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European HC model. Design and implementation of the APO

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TABLE OF CONTENTS

1	INTRODUCTION	5
1.1	MOTIVATION OF THIS WORK.....	7
1.2	GOALS.....	8
1.3	DOCUMENT STRUCTURE.....	8
2	STATE OF THE ART	11
2.1	ONTOLOGIES	11
2.1.1	<i>What is an Ontology?</i>	11
2.1.2	<i>Ontology components</i>	11
2.1.3	<i>Classification of ontologies</i>	12
2.1.4	<i>Ontology engineering techniques</i>	12
2.1.5	<i>Ontology applications</i>	13
2.2	HOME CARE	14
2.2.1	<i>What is home care?</i>	14
2.2.2	<i>Home Care Information systems</i>	16
3	PROBLEM DEFINITION.....	17
3.1	K4CARE MODEL DEFINITION	17
3.2	APO DEFINITION	18
3.3	NEW CARE UNITS ADDITION	19
4	THE K4CARE MODEL.....	21
4.1	HOME CARE NUCLEAR STRUCTURE (HCNS).....	22
4.1.1	<i>HCNS Actors</i>	23
4.1.2	<i>HCNS Actions</i>	24
4.1.3	<i>HCNS Services</i>	27
4.1.4	<i>HCNS Documents</i>	35
5	CONSTRUCTION OF THE SET OF HCNS PROCEDURES.....	41
5.1	MOTIVATION.....	41
5.2	METHODOLOGY	41
5.3	RESULTS	42
6	APO.....	53
6.1	APO FUNCTIONALITY	53
6.2	OWL WRAPPER	57
6.3	APO ENGINEERING	57
7	NEW CARE UNITS ADDITION	61
7.1	HOME CARE ACCESSORY SERVICE (HCAS) EXAMPLE: REHABILITATION.....	61
7.1.1	<i>Rehabilitative Actors</i>	61
7.1.2	<i>Rehabilitative Actions</i>	62
7.1.3	<i>Rehabilitative Services</i>	64
7.1.4	<i>Rehabilitative Procedures</i>	67
7.1.5	<i>Rehabilitative Documents</i>	71
7.2	THE NEED OF ADDING NEW CARE UNITS	72
7.3	THE APO RESTRUCTURATION	73
7.4	INTELLIGENT SERVICE ADDER	77
8	TESTING.....	79
8.1	APO.....	79
8.2	OWL WRAPPER	79

8.3	ISA	79
9	USER'S GUIDE	81
9.1	START	81
9.2	EXISTING CARE UNITS	82
9.3	CARE UNIT DETAILS	83
9.4	NEW CARE UNIT SERVICES	84
9.5	CREATE ACTION	85
9.6	CREATE ACTOR.....	86
9.7	CREATE DOCUMENT	87
9.8	CREATE SERVICE	88
9.9	CREATE PROCEDURE.....	90
9.10	ACTION DETAILS	92
9.11	SERVICE DETAILS	93
10	CONTRIBUTIONS AND PUBLICATIONS.....	95
10.1	CONTRIBUTIONS.....	95
10.2	PUBLICATIONS	95
11	CONCLUSIONS AND FUTURE WORK	97
	REFERENCES	99

TABLE INDEX

Table 1 HCNS Actions	26
Table 2 HCNS Initiators	35
Table 3 Access documents	36
Table 4 HCNS Documents	39
Table 5 HCNS Procedures	52
Table 6 Rehabilitative Actions	63
Table 7 Rehabilitative Documents	72

FIGURE INDEX

Figure 1 HCNS Schema	22
Figure 2 K4CARE platform architecture.....	54
Figure 3 APO schema.....	58
Figure 4 Multiple Care Unit, solution 1	74
Figure 5 Multiple Care Unit, solution 2	75
Figure 6 APO structure with multiple care units.....	76
Figure 7 Representation of the APO with the Jambalaya tool	77
Figure 8 Presentation window	81
Figure 9 Existing care units window.....	82
Figure 10 Service details window	83
Figure 11 New care unit services	84
Figure 12 Create action window.....	85
Figure 13 Create actor window	86
Figure 14 Group members window.....	87
Figure 15 Create document window.....	88
Figure 16 Service creation window.....	89
Figure 17 Procedure creation window.....	91
Figure 18 Action details window.....	92
Figure 19 Service details window	93

1 Introduction

K4CARE [16] is a project financed by the European Commission devoted to develop an intelligent web platform in order to provide e-services to health professionals, patients and citizens involved with the Home Care (HC) of elderly patients living at home. Those services aim to improve the capabilities of the new EU society to manage and respond to the needs of the increasing number of senior population requiring a personalized Home Care assistance.

In eHealth it is increasingly necessary to develop tele-informatic applications to support people involved in providing basic medical care (physicians, nurses, patients, relatives, and citizens in general). The care of chronic and disabled patients involves life long treatment under continuous expert supervision. Moreover, healthcare workers and patients accept that being cared for in hospitals or residential facilities may be unnecessary and even counterproductive. From a global view, such patients may saturate national health services and increase health related costs. The debate over the crisis of financing healthcare is open and is a basic political issue for old and new EU member countries and could hinder European convergence. To face these challenges we can differentiate medical assistance in health centres from assistance in a ubiquitous way (Home Care -HC- model); the latter can undoubtedly benefit from the introduction of ICT. The K4CARE project will develop a platform to manage the information needed to guarantee an ICT Home Care service. It will:

- a) integrate information of different types and from different sources.
- b) be integrated with ICT whilst ensuring private and customized data access.
- c) use Ontologies to define the profile of accessing subjects (e.g. physicians, patient) and objects (e.g. disease, case study).
- d) have a mechanism to combine and refine the Ontologies to personalize the system, taking into account the way a physician works and the individual patient characteristics.
- e) incorporate 'know-how' from geriatric clinical guidelines as Intervention Plans (IP).
- f) generate IPs from the healthcare centres databases if clinical guidelines do not exist or are inappropriate for a particular situation.
- g) configure a knowledge-based decision support tool that can supply eServices to all subjects involved in the Home Care model.
- h) extract evidence from real patients and integrate it with published evidence derived from RCTs.

The project will capture and integrate the information, skills, expertises, and experiences of specialised centres and professionals of several old and new EU countries, and will incorporate them in an intelligent web platform in order to provide e-services to health professionals, patients, and citizens in general.

One of the most important tasks in the creation of the K4CARE system is the definition of the data model that will represent the medical knowledge that the K4CARE platform has to

manage. This data is represented using an Actor Profile Ontology (APO), a patient-Case Profile Ontology (CPO) and the Formal Intervention Plans (FIPs). The aim of the APO is to store the information about the actors involved in the K4CARE model, the corresponding services and how they are performed. The CPO stores information about the symptoms, diseases, syndromes, drugs, surgical procedures etc. The FIPs [28] contain information regarding how the HC must be provided by using evidence-based practice guidelines which represents standards of practice.

In this work, the effort will be focused in the definition of the APO, which will store the information regarding the actors that take part in the K4CARE system and their roles represented by the services. To obtain the needed information, we will start from the specifications provided by the domain experts, and then we will define a detailed model working together. This model also needs to allow the addition of new groups of services, with the objective of making the K4CARE system incremental and more powerful.

In [33] an Ontology is defined as a *formal, explicit specification of a shared conceptualization*. *Conceptualization* refers to an abstract model of some phenomenon in the world by having identified the relevant concepts of that phenomenon. *Explicit* means that the type of concepts used, and the constraints of their use, are explicitly defined. *Formal* refers to the fact that the Ontology should be machine-readable. *Shared* reflects the notion that Ontology captures consensual knowledge, that is, not a personal view of the target phenomenon of some particular individual, but one accepted by a group, in our case, the different medical partners of the K4CARE project, which include people from eastern and western European countries.

The set of activities that concern the Ontology development process, the Ontology life cycle, the principles, methods and methodologies for building Ontologies, and the tool suites and languages that support them is called Ontological Engineering [9]. With regard to methodologies, several proposals have been reported for developing Ontologies manually. However, building the Ontology of a phenomenon as the one faced by the K4CARE project is a huge and very complex task, because a great number of services, people and institutions are involved in the home care.

The first step of the K4CARE project was to identify which were the common and basic home care structures shared by the main sanitary systems in Europe. They are called HCNS (Home Care Nuclear Structure). The Home Care Nuclear Structure of the K4CARE HC Model comprises the minimum elements needed to provide a basic HC service.

In a second step, the need of adding new service structures to the HCNS model, which are specific of a determinate context (a country, a hospital, etc.), was faced. Those new structures will be called along this work “Care Units”. Two examples of what can be considered as an additional care unit to be added into the basic K4CARE model are the rehabilitation or oncology services. As the knowledge related to the services must be encoded in the K4CARE model, this work studies how to do it by enlarging the nuclear APO Ontology. Enlarging the Ontology with reliability and avoiding redundancies as much as possible requires the definition of some methodological process to be followed for all new care units to be included in the model. Another issue is that the K4CARE platform

must be able to provide the specific ontology of a concrete care unit. This work is concerned with these methodological issues. Enlarging the K4CARE model with the rehabilitation services is presented as a reference application.

1.1 Motivation of this work

I am a member of the K4CARE project (IST-2004-026968), and more concretely my work is inside the work package 3. The two main objectives of this work package are:

- Propose a set of ontologies representing an abstraction of the profiles of the actors involved in the process.
- Supply a set of ontologies representing common pathologies of the sort of patients considered in the project.

Ontologies will be the vehicles to both personalize the access to the K4C platform, and also describe the healthcare case to attend. K4CARE actor profile ontologies (APO) will represent prototypes of healthcare professionals, patients and relatives, citizens and social organisms in a hierarchical structure.

Each APO will contain the skills, expertise, knowledge, concerns, aspirations, etc. of the people they represent, together with the healthcare services those people offer to or receive from the K4C model (deliverable D1). These ontologies will integrate the best ways of doing of old and new EU countries in a handbook of good medical practice to assist ill, disabled, chronic senior patients in a technological society.

On the other hand, K4CARE case profile ontologies (CPO) represent the pathologies of the sort of patients the K4CARE model deals with (e.g. post-stroke patients, diabetics, cognitively impaired, mobility impaired). Among other concepts, these ontologies include conditions and diseases, medical case descriptions, and references to Formal Intervention Plans representing healthcare guidelines for assisting those patients.

The medical model for Home Care was defined by the medical partners of the K4CARE project (mainly physicians from the Fondazione Santa Luccia). After an initial analysis of the model that they did, we detected the lack of some information and the ambiguity of some definitions. The reason was that the model was defined in plain text, so it was quite informal, partial and fussy in some points. Since the model should be formalized using ontologies, we have had to first review and complete the model in collaboration with the physicians.

Once defined the K4CARE model where the main care tasks are defined, the model has been redefined to allow the addition of new services. These services will respond to specialized cares, specific needs, opportunities, means, etc. of either the users of the K4CARE model or the health-care community where the model is applied. These

additional services are called additional care units. An example of these additional care units are the oncology and the rehabilitation services.

1.2 Goals

The objectives of this work are:

1. To review the medical K4CARE model in order to make it codifiable some formal language. As the model was defined informally, it is expected to be incomplete, incoherent and redundant. So, the goal is to create a model complete and coherent, in particular, we will have to concentrate in the description of the process by which the different services are performed, which are the resources needed to perform the process, and which are the roles played by the different actors inside the service performance.
2. Represent the K4CARE model in a machine readable language. This information will be stored in the *Actor Profile Ontology* (APO), which represents the profiles of the subjects involved in the K4CARE mode. In particular, the K4CARE model will comprise: healthcare professionals, patients and relatives, citizens, and social organisms. APOs contain the skills, concerns, aspirations, etc. of the people that they represent, together with the healthcare services that those people offer to or receive from the K4CARE model (e.g. *medical services* such as drug prescription, clinical consultations, laboratory analysis; *social services* such as counselling, information, advice, social support).
3. Allow the addition of new groups of services to the K4CARE model. The addition of those services does not have to affect the efficiency of the system, so that the new services have to be added in a scalable way. The definition of new services will allow the system to be used in different contexts, and will make it more powerful and useful. To allow this addition of services, the previously defined ontology, will be remodelled and restructured.

1.3 Document structure

In the second section of this work, we present a study of the state of the art concerning to the two main scopes of this work, the ontologies and the home care, more concretely, the home care information systems. In the next section, section 3, we present which are the three problems aimed to solve in this paper, the K4CARE model definition, the APO creation and the addition of new sets of services. The following sections explain in detail the work done in these three aspects. The 4 section describes the K4CARE model that we have built, concretely, describes the actions and services involved in it. Section 5 continues defining the model by indicating, which are the procedures defined to provide home care are presented, and also how they were defined and which are their details. The section 6

gives a description of the APO ontology, which is used to store the information defined in the K4CARE model, inside the K4CARE system. In this section we also explain which role is played by the APO inside the project, and how it is consulted, using the OWL Wrapper. In the seventh section, we propose how new groups of services can be added to the APO, by restructuring this ontology and by using an intelligent tool called ISA (Intelligent Service Adder) which helps the medical experts during the addition of the new sets of services to the system. In the next sections (9 and 10) we explain how the ISA tool and the Wrapper were tested and we give an user's guide that explains how to use the ISA. In section 10 the contributions and publications of this work are presented, and finally in the section 11 we present the conclusions and the future work.

2 State of the art

2.1 Ontologies

2.1.1 What is an Ontology?

The word ontology was taken from Philosophy, where it means a systematic explanation of being. In the last decade, this word has become very used for the Knowledge Engineering community. The use of the words ‘Ontology’ (with capital ‘o’) and ‘ontology’ to refer to the Philosophical and Knowledge Engineering senses respectively was proposed by [12].

There are several definitions about what an ontology is. One is presented below:

In [33] an ontology is defined as a *formal, explicit specification of a shared conceptualization*. *Conceptualization* refers to an abstract model of some phenomenon in the world by having identified the relevant concepts of that phenomenon. *Explicit* means that the type of concepts used, and the constraints of their use, are explicitly defined. *Formal* refers to the fact that the Ontology should be machine-readable. *Shared* reflects the notion that Ontology captures consensual knowledge, that is, not a personal view of the target phenomenon of some particular individual, but one accepted by a group.

In [21] a definition focused on the form of an ontology is given. An ontology defines the basic terms and relations comprising the vocabulary of a topic area as well as the rules for combining terms and relations to define extensions to the vocabulary.

Other approaches have defined ontologies as explicit specifications of a conceptualization [10] or as a shared understanding of some domain of interest [35].

2.1.2 Ontology components

There are different ontology knowledge representations formalisms used, however, there are three common components shared by all the formalisms. Those three components are shown below:

- **Classes:** represent concepts taken in a broad sense. For instance, in the travelling domain, concepts are: locations (cities, villages, etc.), lodgings (hotels, campings, etc.) and means of transport (planes, trains, cars, etc.). Classes in ontologies are organized in taxonomies through which inheritance mechanisms can be applied.
- **Relations:** represent a type of association between concepts of the domain. Ontologies usually contain binary relations. The first argument is known as the domain of the relation, and the second argument is the range. Binary relations are sometimes used to express concept attributes. Attributes are usually distinguished

from relations because their range is a datatype, such as string, numeric, etc, while the range of relations is a concept.

- **Instances:** are used to represent elements or individuals in an ontology.

2.1.3 Classification of ontologies

There exist several classifications of ontologies in function of a particular aspect (such as expressiveness [17] or subject and type of structure of conceptualizations [36]). An interesting classification was proposed by [guarino 1998], who classified types of ontologies according to their level of dependence on a particular task or point of view.

- **Top-level ontologies:** describe very general concepts like *space*, *time*, *event* which are independent of a particular problem or domain. It seems reasonable to have unified top-level ontologies for large community of users. Some top-level ontologies are Sowa's [31], Cyc's [18] and SUO [25].
- **Domain ontologies:** [mizoguchi et al, 1995][van heijst et al, 1997]describe the vocabulary related to a generic specific domain by specialising the concepts the concepts introduced in the top-level ontology. There are several examples of domain ontologies like for example EngMath [11], PysSys [3], KA [5].
- **Method ontologies:** give definitions of the relevant concepts and relations applied to specify a reasoning process so as to achieve a particular task [tijerino and mizoguchi, 1993].
- **Task ontologies:** describe the vocabulary related to a generic task or activity (like diagnosing, scheduling, selling, etc.) by specializing the terms in the top-level ontologies. An example of a task ontology is the *Scheduling task Ontology* presented in [20].
- **Domain-Task ontologies:** are task ontologies reusable in a given domain, but not across domains. They are application independent.
- **Application ontologies:** [36] are application dependent. They contain all the definitions needed to model the knowledge required for a particular application.

2.1.4 Ontology engineering techniques

There are several techniques applied to ontology engineering. Those techniques are focused in different aspects of ontology engineering. Some of them present approaches that avoid building ontologies from scratch, by reusing onthologies or by using semiautomatic methods that reduce the knowledge acquisition time during the ontology development process.

In 1990 appeared a method proposed by Lenat and Guha called Cyc [19].

In 1996 Bernaras and colleagues presented a method to build ontologies in the domain of electrical networks [2]. In the same year, Gómez and Pérez proposed the METHONTOLOGY method [8], which was extended in further papers.

The APO engineering has been done by using the On-To-Knowledge [32] methodology. This methodology is focused in the creation of ontologies to improve the knowledge management in large and distributed organizations. The On-To-Knowledge is based in 5 steps, the feasibility study, the kickoff, the refinement, the evaluation and the maintenance.

Feasibility: The feasibility study is applied to the complete application and serves as a basis for the kickoff process.

Kickoff: The result of this process is the ontology requirements specification document. These documents define the domain and goal of the ontology, the design guidelines, the available knowledge sources, the potential users, and the use cases.

Refinement: The goal of this step is to produce a mature ontology according to the specification given by the kickoff. This is performed by two steps:

1. Knowledge elicitation process with domain experts.
2. Formalization.

Evaluation: The evaluation process serves as a proof of the usefulness of the developed ontologies. This is performed in two steps:

1. Checking the requirements and competency questions.
2. Testing the ontology in the target application environment.

Maintenance: On-To-Knowledge proposes to carry out ontology maintenance as a part of the system software.

2.1.5 Ontology applications

Ontologies are widely used in Knowledge Engineering, Artificial Intelligence and Computer Science, in applications related to knowledge management, natural language processing, e-commerce, intelligent integration information, information retrieval, database design and integration, bio-informatics, education, and in new emerging fields like semantic web.

Protégé [23] is an open source, standalone application with an extensible architecture. The core of Protégé is its ontology editor, which can be extended with plug-ins that add more functions to the environment, such as ontology language import and export (FLogic, Jess, OIL, XML Prolog), OKBC access, constraints creation and execution (PAL), ontology merge (PROMPT [24]).

2.2 Home Care

2.2.1 What is home care?

Home care, also known as domiciliary care, is health care provided in the patient's home by healthcare professionals (often referred to as home health care or formal care; in the United States, it is known as skilled care) or by family and friends (also known as caregivers, primary caregiver, or voluntary caregivers who give informal care). Often, the term home care is used to distinguish non-medical care or custodial care, which is care that is provided by persons who are not nurses, doctors, or other licensed medical personnel, whereas the term home *health* care, refers to care that is provided by such licensed personnel.

[6] Generally, home care policies serve people with physical or mental impairment who return home from hospital or who reside in the community and who have been professionally assessed as requiring formal resources to meet their health and social support requirements. Increasingly, home care is called upon to meet the needs of the acutely ill who require intensive and sophisticated services and equipment and to address needs specifically associated with a medical diagnosis or impending death or to compensate for functional deficits in the activities of daily living. There are generally no age limits on home care use, although use tends to increase with age. Some definitions only consider that home care is the provision of assistance to persons over the age of 16 in their home, so sometimes the age is considered.

Home care has three main functions:

- To substitute for other more costly services such as hospitals.
- To substitute for care in long-term facilities.
- To provide maintenance and preventive function that allows clients to remain in the home environment rather than moving to a new and often more costly venue.

There are two main streams of home care:

- Professional services, including nursing, social workers, therapists, and home support services.

- A wide range of additional programs and services may also be provided, including adult day programs (i.e., geriatric day hospitals), meal programs, home maintenance, respite, medical equipment and supplies, and counselling.

Referrals to home care can come from any source – hospitals, physicians, other community agencies, family members, or potential recipients. Home care is centred on assessing the client, the family, and the home environment. It coordinates the delivery of the health and social support services required by clients living in the community and ensures the provision of a continuum of care to vulnerable clients in accordance with their changing needs.

Because of its intimate connections with other health care sectors and its continuum of care perspective, home care is, by definition and by function, an important health care service in its own right, with its own mandate, its own organizational structure, its own workforce, and its own established links with the other health care sectors.

In [6] the main motivations of home care are presented. The current drive to move patients from hospitals to communities is not new. Home care has been practised in varying degrees in countries throughout Europe since the last century, notably by voluntary organizations.

The home care increase in Europe is not a chance, because it has several important reasons that make it necessary. The main motivation that encourages the home care is the increasing in the patient's live quality, due to the belief that nursing at home, whenever appropriate, helps preserve a patient's well being and dignity. The increase in the well being is not only due to the fact that the patient increases his psychological health, but he also increases if physical health. Also the recuperation time is decreased. Improved technologies that assure quality care outside hospitals. Examples are the day surgery at clinics and transfusions and intravenous chemotherapy at home.

The other main motivation that encourages the home care is the reduction of the economical costs that the patient's care implies to the institutions. The increasing longevity and thus larger elderly populations imply more chronically ill individuals who need of prolonged medical care.

While economy is the major driving force behind the renew interest in home care, the official attitude towards the financial aspect varies from one country to next. In the former Soviet-bloc countries currently undergoing economic hardships, home care can be an easily implemented and sensible alternative to modernizing their healthcare infrastructure. West European countries consider limited resources and "cost effectiveness" a part of current medical philosophy. In the Scandinavian countries with their long tradition of home care, the economic argument is secondary. They place a higher priority on ethical argument and the patient's preferences to stay at home.

2.2.2 Home Care Information systems

In this section some home care information systems are presented. The information systems presented are focused in solving different aspects of home care.

Mohoc [26] is a home care information system focused in planning the appointments of the different home care workers with the patients. In Mohoc workers can see others' appointments with shared patients when they set their own appointments. This allows workers to selectively avoid the appointments times of others. When a schedule conflict does occur, the system flags the time block where the overlap occurs by turning it bright red so that workers can resolve it, or ignore it if the overlap is desirable,

In 1995, a study was conducted in northern California, USA where the researchers evaluated a home monitoring system for patients with heart failure [14]. The patients were equipped with a digital scale and an automatic blood pressure cuff and every day, the patient called a toll-free telephone number and entered the medical data into a computerized voice answering system. After that, a computer algorithm compared the patient's vital signs to certain trigger levels previously set by a physician. If the values were outside of the accepted range or if new symptoms were detected, a nurse was paged who called the patient to confirm the reported data. When the nurse had contacted the patient, he or she sent a one page fax message to the physician for further actions. The result of the study showed that patients included in the program used less resources and hospitalizations while maintaining quality of life.

In 1998, in Japan was developed an information system [15] with the aim of collecting vital signs of the elderly including patients and healthy people for health evaluation. They developed a system to collect, record, and transmit various data, named PHD (personal health data) by them, of the elderly at home by applying a telephone set with a multifunction called "Telemation". The objectives of the project were the ones presented below:

1. A portable monitoring equipment and its data processing system by which blood pressure, ECG, and physical activity data can be measured simultaneously and continuously, and displayed without restraints at home.
2. A portable system by which respiratory function of the elderly can be noninvasively and continuously monitored at home.

3 Problem definition

In different European Countries, and in different areas of the same Countries, HC is structured in different ways, according to local rules, laws, and funding. The different prototypes reflect different approaches to HC, particularly referring to the kind of services provided, human resources organization and dependences. The K4CARE model provides a paradigm easily adoptable in any of the EU countries to project an efficient model of HC. The model proposes that the K4CARE services are distributed by local health units and integrated with the social services of municipalities, and eventual other organizations of care or social support. It is aimed at providing the patient with the necessary sanitary and social support to be treated at home; in these terms, it is easily adaptable to those socio-sanitary systems which provide the so called “unique access” for both social and sanitary services, unifying and simplifying procedures of admission to the services.

This work is focused in solving three points related to the definition of the knowledge K4CARE model and how it is stored in the system.

1. The first point to solve in this work is the definition of the model that allows the specification of the different actors and the different roles played inside the system.
2. The second point to solve is the creation of an ontology called APO. This ontology will store the knowledge defined in the previously described of the model.
3. Finally, the system has to allow its enlargement with additional groups of services. Those additional groups of services will be focused in the treatment of certain diseases and syndromes, like the treatments provided by the rehabilitation group of the oncology group.

3.1 *K4CARE model definition*

To have a detailed description of the tasks offered by the K4CARE system a detailed model definition that gives a concrete description of the model is needed. This model definition must establish which are the different actors involved in the system and which are the tasks in which they will take part.

The initial definition of the K4CARE model was elaborated by a group of Italian physicians from the Fondazione Santa Luccia. They elaborate a first version of the deliverable that contains the definitions of the model without the collaboration of any expert in computer sciences. The inexistence of collaboration with experts in knowledge engineering implied a lack of information and at the same time a lack in the structuration of the knowledge given.

In the beginning of this work we had a partial specification of the model. This first version contained a non-detailed description of the actors that took part in the system. The model description neither has a detailed description of the services and how they will be performed. The model description only had an informal definition that specified the services from a general point of view, specifying which services are offered by the system, and which is their utility. As a consequence of the non-detailed description of services offered, the documents used during the service performance and their using were unknown.

So that, the work that must be done, was the creation of a detailed specification of how the different services will be performed. The specification of the service performance is detailed with the definition of a procedure that will be linked with the service, and will give details about the different steps needed to perform the service. The procedures will indicate which steps must be performed to carry out them, which documents will be needed and who will perform the different steps.

Later, once defined the K4CARE nuclear model, new additional groups of services can be defined and added to the model. This work has worked in the definition of a set of services focussed in the rehabilitation of patients. To define those services the work has started from a definition similar to the one used in the nuclear service case, but in this time, the experience was very handful. So that, the medical team defined a new set of actors that will take part inside the rehabilitation, which are the services that will be performed and which is the set of steps and documents needed to carry out them. Then this specification was revised and the rehabilitation procedure details were given

3.2 APO definition

One of the most important tasks in the creation of the K4CARE system is the definition of the data model that will represent the medical knowledge that the K4CARE platform has to manage. This data is represented using an Actor Profile Ontology (APO), a patient-Case Profile Ontology (CPO) and the Formal Intervention Plans (FIPs). The aim of the APO is to store the information about the actors involved in the K4CARE model, the corresponding services and how they are performed. The CPO stores information about the symptoms, diseases, syndromes, drugs, surgical procedures etc. The FIPs [28] contain information regarding how the HC must be provided by using evidence-based practice guidelines which represents standards of practice. In this work we will concentrate in the APO Ontology. The first version of the APO contains the knowledge referring those common and basic services previously identified in the medical model. The APO Ontology is coded in OWL [97] language, using the Protégé tool [22].

The APO definition has to start from a previous specification of the K4CARE model. Despite this, the ontology definition task was carried out at the same time than the information that has to be stored was specified. This allows the detection of non specified information that should be defined, and to detect how to define the model allowing an easy

translation to a structured knowledge inside an ontology. The definition of the APO has been done in collaboration with the medical experts, who reviewed the APO and analysed the model.

3.3 *New care units addition*

In the K4CARE model new sets of services related with the additional care units (HCAS - Home Care Accessory Services) can be added to the K4CARE model, like for instance the services provided by rehabilitation or the oncology care units. In this work the case of rehabilitation is considered. As the work done with the definition of the nuclear services of the K4CARE model, the additional services must be included into the ontology, starting from the definition given inside the model. So that, the different services actors and their roles inside the system must be defined with detail.

Once defined the new Care Unit, the system has to allow the enlarging of the K4CARE model with the new knowledge related to the new Care Unit.

To allow the addition of new Care Units, the model represented by the APO has to be able to allow its enlargement. The way to enlarging the model has to be considered, since there are several options to face it. The enlargement could be focused by creating specific sub-APO for every new care unit, where every sub-APO will have the knowledge corresponding to a specific Care Unit, or by another side, the enlargement could be performed over an APO containing all the knowledge providing from the different Care Units defined inside the K4CARE model. So that, the main question that has to be answered inside this work is how the new Care Units are added to the model and how are they managed.

4 The K4CARE model

The K4CARE model aims to represent an incentive and facilitate the shift towards the achievement of an European standard for Home Care. To accomplish this duty, the K4CARE Model is designed to give priority to the support of the HCP, his relatives and Family Doctors (FD) as well. Because of the aim of providing a model which can be proposed as European standard, the K4CARE project recommends a modular structure that can be adapted to different local opportunities and needs. The success of this model is directly related to the levels of efficacy, effectiveness and best practice of the health-care services the model is able to support. The K4CARE Model is based on a nuclear structure (HCNS) which comprises the minimum number of common elements needed to provide a basic HC service. The HCNS can be extended with an optional number of accessory services (HCAS) that can be modularly added to the nuclear structure. These services will respond to specialized cares, specific needs, opportunities, means, etc. of either the users of the K4CARE model or the health-care community where the model is applied. The distinction between the HCNS and the complementary HCASs must be interpreted as a way of introducing flexibility and adaptability in the K4CARE model and also as an attempt to provide practical suggestions for standards to be used when projecting and realizing new services in largely different contexts. This document provides a detailed description both of the HCNS and also of a prototype of HCAS, namely a Rehabilitation Unit. It also provides insight information about the process that the K4CARE project proposes in order to develop new HCASs that could be appended to the K4CARE model, attending for example nutritional issues, oncology units, etc. Going into detail, each one of the HC structures (i.e. HCNS and HCAS's) consists of the same components: actors, actions, services, procedures, and documents. Actors are all the sort of human figures included in the structure of HC.

- Professional Actions and Liabilities are the actions each actor performs to provide a service within the HC structure.
- Services are all the utilities provided by the HC structure for the care of the HCP.
- Procedures are the chain of events that leads an actor in performing actions to provide services.
- Information are the documents required and produced by the actors to provide services in the HC structure.

As new HCAS's are incorporated to the K4CARE Model, new actors, actions, services, procedures and information enter to be part of the extended model. This way, the K4CARE model is compatible both with the current situation in the European countries where the international, national, and regional laws define different HC systems for different countries, and also with the forthcoming expected situation in which a European model for HC was decided.

4.1 Home Care Nuclear Structure (HCNS)

The Home Care Nuclear Structure of the K4CARE HC Model comprises the minimum elements needed to provide a basic HC service. These elements are the actors involved in HC, the actions and liabilities of such actors, the services available in the HC model, the procedures, and the information to provide such services. A graphical representation of the K4CARE HCNS schema is given in the Figure 1 HCNS Schema.

As it has been said, the K4CARE model was initially described too informally. So part of the work done in this project has been devoted to achieve a complete HC model. The elements presented in this section correspond to the final K4CARE model, so this is the version of the model that has been codified in the APO.

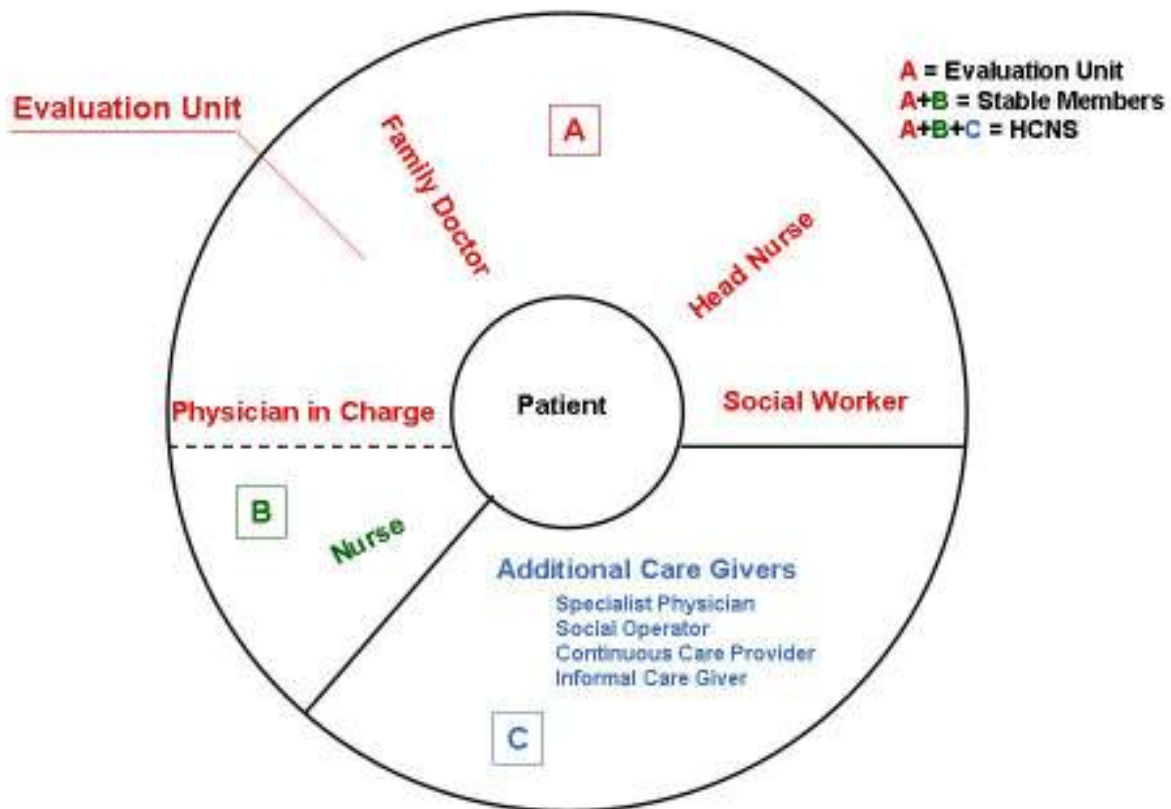


Figure 1 HCNS Schema

4.1.1 HCNS Actors

In HC there are several people interacting: patients, relatives, physicians, social assistants, nurses, rehabilitation professionals, informal care givers, citizens, social organisms, etc. In the HCNS, these individuals are the members of three different groups of HC actors that this section describes. These groups are the patient; the stable members of HCNS (the family doctor, the physician in charge of HC, the head nurse, the nurse, the social worker, each of them present in the HCNS); the additional care givers. The family doctor, the physician in charge of HC, the head nurse, and the social worker join in a temporary structure - the Evaluation Unit - devoted to assess the patient's problems and needs.

Patient (HCP) The average patient is an elderly patient, with co-morbid conditions and diseases, cognitive and/or physical impairment, functional loss from multiple disabilities, and impaired self-dependency.

Family Doctor (FD) The Family Doctor is the physician who is in charge of the patient. FD diagnoses and treats the diseases, physiological disorders and injuries of patients. He provides primary contact and continuous care toward the management of patients' health.

Physician in Charge of the HC (PC) The Physician in Charge of the HC is a supervisor in the EU and the medical responsible of the HC service. In some countries or areas he may correspond to the FD.

Head Nurse (HN) The Head Nurse mainly coordinates the work of the nurses to accomplish the intervention plan.

Social Worker (SW) The Social Worker identifies and evaluates social needs, manages the social implication of the intervention plan and starts up social services, coaches the patient's social network organizing the empowerment of skills and resources of his formal and informal care providers.

Nurse (Nu) The Nurse is the provider of therapeutic procedures. Nu works at patient's home according to scheduled access. He provides general nursing care and can also provide specialized nursing care. In these cases he can be part of a HCAS.

Evaluation Unit (EU) The Evaluation Unit is composed by the Family Doctor, the Physician in Charge of the HC, the Head Nurse, and the Social Worker. The EU is a team of HC professionals which assesses the problem(s), defines an individual intervention plan (IP), identifies the proper procedures, evaluates the results and verifies the achievement of the goals defined by the IP. The EU selects the professional to cover the role of Case Management (CM) played by the person who manages the overall accomplishment of the IP (usually the HN). The EU is a temporary team and only constitutes in the circumstances of the first assessment of a HCP and of the re-evaluations.

Additional Care Givers (ACG) Other groups of professionals and non professional actors are usually part of the HC. Their presence is almost ubiquitous, even if their position can hardly be comprised inside the core structure of HC (i.e., Stable Members). Namely, Specialist Physicians are not directly employed by the HC service; Social Sanitary Operators usually work for local municipalities; the Continuous Care Provider can be, in different cases, a relative or a third person on salary; the Informal Care Giver can be part of citizen's organizations or simply a neighbour. These groups of Additional Care Givers do not have an exact and definite position in the context of the HC network, but their role results, in most case, fundamental for the continuous care of the HCP. In the K4CARE model, they are labelled as "additional" because they are actors who operate to complete competences and interventions within the HCNS. Their individual presence in a particular HCNS is optional. Specialist Physician

Specialist Physician (SP) The Specialist Physician is a medical doctor specialized in one branch of medicine. A specialist in clinical medicine diagnoses and treats diseases and disorders and he acts as a consultant to other physicians. Specialists in surgery perform and supervise surgical procedures. SP can provide highly specialized medical services; in these cases SP can be part of a HCAS. In HCNS, the most frequently employed sorts of SPs are Geriatricians, Cardiologists, Surgeons, Neurologists, Urologists, etc.

Social Operator (SO) The Social Operator usually works for local municipalities, or is hired from private companies. SO represents the operative branch to support social needs of the HCP directly at home, with special regard to ADLs and IADLs.

Continuous Care Provider (CCP) The Continuous Care Provider is the actor who is in charge of the continuous care of the HCP, usually 24 hours a day. CCP can be, in different cases, a relative or a third person on salary. In most cases CCP corresponds to a spouse or a semi-professional care-giver on salary. Informal Care Giver

Informal Care Giver (ICG) The Informal Care Giver is a person who provides the HCP with a more or less relevant amount of support, not being tied by professional or familiar relationships. ICG can be part of citizen's organizations, religious communities, or simply a neighbour. ICG action is mainly related with the preservation of social relationship between the HCP and his environment.

4.1.2 HCNS Actions

Actions represent concrete activities that can be performed by the different Actors of the K4CARE model, depending on their duties and liabilities. The Actions are performed inside a Procedure, and modify Document.

In the Table 1 the last version of the actions provided by the K4CARE model are presented.

Code	Action	Actors
Back Office Activities		
BO.01	provide information	ALL
BO.02	ask information	ALL
BO.03	refer the admitted patient for CA	PC HN
BO.04	assign actor	PC HN
BO.05	assign members of EU	PC HN
BO.06	confirm or modify waiting lists	PC HN
BO.07	schedule activity	HN
BO.08	send message to the patient	HN SW SP
BO.09	supervise HCP information	HN FD PC HCP
BO.10	authorize nursing care service	PC
BO.11	forward the Blood Transfusion request	PC
BO.12	send Transfusion Report	HN SP PC
BO.13	actor confirmation	ALL CG
Case Management Activities		
CM.1	supervise IP	HN
CM.2	control performance of activities	HN
CM.3	supervise achievement of outcomes	HN
Patient Activities		
P.1	confirm appointment	HCP CCP
P.2	agree on interventions	HCP CCP
P.3	give consent	HCP CCP
P.4	request certification	HCP CCP
P.5	ask intervention	HCP CCP ICG
EU Activities		
EU.1	evaluate through scales	EU
EU.2	define intervention plan	EU
EU.3	define outcomes	EU
EU.4	schedule controls	EU
EU.5	schedule re-evaluations	EU
Medical Activities		
M.1	perform Clinical Assessment	FD PC SP
M.2	perform Physical Examination	FD PC SP
M.3	request Diagnostic Procedures	FD PC SP
M.4	request Laboratory Analysis	FD PC SP
M.5	prescribe Pharmacological Treatment	FD PC SP
M.6	prescribe non-Pharmacological Treatment	FD PC SP
M.7	prescribe assistive devices	FD PC SP
M.8	prescribe nursing care	FD PC SP
M.9	refer to SP	FD PC SP
M.10	write medical follow-up	FD PC SP
M.11	write Certification	FD PC SP
M.12	write INR Report	FD PC SP
M.13	refer for transfusion	FD PC SP
Medical FD Activities		
M.FD.1	request HC	FD
M.FD.2	request of re-evaluation	FD
M.FD.3	authorize treatment proposed by SP or PC	FD
M.FD.4	refer the HCP to SP for Certification	FD
M.FD.5	refer the HCP for INR Follow-up	FD
M.FD.6	authorize nursing care	FD
Medical SP Activities		

M.SP.1	write consultation report	SP
M.SP.2	arterial blood collection	SP
M.SP.3	takes specimen to laboratory	SP
M.SP.4	collect blood bags	SP
M.SP.5	perform the transfusion	SP
M.SP.6	write transfusion report	SP
Social Activities		
S.1	assess social needs and network	SW
S.2	define social intervention	SW
S.3	supervise achievement of social outcomes	SW
S.4	contact social service providers	SW
S.5	coach social network	SW
S.6	write social report	SW
S.7	perform assistive actions	CCP SO ICG
Nursing Activities		
N.01	Specimen Collection (blood, urine, faeces).	Nu FD PC SP HN
N.02	I.M. Injection.	Nu FD PC SP HN
N.03	Intravenous therapy .	Nu FD PC SP HN
N.04	Insertion, care and maintenance of peripheral intravenous infusion.	Nu FD PC SP HN
N.05	Catheter care (insertion or removal, including perineal/penile toilet and change of drainage bag).	Nu FD PC SP HN
N.06	Stoma maintenance, including replacement of stoma bags and wafer maintenance.	Nu FD PC SP HN
N.07	Establishing and reviewing a stoma care program.	Nu FD PC SP HN
N.08	Care and maintenance of tracheostomy.	Nu FD PC SP HN
N.09	Care and maintenance of feeding tubes anasogastric and PEG)	Nu FD PC SP HN
N.10	Care and maintenance of urostomic tubes	Nu FD PC SP HN
N.11	Care of analgesic pump	Nu FD PC SP HN
N.12	Care and fitting of prosthesis, and anti-embolic stockings	Nu FD PC SP HN
N.13	Assistance with nebulisers, metered aerosols, turbuhalers, canisters and inhalers	Nu FD PC SP HN
N. 14	Monitoring of vital signs (checking the patient's temperature, pulse, respiration, BP, and pain)	Nu FD PC SP HN
N.15	Blood sugar measurement.	Nu FD PC SP HN
N.16	ECG	Nu FD PC SP HN
N.17	Maintenance of skin integrity, including changing of position of a chairfast or bedfast care recipient.	Nu FD PC SP HN
N.18	Pressure Ulcer treatment	Nu FD PC SP HN
N.19	Treatment of other skin lesions	Nu FD PC SP HN
N.20	Simple wound dressings	Nu FD PC SP HN
N.21	Complex wound management	Nu FD PC SP HN
N.22	Insulin therapy	Nu FD PC SP HN
N.23	Suctioning airways	Nu FD PC SP HN
N.24	Enema administration	Nu FD PC SP HN
N.25	Training of CCP	Nu FD PC SP HN
N.26	write Nursing follow-up	Nu HN

Table 1 HCNS Actions

4.1.3 HCNS Services

The HCNS provides a set of services for the care of HCP. These services are classified into Access services, Patient Care services, and Information services. Access services see the actors of the HCNS as elements of the K4CARE model and they address issues like patient's admission and discharge from the HC model. Patient Care services are the most complex services of the HC model by considering all the levels of care of the patient as part of the HCNS. Finally, Information services cover the needs of information that the HCNS actors require in the K4CARE model.

A. ACCESS SERVICES

- a. Individual Services
 - i. HC Request
 - ii. HCP Admission
 - iii. HCP Discharge
 - iv. Professional Admission
 - v. Professional Discharge
 - vi. Edit HCP/Professional information
- b. Structural Services
 - i. EU Constitution
 - ii. EU-HCP Binding

B. PATIENT CARE SERVICES

- a. Problem Assessment and Re-Evaluation
 - i. Comprehensive Assessment (CA)
 - ii. Multi-Dimensional Evaluation
 - iii. Clinical Assessment
 - iv. Physical Examination
 - v. Request of Diagnostic Examination
 - vi. Request of Laboratory Analysis
 - vii. Consultation
 - viii. Social Needs and Social Network Assessment
 - ix. Follow-up
- b. Intervention Plan Definition
 - i. Planning Intervention Plan
 - ii. Prescription of Pharmacological Treatment
 - iii. Prescription of Non-Pharmacological Treatment
 - iv. Prescription of Nursing Care
 - v. Prescription of Assistive Devices
- c. Intervention Plan Performance
 - i. Case Management
 - ii. Special Medical Services
 - iii. Nursing Care
 - iv. Social Assistance
 - v. Counselling

C. INFORMATION SERVICES

- a. Service Monitoring
 - i. Patient Record Overview
 - ii. Patient Record Social Overview
 - iii. IIPs Overview
 - iv. Schedule Overview
 - v. Waiting List
- b. HC Practice
 - i. Guide Line Consultation
 - ii. FIP Overview
 - iii. Pharmacological Therapy Handbook
 - iv. Best Practice Handbook
 - v. Brochure Consultation
- c. Database Inquiring
 - i. Activities Report
 - ii. Database Queries services
 - iii. Database Queries clinical
- d. Personal Information
 - i. Individual Scheduling Overview
 - ii. P2P Messages

Access Services The K4CARE model introduces a set of basic services in the HCNS, all of them oriented to the organization of the actors and groups involved in the care of HCP.

Individual Services Individual services are the HCNS services that allow actors to be related to the K4CARE Model. They are used to admit, to discharge or to edit information about the people that is part of the model. The six individual services are:

S1.1 HC Request this is for the HC system to know that a person needs care. The FD uses this service to demand HC for a particular HCP.

S1.2 HCP Admission allows the K4CARE model to know which patients are involved in the HC service and which are not. An admitted HCP is part of the model until he is discharged. The admission is done by the PC and HN, under FD request.

S1.3 HCP Discharge the HCP is discharged (is no longer part of the HC service) by PC and HN.

S1.4 Professional Admission regards the inclusion of the defined actors when they have to perform an action connected with the services. It is done by the PC and HN.

S1.5 Professional Discharge an actor with a professional profile is discharged when he is not allowed to be part of the K4CARE model anymore. It is done by the PC and HN.

S1.6 Edit HCP/Professional information allow the change of administrative data concerning the actors involved in the care system. For example: telephone or address updates, etc.

Structural Services Structural services are the HCNS services to define the Evaluation Units in the K4CARE Model. The two structural services are:

S2.1 EU Constitution is realized in occasion of CA or re-evaluation. Is done by HN. Being a temporary team, it is automatically dissolved at the end of evaluation.

S2.2 EU-HCP Binding is the service that links the EU to a concrete HCP. This service is provided by “Actor Assignment” inside the management of the patient case.

Patient Care Services HC is based upon the synergic actions of the actors, including the assessment of the problem and the identifying of the needs of the HCP, the definition of an individual intervention plan (IP), the accomplishment of it through the proper procedures, the evaluation of the results. This step-by step process can be executed several times, until the achievement of proper results. These are the services to assess the condition of the patient during the first encounter, and whenever a re-evaluation is required. The HCNS covers the following nine services:

Problem Assessment and Re-Evaluation These are the services to *assess the condition of the patient* during the first encounter, and whenever a re-evaluation is required. The HCNS covers the following nine services:

S3.1 Comprehensive Assessment (CA) comprises Multi-Dimensional Evaluation plus Clinical Assessment and Physical Examination (integrating the medical side) and Social Needs and Social Network Assessment (integrating the social side). It is the service devoted to detect the whole series of HCPs diseases, conditions, and difficulties, from both the medical and social perspectives. It is performed at admission, at periodical or end-treatment re-evaluation time defined inside the IP and in case of emerging peculiarities during the follow-up.

S3.2 Multi-Dimensional Evaluation represents a standardized interview based on structured scales providing evidence about problems and conditions of the HCP (not only with regard to medical diagnoses, but including self-dependency, socio-demographic issues, lifestyle, physical and cognitive function, social needs and network) to delineate an overall functional profile of the patient. The K4CARE

model follows a two level approach: a first level which is common to all the HCPs; and a second level which examines in depth those HCPs or situations related with one or both of the primary syndromes considered in the model: immobility and cognitive impairment. The instruments proposed are reported in part VI. The set of scales can be used as a whole during the Comprehensive Assessment, or individually according to problems emerging at follow-up.

S3.3 Clinical Assessment it is carried out to gather and evaluate all the available information to delineate the HCP condition (previous test results, discharge sheets, consultations, previous treatment). Clinical Assessment completes CA and it is part of the Follow-up.

S3.4 Physical Examination it is used to find signs and symptoms of diseases and/or conditions. It is performed by physicians according to common practice. Physical Examination integrates the Comprehensive Assessment and is part of the Follow-up.

S3.5 Request of Diagnostic Examination diagnostic procedures must be determined in order to diagnose new conditions or to follow the evolution of the patient, the results of therapy, or to monitor clinical parameters. Prescription of Diagnostic Procedures integrates the CA and is part of the Follow-up.

S3.6 Request of Laboratory Analysis is a service required to diagnose new conditions or to follow the evolution of the patient, the results of therapy, or to monitor clinical parameters. Prescription of Laboratory Analysis integrates the CA and is part of the Follow-up.

S3.7 Consultation to refer the HCP to another physician - usually a SP - in order to assist the FD to better define diagnosis and/or treatment with relation to peculiar conditions related with special competences linked to different branches of medicine. Consultation integrates the CA and is part of the Follow-up.

S3.8 Social Needs and Social Network Assessment it is a service that identifies, analyzes and evaluates the patient's social needs in order to implement the IP: social sanitary assistance, financial assistance, legal aids, the supply of ambulation devices, home shortages and obstacles, etc. The network identification, analysis and evaluation is performed not only to assess and empower the skills and resources of the patient's relatives, continuous or occasional care providers, and other informal assistants (in order to replace, help, improve and supervise the HCP's abilities to perform ADLs and IADLs or to satisfy the patient social needs -i.e. to vote during elections), but also to evaluate the stress of the patient's relatives and continuous care

providers. Social Needs and Network Assessment integrates CA and is part of the Follow-up.

S3.9 Follow-up it is a service used to evaluate the patient condition through time, assessing results and goals. Provides evidence about the evolution of specific diseases or disorders, and the overall function. It informs actions aimed at modifying the IP and surveys the accomplishment of the defined goals. It includes social issues, to improve, verify and modify the individual program according to the patient needs. Formal instruments to be used are the follow-up forms and appropriate scale(s) of the Multi-Dimensional Assessment. When intervening conditions substantially modify HCP's overall status, CA for re-evaluation can be requested by the FD, apart from the re-evaluation defined inside the IP.

Intervention Plan Definition This section describes the HCNS services addressed to the construction of an individual intervention plan for the HCP.

S4.1 Planning of an Individual Intervention Plan the individual IP represents the course of actions to be performed in order to provide care to the HCP in terms of treatment and support. It aims at taking care of diseases and conditions, with the goal of improving functions and self-dependency. It includes a Social Assistance Program to provide and start up all the social services the HCP needs, including social assistance, financial assistance, legal aids. Defines periodical or end treatment re-evaluations.

S4.2 Prescription of Pharmacological Treatment to treat new conditions, to carry on a treatment, to redefine treatment.

S4.3 Prescription of Non-Pharmacological Treatment to provide a treatment alternative or supplementary to pharmacological treatment.

S4.4 Prescription of nursing care represents the operative branch of the sanitary side of care.

S4.5 Prescription of Assistive Devices in order to support impairments, deficits, or disabilities to sustain daily life activities.

Intervention Plan Performance Once it has been assigned to a patient, an individual intervention plan must be put into practice. The following services of the HCNS are introduced for the K4CARE model to permit this.

S5.1. Case Management is the service which organizes and controls the specific actions of specific actors on the individual HCP.

S5.2. Special Medical Services those that appear in the following list:

S5.2.a. Blood Gas Analysis This service consists on monitoring blood gas concentration and oxygen therapy.

S5.2.b. Blood Transfusion It is to manage blood transfusion procedures for anaemic HCPs.

S5.2.c. Certification Service to certify clinical and functional status of the HCP for legal purposes.

S5.2.d. INR Follow-up It is a service to provide a special prescription and clinical evaluation of International Normalized Ratio test to control patients on anti-coagulant treatment.

S5.2.e. Nursing Care are all those services performed at home by the Nu and represent one of the operative branches of HC (actions related to Nursing Care are reported in Table 13). When necessary, a physician can perform any of the nursing care actions.

S5.2.f. Social Assistance to support functional status and environment (to define skills, personal abilities and social and physical environmental issues); to replace, help, improve or supervise the patient's abilities to perform ADLs and IADLs, and to suggest the equipment to make specific activities easier (such as eating, dressing or bathing) and change the physical environment to support task performance and make the house safer and more accessible.

S5.2.g. Counselling to interview the HCP and his relatives in order to mediate between their needs and the HC supply. Information Services Information Services are those services which allow access to the information and the knowledge that the system contains. Such services are provided to any HC actor, out of those related to a particular Care Service. Information and knowledge provided can be used for different purposes, mainly service monitoring, social issues, clinical issues, and health care related topics.

Information Services

Service Monitoring

S6.1. Patient Record Overview to review information, ongoing services, IIPs, regarding an individual HCP. The access is permitted to the PC (for all the HCPs), to the HN (for all the HCPs), to the FD (for the

HCPs he is in charge of), to the HCP, to a delegate of the HCP (CCP). A temporal permission is given to the SP.

S6.2. Patient Record Social Overview to review information, ongoing services, IIPs, regarding social issues of an individual HCP. The access is permitted to the SW (for all the HCPs).

S6.3. IIPs Overview to review all the ongoing IIPs, for resources allocation purposes. The access is permitted to the PC and the HN.

S6.4. Schedule Overview to review all the scheduled activities, for human resources allocation purposes. The access is permitted to the PC and the HN.

S6.5. Waiting List to report waiting time and lists for the different services. The access is permitted to the professional actors, according to their liabilities.

HC Practice Information

S7.1. Guidelines Consultation to consult clinical guidelines related to syndromes and diseases. The access is permitted to the professional actors, according to their liabilities.

S7.2. FIP Overview to consult standard FIPs. The access is permitted to the professional actors, according to their liabilities.

S7.3. Pharmacological Therapy Handbook to consult information related to pharmacological treatment. The access is permitted to the medical actors.

S7.4. Best Practice Handbook to read information related to the best way of performing care related procedures and actions. The access is permitted to the professional actors, according to their liabilities.

S7.5. Brochure Consultation to read informative brochures, related to the counselling service. It encloses information about K4CARE services.

Database Inquiring

S8.1. Activities Report to report about all the activities by the whole HC service (to be subdivided by actors, time, services) for administrative and resource allocation purposes. The access is permitted to the PC and the HN.

S8.2. Database Queries - services semi-automatic queries to extract from the data base user tailored information regarding different services of

the HC service. The access is permitted to the professional actors, according to their liabilities.

S8.3. Database Queries - clinical semi-automatic queries to extract from the data base user tailored information regarding clinical issues. The access is permitted to the health care professional actors, according to their liabilities.

Personal Information

S9.1. Individual Scheduling Overview to report about all the scheduled appointments related to an individual HCP. The access is permitted to the HCP, to a delegate of the HCP (CCP), to the PC (for all the HCPs), to the HN (for all the HCPs), and to the FD (for the HCPs he is in charge of).

S9.2. P2P Messages to allow non-formalized information exchange among actors. The access is permitted to all the actors.

In the next table (Table 2) shows the different actors that can initiate the different services inside the K4CARE HCNS model.

Service		Actors
Access services		
	Individual Services	
	HC Request	FD
	HCP Admission	PC HN
	HCP Discharge	PC HN
	Professional admission	PC HN
	Professional discharge	PC HN
	Edit HCP/Professional information	PC HN
	Structural Services	
	EU Constitution	PC HN
	EU-HCP Binding	PC HN
Patient care services		
	Problem assessment and re-evaluation	
	Comprehensive assessment	PC HN
	Multi-dimensional evaluation	EU
	Clinical assessment	FD PC SP
	Physical examination	FD PC SP
	Request of diagnostic examination	FD PC SP
	Request of laboratory analysis	FD PC SP
	Consultation	FD PC SP
	Social needs and network assessment	SW
	Follow-up	FD SW Nu
	Intervention plan definition	
	Planning intervention plan	EU
	Prescription of pharmacological treatment	FD PC

	Prescription of non-pharmacological treatment	FD PC SP
	Prescription of nursing care	FD PC SP
	Prescription of assistive devices	FD PC SP
	Intervention plan performance	
	Case management	HN
	Special medical services: Blood gas analysis	FD PC SP
	Special medical services: Blood transfusion	FD PC SP
	Special medical services: Certification	HCP CCP
	Special medical services: INR Follow up	FD EU
	Nursing care	EU
	Social assistance	SW
	Counselling	ALL
Information Services		
	Service monitoring	
	Patient record overview	PC, HN, FD, HCP, CCP, SP
	Patient record social overview	SW
	IIPs overview	PC, HN
	Schedule Overview	PC HN
	Waiting list	PC HN FD SP Nu SW SO
	HC Practice	
	Guide Line consultation	PC HN FD SP Nu SW SO
	FIP overview	PC HN FD SP Nu SW SO
	Pharmacological therapy handbook	PC FD SP
	Best Practice Handbook	PC HN FD SP Nu SW SO
	Brochure consultation	ALL
	Database Inquiring	
	Activities report	PC HN
	Database queries-services	PC HN FD SP Nu SW SO
	Database queries-clinical	PC HN FD SP Nu SW SO
	Personal information	
	Individual scheduling overview	HCP PC HN FD
	P2P Messages	ALL

Table 2 HCNS Initiators

4.1.4 HCNS Documents

The HCNS structure defines a set of information units whose main purpose is to provide information about the care processes realized by the actors to accomplish a service. Different kinds of actors will be supplied with specific information that will help them to carry out their duties in the K4CARE model. All these data are considered here to be part of documents.

Documents in Access Services (AD)

The information required in each one of the K4CARE access services is summarized in Table 3 in the form of documents. The rights of the actors to read or write these documents are also depicted in the table.

Document	Code
HC Request Document	AD1
HCP Admission Document	AD2
HCP Discharge Document	AD3
Professional Admission Document	AD4
Professional Discharge Document	AD5
EU Constitution Document	AD6

Table 3 Access documents

Documents in Patient Care Services (D)

In order to support the actors taking part of the patient care services a list of documents are defined. Since these documents may have different general purposes inside the sets of services and procedures, they can be sub-divided into request documents, authorization documents, prescription documents, and anamnestic documents.

Request documents contain information about a request of a service, an action of a service, an appointment. They usually initiate a procedure for a service or a part of it.

Authorization documents are used to confirm and to authorize a certain action to be performed. They are connected with key points in the development of a procedure.

Prescription documents contain the instructions deriving from a medical action.

Anamnestic documents contain information about the patient that will be historically used in the process of care.

The actors involved in the different patient care services and procedures can contribute to the generation of the document (write option) or may require the total or partial information the document hosts (read option). The interaction between actors and documents is then defined of the sorts read (R), write (W) or both (RW).

The

Request	D33	Request of Blood Gas Analysis	Request of BGA laboratory test.
Request	D34	Request of Blood Transfusion	Request of BT.
Anamnestic	D35	Transfusion Report	Document declaring that a BT has been performed.
Request	D36	Request of Certification	Request of a medical document to be used for legal purposes.

Anamnestic	D37	Certification	Medical document to be used for legal purposes.
Request	D38	Request of INR	Request of actions needed to perform an INR test.
Anamnestic	D39	INR Report	Contains the results of the INR test.
Request	D40	Request of Nursing Care	Request of activating nursing care, following the prescription of nursing care.
Request	D41	Social Support Request	Request of actions of social support, written by the SW.
Anamnestic	D42	Social Coaching Report	Definition of a series of social support action, written by the SW.
Anamnestic	D43	Information Sheet	Information addressed to the care givers, mainly to the non-professional ones.

Table 4 provides a description of the documents implied in the patient care services, subdividing them into common documents, those which are used in different services, and service specific documents, those which are specific for a definite service. For each document it is provided the type (i.e. request, authorization, prescription, or anamnestic), the abbreviation (i.e. document code for identification purposes), the name, and a description.

Type	Code	Name	Description
Common documents			
Request	D1	Actor Assignment	Is the information that links an individual action to an individual HCP for an action (or series of actions) to be performed.
Authorization	D2	Actor Confirmation	Is the information that declares that the actor knows the assignment and accepts it.
Authorization	D3	Waiting List	The waiting list is automatically generated on the basis of requests, daily schedules, and priorities. Is confirmed by the HN. Can be modified by the HN.
Authorization	D4	Daily Schedule	Daily Schedules are automatically generated on the basis of waiting lists and priorities. Different daily schedules exist for different services and actors. They are confirmed by the HN. They can be modified by the HN.
Request	D5	Message to the Patient	Is a message delivered to the HCP to inform that an action for a service is going to be performed and to make an appointment. Can be delivered by phone, via SMS or others.
Authorization	D6	Patient Confirmation	Is a message delivered by the HCP to inform that he/she accepts the appointment for an action to be performed. Can be delivered by phone, via SMS or others.
Authorization	D7	Patient Consent	Is the information which consents that a certain action (or series of actions) is accepted by the HCP and can be performed.
Authorization	D8	CCP Consent	Is the information which consents that a certain action (or series of actions) is accepted by the (legally responsible) CCP and can be performed, in case of HCP non capable of giving consent.
Authorization	D9	FD Authorization	Is the authorization that the FD (ultimate responsible of the HCP's care) gives for certain actions to be performed.
Service specific documents			
Request	D10	Request of CA	Is the request that allows the HCP to undergo a comprehensive assessment. Is done by the PC or the HN, after patient's admittance to the service.
Anamnestic	D11	MDE Scales	Set of forms filled in by the EU during the first problem assessment and/or in occasion of the periodical or end-treatment re-evaluation.
Anamnestic	D12	Clinical history	All the available pertinent clinical information of the HCP (previous test results, discharge sheets, consultations, previous treatment). It is written by the FD and PC; is read by EU and the other professionals in charge of the patient (according to their competencies in the process of care of the individual patient), by the patient him/herself.
Anamnestic	D13	Physical	The report contains signs and symptoms of diseases and/or

		Examination Report	conditions. It is written by FD, PC, SP; can be updated in any occasion of evaluation. It is read by FD, PC, HN; SP and Nu in charge of the Patient.
Request	D14	Request of Diagnostic Examination	Request of diagnostic examination necessary to define the actual clinical condition of the HCP; is written by FD, PC, SP in charge of the patient.
Request	D15	Request of Laboratory Analysis	Request of laboratory analysis necessary to define the actual clinical condition of the HCP; is written by FD, PC, SP in charge of the patient.
Request	D16	Request of Consultation	Is the information to refer the HCP to a SP, to better define different aspects of care. It is usually done by the SP, but can also be done by the PC or the SP.
Anamnesic	D17	Consultation Report	Contains clinical observations and proposals made by the SP. Is usually addressed both to the patient and the FD.
Anamnesic	D18	Social Report	Contains the observations regarding social issues done by the SW at evaluation times.
Anamnesic	D19	Medical follow-up form	It is written by the FD or the PC during the follow-up activities.
Anamnesic	D20	Nursing follow-up form	It is written by the Nu or the HN during the follow-up activities.
Anamnesic	D21	CCP Report	It is written by the CCP during the follow-up activities. Can be used to indicate intervening difficulties or changes.
Anamnesic	D22	SO Report	It is written by the SO during the follow-up activities. Can be used to indicate intervening difficulties or changes.
Anamnesic	D23	ICG Report	It is written by the ICG during the follow-up activities. Can be used to indicate intervening difficulties or changes.
Anamnesic	D24	HCP Report	It is written by the HCP during the follow-up activities. Can be used to indicate intervening difficulties or changes.
Request	D25	Request of Extra CA	It is written by the FD when he detects such changes during the follow-up activities to deserve an extra CA of the HCP.
Prescription	D26	IP	Is written by members of the EU in order to define actions, actors and outcomes of the IP.
Prescription	D27	Re-evaluation Plan	Defines times and modalities to evaluate the accomplishment of the IP in terms of goals and results.
Prescription	D28	Prescription of Pharmacological Treatment	Medical instructions to treat diseases or disorders.
Prescription	D29	Prescription of Non-Pharmacological Treatment	Medical instructions to treat diseases or disorders.
Prescription	D30	Prescription of nursing care	Medical instructions define nursing care to be used to treat diseases or disorders.
Authorization	D31	Authorization of nursing care	It is written by PC to authorize the performance of nursing care.
Prescription	D32	Prescription of Assistive Devices	Medical definition of assistive devices to be used to support impairments and handicaps.
Request	D33	Request of Blood Gas Analysis	Request of BGA laboratory test.
Request	D34	Request of Blood Transfusion	Request of BT.
Anamnesic	D35	Transfusion Report	Document declaring that a BT has been performed.
Request	D36	Request of Certification	Request of a medical document to be used for legal purposes.
Anamnesic	D37	Certification	Medical document to be used for legal purposes.
Request	D38	Request of INR	Request of actions needed to perform an INR test.
Anamnesic	D39	INR Report	Contains the results of the INR test.
Request	D40	Request of Nursing Care	Request of activating nursing care, following the prescription of nursing care.
Request	D41	Social Support	Request of actions of social support, written by the SW.

		Request	
Anamnestic	D42	Social Coaching Report	Definition of a series of social support action, written by the SW.
Anamnestic	D43	Information Sheet	Information addressed to the care givers, mainly to the non-professional ones.

Table 4 HCNS Documents

5 Construction of the set of HCNS Procedures

In the K4CARE Model a procedure represents the way that the actions provided by/to the actors are combined to accomplish one service. In section 0, K4CARE services were divided into access services, patient care services, and information services. The first group is about how actors and working teams are created, updated, and destroyed in the K4CARE model. The second group is about how the actors of the model interact to provide an effective and efficient home care. The third group gathers all the services devoted to provide information, outside the actual performance of single services.

5.1 Motivation

The Deliverable 1 gives a broad description of the different K4CARE procedures related to the different services. This description did not contain details about the concrete actions needed to perform the different procedure steps, and which documents were needed to in the different actions. The deliverable contained a detailed description of the documents needed in the different services, but it was then rejected, because during further works over the procedures some inconsistencies were found.

So that, one important task to perform inside the K4CARE model definition, was to define a detailed description of the different procedures. The main detail needed for every procedure is to give the set of actions and/or services needed to perform every one of the different procedure steps. Then another important detail needed, is to link the different actions with its corresponding documents used. As a consequence of this specification some changes in other elements, like the actions or the documents can occur.

5.2 Methodology

To define all the procedures, the work started from the broad procedure description given by the physicians. They give a set of steps needed to perform every one of the different procedures. Those steps correspond to the first column given in the Table 5. Starting from this definition a relation between the steps and the actions was given, and once revised, it was sent to the physicians. This way of working was repeated several times, and finally, to create the definitive version of the details of the procedures, a meeting in the Fondazione Santa Luccia (Rome) was realized and concluded with the definitive version of the HCNS procedures.

5.3 Results

In the table (Table 5) presented below, the details obtained for every one of the different procedures are given.

Description	Step code	Step name	Doc. code	Document name
3. Problem Assessment and Re-Evaluation				
S3.1. Comprehensive Assessment (CA)				
a) The PC or the HN refers the admitted patient for a CA.	BO.3	refer the admitted patient for CA	D10	Request of Comprehensive Assessment
(b) The HN assigns the members of the EU.	BO.5	assign members of EU	D1	Actor Assignment
	BO.13	actor confirmation	D2	Actor Confirmation
(c) The HN sends a message to the patient to make an appointment.	BO.8	send message to the patient	D5	Message to the Patient
(d) The HCP confirms the appointment	P.1	confirm appointment	D6	Patient Confirmation
(e) The EU makes the patient's assessment at home according to a standardized interview (<i>Multi-Dimensional Evaluation</i>).	EU.1	evaluate through scales	D11	MDE Scales
(f) FD or PC performs <i>Clinical Assessment and Physical Assessment</i> .	S3.3	Clinical Assessment		
(g) The SW performs the <i>Social Needs and Social Network Assessment</i> .	S3.8	Social Needs and Network Assessment		
(h) The HCP provides the necessary information. In case of a non-compliant or non reliable HCP, the CCP provides the necessary information.	BO.1	provide information		
(j) The HN performs Case Management or Back Office proper actions	S5.1.A	Case management A		
S3.2. Multi-Dimensional Evaluation				
(a) A standardized interview according to a set of standardized evaluation scales is performed by the EU in occasion of the Comprehensive Assessment (after patient's admission). The same interview is repeated in occasion of the periodical and end-treatment re-evaluation(s), as defined inside the IP or on request of the FD during the <i>follow-up</i> .				
(b) The PC or the HN refers the admitted patient for a CA	BO.3	refer the admitted patient for CA	D10	Request of Comprehensive Assessment

(c) The re-evaluation is defined inside the IP.	EU.5	schedule re-evaluations	D27	Re-evaluation Plan
(d) The re-evaluation is requested by the FD, based on elements deriving from the follow-up.	M.FD.2	request of re-evaluation	D25	Request of Extra re-evaluation
(e) The EU interviews the HCP according to a set of standardized evaluation scales.	EU.1	evaluate through scales	D11	MDE Scales
(f) The HCP provides the necessary information. In case of a non-compliant or non reliable HCP, the CCP provides the necessary information.	BO.1	provide information		
S3.5. Request of Diagnostic Examination				
(a) The FD, PC, SP write a request of Diagnostic Examination.	M.3	request Diagnostic Examination	D14	Request of Diagnostic Examination
(b) The HN performs Case Management's proper actions.	S5.1.B	Case management B		
S3.6. Request of Laboratory Analysis				
(a) The FD, PC, SP write a request of Laboratory Analysis.	M.4	request Laboratory Analysis	D15	Request of Laboratory Analysis
(b) The HN performs Case Management's proper actions.	S5.1.B	Case management B		
S3.7. Consultation				
(a) The FD refers the HCP to the SP.	M.9	refer to SP	D16	Request of Consultation
(b) The HN performs Case Management's proper actions.	S5.1.C	case management C		
(c) The HN sends a message to the patient to make an appointment.	BO.8	send message to the patient	D5	Message to the Patient
(d) The patient confirms the appointment.	P.1	confirm appointment	D6	Patient Confirmation
(e) The SP makes a patient's assessment (Clinical Assessment, Physical Assessment).	S3.3	Clinical Assessment		
	S3.4	Physical Examination		
(f) The SP writes a consultation.	M.SP.1	write consultation report	D17	Consultation Report
(g) The SP eventually requests laboratory tests, and/or other diagnostic procedures.	S3.6	Request of laboratory analysis		
	S3.5	Request of diagnostic examination		
(h) The SP eventually refers patients for different consultations.	M.9	refer to SP	D16	Request of Consultation

(i) The SP prescribes medication and treatment, under an agreement with the FD.	S4.2	Prescription of Pharmacological Treatment		
	S4.3	Prescription of non-pharmacological treatment		
(j) The FD authorizes pharmacological/non-pharmacological treatment proposed by the SP.	M.FD.3	authorize treatment proposed by SP or PC	D9	FD Authorization
S3.8. Social Needs and Social Network Assessment				
(a) The SW makes an assessment of the patient's social needs and social network in order to define the IP				
(b) According to an interdisciplinary scale the SW identifies, analyses and evaluates the patient's social needs in order to define the IP. The SW makes a contextual examination in skills and resources of the patient's family and the care providers' group.	S.1	assess social needs and network	D11	MDE Scales
(d) The SW evaluates the results of the patient's program for social assistance and defines best practice.	S.3	supervise achievement of social outcomes	D18	Social Report
S3.9. Follow-up				
(a) The evolution of clinical and functional status of HCP is assessed according to scheduled controls and/or in case of emerging medical and social issues by the FD, SW, Nu.	EU.4	schedule controls	D26	IP
(b) The HN sends messages to the patient to make appointments.	BO.8	send message to the patient	D5	Message to the Patient
(c) The patient confirms the appointments.	P.1	confirm appointment	D6	Patient Confirmation
(d) The FD monitors parameters indicating health status and overall condition of the patient through evaluation scales, Clinical Assessment, Physical Examination, Request of Diagnostic Examination, Request of Laboratory Analysis, Consultation.	EU.1	evaluate through scales	D11	MDE Scales
	S3.3	Clinical Assessment	D12	Clinical history
	S3.4	Physical Examination	D13	Physical Examination Report
	S3.6	Request of laboratory analysis		
	S3.5	Request of diagnostic examination		

	M.9	refer to SP	D16	Request of Consultation
(e) The FD fills in the medical follow-up form.	M.10	write medical follow-up	D19	Medical follow-up form
(f) The FD refers the HCP to a SP when he/she needs specific contribution from different professionals to maintain the necessary care of the patient and in order to avoid unnecessary admissions to hospital.	M.9	refer to SP	D16	Request of Consultation
(g) The Nu fills in the Nursing follow-up form during the scheduled activities.	N.26	write Nursing follow-up	D20	Nursing follow-up form
(h) The SW evaluates periodically the patient's program for social assistance and may improve it.	S.3.8	Social Needs and Network Assessment		
(i) The SW periodically supervises and improves the care providers' group.	S.3	supervise achievement of social outcomes	D18	Social Report
	S.6	write social report	D18	Social Report
(j) Trained actors can use part of the Multi-Dimensional Evaluation (one or more scales) to define special issues.	EU.1	evaluate through scales	D11	MDE Scales
(k) Other care-givers (all the actors not specified here) could provide information about HCP status.	BO.1	provide information	D21	CCP Report
			D22	SO Report
			D23	ICG Report
			D24	HCP Report
(l) When intervening conditions substantially modify HCP's overall status, re-evaluations can be requested by the FD, apart from the re-evaluation defined inside the IP.	M.FD.2	request of re-evaluation	D25	Request of Extra re-evaluation
(m) The HN performs Case Management's proper actions.	S5.1.B	Case management B		
4. Intervention Plan Definition.				
S4.1. Planning Intervention Plan				
(a) The EU defines an intervention plan – based on Comprehensive Assessment information – indicating means and timing of HCP's care and assigning the proper actors in order to accomplish defined outcomes.	EU.2	define intervention plan	D26	IP

(b) Defined goals are indicated.	EU.3	define outcomes	D26	IP
(c) The SW plans an individual program for social assistance in order to provide and start up all the social services the HCP needs (i.e. social sanitary assistance, financial assistance, legal aids, home shortages and obstacles, the supply of ambulation devices, etc). The SW defines a priority list of the patient's social needs to fulfil. The SW defines, together with the patient's family and the care providers' group, their skills and resources in order to organize and empower them inside the IP.	S.2	define social intervention	D26	IP
(f) The EU schedules periodical and end-treatment re-evaluations.	EU.5	schedule re-evaluations	D27	Re-evaluation Plan
(g) The EU schedules periodic controls of the FD, SW.	EU.4	schedule controls	D27	Re-evaluation Plan
(h) The HCP agrees on the proposed interventions. In case of a non-compliant or non reliable HCP, the CCP agrees on the proposed interventions.	P.3	give consent		
(j) The HN provides the Case Management.	S5.1.B	Case management B		
(k) The HN looks after the fulfilment of the IP.	CM.1	supervise IP		
	CM.2	control performance of activities		
	CM.3	supervise achievement of outcomes		
S4.2. Prescription of Pharmacological Treatment				
(a) The FD, PC, SP write a prescription for Pharmacological Treatment.	M.5	prescribe Pharmacological Treatment	D28	Prescription of Pharmacological Treatment
(b) The FD authorizes pharmacological treatment proposed by the SP or PC.	M.FD.3	authorize treatment proposed by SP or PC	D9	FD Authorization
S4.3. Prescription of Non-Pharmacological Treatment				
(a) The FD, PC, SP write a prescription for non-Pharmacological Treatment.	M.6	prescribe non-Pharmacological Treatment	D29	Prescription of Non-Pharmacological Treatment
(b) The FD authorizes non-pharmacological Treatment proposed by the SP or PC.	M.FD.3	authorize treatment proposed by SP or PC	D9	FD Authorization
(c) In case of involvement of third actors, proper case	BO.4	assign actor	D1	Actor Assignment

management activities are performed by the HN.	BO.13	actor confirmation	D2	Actor Confirmation
S4.4. Prescription of Nursing Care				
(a) The FD, SP, PC write a prescription of nursing care.	M.8	prescribe nursing care	D30	Prescription of nursing care
(b) The FD and PC jointly authorize nursing care proposed by the SP.	M.FD.6	authorize nursing care	D31	Authorization of nursing care
(c) The PC authorizes nursing care proposed by FD.	BO.10	authorize nursing care service	D31	Authorization of nursing care
S4.5. Prescription of Assistive Devices				
(a) The FD, PC, SP write a prescription for assistive devices.	M.7	prescribe assistive devices	D32	Prescription of Assistive Devices
5. Intervention Plan Performance.				
S5.1.A Case Management A				
(a) The HN confirms or modifies waiting lists.	BO.6	confirm or modify waiting lists	D3	Waiting List
(b) The HN confirms or modifies daily schedules.	BO.7	schedule activity	D4	Daily Schedule
S5.1.B Case Management B				
(a) The HN assigns the pertinent actor(s) to the HCP.	BO.4	assign actor	D1	Actor Assignment
	BO.13	actor confirmation	D2	Actor Confirmation
(b) The HN confirms or modifies waiting lists.	BO.6	confirm or modify waiting lists	D3	Waiting List
(c) The HN confirms or modifies daily schedules.	BO.7	schedule activity	D4	Daily Schedule
	BO.8	send message to the patient	D5	Message to the Patient
	P.1	confirm appointment	D6	Patient Confirmation
	P.3	give consent	D7 D8	Patient Consent CCP Consent
S5.1.C Case Management C				
(a) The HN assigns the pertinent actor(s) to the HCP.	BO.4	assign actor	D1	Actor Assignment
(b) The HN confirms or modifies waiting lists.	BO.13	actor confirmation	D2	Actor Confirmation
	BO.6	confirm or modify waiting lists	D3	Waiting List
(c) The HN confirms or modifies daily schedules.	BO.7	schedule activity	D4	Daily Schedule
S5.1.D Case Management D				
(a) The HN assigns the pertinent actor(s) to the HCP.	BO.4	assign actor	D1	Actor Assignment
	BO.13	actor confirmation	D2	Actor Confirmation
S5.1.E Case Management E				
(a) The HN assigns the pertinent actor(s) to the HCP.	BO.4	assign actor	D1	Actor Assignment
	BO.13	actor confirmation	D2	Actor Confirmation
(b) The HN confirms or modifies waiting lists.	BO.6	confirm or modify waiting lists	D3	Waiting List
S5.2. Special Medical Services				
Blood Gas Analysis				

(a) The FD, PC, SP refers his patient to the HC service for a BGA or the BGA is part of the intervention plan.	S3.6	Request of laboratory analysis	D33	Request of Blood Gas Analysis
(b) The HN performs Case Management's proper actions.	S5.1.C	Case management C		
(c) The HN sends a message to the patient to make an appointment.	BO.8	send message to the patient	D5	Message to the Patient
(d) The patients confirms the appointment.	P.1	confirm appointment	D6	Patient Confirmation
	P.3	give consent	D7	Patient Consent
			D8	CCP Consent
(e) The SP performs the arterial blood collection at patient's home.	M.SP.2	arterial blood collection		
(f) The SP (or other instructed actor) takes the specimen to the laboratory.	M.SP.3	takes specimen to laboratory		
Blood Transfusion				
(a) On the basis of a low blood cell count (red cells and haemoglobin concentration), the FD (or the PC, or the SP) refers the HCP for a BT.	M.13	refer for transfusion	D34	Request of Blood Transfusion
(b) The HCP gives consent. In case of a non-compliant or non reliable HCP, the CCP gives consent.	P.3	give consent	D7	Patient Consent
(c) The PC forwards the Blood Transfusion request to the Blood Transfusion Service.	BO.11	forward the Blood Transfusion request	D34	Request of Blood Transfusion
(d) The HN schedules two blood specimens collections at 24-hour interval (only one for the following BTs) for cross-reaction tests.	BO.7	schedule activity	D4	Daily Schedule
(e) The HN performs Case Management's proper actions.	S5.1.D	Case management D		
(f) The HN sends messages to the patient to make appointments.	BO.8	send message to the patient	D5	Message to the Patient
(g) The patient confirms the appointments.	P.1	confirm appointment	D6	Patient Confirmation
(h) The Nu performs the activities.	N.1	Specimen Collection (blood, urine, faeces).		
(i) The HN alerts the Physician in charge of the transfusion.	BO.4	assign actor	D1	Actor Assignment
	BO.13	actor confirmation	D2	Actor Confirmation
(j) The Physician in charge (SP) of the transfusion collects the blood bags.	M.SP.4	collect blood bags		

(k) The Physician in charge (SP) of the transfusion sends a message to the patient to make an appointment	BO.8	send message to the patient	D5	Message to the Patient
(l) The patient confirms the appointment.	P.1	confirm appointment	D6	Patient Confirmation
(m) The Physician in charge (SP) of the transfusion performs the transfusion.	M.SP.5	perform the transfusion		
(n) The Physician in charge (SP) of the transfusion delivers to the HCNS a Transfusion Report	M.SP.6	write transfusion report	D35	Transfusion Report
(o) The PC or the FD refers the HCP for a post-transfusion blood count.	S3.3	Clinical Assessment	D15	Request of Laboratory Analysis
(p) The HN schedules the blood specimen collections at 24-hour interval.	BO.7	schedule activity	D4	Daily Schedule
(q) The HN performs Case Management's proper actions.	S5.1.D	Case management D		
(r) The HN sends a message to the patient to make an appointment.	BO.8	send message to the patient	D5	Message to the Patient
(s) The patient confirms the appointment.	P.1	confirm appointment	D6	Patient Confirmation
(t) The Nu performs the activity.	N.1	Specimen Collection (blood, urine, faeces).		
(v) The HN sends the Transfusion Report and results of the post-transfusion blood cell count to the Blood Transfusion Service.	BO.12	send Transfusion Report	D35	Transfusion Report
Certification				
(a) The HCP or the CCP request a Certification.	P.4	request certification	D36	Request of Certification
(b) The FD refers the HCP to the SP for a Certification (according to competencies).	M.FD.4	refer the HCP to SP for Certification	D16	Request of Consultation
(c) The HN performs Case Management's proper actions.	S5.1.D	Case management D		
(d) The HN sends a message to the patient make an appointment.	BO.8	send message to the patient	D5	Message to the Patient
(e) The patient confirms the appointment.	P.1	confirm appointment	D6	Patient Confirmation
(f) The SP or the FD makes a patient's assessment at home.	S3.3	Clinical Assessment	D12	Clinical history

(g) The SP or the FD writes the Certification.	M.11	write Certification	D37	Certification
INR Follow-up				
(a) The FD refers his patient for an INR Follow-up or it is part of the intervention plan.	M.FD.5	refer the HCP for INR Follow-up	D38	Request of INR
(b) The HN performs Case Management's proper actions.	S5.1.E	Case management E		
(c) The HN schedules periodic specimen collections.	BO.7	schedule activity	D4	Daily Schedule
(d) The HN sends a message to the patient to make an appointment.	BO.8	send message to the patient	D5	Message to the Patient
	P.1	confirm appointment	D6	Patient Confirmation
(e) The Nu performs the blood collection.	N.1	Specimen Collection (blood, urine, faeces).		
(f) Results of the test are delivered to the FD or to the SP (Cardiologist) who writes the INR Report.	M.12	write INR Report	D39	INR Report
(f) FD or the SP (Cardiologist) prescribes the new anti-coagulant therapy.	S4.2	Prescription of Pharmacological Treatment	D28	Prescription of Pharmacological Treatment
S5.3. Nursing Care				
(a) The FD or PC refers the HCP for nursing care or it is part of the intervention plan.	S4.4	Prescription of nursing care	D30	Prescription of nursing care
(b) The HCP gives consent. In case of a non-compliant or non reliable HCP, the CCP gives consent.	P.3	give consent	D7	Patient Consent
(d) The HN performs Case Management's proper actions.	S5.1.C	Case management C		
(e) The HN sends a message to the patient to make an appointment.	BO.8	send message to the patient	D5	Message to the Patient
(f) The patient confirms the appointment.	P.1	confirm appointment	D6	Patient Confirmation
(g) The Nu performs the procedure.	N.1	confirm appointment		
	N.2	I.M. Injection.		
	N.3	Intravenous therapy .		
	N.4	Insertion, care and maintenance of peripheral intravenous infusion.		
	N.5	Catheter care (insertion or removal, including perineal/penile toilet and change of drainage bag).		
	N.6	Stoma maintenance,		

		including replacement of stoma bags and wafer maintenance.		
	N.7	Establishing and reviewing a stoma care program.		
	N.8	Care and maintenance of tracheostomy.		
	N.9	Care and maintenance of feeding tubes (nasogastric and PEG)		
	N.10	Care and maintenance of urostomic tubes		
	N.11	Care of analgesic pump		
	N.12	Care and fitting of prosthesis, and anti-embolic stockings		
	N.13	Assistance with nebulisers, metered aerosols, turbuhalers, canisters and inhalers		
	N.14	Monitoring of vital signs (checking the patient's temperature, pulse, respiration, blood pressure, and pain)		
	N.15	Blood sugar measurement.		
	N.16	ECG		
	N.17	Maintenance of skin integrity, including changing of position of a chairfast or bedfast care recipient.		
	N.18	Pressure Ulcer treatment		
	N.19	Treatment of other skin lesions		
	N.20	Simple wound dressings		
	N.21	Complex wound management		
	N.22	Insulin therapy		
	N.23	Suctioning airways		
	N.24	Enema administration		
	N.25	Training of CCP		
S5.4. Social Assistance				
(a) The SW gets in touch with the social service providers in order to verify their availability and resources for the patient's social needs	S.4	contact social service providers	D41	Social Support Request
(b) The SW coaches the patient's social network and	S.5	coach social network	D42	Social Coaching Report

negotiates further activities for improving the IP inside the care providers' group. [supervision]				
(c) The HCP gives consent. In case of a non-compliant or non reliable HCP, the CCP gives consent.	P.3	give consent	D7	Patient Consent
(e) The SW sends a message to the patient to make an appointment.	BO.8	send message to the patient	D5	Message to the Patient
The CCP, SO, ICG perform the assistive actions.	P.1	confirm appointment	D6	Patient Confirmation
	S.7	perform assistive actions		
S5.5. Counselling				
(a) The HCP and his CCP are interviewed (by FD, PC, HN, SW, Nu, SP, SO) about their needs connected with the HC.	BO.2	ask information		
(b) Information is given about the actual HC service supply, sanitary rules, diseases and condition management.	BO.1	provide information	D43	Information Sheet

Table 5 HCNS Procedures

6 APO

The APO is an ontology that contains the medical knowledge about HC corresponding to the K4CARE model. So that, this ontology has to store all the information regarding to which are the different actors that appear in the system and which are they roles, that is, the services where the actors take part and which actions and liabilities they have inside the services have to be specified.

6.1 APO functionality

Once the work of defining the K4CARE model with the aid of the medical experts from the Fondazione Santa Lucia has been done, the next task to perform is the codification of the defined knowledge into an ontology. The ontology that will contain all this knowledge is called APO (Actor Profile Ontology). The APO will be used by the K4CARE system to obtain information about the actors, and their roles in the system services.

The APO goal is not the usual goal of the ontologies, because utilities like reasoning or the creation of instances of the defined classes are not necessary. The APO will be used to store the information about the roles played by the different actors, services and documents inside the K4CARE system in a structured way. By the use of the APO the system can know which are the services offered by the system, which documents they use, and how they are linked to their corresponding SDA, which specifies detailly which are the steps to follow when a service is performed, and which conditions are established between the different steps. APOs represent the skills, expertise, experiences, concerns, etc. of the actors in the K4C model, and therefore, they act as a filter of how the K4C model is perceived. So, for instance the orthopaedist APO will stress some patient features that other APOs as geriatrician or patient at home will ignore. This way the same K4C model will have different interpretations depending on the “eyes” (i.e. APO) of the observer. However, an APO must be instantiated in a particular physician, patient or citizen before it is applicable. This instantiation process will permit that a particular actor could introduce his or her particular vision of his role in the K4C model.

To correctly understand the role played by the APO inside the K4CARE system, next is shown the internal system structure to observe which the different roles are played by the different elements inside the system, and more concretely, the APO. The Figure 2 shows the K4CARE schema. Inside this can be observed that the system is composed by the K4CARE platform, several data sources, and the data abstraction layer [1]. The K4Care platform is divided in tree components the Servlet, the Gateway agent and the Multi-Agent System (MAS) [37]. The second one is the Knowledge Layer, this layer stores all the medical knowledge about the patients, diseases, and healthcare professionals.

In Figure 2 K4CARE Figure 2 the green colour indicates the modules that I have designed and implemented.

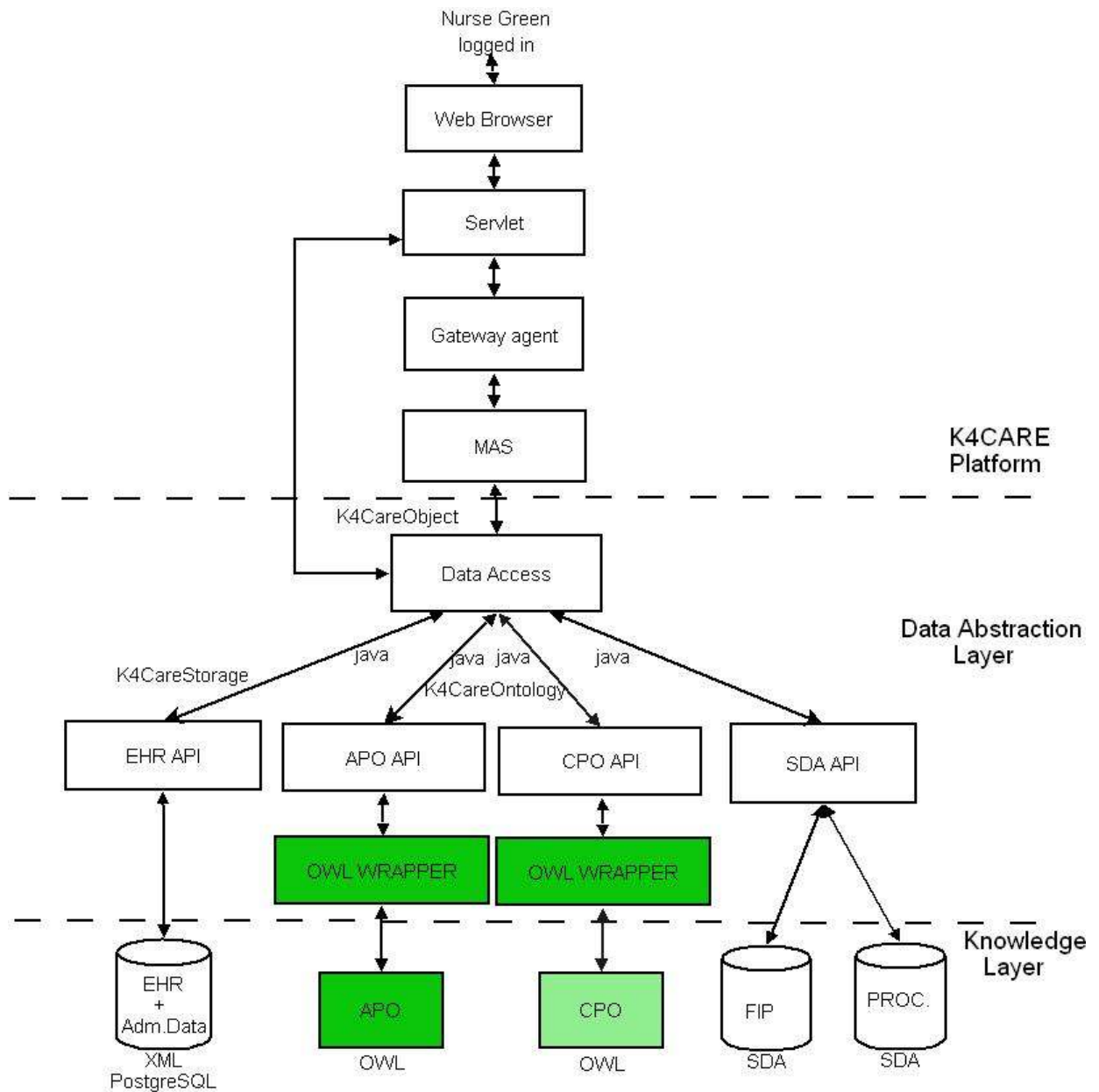


Figure 2 K4CARE platform architecture

K4Care platform

The K4CARE system is an agent-based platform, so that the MAS manages the functionality of the system inside the K4Care project. The MAS in K4Care is composed by different kinds of HealthCare agents which represent the different actors involved in the system (i.e. family doctors, nurses, patients, etc.). In addition there are other kinds of agents that perform other specific tasks, like the agents that execute IIPs.

The K4Care model defines a set of services to assess patients. The main purposes of the MAS are to connect the Web Interface with the HealthCare Agents and provide these services. The agents are in charge of executing different functionalities inside the K4CARE system, like the execution of long-term treatments, Individual Intervention Plans, and the execution of Procedures.

The connection between the User Interface (World Wide Web) and the agents in the system (HealthCare agents) is done through a set of gateway agents. The access to the K4Care MAS system is done through a web browser. The server side would be implemented using servlets. The entry point for the servlet to the MAS will be an agent called Gateway Agent whose job will be to translate objects coming from the servlet to FIPA messages that go to the MAS.

Knowledge Layer

The Knowledge Layer contains all the formal knowledge used in the K4Care. We can divide the K4Care Knowledge Layer into two knowledge levels: a *data base level* based on the relational model, on the Electronic Health Record and documents encoded in XML and a *knowledge level* based on ontologies. This formal knowledge in the form of ontologies will be used to personalise the assistance to all the agents working with the platform: healthcare professionals, patients, and citizens in general; as they mutually interact.

The knowledge in the Knowledge Layer is distributed in the following data sources:

- **Electronic Health Record (EHR)** and a relational data base: it stores administrative data about the actors implied in the K4Care and the information related to a patient, this means, his clinical history, etc.
- **Actor Profile Ontologies (APO)**: it formalises the knowledge related to all the agents involved in the care of chronic senior patients. The APO stores the permissions, procedures, services and documents related to each actor
- **Case Profile Ontologies (CPO)**: it formalises the knowledge of the ailments of these patients. The CPO contains the description of each disease that the patients can suffer.
- **Formal Intervention Plans (FIP)**: it formalises the treatment processes.
- **Procedures**: it is a set of actions combined in order to accomplish one service, those procedures are coded with SDA* diagrams.

Data abstraction layer

To allow an efficient access to the different data sources existing in the K4CARE model, an intermediate layer is introduced. This layer consists on creating an intelligent intermediate layer that implicitly knows where is the knowledge required by the agents and which is able to manage the communication requirements to the proper knowledge sources. This intermediate mediator is called Data Abstraction Layer (DAL). This layer permits the agents of the Multi-Agent System to access to the knowledge through high level queries.

6.2 *OWL Wrapper*

The OWL Wrapper has been created to facilitate the access to the OWL files. This API is a layer that works over the Jena API. Jena is a Java framework for building Semantic Web [7] applications. It provides a programmatic environment for RDF, RDFS and OWL, SPARQL and includes a rule-based inference engine. Jena allows to access to any OWL file, but Jena does it in a non-intuitive way, because the functions offered by its API are oriented to the OWL file structure, and not oriented to the ontology structure.

L'OWL Wrapper allows doing an easy and intuitive access to the different classes, properties and restrictions established in OWL ontologies, offering a powerful and easy to use way to access to the different OWL elements of an ontology. The OWL Wrapper allows accessing to an ontology without the necessity of knowing the internal structure of the OWL code, so that, the access to the ontology is very intuitive. Moreover, the Wrapper allows the modification of the ontology by using a set of functions which prevent the user to do incorrect modifications and/or creations of elements that can imply inconsistencies inside the ontology structure.

In the K4CARE project, the OWL Wrapper is used inside the Data Abstraction Layer (6.1) and inside the ISA tool (Section 7.4).

6.3 *APO engineering*

To create the APO ontology, a tool that allows creating ontologies by using a graphical interface has been used. This tool is known as Protégé [4], and it has been developed inside the Stanford University. This tool allows creating different ontology types, and in the case of the APO, has been decided to code the ontology in OWL language, because it is a well known standard.

Protégé also incorporates a set of tools that not only allow to create and/or modify ontologies, but it also allows to visualize them (Jambalaya, Onto Viz, etc.), to perform ontology merging (PROMPT [24]) and other capabilities. Protégé also allows adding several plug-ins that can increment its utilities.

In this section the main classes defined in the APO Ontology of the K4CARE are explained. They correspond to the basic concepts of the HC medical model, the ones defined by the HC Nuclear Structure (HCNS). This Ontology will be referred as primary APO.

Since the representation of the complete APO Ontology is too huge to fit in one page, the Figure 3 displays only the most important classes of the APO Ontology. Below some of those classes have a more specific hierarchy of concepts.

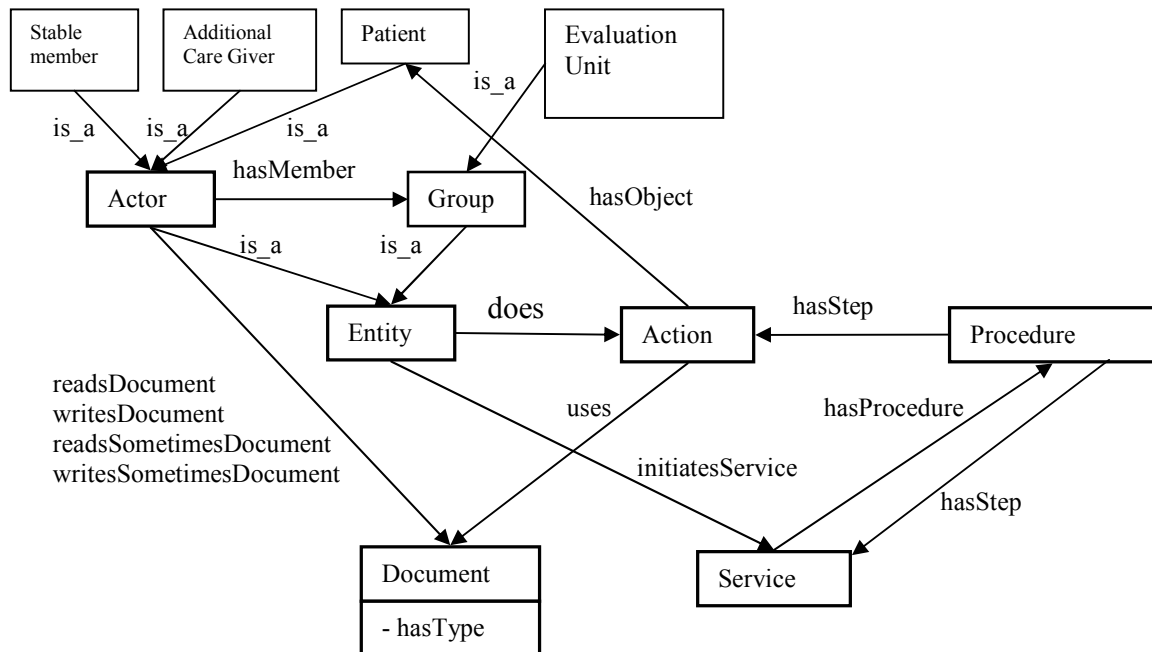


Figure 3 APO schema

Entity An Entity is everything that can perform an action inside the K4CARE model. The two main classes of *Entities* are the *Actors* and the *Groups*. The *Groups* are sets of actors which depending on the circumstances can act as a unique one. The property *hasMember* specifies which are the members (*Actors*) of a *Group*. In the HCNS there is a *Group* of *Actors* called Evaluation Unit, which is composed by the Family Doctor, the Head Nurse, the Physician in Charge and the Social Worker. The *Actors* of the HCNS can be subdivided in the groups shown below:

- Stable Members are professionals and non professional actors which usually are part of the HC and they are directly employed by the health care system. The stable members are: the physician in charge, the head nurse, the family doctor, the nurse and the social worker.
- Additional Care Givers are professionals and non professional actors which usually are part of the HC, but they are not directly employed by the health care system. The additional care givers are the specialist physician, the social operator, the informal care giver and the continuous care provider.
- Patient, the object of the HC.

An *Entity* has the following properties:

- a) An *Entity* can do a set of *Actions* (*doesAction*)

- b) An *Entity* can initiate a set of *Services* (*initiatesService*)

Action Actions represent concrete activities that can be performed by the different *Actors* of the K4CARE model, depending on their duties and liabilities. The *Actions* are performed inside a *Procedure*, and modify *Document*. An *Action* has these properties:

- a) An *Action* works on a *Document* (*usesDocument*).
- b) An *Action* has an object, which is the (*Patient*) over which the *Action* is applied (*hasObject*).
- c) An *Action* has a set of subjects who can perform it (*hasSubject*).

Document The documents are used to store medical and administrative information about the patients. This information can be of many different types, like for example documents that contain a waiting list for a medical service, a prescription of pharmacological treatment, or a clinical history, etc.

A Document has the properties listed below:

- a) The *Documents* are linked with the actions that can interact with them (*isUsedInAction*).
- b) The *Documents* have a set of rights which indicate who can read, or modify them. Sometimes those rights can be under certain conditions (*isReadBy*, *isWrittenBy*, *isReadSometimesBy*, *isWrittenSometimesBy*).
- d) The *Documents* can be used in several *Services* (*hasDocument*).

Service A *Service* describes a task performed inside the K4CARE model.

- Access Services see the actors as elements of the K4CARE model and address issues like patient's admission or professional discharge.
- Patient Care Services consists of all the services needed for the patient care, like for example consultation or prescription of pharmacological treatment.
- Information Services cover the needs of information that the actors require in the K4CARE model. Those services can address issues like guidelines consultation or overview of waiting lists.

A Service has the properties listed below:

- a) A Service uses a set of Documents (*hasDocument*)

- b) A Service is performed following some Procedures (*hasProcedure*).
- c) A Service can be initiated by one or more Actors (*serviceInitiatedBy*)

Procedure A procedure indicates which is the set of actions that should be performed to complete a Service, so that, a *Procedure* is related to a unique *Service*. To store the order of the steps of a concrete process of a procedure, the conditions between the steps, and other details of the procedure, a SDA¹ [29] diagram is used.

A Procedure has these properties:

- a) A *Procedure* has a set of Actions and/or Services that perform it (*steps*)
- b) A *Procedure* belongs to one Service (*isProcedureOf*)
- c) A *Procedure* has an SDA file (*hasSDA*)

The structure described above is a representation of all the services that the K4CARE model will provide, together with all their corresponding resources (*Actors, Documents, Procedures and Actions*).

¹ SDA stands for State-Decision-Action, SDA* represents the repetition of states, decisions and actions required to describe health care procedural knowledge.

7 New care units addition

This section discusses how add new groups of services to the K4CARE model. First an additional group of services related to rehabilitation is presented, and then is discussed how them can be included inside the APO.

7.1 *Home Care Accessory Service (HCAS) example: Rehabilitation*

Rehabilitation is typically needed by patients who suffer from the consequences of one of the main syndromes considered in the K4CARE model (i.e. immobility syndrome and cognitive impairment). There are several different types of rehabilitative interventions. Physical therapy focuses on enhancing physical movement. Speech therapy works on communication problems. Occupational therapy helps people overcome problems of daily living at home or at work. Cognitive therapy deals with cognitive impairments of the patient.

The activation of HCAS-R is activated on request of the Evaluation Unit (namely, by the Family Doctor or Physician in Charge) at time of Comprehensive Assessment or re-evaluation. Since the activities of the two structures (HCNS and HCAS-R) have to be integrated, it is proposed that the actors (Head Nurse and Rehabilitation Service Coordinator, respectively) who manage (Case Management) the performance of the two intervention plans (general and rehabilitative) could in fact be represented by the same individual. The HCAS-R relies on the HCNS for those services already provided by the latter structure.

7.1.1 Rehabilitative Actors

Patient to rehabilitate (HCP) The HCP susceptible of rehabilitation is typically a person who suffers from the consequences of a condition which diminishes physical capability or from a functional impairment, such as immobility syndrome. A patient to rehabilitate can be a cognitively impaired patient, to be treated to preserve both cognition and functional repercussions of the main impairment.

Physician in Charge of the Rehabilitation Service (PCR) The PCR is a SP, usually a Psychiatrist (SP specializing in physical medicine and rehabilitation) or a Geriatrician.

Rehabilitation Service Coordinator (RSC) The RSC mainly coordinates the work of the therapists, schedules and coordinates different stages of treatment. To provide a high level of integration of different services, the HN can play the role of RSC.

Therapists (Th) Therapist is the rehabilitative treatment provider, working at patient's home according to scheduled accesses. He/she works to restore, maintain or enhance the abilities of HCPs. According to the several types of therapies, therapists are subdivided in:

Physical Therapist (PT) helps patients regain strength and function, improve mobility, relieve pain and prevent or limit permanent physical disabilities.

Occupational Therapist (OT) works to improve patient's ability to perform basic and instrumental activities of daily living (e.g., eating, dressing or bathing), productive activities and leisure activities.

Speech and Language Therapist (SLT) assesses and treats speech, language and communication problems to enable HCPs to communicate to the best of their ability.

Psychologist (Ps) is a clinical psychologist, usually a neuro-psychologist, that is in charge of the cognitive rehabilitation. Assesses and treats behavioural, emotional and cognitive disorders to improve behavioural and cognitive symptoms.

7.1.2 Rehabilitative Actions

Code	Action	Actors
Back Office Activities		
R.BO.01	provide information	ALL
R.BO.02	ask information	ALL
R.BO.03	assign actor	RSC PCR
R.BO.04	confirm or modify waiting lists	RSC PCR
R.BO.05	schedule activity	RSC
R.BO.06	send message to the patient	RSC PCR
R.BO.07	supervise HCP information	RSC PCR
R.BO.08	authorize rehabilitation	PCR
R.BO.09	actor confirmation	ALL_CG
Case Management Activities		
R.CM.1	supervise IRP	RSC
R.CM.2	control performance of activities	RSC
R.CM.3	supervise achievement of outcomes	RSC
Patient Activities		
R.P.1	confirm appointment	HCP
R.P.2	agree on interventions	HCP
R.P.3	give consent	HCP
PCR Activities		
R.PCR.1	evaluate through scales	PCR
R.PCR.2	define RIP	PCR

R.PCR.3	define outcomes	PCR
R.PCR.4	schedule controls	PCR
R.PCR.5	schedule re-evaluations	PCR
R.PCR.6	perform Clinical Assessment	PCR
R.PCR.7	perform Physical Examination	PCR
R.PCR.8	request Diagnostic Procedures	PCR
R.PCR.9	request Laboratory Analysis	PCR
R.PCR.10	prescribe Pharmacological Treatment	PCR
R.PCR.11	prescribe non-Pharmacological Treatment	PCR
R.PCR.12	prescribe assistive devices	PCR
R.PCR.13	prescribe nursing care	PCR
R.PCR.14	refer to SP	PCR
R.PCR.15	write medical follow-up	PCR
Medical FD Activities		
M.FD.1	request HC	FD
M.FD.2	request of re-evaluation	FD
M.FD.3	authorize treatment proposed by SP or PC	FD
M.FD.4	refer the HCP to SP for Certification	FD
M.FD.5	refer the HCP for INR Follow-up	FD
M.FD.6	authorize nursing care	FD
M.SP.1	write consultation report	SP
M.SP.2	arterial blood collection	SP
M.SP.3	takes specimen to laboratory	SP
M.SP.4	collect blood bags	SP
M.SP.5	perform the transfusion	SP
M.SP.6	write transfusion report	SP
Rehabilitative Activities		
R.R.1	range of motion exercises	PT
R.R.2	muscle-strengthening exercise	PT
R.R.3	proprioceptive neuromuscular facilitation	PT
R.R.4	coordination exercises	PT
R.R.5	transfer training	PT
R.R.6	ambulation exercises	PT
R.R.7	ADL/IADL training	OT
R.R.8	caregiver education	OT
R.R.9	changes of physical environment	OT
R.R.10	training devices	OT
R.R.11	treatment of aphasia	SLT
R.R.12	treatment of dysarthria	SLT
R.R.13	treatment for Attention	Ps
R.R.14	ROT	Ps
R.R.15	request re-evaluation	FD PT OT SLT Ps
R.R.16	write follow-up form	ALL

Table 6 Rehabilitative Actions

7.1.3 Rehabilitative Services

A. Individual Services

- a. Access Services
 - i. HC Request
 - ii. HCP Admission
 - iii. HCP Discharge
 - iv. Professional Admission
 - v. Professional Discharge
 - vi. Edit HCP/Professional information

B. Patient Care Rehabilitative Services

- a. Rehabilitative Assessment and Re-Evaluation
 - i. Comprehensive Rehabilitative Assessment
 - ii. Request of Diagnostic Examination
 - iii. Request of Laboratory Analysis
 - iv. Consultation
 - v. Follow-up
- b. Individual Rehabilitation Plan Definition
 - i. Planning of an Individual Rehabilitative Plan
 - ii. Prescription of Pharmacological Treatment
 - iii. Prescription of Assistive Devices
- c. Individual Rehabilitation Plan Performance
 - i. Rehabilitative Case Management
 - ii. Rehabilitative Treatment

Patient Care Services

Rehabilitative Assessment and Re-Evaluation

RS3.1 Comprehensive Rehabilitative Assessment it is the service devoted to detect the whole physical and functional status, including locomotion, self care skills, posture, and body mechanics by using standardized assessment tools. It is performed at admission, at periodical or end treatment re-evaluation time defined inside the IRP and in case of emerging peculiarities during the follow-up on request of the Therapist or the FD. It encloses Functional Evaluation, Clinical Assessment, Physical Examination, and Environmental Evaluation.

Functional Evaluation: represents a standardized interview based on structured scales providing evidence about problems and conditions of the HCP with regard to self dependency, locomotion, gait, balance to delineate an overall functional profile of the patient. Functional Evaluation is part of the Comprehensive Rehabilitation Assessment.

Clinical Assessment it is carried out to gather and evaluate all the available information to delineate the HCP condition (previous test results, discharge sheets, consultations, previous treatment). Clinical Assessment is part of the Comprehensive Rehabilitative Assessment.

Physical Examination: it is used to find signs and symptoms of diseases and/or conditions. It is performed by physicians according to common practice to evaluate physical and functional status, joints and musculoskeletal system, neuromuscular and cardiopulmonary system. Physical Examination is part of the Comprehensive Rehabilitative Assessment.

Environmental Evaluation: assessment of the physical environment, including lighting, walking surfaces, resting surface, condition and placement of objects in the environment, presence of barriers, The physical environment is assessed using standardized checklists. Environmental Evaluation is part of the Comprehensive Rehabilitative Evaluation.

RS3.2 Request of Diagnostic Examination diagnostic actions must be determined in order to diagnose new conditions or to follow the evolution of the patient, the results of therapy, or to monitor clinical parameters. Prescription of Diagnostic Procedures integrates the Comprehensive Rehabilitative Evaluation and is part of the Follow-up.

RS3.3 Request of Laboratory Analysis it is a service required to diagnose new conditions or to follow the evolution of the patient, the results of therapy, or to monitor clinical parameters. Prescription of Laboratory Analysis integrates the Rehabilitative Assessment and is part of the Follow-up.

RS3.4 Consultation to refer the HCP to a physician (usually a SP) in order to better define diagnosis and/or treatment with relation to peculiar conditions related with special competences linked to different branches of medicine. Consultation integrates the Rehabilitative Assessment and is part of the Follow-up.

RS3.5 Follow-up it is a service used to evaluate the patients overall function through time, assessing results and goals. It provides evidence about the results of the IRP, and the evolution of specific diseases or disorders. It informs actions aimed at modifying the IRP and surveys the accomplishment of the defined goals. Formal instruments to be used are the appropriate scale(s) of the Functional Assessment and

the Follow-up forms. When intervening conditions substantially modify HCPs overall status, RE can be requested by the Therapist, apart from the re-evaluation defined inside the IRP.

Individual Rehabilitation Plan Definition

RS4.1 Planning of an Individual Rehabilitative Plan the individual IRP represents the course of actions to be performed in order to provide care to the HCP in terms of rehabilitative treatment and support. IRP defines which kind of rehabilitative therapy(s) (Physical Therapy, Occupational Therapy, Speech Therapy, ROT) has to be used in the individual case. IRP establishes goals of rehabilitation and the actions to be carried out to achieve each goal, with the aim of improving functions and self-dependency.

RS4.2. Prescription of Pharmacological Treatment to treat new conditions, to carry on a treatment, to redefine treatment.

RS4.3. Prescription of Assistive Devices special equipment or assistive devices are prescribed to enhance independence, promote safety or to compensate for specific impairments (e.g., splint, canes, others). RS5.

Individual Rehabilitation Plan Performance

RS5.1 Rehabilitative Case Management Case Management is the service which organizes and controls the specific actions of specific actors on the individual HCP.

RS5.2. Rehabilitative Treatment there are several different types of rehabilitative interventions. The specific treatment is defined (through the IRP) according to the peculiar needs of the individual HCP. Rehabilitative Treatment could be subdivided in:

Physical Therapy: o range of motion exercises (active, active-assistive, passive), o musclestrengthening exercise o proprioceptive neuromuscular facilitation o coordination exercises o transfer training o ambulation exercises.

Occupational Therapy: o ADL and IADL training o caregiver education o changes of physical environment o training in the use of therapeutic devices.

Speech therapy: o Treatment of aphasia o Treatment of disarthria.

Cognitive Therapy: o Treatment for Attention o Reality Orientation Therapy (ROT).

7.1.4 Rehabilitative Procedures

Description	Step code	Step name	Doc. code	Document name
Rehabilitative Problem Assessment and Re-Evaluation				
RP3.1. Comprehensive Rehabilitative Assessment				
a) The PC or the HN refers the admitted patient for a CA.	RBO.10	refer the admitted patient for CRA	D10	Request of CA
(b) The re-evaluation is defined inside the IRP, or	R.PCR.5	schedule re-evaluations		
(c) The re-evaluation is requested by PT, OT, SLT, Ps or FD, based on elements deriving from the follow-up.	RR.15	request re-evaluation		
(d) The RSC sends a message to the patient to make an appointment.	RBO.6	send message to the patient		
(e) The HCP confirms the appointment	RP.1	confirm appointment		
(f) The RSC performs Case Management's proper actions.	RBO.4	confirm or modify waiting lists		
	RBO.5	schedule activity		
(g) The PCR makes the patient's assessment at home according to a standardized interview (Functional Evaluation) and performs Clinical Assessment (collects the pertinent existing medical information), Physical Examination (according to established medical practice), and Environmental Evaluation (checklists).	R.PCR.1	evaluate through scales	RD11	Functional Scales
		Clinical Assessment	RD12	Clinical history
		Physical examination	RD13	Physical Examination Report
	R.PCR.1	evaluate through scales	RD14	Environmental Evaluation Checklist
(h) The HCP provides the necessary information.	RBO.1	provide information		
(i) In case of a non-compliant or non reliable HCP, the CCP provides the necessary information.				
RP3.2. Request of Diagnostic Examination				
(a) The PCR writes a request of Diagnostic Examination.	R.PCR.8	request diagnostic procedures	RD15	Request of Diagnostic Examination
(b) The RSC performs Case Management's proper actions.		Case management F		
RP3.3. Request of Laboratory Analysis				
(a) The PCR writes a request of Laboratory Analysis.	R.PCR.9	request of laboratory analysis	RD16	Request of Laboratory

				Analysis
(b) The RSC performs Case Management's proper actions.		Case management F		
RP3.4. Consultation				
(a) The FD refers the HCP to the SP.	R.PCR.14	refer to SP	RD17	Request of Consultation
RP3.5. Follow-up				
(a) The PT, OT, SLT, Ps monitor the achievement of goals defined inside the IRP. Therapists can use part of the Functional Assessment (one or more scales) to define special issues. They use Follow-up forms.	R.PCR.1	evaluate through scales	RD11	Functional Scales
	RR.16	write follow-up form	RD20	PT Report
			RD21	OT Report
			RD22	SLT Report
			RD23	Ps Report
			RD24	HCP Report
			RD25	CCP Report
(b) When intervening conditions substantially interfere with the achievement of the defined goals, PCR's re-evaluations can be requested by the PT, OT, SLT, Ps, apart from the re-evaluation defined inside the IRP.	RR.15	request re-evaluation	RD26	Request of re-evaluation
(c) The evolution of clinical and functional status of HCP is assessed according to scheduled controls and/or in case of emerging problems by the PCR.	R.PCR.15	write medical follow-up	RD19	Medical follow-up form
(d) The PCR refers the HCP to the HCNS when he/she needs specific contribution from EU or for Consultation.	R.PCR.14	refer to sp		
(e) The RSC performs Case Management's proper actions.		Case management F	RD17	Request of Consultation
RP4.1. Planning of Individual Rehabilitation Plan				
(a) The PCR defines an individual rehabilitation plan (IRP) indicating means and timing of HCP's rehabilitation and indicating the proper actors in order to accomplish defined outcomes.	R.PCR.2	define rip	RD27	IRP
	R.PCR.3	define outcomes		
	RBO.3	assign actor		
(b) The PCR schedules periodical and end-treatment re-evaluations.	R.PCR.4	schedule controls	RD28	Re-evaluation Plan
	R.PCR.5	schedule re-evaluations		
(c) The HCP agrees on the proposed interventions.	RP.2	agree on interventions	RD7	Patient Consent
(d) In case of a non-compliant or non reliable HCP, the CCP agrees on the proposed interventions.			RD8	CCP Consent

(e) The RSC provides the Case Management.		case management F		
(f) The RSC looks after the fulfilment of the IRP.	R.CM.1	supervise IRP		
	R.CM.2	control performance of activities		
	R.CM.3	supervise achievement of outcomes		
RP4.2. Prescription of Pharmacological Treatment				
(a) The PCR writes a prescription for Pharmacological Treatment.	EU.2	define intervention plan	D26	IP
(b) The FD authorizes pharmacological treatment proposed by the PCR	EU.3	define outcomes	D26	IP
S4.2. Prescription of Pharmacological Treatment				
(a) The FD, PC, SP write a prescription for Pharmacological Treatment.	R.PCR.10	prescribe pharmacological treatment	RD29	Prescription of Pharmacological Treatment
(b) The FD authorizes pharmacological treatment proposed by the SP or PC.	M.FD.3		D9	FD Authorization
RP4.3. Prescription of Assistive Devices				
(a) The PCR writes a prescription for assistive devices.	R.PCR.12	prescribe assistive devices	RD30	Prescription of Assistive Devices
RP5.1. Rehabilitative Case Management				
(a) The RSC assigns the pertinent actor(s) to the HCP.	RBO.3		RD1	Actor Assignment
(b) The RSC confirms or modifies waiting lists.	RBO.4		RD3	Waiting List
(c) The RSC confirms or modifies daily schedules.	RBO.5		RD4	Daily Schedule
(d) The RSC controls actual performance of scheduled activities.	RCM.2			
(e) The RSC supervises global HCP information.	RCM.1			
(f) The PCR supervises the achievement of defined outcomes.	RCM.5			
RP5.2. Rehabilitative Treatment				
(a) The RSC performs Case Management's proper actions.		case management C		
(b) The RSC sends a message to the patient to make an appointment.	R.BO.6	send message to the patient	RD5	Message to the Patient
(d) The Physical Therapist. performs the Physical Therapy	RR.1	range of motion exercises		
	RR.2	muscle-strengthening exercise		
	RR.3	proprioceptive neuromuscular facilitation		

(e) The Occupational Therapist performs the Occupational Therapy	RR.4	coordination exercises		
	RR.5	transfer training		
	RR.6	ambulation exercises		
	RR.7	ADL/IADL training		
	RR.8	caregiver education		
	RR.9	changes of physical environment		
	RR.10	training devices		
(f) The Speech and Language Therapist performs the Speech therapy	RR.11	treatment of aphasia		
	RR.12	treatment of dysarthria		
(g) The Psychologist performs the Cognitive Therapy	RR.13	treatment for Attention		
	RR.14	ROT		
Functional evaluation				
	R.BO.10	refer the admitted patient for CRA	D10	Request of Comprehensive Rehabilitative Assessment
	R.PCR.5	schedule re-evaluations	RD28	Re-evaluation Plan
	RR.15	request re-evaluation	RD26	Request of re-evaluation
	RP.1	confirm appointment	RD6	Patient Confirmation
	RBO.1	provide information		
Clinical assessment				
	R.PCR.6	perform clinical assessment	RD12	Clinical history
	R.BO.1	provide information		
Physical Examination				
	R.PCR.7	perform physical examination	RD13	Physical Examination Report
Environmental evaluation				
	R.PCR.1	evaluate through scales	RD14	Environmental Evaluation Checklist
Case management F				
	RBO.3	assign actor	RD1	Actor Assignment
	RBO.9	actor confirmation	RD2	Actor Confirmation
	RBO.4	confirm or modify waiting lists	RD3	Waiting List
	RBO.5	schedule activity	RD4	Daily Schedule
	RBO.6	send message to the patient	RD5	Message to the Patient
	RBO.1	provide information	RD6	Patient Confirmation
	RBO.3	assign actor	RD7	Patient Consent
			RD8	CCP Consent

7.1.5 Rehabilitative Documents

Type	Code	Name	Description
Common documents			
Request	RD1	Actor Assignment	Is the information that links an individual action to an individual HCP for an action (or series of actions) to be performed.
Authorization	RD2	Actor Confirmation	Is the information that declares that the actor knows the assignment and accepts it.
Authorization	RD3	Waiting List	The waiting list is automatically generated on the basis of requests, daily schedules, and priorities. Is confirmed by the HN. Can be modified by the HN.
Authorization	RD4	Daily Schedule	Daily Schedules are automatically generated on the basis of waiting lists and priorities. Different daily schedules exist for different services and actors. They are confirmed by the HN. They can be modified by the HN.
Request	RD5	Message to the Patient	Is a message delivered to the HCP to inform that an action for a service is going to be performed and to make an appointment. Can be delivered by phone, via SMS or others.
Authorization	RD6	Patient Confirmation	Is a message delivered by the HCP to inform that he/she accepts the appointment for an action to be performed. Can be delivered by phone, via SMS or others.
Authorization	RD7	Patient Consent	Is the information which consents that a certain action (or series of actions) is accepted by the HCP and can be performed.
Authorization	RD8	CCP Consent	Is the information which consents that a certain action (or series of actions) is accepted by the (legally responsible) CCP and can be performed, in case of HCP non capable of giving consent.
Authorization	RD9	FD Authorization	Is the authorization that the FD (ultimate responsible of the HCP's care) gives for certain actions to be performed.
Service specific documents			
Request	RD10	Request of Comprehensive Rehabilitative Assessment	Is the request that allows the HCP to undergo a rehabilitative assessment. Is done by the PC or the FD.
Anamnesic	RD11	MDE Scales	Set of forms filled in by the EU during the first problem assessment and/or in occasion of the periodical or end-treatment re-evaluation.
Anamnesic	RD12	Clinical history	All the available pertinent clinical information of the HCP (previous test results, discharge sheets, consultations, previous treatment). It is written by the FD, PC and PCR; is read by the other professionals in charge of the patient (according to their competencies in the process of care of the individual patient), by the patient him/herself.
Anamnesic	RD13	Physical Examination Report	The report contains signs and symptoms of diseases and/or conditions. It is written by PCR; can be updated in any occasion of evaluation. It is read by all the professionals in charge of the Patient.
Request	RD14	Environmental Evaluation Checklist	Formal instrument for the evaluation of the Physical Environment
Request	RD15	Request of Diagnostic Examination	Request of diagnostic examination necessary to define the actual clinical condition of the HCP; is written by PCR.
Request	RD16	Request of Laboratory Analysis	Request of laboratory analysis necessary to define the actual clinical condition of the HCP; is written by PCR.
Anamnesic	RD17	Request of Consultation	To refer the HCP to a SP, to better define different aspects of care. It is done by the PCR. It refers to the corresponding service of HCNS.
Anamnesic	RD18	Consultation Report	Contains clinical observations and proposals made by the SP.
Anamnesic	RD19	Medical follow-up form	It is written by the PCR during the follow-up activities.
Anamnesic	RD20	PT Report	It is written by the PT during the follow-up activities.
Anamnesic	RD21	OT Report	It is written by the OT during the follow-up activities.
Anamnesic	RD22	SLT Report	It is written by the SLT during the follow-up activities.
Anamnesic	RD23	Ps Report	It is written by the Ps during the follow-up activities.

Anamnesic	RD24	HCP report	It is written by the HCP during the follow-up activities.
Request	RD25	CCP Report	It is written by the CCP during the follow-up activities.
Prescription	RD26	Request of re-evaluation	It is written by the PT, OT, LST, Ps ,FD, PC when he detects such changes during the follow-up activities to deserve a reevaluation (CRA) of the HCP.
Prescription	RD27	IRP	Is written by the PCR in order to define actions, actors and goals of the IRP.
Prescription	RD28	Re-evaluation Plan	Defines times and modalities to evaluate the accomplishment of the IRP in terms of goals and results.
Prescription	RD29	Prescription of Pharmacological Treatment	Medical instructions to treat diseases or disorders.
Prescription	RD30	Prescription of Assistive Devices	Medical prescription of assistive devices to be used to support impairments and handicaps.

Table 7 Rehabilitative Documents

7.2 The need of adding new care units

As was introduced before, new sets of services related with the additional care units (HCAS - Home Care Accessory Services) can be added to the K4CARE model. In this work the case of the care unit rehabilitation is considered. The rehabilitation services can perform therapies on different aspects, like the physical therapy which focuses on enhancing physical movement, the speech therapy which works on communication problems, the occupational therapy which helps people overcome problems of daily living at home or at work or the cognitive therapy which deals with cognitive impairments of the patient.

The first approach to add new services consists on creating a new APO Ontology for every additional care unit. This approach implies the development of a tool for automatically joining the new Ontology with the primary APO services, which is known as Ontology merging [27]. However we have stated that the use of this approach bears the following problems:

- Designing new ontologies corresponding to the new services is done practically from scratch. So, the designer of the new Ontology will have to apply a big amount of time on that work. Moreover he will have to consider a lot of concepts already existing in the primary APO.
- The new Ontology design can imply redundancies between the different versions due to the fact that some concepts will appear in the different ontologies, so that some classes and relations could be repeated.
- During the Ontology redesign, inconsistencies can appear because the different versions of the same concepts in the primary APO and the new APO, which may contain different points of view of the same things. Those problem approximations might be incompatible between them.

To solve all those inconvenients a new approach is proposed. This approach consists on having a single APO Ontology that centralizes all the knowledge of the K4CARE model

including the different care units. To create this Ontology, the work will start from the latest version of the primary APO, which will contain all the nuclear knowledge of the model and the previously included care units. Starting from this Ontology, the work will consist on adding to it the new services that will be incorporated in a particular instance of the K4CARE system. The approach of enlarging the existing APO Ontology takes advantage of the reuse of concepts and relations like *Actors*, *Documents* or other resources already existing in the previous model.

The new *Services*, should, of course, be incorporated with their corresponding required resources, it is to say that the corresponding Entities (Actors or groups of those), the *Documents* and *Procedures* may be incorporated, and correctly linked among them and with the previous concepts already defined in the primary APO.

7.3 The APO restructuring

In the previous section it was justified to keep a single global Ontology centralizing the knowledge for all the basic services together with those of the new care units. After a careful study of the APO schema, that was designed in the first stage, it has been detected that the APO structure was not appropriate to support the information of the additional Care Units. In this section the modifications done to obtain a new APO structure that permits to distinguish the information to each Care Unit, is explained. Another consideration that has been taken into account is the reuse of the concepts already defined when new Care Units are added. Reusing Services and resources respond to the fact that some Services and resources can be part of different care units (as asking for a specialist opinion, or programming a blood test, for example). Two different solutions have been considered:

- a) Replicate the service hierarchy for each care unit.
- b) Add the new service elements to the existing hierarchy.

Both proposals are presented in this section, discussing their advantages and inconvenients.

One possible solution to the problem consists on replicate the intermediate service hierarchy structure. By this way, for every new care unit the intermediate structure is replicated but the leaf classes are not replicated. It is to say that for every new care unit a new service hierarchy will be created with its corresponding services, but the services that belong to both care units will not be replicated, they will belong to both hierarchies. We can observe in the Figure 4 an example of this structuration for the access services with two care units, the HCNS and the rehabilitation. This proposal has the following advantages:

- This solution allows that every service can be assigned to different care units.
- This solution allows the definition of different substructures for every care unit, which increases the flexibility of the representation model.

- This solution allows to the user to visualize easily the service structure for every care unit.

Despite those advantages this proposal has an important inconvenient:

- This structure implies the replication of the hierarchy for every care unit.

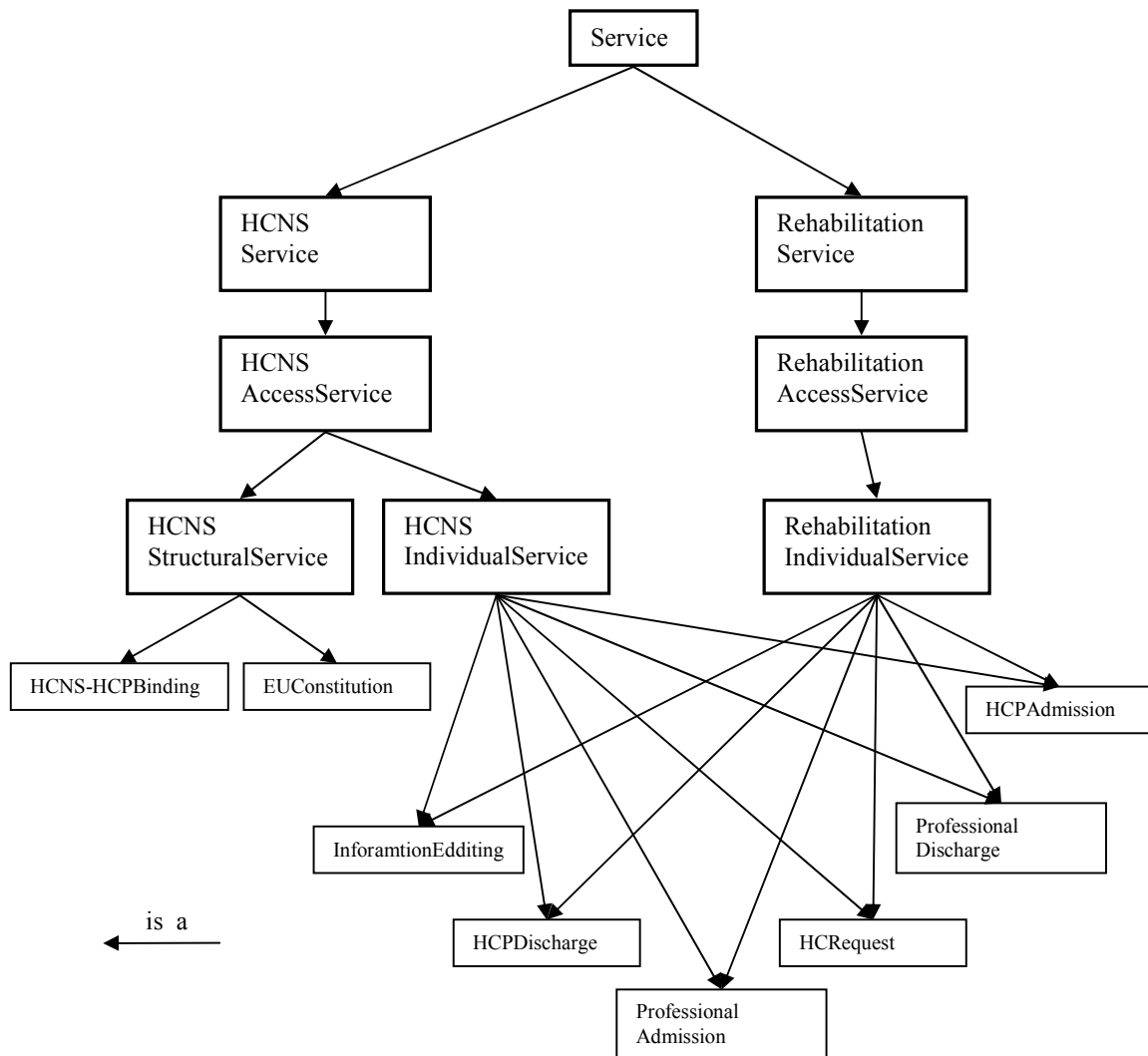


Figure 4 Multiple Care Unit, solution 1

After considering different solutions, we propose to add the elements of the new care units definition directly to the primary APO, but creating a parallel hierarchy that allows classifying them and distinguishing in which care unit are used.

This parallel hierarchy is used to distinguish to which care unit a *Service*, an *Entity*, a *Procedure* or *SDA* belongs to. The other classes do not need to be included in this hierarchy, because it is easy to deduce the Care Unit they belong to. Thus, a new class *CareUnitElement* is created. Every subclass of *CareUnitElement* identifies to which care unit an element belongs. So that, a subclass of *CareUnitElement* called *HCNSElement* is created to identify all the HCNS *Services*, *Entities*, *Procedures* or *SDAs* that belong to the nuclear part of the model. When the services of a new care unit, like rehabilitation, are defined, a new subclass of *ServiceGroup* called *RehabilitationElement* will be created. So that, if a *Service*, an *Entity*, a *Procedure* or *SDA* belongs to HCNS services it will inherit from *HCNSElement*; if one of those belongs to rehabilitation services it will inherit from *RehabilitationElement*; and if one of those belongs to HCNS and rehabilitation services will inherit from both classes. Those services also have to inherit of its corresponding super class corresponding to their position in the general structure of services. With this approximation the Ontology has a structure like the shown in the Figure 5.

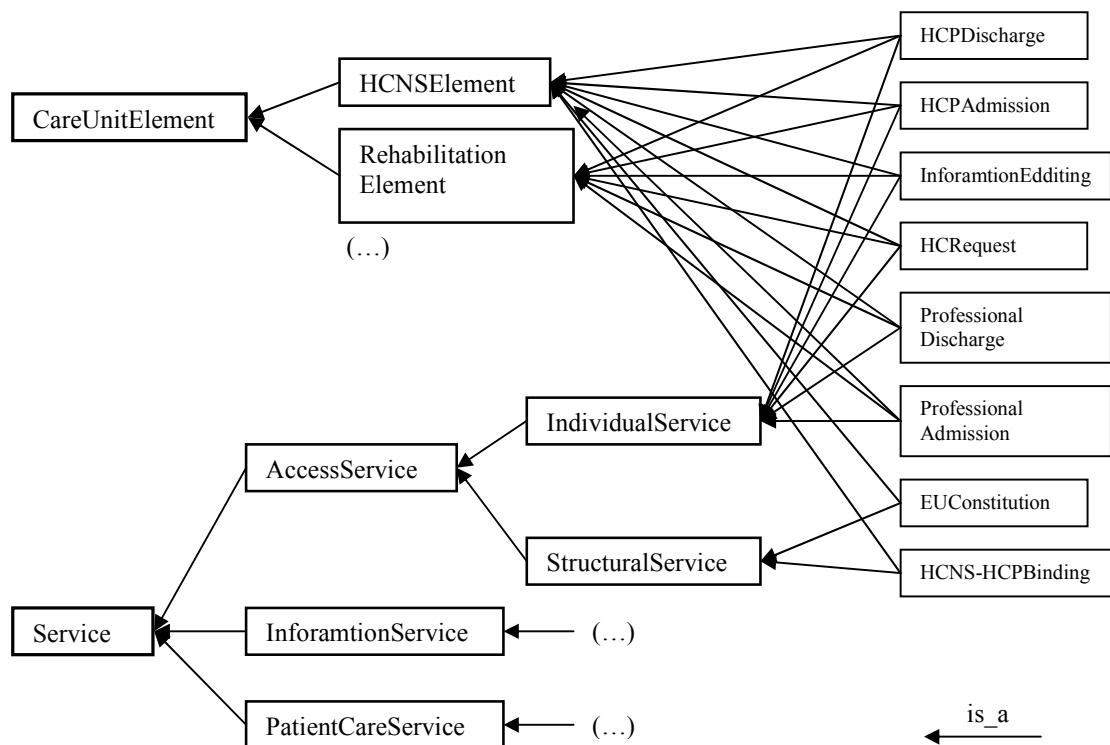


Figure 5 Multiple Care Unit, solution 2

This approach has some advantages that increase the reliability of the system:

- The elements in the Ontology are not repeated, but reused. As a consequence, the time of introducing the description of the new care unit into the global model is reduced, since only new services and resources need to be explicitly defined. This

also reduces the complexity of defining the new care units. The risk of having redundancies or inconsistencies between the new elements and the previously introduced ones is decreased.

- A way for a rapid identification of the complete set of Services that belong to each care unit is provided.

The distinction of the care units is not the unique variation introduced in the initial APO structure. With the inclusion of new care units, a new situation which was not supported by the first version of the APO appears: one *Service* can have different *Procedures* in the different care units. The difference can be in the set of actions or the actors that perform them. As a consequence of it, the same procedure must be associated to two different SDA diagrams (where the Actors who perform the Actions are defined). The initial APO definition in OWL was not prepared to allow multiple relations with SDAs. To solve this problem, a new class called *SDA* has been defined. The *SDA* class contains the property *hasSDA*, then for every different SDA diagram a subclass *SDA* is defined which relates the SDA diagram with the class; The structure of the rest of classes (*Action*, *Document*) does not need to be changed. Simply the new *Actions* or *Documents* may be added and related with their corresponding resources.

The Figure 6 shows the structure of the APO that allows the inclusion of multiple care unit.

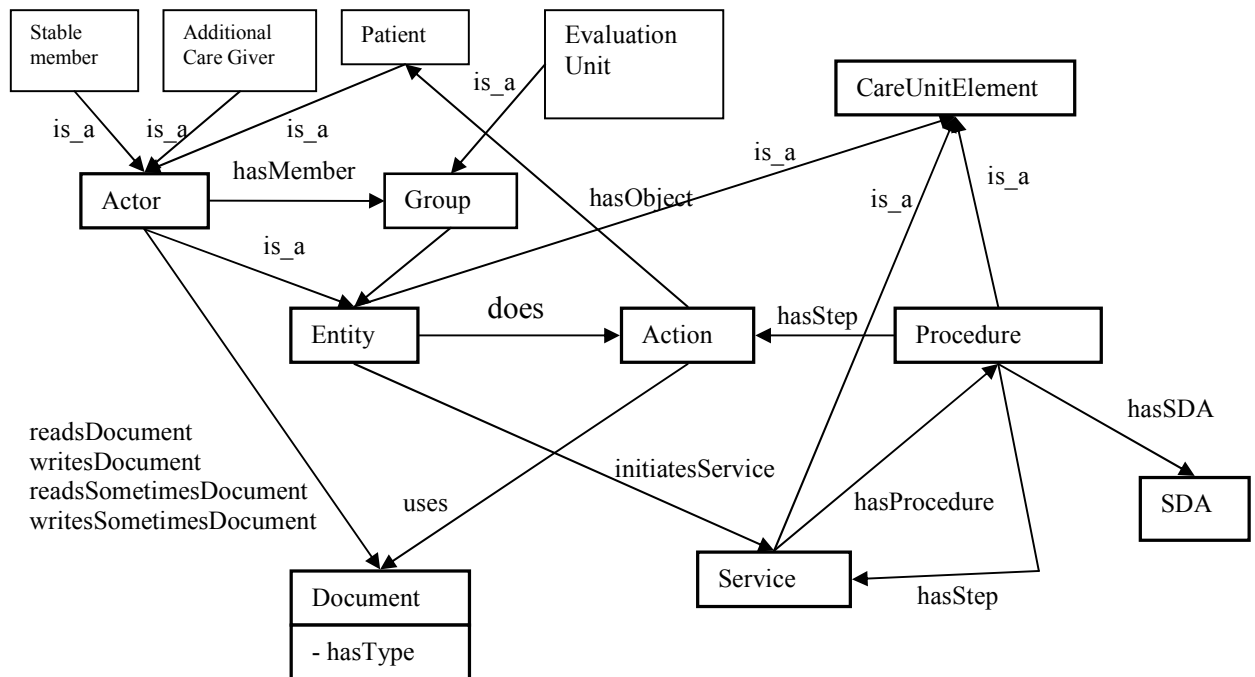


Figure 6 APO structure with multiple care units

The Figure 7 shows a representation of the K4CARE APO ontology by using the Jambalaya tool. Every box corresponds to a class, and the boxes contained into another are its subclasses. The lines that link the different classes are the restrictions applied in the classes over its properties that link every class to its corresponding related classes.

It can be seen that this ontology is quite complex with respect to the properties and relations between concepts.

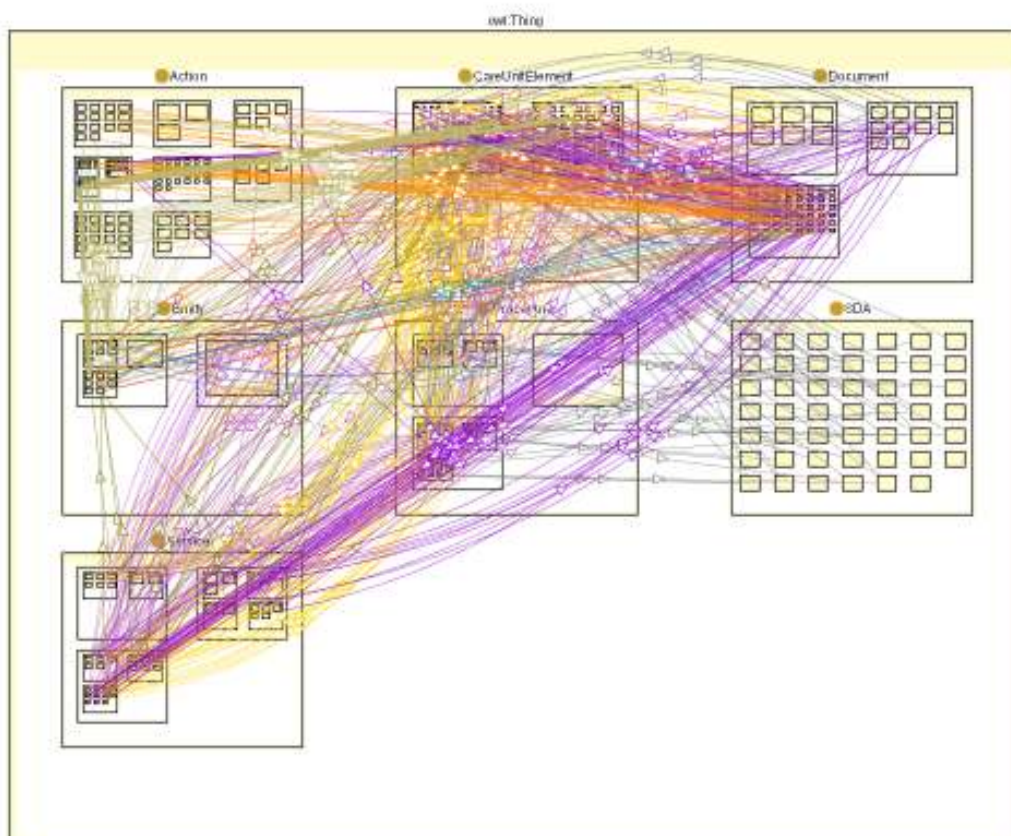


Figure 7 Representation of the APO with the Jambalaya tool

7.4 Intelligent Service Adder

The Intelligent Service Adder (ISA) is a software tool developed to help medical users to define new care units to be added to the primary APO. To start, this tool needs an initial APO with the structure defined in the previous section. So that, it already has the HCNS services, and the classes that allow the inclusion of new care units.

ISA has been designed with the aim of being easy to use, and at the same time, guarantees that the information introduced is correct and complete. To get those goals, ISA guides the user along the definition process of new elements, so that, the user has to take the minimal possible decisions concerning the structure. He only must have the medical knowledge. During the process, ISA is able to introduce and fill-in, by using a little amount of

information introduced by the user, as much information into the APO as possible, avoiding the appearance of inconsistencies and redundancies.

Inconsistencies could appear for several reasons. First, the no re-utilization of concepts. A clear example of that is the redefinition of Services and/or Procedures, as ordering a blood test. Second, the appearance of properties that are not linked with their corresponding concepts, as for instance, all the properties that have an inverse one (like *Entity does Action* or *Action isDoneBy Entity*) have a great probability to not being linked in both directions.

To define and add the new care units having into account all those points, the system controls the flow and how the different elements are introduced into the Ontology. ISA starts from the definition of new Services. To define the Services, the system shows to the user, one by one, all the different types of Services already defined into the primary APO. For every type, the system shows the existing Services of this type, and allows the user to link them with the new care unit and to create new ones if is required.

Secondly, the specification of the Procedures for each Service is required. ISA performs it in 4 steps.

1. The *Entities* that can initiate a *Service* are specified.
2. The user has to check if any of the previously defined *Procedures* corresponds to the one needed in the new care unit.
3. If none of the previously defined *Procedures* can be reused, then the user has to create a new *Procedure* by using an editor provided by ISA. This editor helps the user to introduce all the necessary information for a correct definition of the *Procedure*, either manually or reusing the elements already existing in the primary APO.

With the definition of the *Services* and their corresponding *Procedures*, ISA has obtained practically the 100% of the required information from the user. With this information the ISA system is able to automatically complete the following data:

- The list of *Actions* and/or *Services* that compose the *Procedure* (*steps*)
 - The list of *Documents* that are used in the *Service* (*hasDocument*), and at the same time, the list of *Documents* to which an *Action* can interact to (*usesDocument*).
 - The list of *Actions* that can be performed by an *Actor*.
4. So that the unspecified information after the performance of the Procedure definition are the read and write rights of the new Actors over the new Documents created. Defining permissions has to be done as a final step.

8 Testing

In this section the validation of the correct working and designing of the APO, the ISA and the OWL Wrapper are treated. The correctness of the different elements developed is absolutely necessary due to the fact that the K4CARE system needs to avoid the errors and system failures, which can come from every of their subcomponents. A failure in the K4CARE system can imply serious errors in the home care system which can imply problems in the operation of the system, included problems related to the patient's health.

8.1 APO

The validation of the knowledge container inside the APO was done while it has been developed, thus while the information was introduced to it, the information consistence and completeness has been validated. Moreover, by using the OWL Wrapper, the ISA and the Data Abstraction layer, different revisions of the knowledge contained inside the APO have been performed. This has been done by using some aspects provided by them. The OWL Wrapper performs some validations of the ontology structure while it is loaded, validating some possible inconsistencies. By the other side the Data Abstraction Layer and the ISA can perform validations of the ontology structure and of the knowledge contained in it. This is due to the fact that those applications have knowledge of the some information stored in the APO ontology, concretely, they know the structure and the main relations established between the main classes of the ontology. The ISA and the Data Abstraction layer have been used by a human user who has performed a testing those applications and as a consequence, a testing over the APO.

8.2 OWL Wrapper

The case of OWL Wrapper is similar to the one presented with the APO, because the library has been tested with a custom made test, but by the other side, it has been used inside the ISA tool and the Data abstraction Layer, which have given a more exhaustive testing of the library while those applications have been tested.

8.3 ISA

To perform the testing of the well operation of the ISA system, the knowledge regarding the additional care unit of rehabilitation (Details in 7.1) has been introduced to the APO ontology by using the ISA tool. The addition of this care unit has permitted to validate correctness of its operation. Moreover, it has permitted to validate its advantages and its inconvenient, and as a consequence of this validation, the corresponding modifications to improve its functionality have been done. By the other side, the ISA tool have been tested

by some people not involved in its development who give a more objective and exhaustive evaluation. The indications given by them allowed to the developers to make some important changes on it to make it more useful and stable.

9 User's guide

9.1 Start

When the ISA system is started, first the presentation window is shown. The Figure 8 shows the presentation window.

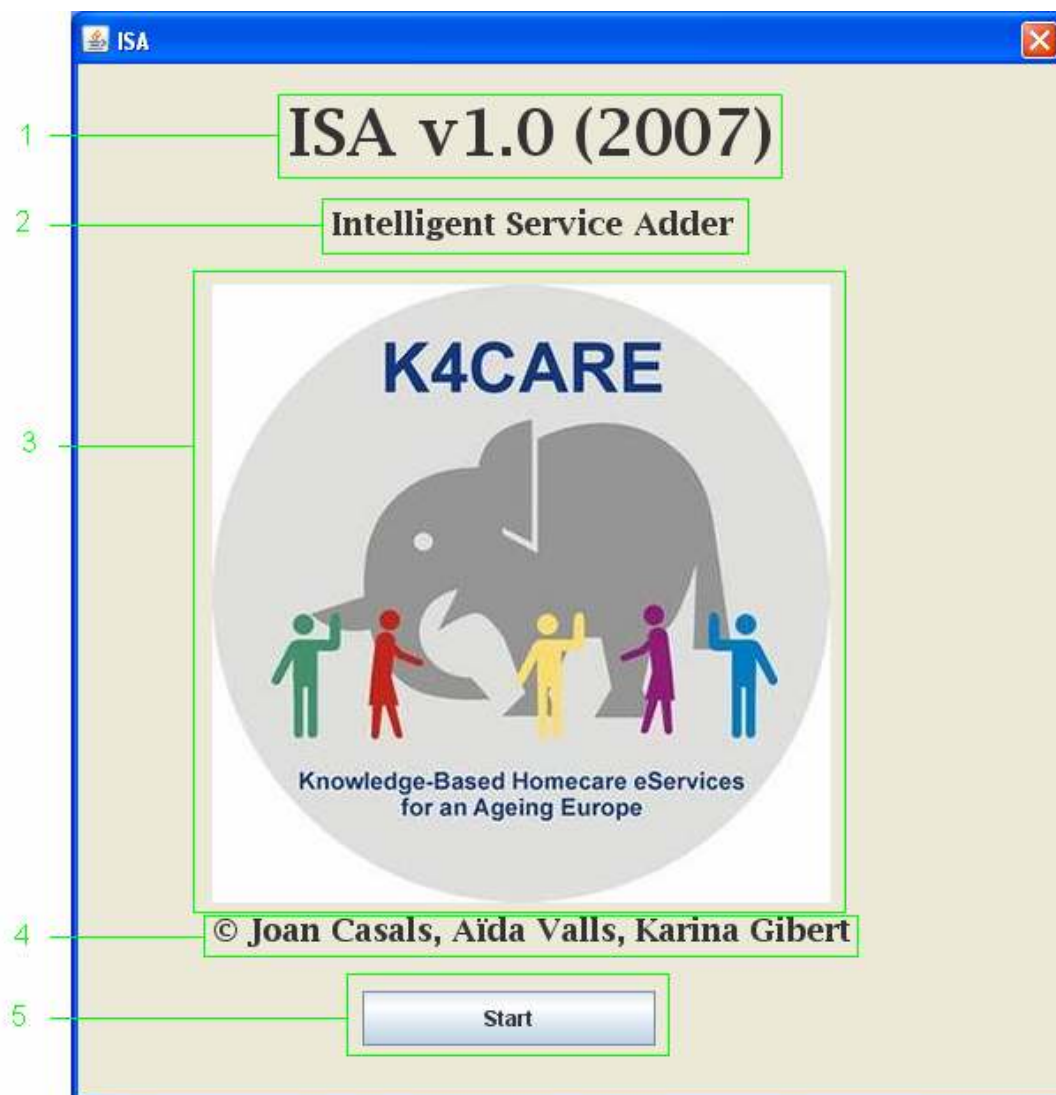


Figure 8 Presentation window

Elements details:

1. ISA version.

2. ISA name.
3. K4CARE logo.
4. ISA authors
5. To start, this button should be clicked; the user will go to 9.2.

9.2 Existing Care Units

Once presented the ISA intro, the systems shows a new window presented in the that Figure 9 shows the already existing care units, and allows to the user to look-up them or to create a new one.

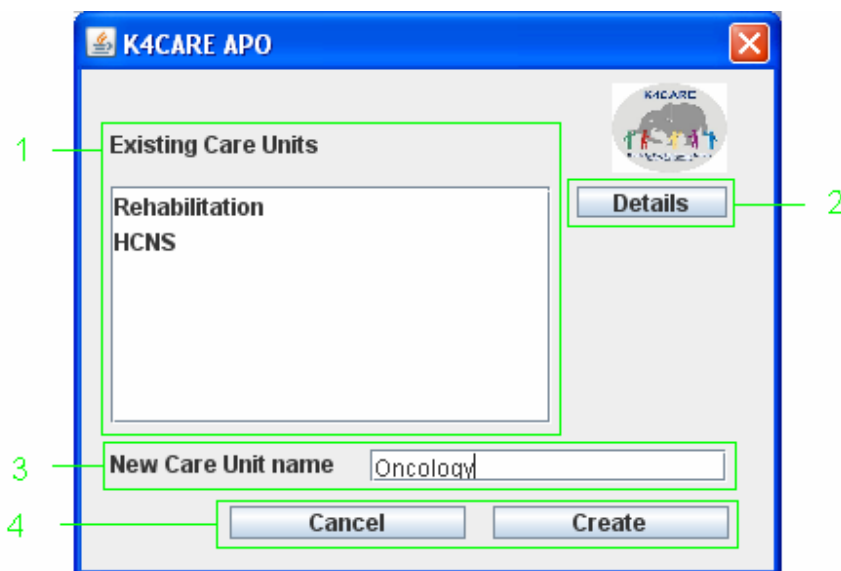


Figure 9 Existing care units window

Elements details:

1. Here the existing care units are shown.
2. If clicked it will show the details selected care unit details (See 9.3).
3. Here is indicated the name of the new care unit to create.
4. These buttons allow to 'accept' or to 'cancel' if the user wants to create a new care unit with the specified name or if he wants close the system, respectively. If clicked 'accept' the user will go to 9.4.

9.3 Care unit details

The window presented in the Figure 10 allows the user to look-up to all the services defined for a concrete care unit. For every service the corresponding steps and the resources used by them.

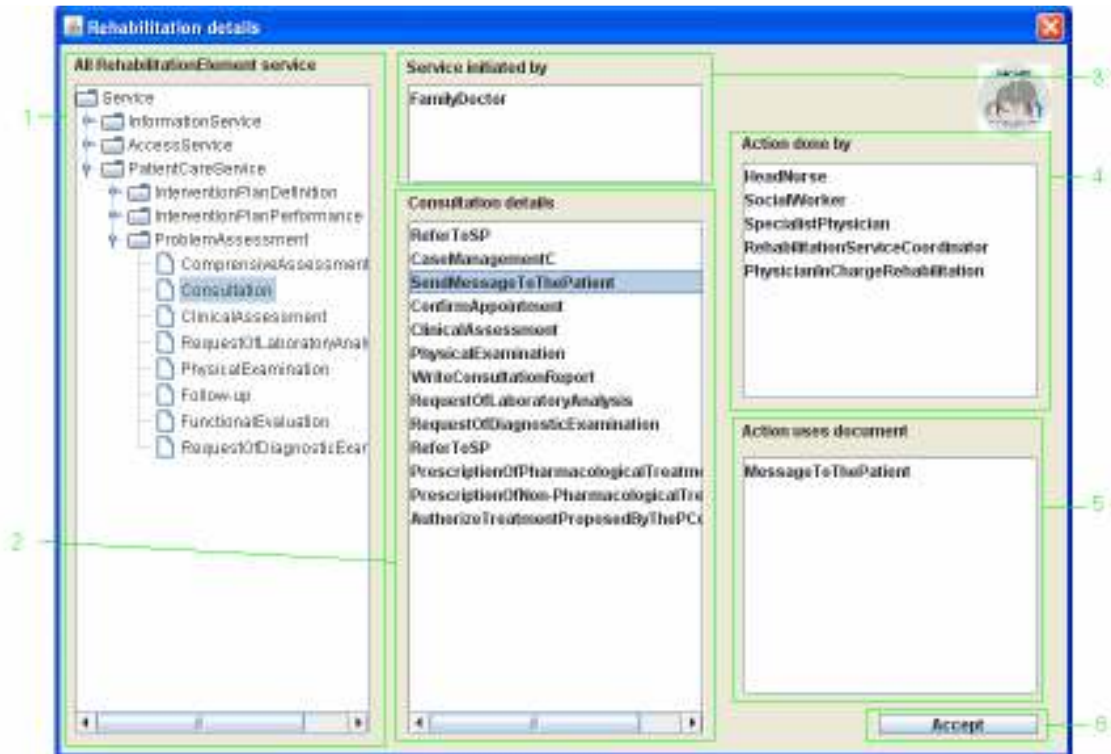


Figure 10 Service details window

Element details:

1. Here are presented all the services of the care unit.
2. This is the list of steps needed to perform the selected service.
3. Here is presented the list of service initiators.
4. Here are presented the actors that can perform the selected action.
5. Here are presented the documents used by the selected action.
6. When accept is clicked, the user returns to the 'create care unit' window.

9.4 New care unit services

To create a new care unit, the main work is to establish which the services given by it are. So, ISA, focuses the definition of the new care unit in the services. To define the services, the system shows to the all the existing services of one type, and allows him to decide which ones of the existing can be reused, and if needed to define new ones. Once defined all the services of one type, the user may click the button 'next' and continue with the definition of another group, until all the service types are treated.

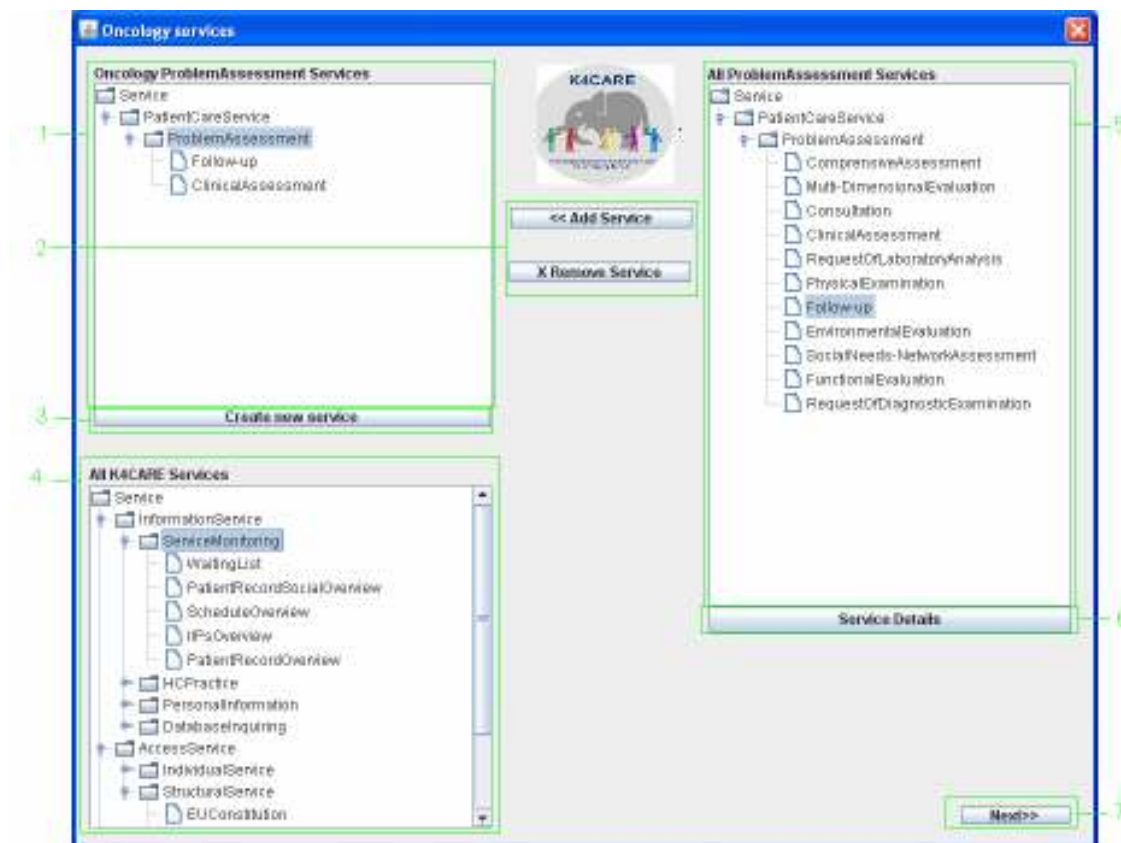


Figure 11 New care unit services

Elements details:

1. The tree shows the set of services of a concrete type which belong to the new care unit. Those services can be reused from the ones previously existing in another care unit, or they can be created for the new care unit.
2. With the use of these buttons the user can add or remove existing services from '5' to '1'.
3. Clicking this button the user can create a new service of the actual type.

4. This tree shows all the K4CARE services.
5. Here are shown all existing K4CARE services from a concrete type.
6. By clicking this button the user can observe the details of the selected service (See 9.11).
7. By clicking this button the user will go to the definition of a new type of services.

9.5 Create Action

To create a new Action ISA provides the window shown in Figure 12. This window allows to the user to create new actions and new groups of them.

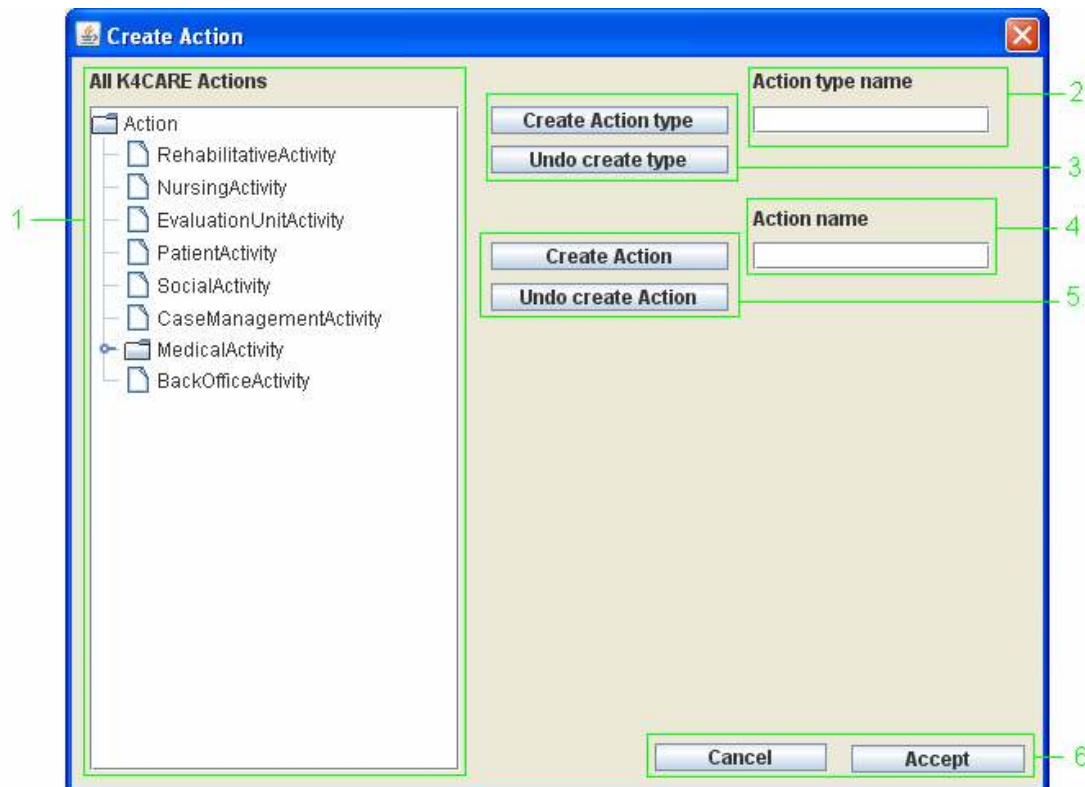


Figure 12 Create action window

Elements details:

1. This tree organizes all the types of actions defined inside the K4CARE model.
2. If the user wants to create a new action group, with the use of this textbox, he can introduce the name of it.

3. Those buttons allow to the user to create or eliminate an action group. Note that an action group previously defined can not be removed.
4. This text box allows to the user to introduce the name of the new defined action.
5. Those buttons allow to the user to create or eliminate an action. Note that the user can not eliminate the previously defined actions.
6. With this buttons the user can accept or decline the changes performed.

9.6 Create Actor

When the creation of an actor is needed, the window shown Figure 13 is used. This allows choosing the type of the Actor, and its name. If the type Group is chosen, the following step will be to detail which are the Group members.

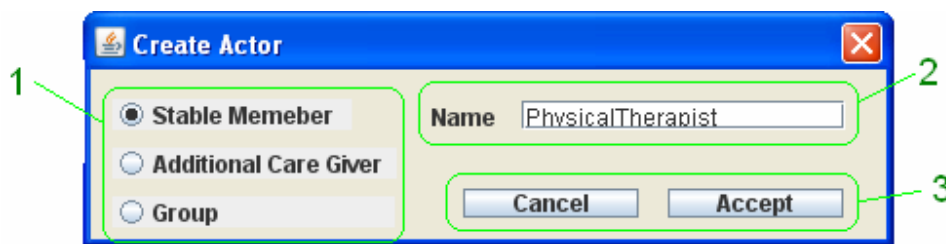


Figure 13 Create actor window

Elements details:

1. These radio buttons allow choosing between to create a 'stable member' an 'additional care giver' or a group of Actors.
2. Here the name of the new actor may be introduced.
3. These buttons allow to 'accept' or to 'cancel' if the user wants to validate the introduced Actor or if he wants to decline the introduction, respectively.

The Figure 14 shows the window that allows the user to define which the members of the new created group are, by using the window shown by the group, until all the service types are treated.

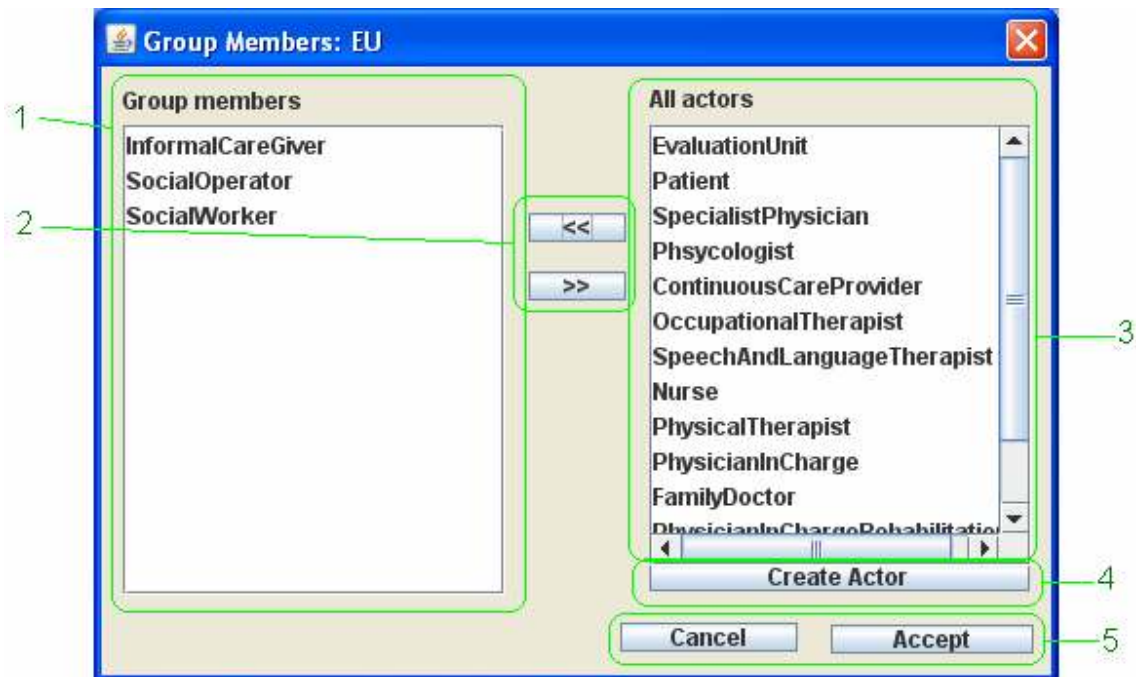


Figure 14 Group members window

Elements details:

1. Here is shown the list of actors that form the Group.
2. These buttons allow adding or removing the group members. The button << adds new Actors and the button >> removes Actors.
3. Here is shown the list of all K4CARE actors.
4. By clicking this button the user can create a new actor, that will be added to the Group.
5. These buttons allow to 'accept' or to 'cancel' if the user wants to validate the introduced Actor or if he wants to decline the introduction, respectively.
6. Allows to create a new K4CARE actor, it drives the actor to the window shown by Figure 13.

9.7 Create Document

To create a new Document, the system shows to the user the window presented in the Figure 15. This window allows choosing between the creation of a 'patient care document', an 'access service document' or an 'information service document'.



Figure 15 Create document window

Elements details:

1. These radio buttons allow choosing between the creation of a 'patient care document', an 'access service document' or an 'information service document'.
2. Here the name of the new Document may be introduced.
3. These buttons allow to 'accept' or to 'cancel' if the user wants to validate the introduced Document or if he wants to decline the introduction, respectively.

9.8 Create Service

It allows the user to introduce the service name, the Actors that can initiate it, and the different steps (Actions and/or Services) that compose it.

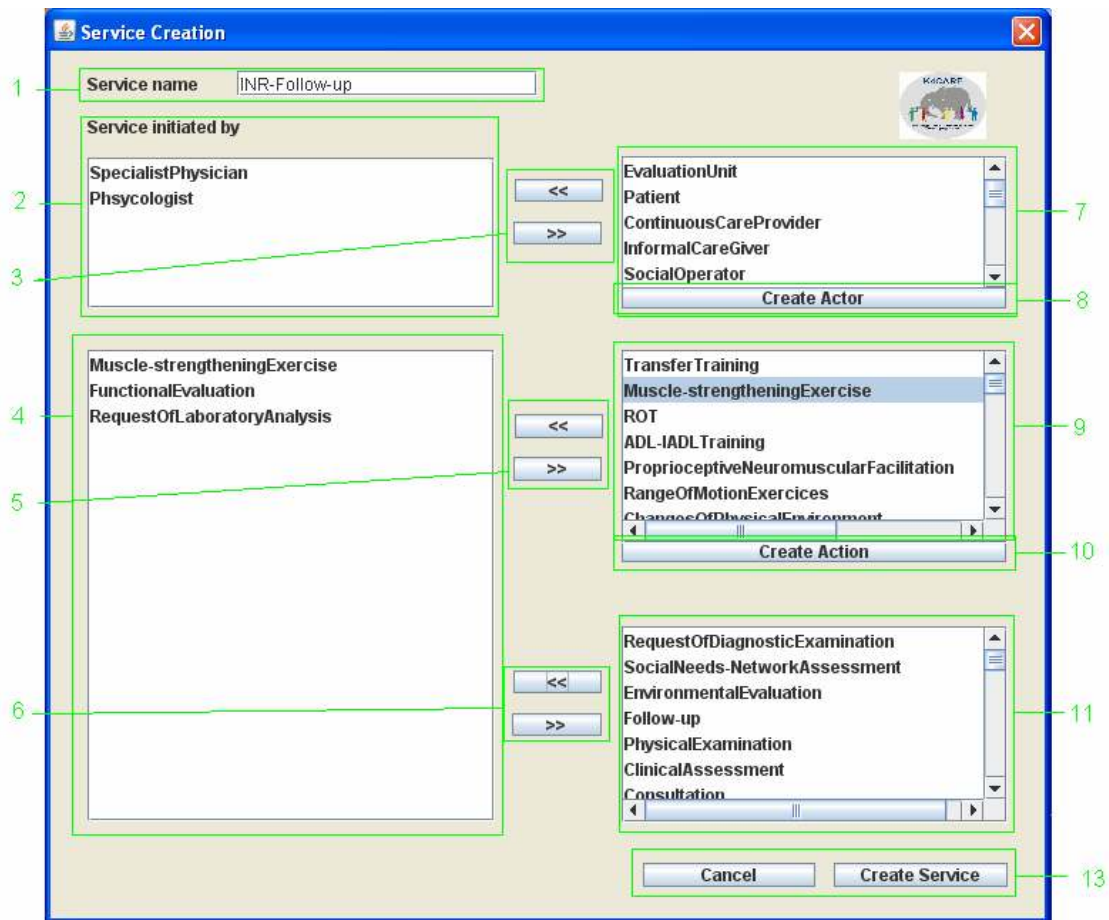


Figure 16 Service creation window

Elements details:

1. Here the user has to introduce the name for the new Service.
2. Here the system shows the different service initiators.
3. By the use of the '<<' button the selected Actor in 7 is added to the service initiators and by clicking '>>' the selected actor in 2 is removed from the set of service initiators.
4. Here are shown the set of steps that should be done to perform the Service.
5. With the use of these buttons the user can add an action from 8 to the service procedure by clicking '<<' (This will show a new window (see Section 9.10) to detail the action and can remove actions by clicking '>>'.

6. With the use of these buttons the user can add services from 9 to the service procedure ('<<') and can remove services from it, by clicking '>>'.
7. This shows the list of all K4CARE Actors.
8. By clicking this button the user can create a new Actor (See 9.6).
9. This shows the list of all K4CARE Actions.
10. By clicking this button the user can create a new Action (See 9.5).
11. This shows the list of all K4CARE Services.
12. Finally the user can create the service by clicking 'create service' or decline its creation by clicking 'cancel'.

9.9 Create Procedure

When a service is already defined, but its procedure is not the needed, the window shown by Figure 17 allows the user to define the new procedure for the service. During the Procedure definition, the user can detail which are the steps that compose it and which are the actors and documents needed.

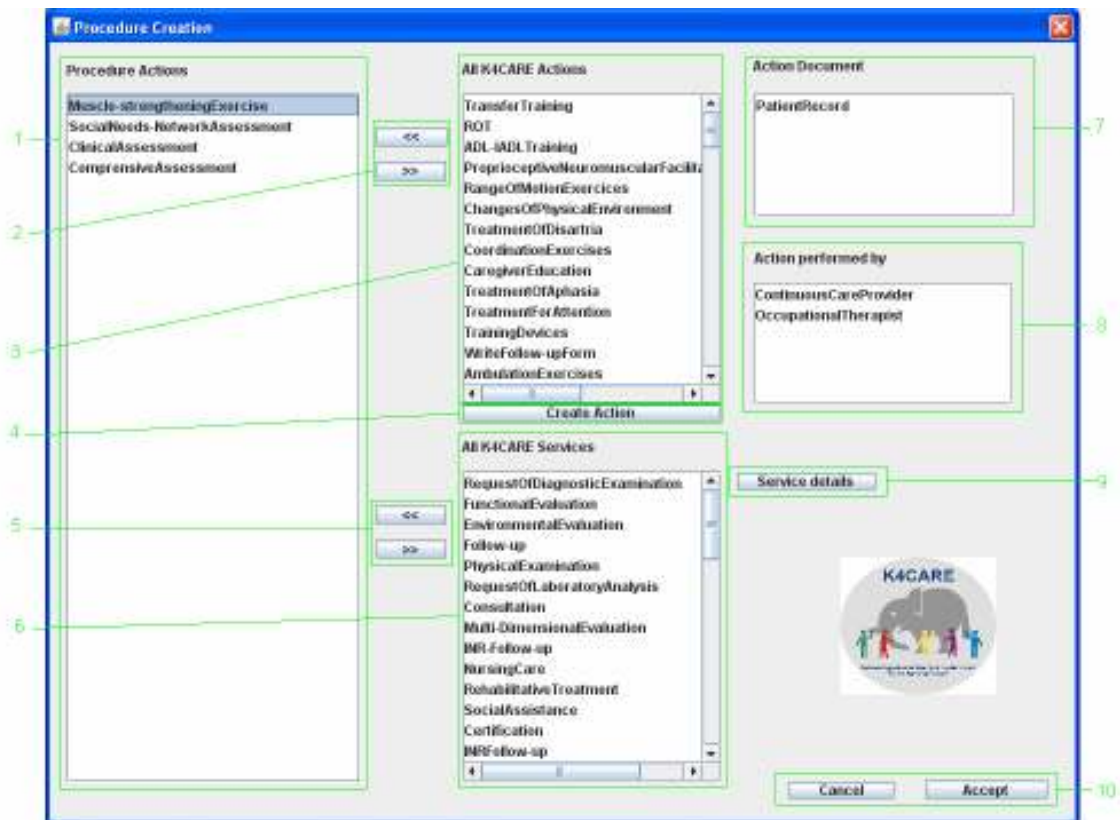


Figure 17 Procedure creation window

Elements details:

1. Here are shown the steps that are part of the procedure.
2. With the use of these buttons the user can add an action by clicking '<<' (This will show a new window (see Section 9.10) to detail the action) and remove an action from the list by clicking '>>'.
3. This list shows all the K4CARE defined Actions.
4. By clicking this button the user can create a new action. Details in Section 9.5.
5. With the use of these buttons the user can add a service to the procedure ('<<') or remove one of it ('>>').
6. This list shows all the K4CARE services.
7. This list shows all the documents used by the step selected in the list of procedure actions (1).

8. This list shows all the Actors that can perform the step selected in the list of procedure steps (1).
9. By clicking this button the user can observe the details of the selected service. Details in 9.11.
10. Finally the user can validate the procedure by clicking 'accept' or decline it by clicking 'cancel'.

9.10 Action details

The window shown by Figure 18 allows the user to indicate which Actor performs an Action inside a service and which document uses.

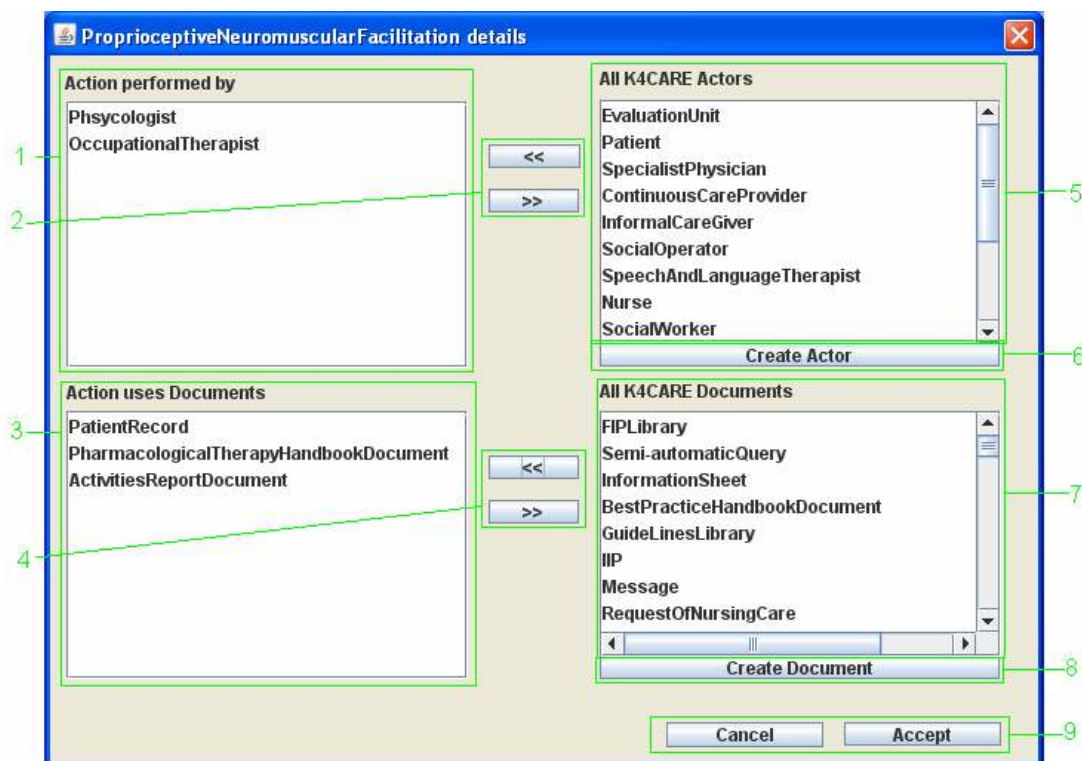


Figure 18 Action details window

Elements details:

1. Here is shown the list of Actors that can perform the Action.
2. With the use of these buttons the user can add Actors ('<<') or remove them ('>>') from the list of Actors (1).
3. Here is shown the list of documents used by the Action inside the Process.

4. With the use of these buttons the user can add Documents ('<<') or remove them ('>>') from the list of Documents (3).
5. The list of all K4CARE Actors.
6. This button allows creating new Actors (See 9.6).
7. The list of all K4CARE Documents.
8. This list allows adding new Documents (See 9.7).
9. Finally the user can validate the Action details ('accept') or decline them ('cancel').

9.11 Service details

The window presented in Figure 19 allows to the user to look the different procedures that are related with a service.

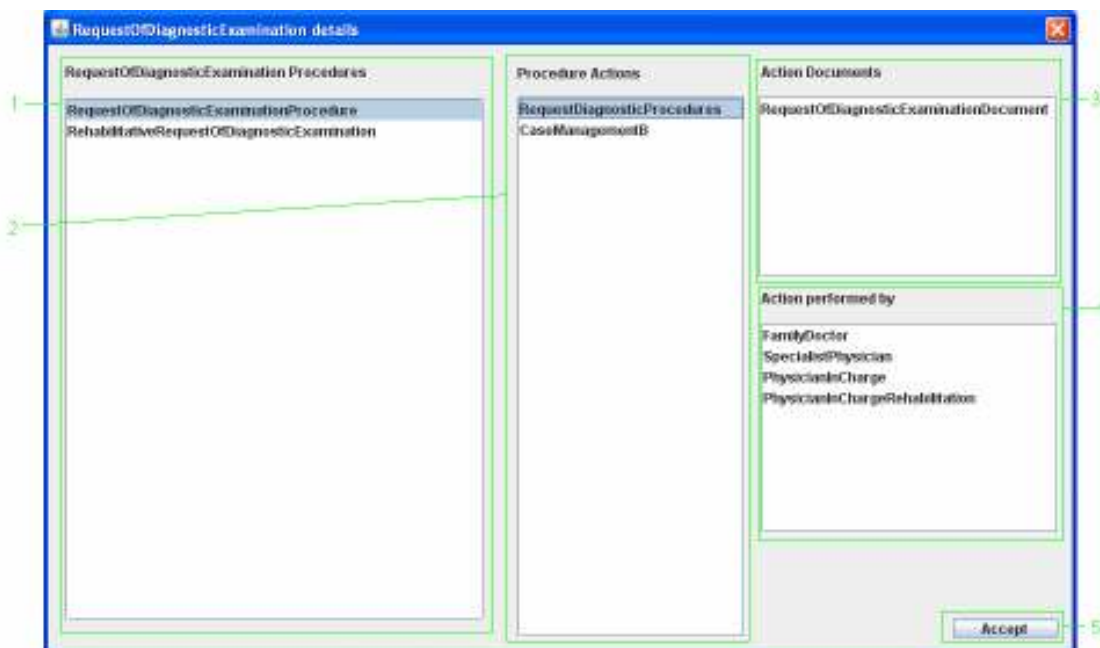


Figure 19 Service details window

Element details:

1. Shows a list that contains all the procedures of the service.

2. This list shows all the steps of the selected procedure in 1.
3. This is the list of documents used by the selected action in 2.
4. This is the list of actors that can perform a concrete action selected in 3.
5. When the user has validated the details of the service, he can close it by clicking the 'accept' button.

10 Contributions and Publications

In this section the contributions and publications of this work are presented.

10.1 Contributions

This work has contributed in the points presented below:

- Revision and enlargement of the K4CARE model defined inside the Deliverable 1.
 - Definition of the different procedures used to perform the different K4CARE services.
 - Revision of the given definition of the actions and documents given by the initial specification of the K4CARE model, provided by the Deliverable 1.
- Creation of an OWL ontology that stores all the K4CARE model knowledge.
- Creation of an OWL API that allows an easy and intuitive access to the OWL ontologies. This API is used inside the ISA tool and the Data Abstraction Layer.
- Definition of a new ontology model of the APO that allows the addition of new care units to it, without reducing the efficiency and maximizing the reusing of resources.
- Creation of a tool called ISA that allows to the user to add new care units to the APO ontology, in a graphic and intuitive way.

10.2 Publications

Casals, J., Gibert, K., and Valls, A.: Enlarging a medical actor profile ontology with new care units 11th Internacional Conference on Artificial Intelligence in Medicine, Workshop from Knowledge to Global Care, Ámsterdam, 2007 (in press).

11 Conclusions and future work

From the first stages of this work we obtained the following conclusions:

- The medical experts needed the aid of the knowledge engineers to establish a concrete and formal definition of the model.
- The new additional services have an structure equal to the HCNS services which allows to reuse the concepts defined inside the ontology.
- The experts do not use a tool that helps in the addition of new care units, some problems like redundancies or inconsistencies can appear, as it has been demonstrated with the rehabilitation example.

Therefore, in this master thesis we have tried to give a solution to these aspects.

In this work the knowledge structure of the K4CARE model is introduced, focusing on the Actor Profile Ontology, which is deeply analysed. A modification of the initial structure of the APO is proposed so that it makes possible future enlargements with the services provided by new care units.

The proposal presented in this work consists of:

- Creating a parallel structure that allows identifying to which care unit an element belongs. This new structure is only applied to some classes (Services, Procedures, SDA and Actors), because the pertinence of Actors and Actions can be deduced.
- A new class SDA is created with the aim to allow the Ontology to have different SDA files for the different care units.

A tool providing intelligent support to the introduction of a new care unit into the K4CARE model has been presented. ISA is an user-friendly software implemented in JAVA that is connected with the Ontology and provides support to the user to ensure the correct linkage between the new elements to be introduced. This tool is needed to palliate the difficulty of defining the medical knowledge. Using ISA we increase reliability, decrease inconsistencies, redundancies and time devoted to the definition of new care units. A first prototype of ISA is being tested with the rehabilitation service at present.

Now, with this new approach there is only one Ontology for all the Services. However, it is interesting to have the possibility of isolating the part of the primary Ontology referred to the specified new care unit incorporated. So that, a tool that provides the corresponding Ontology for a concrete care unit must be developed. The new structure proposed by the APO keeps the possibility of isolating the Ontology corresponding to a certain care unit

easily. Using this tool, every care unit defined in the system is allowed to get its own Ontology from the global one. Those Ontologies will correspond to the different care units, and their corresponding resources. Finally a tool allowing tailoring over APO will also be developed. This tailoring will consist on creating a profile for every user, which makes possible to establish their preferences over the tasks in which he is involved.

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