician, Peter, can check on this in the next visit.

Peter (geriatrician): is 54-year-old physician who is responsible at Smith's Hospital for 20 years for diagnoses and treatment of older adults. Quite often these adults are affected by multimorbidity and cognitive impairment such as MCI (Mild Cognitive Impairment) or dementia. Peter assesses older adults, refers them to other health professionals and collaboratively develops care plans for their treatment.

Nora (general practitioner): Nora is Carmen's GP that Carmen visits in case she is suffering from everyday health conditions such as the flu or gastrointestinal disorders. Nora has access to the care plan Peter has defined for Carmen. She will carry out tasks as prescribed by Peter, e.g., make a blood test every 3 months, uploads the results to the CAREPATH platform and changes Carmen's care plan according to her treatment decisions.

Diane (nurse): is a 48-year-old nurse working together with Peter in the geriatric's department at Smith's Hospital. She is very experienced with the needs of older adults and manages the department. She has access to the CAREPATH platform to see the care plans of her patients, so she knows about their medication plans, examinations and may provide comments in regard to symptoms requiring may be a change in medication or about the mood of the patients.

Emily (occupation therapist): Emily is a 42-year-old occupational therapist at Smith's hospital. She conducts occupational therapy as prescribed by physicians such as Peter. She has access to Carmen's health record and can look at her care plan to be informed about Carmen's overall health status and what Peter wants her to do work on with Carmen. After completion of the prescribed number of occupational therapy sessions, she will report on the CAERPATH platform about Carmen's achievements during the therapy.

Ellen (dietician): is the 30-year-old dietician at Smith's Hospital. She meets with patients to examine their eating habits and how these may affect their health conditions. She agrees with her patients on goals and writes diet plans which she then uploads to the CAREPATH platform. These plans will become part of her patients' care plans and also be made available for patients on their platform (PEP), so they are aware of their diet plan and are supported in following-up on it.

2.1.4 Results. In total, 20 key scenarios were created by clinical partners, 7 scenarios for AICP and 13 for PEP. As expected, there was overlap among key scenarios revealing a different understanding among partners on how the system should behave or which functionalities are necessary to offer and how. Beyond this, key scenarios were matched with existing user requirements and as it was the purpose of this process, mismatches and missing features were identified in the defined user requirements. To harmonize results

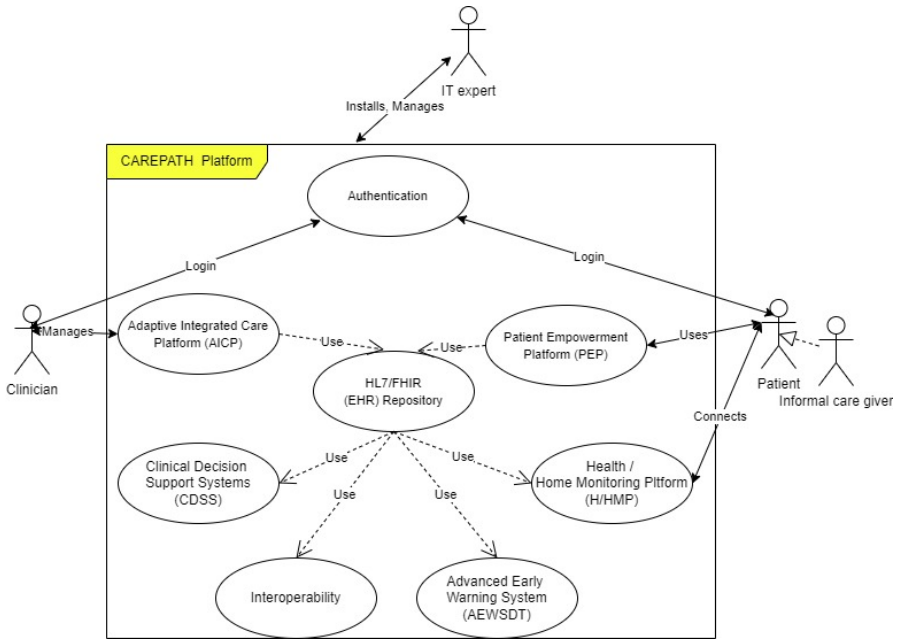

Figure 2: General CAREPATH use case

and update user requirements so they satisfy partners preferences, a list of open issues was compiled and discussed with the consortium, with clinical partners in two dedicated key scenario sessions and one individual session with each clinical partner. After issues were solved user requirements were refined or new ones created to reflect agreed functionalities, features, and workflows. For example, clinical partners pointed out the necessity for personalization of how patients will interact with the daily care plan on PEP. Some patients may prefer to be reminded about most tasks to do others wish to receive only reminders for selected tasks. Therefore, besides that health professionals can define on AICP about which task, e.g., medication intake a patient will be reminded, there will be a configuration page on PEP where patients together with their informal caregiver can configure their preferences in an easy way. During discussion of key scenarios open issues like an escalation scheme for reminders could be agreed on as well. And, country-specific differences became apparent, e.g., in the UK there is a central booking system for appointments with health professionals which clinics can use, whereas in Germany patients/informal caregivers are mainly responsible themselves for making appointments. Missing user requirements were also identified, e.g., it may happen that health professionals change patients' care plans even if the patient is not present, because, e.g., an examination result comes in later. To avoid confusion on patients' and/or informal caregivers' side, they need to be informed about this on their daily care plan and be explained what the change is about. Such a user requirement did not exist so far.

3 USE CASES

The user requirements and key scenarios just give us an outline of what is required. Use Cases are the next step in the design process. In this section we present one use case (see Figure 2) that demonstrates the relevance of CAREPATH for patients' health. It shows the envisioned context of use for patients and their informal as well as formal caregivers such as clinicians. These use cases describe the what and not the how of the envisioned CAREPATH components. The idea is that a product can be described using many use cases, which can be depicted in a use case diagram. A use case is a list of actions or event steps typically defining the interactions between a role (known as an actor) and a system to achieve a goal [8] . We started by detailing the main use cases and then presenting the sub use cases. The general use case of CAREPATH serves as an example (see Figure 2:) it focuses on the enhancement of healthcare interventions for the management of conditions of elderly multimorbid patients.

4 CAREPATH REFERENCE ARCHITECTURE

Considering all the above, we designed the CAREPATH architecture that is described in this section (see Figure 3:). It can be split into six logical layers: bottom up, the persistence layer, the knowledge layer, the service layer, the application layer, the security layer, and the presentation layer. Additionally, connectors to external world, which are an essential part of the described architecture.

The Persistence layer includes the database hard- and software based on SQL and non-SQL repositories. The knowledge layer includes the subcomponents for organising the required data and knowledge. These subcomponents are domain knowledge, reports, history, and guidelines/policies. The service layer includes all the core CAREPATH components: the Home Monitoring, the decision support services, the Polypharmacy, Interoperability components. The Application layer includes all core CAREPATH applications:

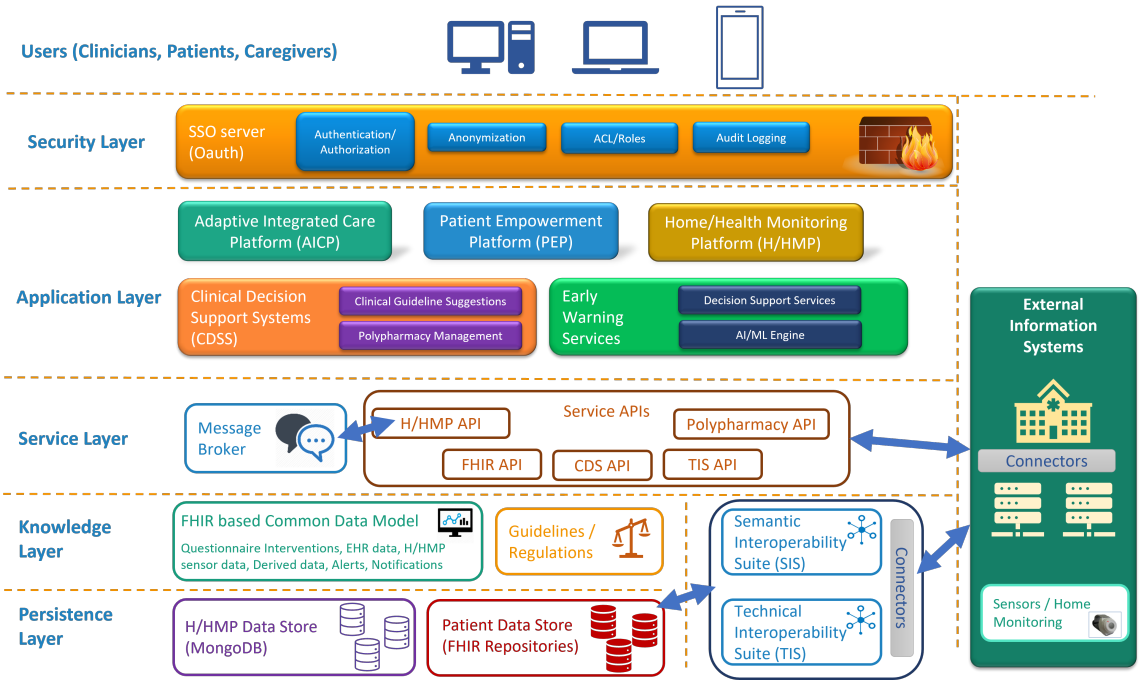

Figure 3: Architecture Overview

Adaptive Integrated Care Plan Platform (AICP), Patient Empowerment Platform (PEP) and Home/Health Monitoring Platform (H/HMP). The security layer is responsible for user authentication, management of user rights according to his role and data encryption for data exchanged through external APIs. The authentication methods that can be used are included in it also. The presentation layer includes all the user interfaces needed for interaction with the services of CAREPATH. Its main component is the User Interface (UI) manager, that is responsible for the proper visualisation of the results in different devices (e.g. desktop PCs, laptops, mobile devices) and platforms in a unified manner. This content serves multiple purposes e.g. creating a common understanding of the envisioned CAREPATH platform within all consortium partners, allowing them to present a joint view to the internal stakeholder of CAREPATH and to the external world.

This architecture will form a communication vehicle between users, designer, developer, and tester of CAREPATH providing them with a joint terminology of CAREPATH parts. As mentioned earlier this architecture will evolve during the project as new knowledge and circumstances will arise during the project.

5 CONCLUSION

In the frame of the design of a homecare telemonitoring eHealth system this paper describes key scenarios, use cases and architecture of an instance as a reference approach. Key scenarios were created by clinicians as assigned and issues arising from mismatches among each other or with user requirements. The use cases were depicted in an iterative process based on a thorough analysis of the key scenarios and user requirements they form a starting point and basis for future work. These results served as important inputs to the design of the instance architecture and the specifications of all components. As a result, a core set of CAREPATH platform is divided into several layers of the system based on their functionality were identified and briefly presented in this paper. Such an approach provides flexibility in all upcoming steps of the software development process.

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REFERENCES

[1] Gappa, H. et al. (2022). Making Person-Centred Health Care Beneficial for People with Mild Cognitive Impairment (MCI) or Mild Dementia – Results of Interviews with Patients and Their Informal Caregivers. In: Miesenberger, K., Kouroupetroglou, G., Mavrou, K., Manduchi, R., Covarrubias Rodriguez, M., Penáz, P. (eds) Computers Helping People with Special Needs. ICCHP-AAATE 2022. Lecture Notes in Computer Science, vol 13341. Springer, Cham. https://doi.org/10.1007/978-3-031-08648-9_54

[2] Jorge Calvillo-Arbizu, et. al. (2021) Internet of things in health: Requirements, issues, and gaps, Computer Methods and Programs in Biomedicine, Volume 208, 2021, 106231, ISSN 0169-2607, https://doi.org/10.1016/j.cmpb.2021.106231.

[3] Architecture of a Web of Things eHealth framework for the support of users with chronic diseases. In Proceedings of the 7th International Conference on Software Development and Technologies for Enhancing Accessibility and Fighting Info-exclusion. Association for Computing Machinery, New York, NY, USA, 47–53. https://doi.org/10.1145/3019943.3019951

[4] Gomaa, Hassan & Olimpiew, Erika. (2005). The role of use cases in requirements and analysis modeling. http://www.ie.inf.uc3m.es/wuscam-05/5-wuscam.pdf

[5] ISO (2019) 9241-210:2019 Ergonomics of human-system interaction – Part 210: Human-centred design for interactive systems, SBN-10 : 1558607129, ISBN-13 : 978-1558607125

[6] Rosson, M.B., Carroll, J. M. (2001). Usability Engineering: Scenario-Based Development of Human-Computer Interaction. Morgan Kaufmann

[7] Shannon, E.T. (20020). The Practical Guide to Experience Design: A Guidebook for Passionate, Curious, and Intentional People who Enjoy Designing for Humans. Artificial Publishing, ISBN-10 : 9083041409, ISBN-13 : 978-9083041407
[8] Gemino, A., Parker, D.(2009) "Use case diagrams in support of use case modeling: Deriving understanding from the picture", Journal of Database Management, 20(1), 1-24.
[9] Pournik O et. Al. CAREPATH: Developing Digital Integrated Care Solutions for Multimorbid Patients with Dementia. Stud Health Technol Inform. 2022 Jun 29;295:487-490. doi: 10.3233/SHTI220771. PMID: 35773917.