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A system of concepts to support the integration of Health and social care and assistive domotics services: the Health@Home project

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ABSTRACT

The main objective of this work is to define a common shared conceptual model that describes the health care environment using the ContSys standard, harmonizing it with the social care and assistive domotics concepts. The development of this model supports the integration of services, the interoperability among systems and the continuity of care across domains.

Starting from the identification and extraction of the portion of the ContSys model suitable for the healthcare part, the article provides the methodology adopted to extend it with social and home automation concepts and to integrate them in a unique framework that supports the continuity of care.

The integrated model defined in this paper has been adopted in the design phase of an interoperable open platform, called Health@Home, that organizes the provision of a set of health, social and home automation integrated services provided at home.

Our model is a starting point to analyze the various determinants of wellbeing able to guarantee a high-level individual's quality of life. At the moment the Health@Home system is at the implementation phase.

KEYWORDS

Continuity of Care; integrated Care; home Care; healthcare; social care; contsys standard

Introduction

In the last decades many European countries have adopted policies to strongly shift the organization and provision of health and social services from formal institutional facilities (e.g. hospitals) to home care.^{1–3} This can support patients with chronic illness as well as temporarily frail individuals in their home⁴ by providing appropriate and high-quality care services taking into account the support of informal caregivers (e.g. family members), the use of appropriate technologies^{2,5,6} to monitor the daily living activities of frail individuals and check a number of his/her home conditions such as safety, hygiene, and domestic hazards.

Both home and community services offered by various providers present a critical aspect referring to the fragmentation of services, which leads to scarce outcomes and wasted resource.³ Thus, on the basis of the different needs of the target persons (e.g. older adults, temporarily fragile, healthy people), it is necessary to improve the coordination and cooperation among stakeholders in both "primary-secondary" care, and "health-social" care. These tasks form the basis to realize continuity of care, which is considered a prerequisite to improve efficiency and effectiveness of both health and social care including services related to assistive domotics that support the target persons to remain at their home safely and comfortably.⁷

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In order to achieve the integration and coordination among the different stakeholders as well as the interoperability between the information systems developed at local and national level, it is necessary to define a common shared conceptual model. It has to combine the main concepts of health and social care with assistive domotics linked to the healthy behavior and lifestyle components from a business process point of view. Although the integrated care is widely studied as a possible solution to the growing demand for improved patient experience and patient's health outcomes,^{8,9} there is a lack in the literature in addressing this challenge from a conceptual modeling perspective. This is particularly evident considering the social side in comparison to the health one, where there is a long tradition and diffusion of information systems, standards as well as policies that concern the digitalization of data and their exchange. Among the standards developed in healthcare that define a common conceptual model with the aim of improving the interoperability at all levels of healthcare, ContSys (A system of concepts for the continuity of care, formally ISO 13940¹⁰) represents a suitable starting point to accomplish our task also considering that it is focused on semantic interoperability from a business process perspective, which is one of the basic requirements to achieve continuity of care. Its advantage is to consider continuity as the integration of different health services provided by formal and informal caregivers belonging to different types of organizations such as primary care, hospital, community. Moreover, this standard provides a comprehensive conceptual framework to describe generic concepts that represent both the content and context of the health services with well-defined relationships among a large set of classes that describe in details the healthcare process.¹¹

However, as continuity in ContSys is mainly clinical-centered, it is necessary to analyze to what extent its conceptual framework can be applied to social and domotics settings and/or has to be extended to include them. Some studies have considered the possible intersection of ContSys with other standards often connected with the development of Electronic Healthcare Record (EHR) models in order to support the semantic interoperability among information systems in clinical processes.^{11–13} Other works, due to the lack of standard conceptual models of social care, have proposed their models on specific social care processes carried out in well-defined contexts,^{14–16} considering also the integration with health care.^{12,17} These studies were focused on the need of developing care plans to be shared among different professionals to manage and provide both health and social care services. In particular, the work proposed by Hägglund and colleagues¹² combines the ContSys as a standard conceptual model with the openEHR, which is a specification to improve the interoperability of EHRs.

Differently from this approach, we adopted the ContSys standard to define a conceptual model as the basis to develop an interoperable open platform that provides a technological and organizational solution to link public, private, profit, nonprofit provider organizations of a set of health, social and home automation integrated services provided at home and to individuals who require those services. Accordingly, the development of a common shared schema that includes and harmonizes concepts of the different settings represents a pre-requisite to achieve interoperability. In line with this requirement, the aim of this paper is to propose a common shared conceptual model that combines the main concepts of the ContSys standard describing the healthcare processes harmonizing them with social care and assistive domotics to support the integration of services, the interoperability among systems and the continuity of care across domains.

In a previously published paper,^{18–23} we introduced the preliminary idea of an integrated model that collates concepts from the health and the social care settings. This was part of the H@H national project whose overall purpose is to improve the *quality of life* of individuals who have temporary or permanent weaknesses, or chronic patients in outpatient settings that need health care assistance and remote monitoring. In the mentioned paper, we selected a fragment of the ContSys conceptual model and insert in it a set of classes that capture social care and assistive domotics services elements. In a previous study,¹³ the HL7 FHIR standards have been used to define the integrated schema by emphasizing, essentially, the *concepts* which can be shared, generalized and extended, in addition to those specified for one context and not included in the others.

In this work, we further analyze the health, social, and home automation settings providing a detailed description and relevant conceptual models of these three contexts also pointing out the

main parts of the schema where they interact. To this end, a high-level conceptual model is introduced that gathers the main concepts based on the ContSys schema, which are shared among the above-mentioned contexts. Successively, the whole integrated model is introduced that combines the three-identified contexts, focusing on the concepts and the content of integrated health and social services provided in a home and community care delivery model. Note that the data models are described using the UML class diagram.

Subsequently, [Section 4](#) illustrates the results of the adopted methodology showing the interaction among the three identified models as well as the shared integrated schema designed to model the H@H project, providing a case study to test its application.

Materials and methods

The objective in the definition of an integrated model is to identify a set of high-level concepts and their relationships that describe health and social care services provided at home from the process point of view. The model is conceived to enable the communication among various information systems at the semantic level in order to facilitate the interaction between a subject of care and health professionals in a patient-centered care delivery model. To this purpose, the core of the system and hence the high-level conceptual model is the Activity.

It affects directly or indirectly the improvement or the maintenance of the individual's health status, his/her lifestyle and compliance to the recommended care plans by considering the different environmental conditions that impact his/her quality of life.

As mentioned above, in our approach we take advantages of the ContSys standard which describes concepts able to represent an activity; these concepts are: who are all the actors involved in healthcare (actors include patient, healthcare provider, and third parties), for what (health issues), and when (time-related concepts such as episode), what is done (decisions, clinical activities), and how (management of data).²⁴ ContSys includes a large set of concepts organized into eight areas closely related to each other that are needed to represent both the content and context of the healthcare services delivered. These areas, called clauses in the standard document, are: 1) healthcare actors involved in the provision of care; 2) healthcare matters specifying issues and needs of the subject of care; 3) activities (e.g. visits, exams, tests) carried out during the care process; 4) process defined as a set of interrelated or interacting healthcare activities; 5) healthcare planning that models and summarizes the individual's plan of care; 6) time that provides a timeline of the healthcare activities; 7) responsibilities that models the management of the healthcare mandate including the third parties involved; 8) information management that summarizes documents and systems involved in the care process. On the basis of this classification, our approach defines an abstract description of a generic activity that can be shared among health, social, and home automation contexts.

In [Figure 1](#), the class **Activity**, that is posed at the center of the model (reported in red color), is described by the following main concepts based on the ContSys schema: 1) **Actor** capturing organizations and persons participating in individual's care process considering: who performs the activity (**Provider**) and for whom the activity is performed (**Subject of Care**) (reported in blue color); 2) **Issue** representing the reason why an activity is performed on a subject of care (reported in light green color); 3) **Time** which identifies the interval during which a set of activities are performed on a subject of care and centered on a specific issue (reported in dark green color); 4) **Information management** to capture data produced during the performance of an activity also specifying if the information are explicitly validated by a professional (reported in orange color); 5) **Resources** required to perform an activity considering by which **Device** the activity is performed and where (**Location**) the activity is performed (reported in red color).

Starting from this abstract model, the definition of the integrated conceptual model encompassing social and domotics concepts is performed considering the following steps:

- (1) Identification of the portion of the ContSys schema that fits the purposes of the health part of the integrated model. This is based on the high-level conceptual model defined previously;

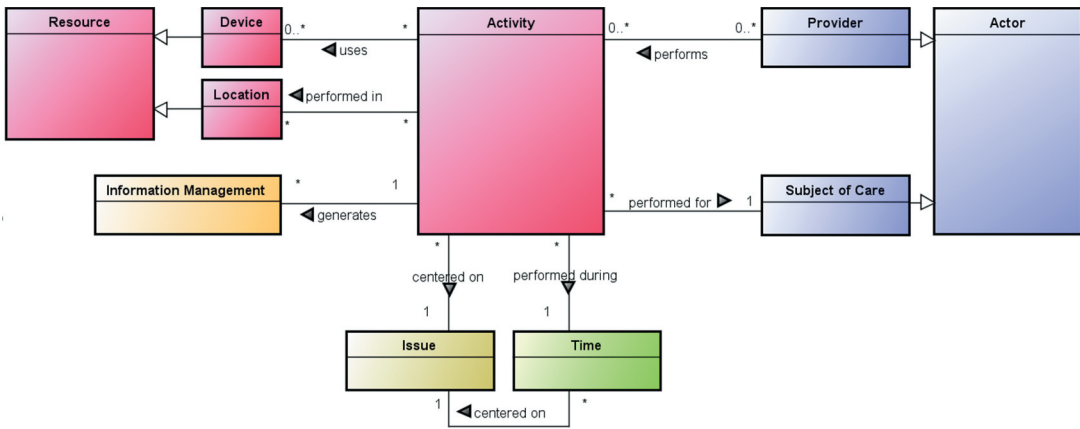


Figure 1. High-level conceptual model describing the generic activity with five different concepts.

- (2) Analysis of the different types of social services to be provided at home to support the subject of care and/or the family to define a conceptual model focused on the social context;
- (3) Identification of the main concepts concerning home automation services to be included in the overall conceptual model by taking into account the high-level schema;
- (4) Integration of the three conceptual models by extending the portion of the ContSys standard (health schema) with the social care and home automation concepts.

Results

By means of the high-level model (Figure 1) we have defined the three models describing the health, social, and home automation contexts. They are described in the following sections using the UML class diagram. For each model, the concepts are reported and colored taking into account the areas/clauses stated in the ContSys standard and illustrated in Figure 1.

Healthcare conceptual model

The result of this step is shown in Figure 2. According to the ContSys standard document,¹⁰ healthcare is delivered through a set of **Healthcare (HC) Activities**¹ provided in health and clinical processes with the purpose of improving or maintaining the health condition of the **Subject of Care** during his/her interaction with the associated **Healthcare Professionals**. The health status of the subject is focused on one or more **Health Issues** that aggrieve the **Subject of Care**, and correspond to a certain disease (e.g. hypertension, cancer), an illness (e.g. loss of weight, fever) or other kind of health conditions (e.g. premature born, frailty).

A **HC Activity** provided to a **Subject of Care** is classified depending on the **Actor** who performs it: 1) **Provider Activity** where the service is provided by a **HC Provider** (either an HC Professional or a HC Organization), such as a Magnetic Resonance Imaging (MRI) performed by a radiologist; 2) **Self-care Activity** where the activity is directly performed by a **Subject of Care**, such as measuring the body temperature; 3) **Third Party Activity** where the service is supplied by a **Third Party** who is responsible for supporting the **Subject of Care**, such as measuring the blood pressure executed by the patient's relative. These activities are carried out during a certain period of time (**Contact**) during which the **Subject of Care** interacts directly or indirectly with one or more **HC Professionals**, such as the visit of the cardiologist, the visit of a nutritionist, a hospitalization. In a clinical case, the delivery of health

¹For the sake of simplicity in the description of the models also the plural of classes that refers to a singular form of them are reported in bold.

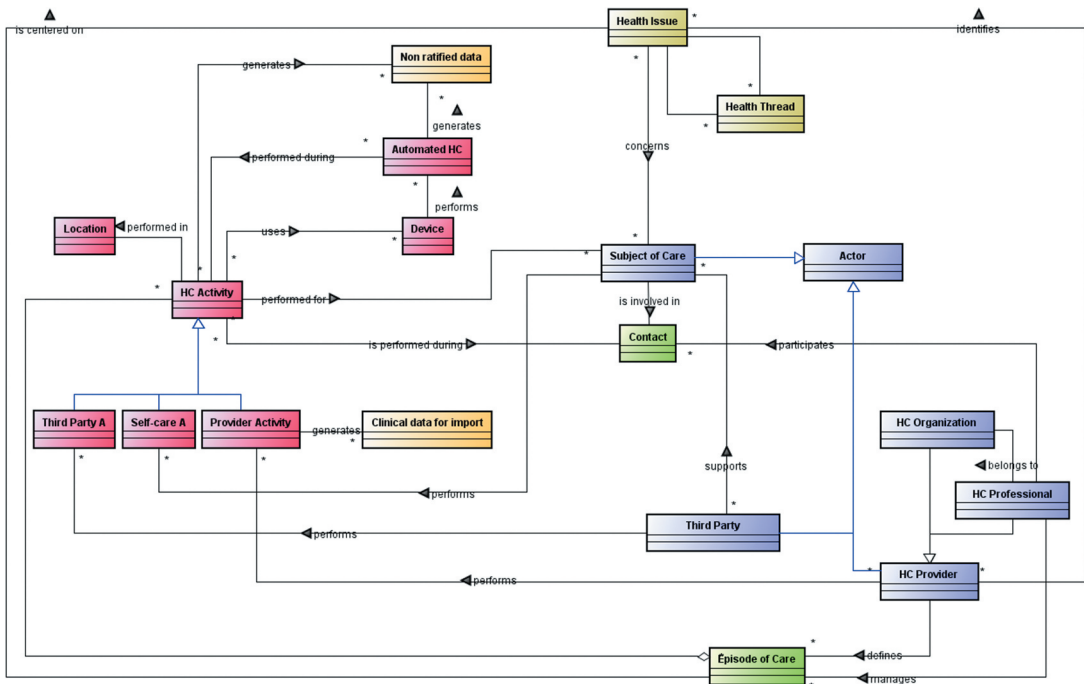


Figure 2. Portion of the ContSys standard model describing the health context.

services can be associated with **Automated HC** activities that are performed by a **Device** without the operation of a person, such as the pulse oximeter that monitors the oxygen saturation of a patient's blood. Finally, each **HC Activity** is associated with a **Location** that identifies the place where the service is performed, such as the home of the **Subject of Care**.

Another main concept of ContSys is the **Episode of Care** that is defined as the period of time during which **HC Activities** are carried out to address a **Health Issue** of the **Subject of Care**. An **Episode of Care** can take place either for a short time interval or on a continuous basis or it can be a sequence of alternating intervals, such as a hyperglycemia for a patient suffering from diabetes. Each **Episode of Care** is determined and labeled by a **HC Professional** begins with the initial **Contact** for a **Health Issue** and is concluded after the accomplishment of all **HC Activities** related to the last **Contact** for the same **Health Issue**. Each health issue is identified by a **HC Provider** involved in the process of care. Two or more **Health Issues** can be related to each other in a self-association (**Health Thread**) that can outline two principal relationships: 1) the worsening of the health status of the individual, such as a fever that becomes bronchitis and subsequently bronchopneumonia; 2) the comorbidities related to a specific health status, such as the asthma related to bronchopneumonia.

Finally, from each **HC Activity** a set of data and documents can be generated, which are registered in specific archives, such as the EHR. Mainly, an activity carried out by professionals (**Provider Activity**) generates data that can be imported into a professional record or sharable data archive (**Clinical data for import**). Conversely, the **Self-care** and **Third Party Activities** generate **Non ratified data** that has not been evaluated and validated by a **HC Professional**.

Social care conceptual model

The result of this step is described in Figure 3. The backbone of the proposed model is very similar to the health one. Based on the ContSys standard, also in this context, social care is delivered through a set of **Social Activities** carried out by **Social Providers** to improve or maintain the social condition

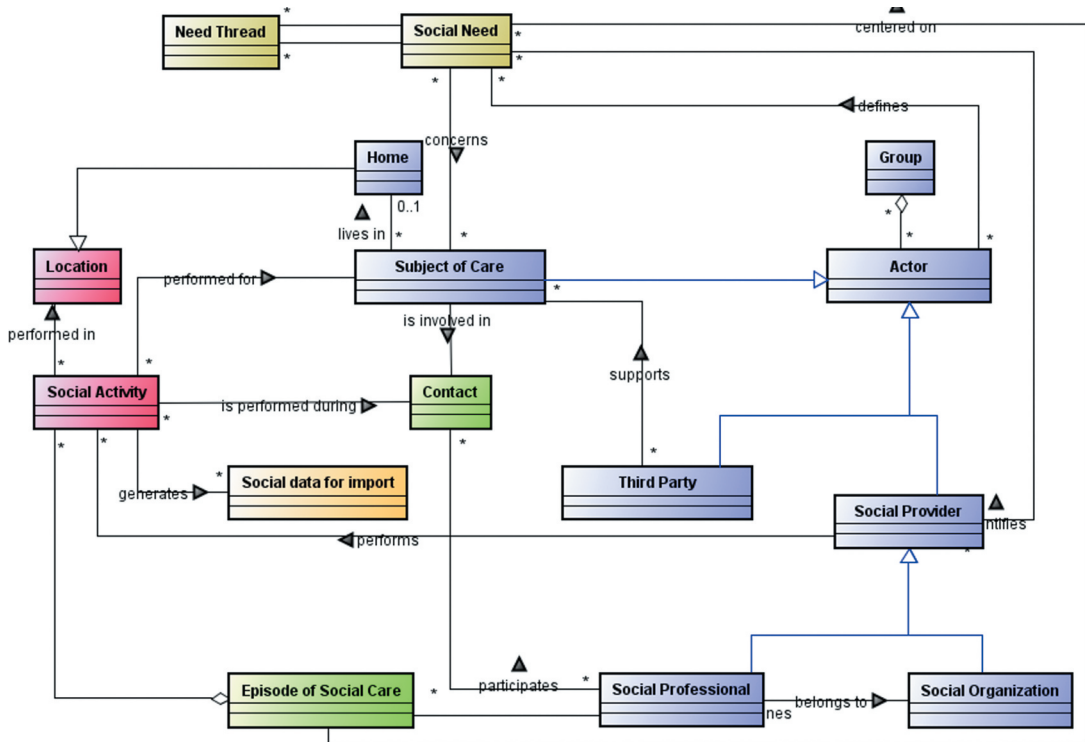


Figure 3. Conceptual model describing the social context.

of an individual (**Subject of Care**). A **Social Provider** can be either a **Social Organization** or a **Social Professional** who belongs to a **Social Organization**. Differently from the healthcare scenario, **Social Activities** can be performed exclusively during the **Contact** of the **Subject of Care** with a **Social Provider** whereas they are not expected to be carried out by a **Third Party** and by the **Subject of Care** him/herself. These activities are delivered during a set of encounters between the **Subject of Care** and the **Social Professionals** and are generally aggregated in an **Episode of Social Care** centered on a specific **Social Need**. Also in this case, two or more **Social Needs** can be related to each other in a self-association (**Need Thread**) that can describe inter-related needs, such as transportation support and the social integration. Moreover, in addition to the health model, the class **Group** is considered to associate two or more **Actors** (super class of **Subjects of Care**) for a specific reason (e.g. same family, citizens living together, coworkers), while the class **Home** specifies the place where the **Subject of Care** lives, in order to verify whether a **Social Activity** (e.g. house cleaning) has already been planned and/or deployed for an individual of a specific group, thus avoiding the duplication of services. Also in this case each **Social Activity** is performed in a specific **Location** that can be also the **Home** of the **Subject of Care**. Each **Social Activity** generates a set of **Social data for import**.

Home automation conceptual model

The result of this task is shown in Figure 4. In this model the main role is played by the class **Domotic Activity**, which can be specialized in three sub-classes depending on whether it is performed for: 1) a **Subject of Care** (**Individual Activity**) or 2) a **Group** of individuals (**Group Activity**). Moreover, 3) the **Home Activity** is reported in the model to specify whether the service is delivered to monitor the environment (**Home**), where the **Subject of Care** lives. Differently from the health and social model, in this context the activity is performed by a **Device** with the supervision of a **Domotic Provider**. Similar to the other domains, the **Domotic Activity** is performed in a specific **Location** (that generally is the

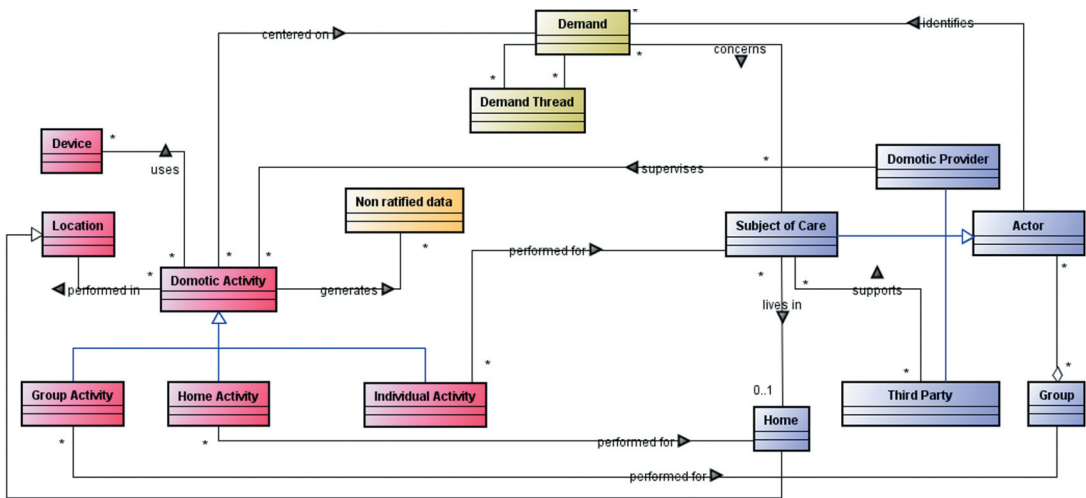


Figure 4. Conceptual model describing the home automation context.

Home of Subject of Care) and is centered on a specific **Demand** that concerns the **Subject of Care** as identified by an **Actor**, such as a **Third Party**. Also in this case, two or more **Demands** can be related to each other in a self-association (**Demand Thread**) that can describe the inter-related demands, such as monitoring the healthy nutrition and the activities of daily living. Moreover, as for the social model, the class **Group** is considered to associate two or more **Actors** (superclass of **Subjects of Care**) for a specific reason (e.g. same family, citizens living together, coworkers), while the class **Home** specifies the place where the **Subject of Care** lives, in order to verify whether a **Domotic Activity** (e.g. monitoring home temperature) has already been planned and/or deployed for an individual of a specific group and avoid the duplication of services. Each **Domotic Activity** generates a set of **Non ratified data**.

Integrated model

The whole integrated conceptual model which combines the three-identified contexts is shown in Figure 5, while its portion is reported in Figure 6 focusing the attention on the points of contact among the conceptual models reported in Figure 2, 3, and 4. This model provides a comprehensive, conceptual basis to describe the concepts and the content of the delivery of integrated health and social services provided in a home and community care delivery model. In particular, it occurs at the following levels:

- **Need:** that is a generalization of the **Health Issue**, **Social Need** and **Demand** classes. At this level, the integrated schema captures and associates the bundle of needs (**Need Thread**) as identified by one or more professionals. Moreover, the specific relationships between **Health Issue**, **Social Need** and **Demand** (see the left part of Figure 6) are highlighted to model scenarios where these **Needs** are strictly related to each other. This mainly happens when a **Health Issue** (e.g. frailty of an elderly due to a breaking of a knee) triggers a **Social Need** (e.g. support in housing services) and/or a home automation **Demand** (e.g. monitoring the interactions of the subject of care with objects in the home environment).
- **Activity:** that is a generalization of the **Healthcare**, **Social** and **Domotic Activity** classes (see the right part of Figure 6). At this level the integrated schema captures and associates the activities related to the three contexts performed by a provider on the Subject of Care using specific relationships between these **Activities** that are strictly related to each other. This mainly happens when an **HC Activity** (e.g. a therapy) triggers a **Social Activity** (e.g. support the patient to administer the injection) and/or a **Domotic Activity** (e.g. monitor the drug leftover using a smart medicine cabinet).

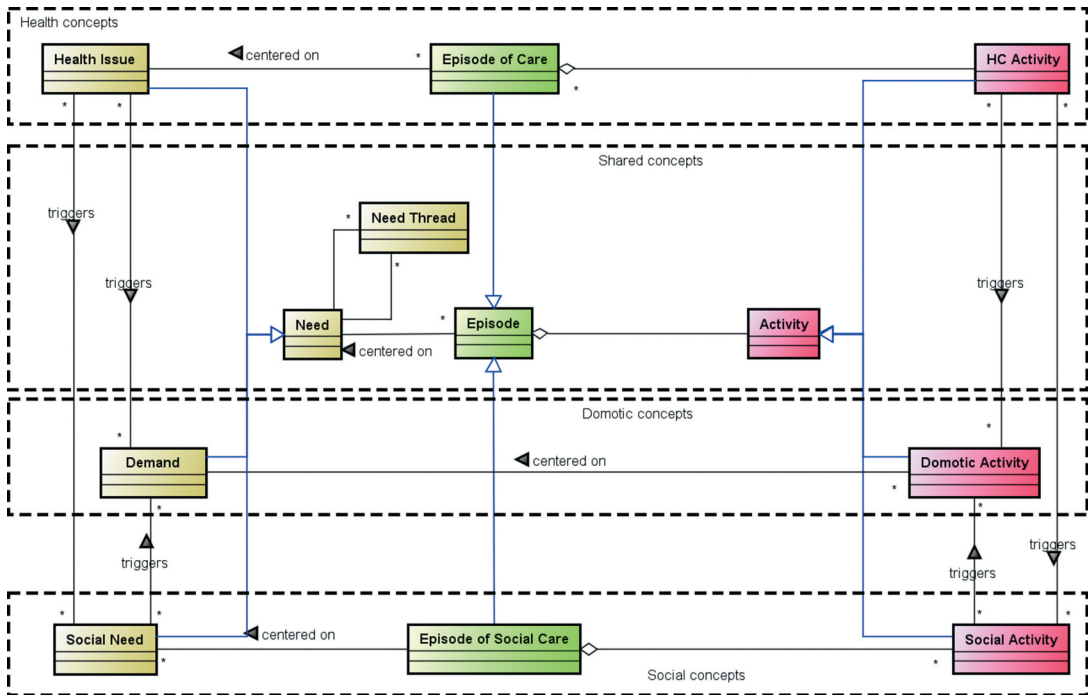


Figure 6. Portion of the extended model describing the integration of health, social care and assistive domotics. classes related to a specific context are grouped using the relevant dashed rectangle.

Table 1. The health, social, and domotic needs of the referring case study.

	Healthcare	Social care	Home automation
Subject of Care 1 (Mark)	Heart disease <ul style="list-style-type: none"> • Blood pressure • Weight • Cardiological visit Arthrosis <ul style="list-style-type: none"> • X-ray • Orthopedic visit 	Mobility <ul style="list-style-type: none"> • Transport to pharmacy • Transport to hospital • Provision of goods/drugs Housekeeping <ul style="list-style-type: none"> • House cleaning • Bill payment Economic <ul style="list-style-type: none"> • House rent support 	Safety environment <ul style="list-style-type: none"> • House temperature • House humidity • Gas leaking Monitoring of consumptions <ul style="list-style-type: none"> • Drug locker • Smart fridge
Subject of Care 2 (Martha)	Diabetes <ul style="list-style-type: none"> • Blood pressure • Glycemia • Diabetic visit Arthrosis <ul style="list-style-type: none"> • X-ray • Orthopedic visit 	Mobility <ul style="list-style-type: none"> • Transport to pharmacy • Transport to hospital • Provision of goods/drugs Housekeeping <ul style="list-style-type: none"> • House cleaning • Bill payment Economic <ul style="list-style-type: none"> • House rent support 	

Moreover, on the basis of the connections among the three settings at the activity level, this relationship exists by considering the cardiological visit (healthcare activity) that triggers the transport to hospital (social activity). In some cases, when the patient needs a specialist or a primary care visit, the transport to these settings could be needed. Note that social care needs and activities are provided on the personal basis according to the Italian social care system and, therefore, they are reported for both patients. On the contrary, home automation services are not delivered individually, but based on the location of the subjects of care.

The integration of information systems for the health and social assistance of an individual allows to perform statistical analysis both for the management and the clinical research. In the scenario proposed in this section, the integrated conceptual model facilitates the analysis performed by the operating center in particular for the identification and management of alerts and periodical measurements of functional parameters of the devices. This is particularly evident considering the monitoring of the implementation of the social-health assistance plan and the health status of both patients as well as of the correct provision of health and social services needed to support the patients' daily life.

Discussion

This paper defines an integrated model that is the conceptual basis for the design of an interoperable open platform, called Health@Home that organizes the provision of a set of health, social and home automation integrated services provided at home. The model was designed on the basis of the ContSys standard deployed in the healthcare context to improve the continuity of care. The integrated schema facilitates the interoperability between systems as well as the coordination and cooperation activities of the different stakeholders involved in the provision of services in a comprehensive continuity of care process. Our model is a starting point to analyze the various determinants of wellbeing able to guarantee a high-level individual's quality of life. At the moment the H@H system is at the implementation phase.

The definition of a standardized conceptual model is required by the increasing need of defining care pathways that are developed, implemented and shared among the different health and social care professionals involved in the individual's care. This is crucial considering the growing proportion of elderly frail population with a particular attention on patients with multi-morbidity healthcare conditions. This makes it necessary to plan, provide, and monitor integrated care services considering not only the health conditions, but also the social needs related to the individuals by implementing interoperable information systems. They can help providers in managing effective, efficient and sustainable social-health assistance pathways both from the economic and social points of view.

The feasibility of the model has been tested on the basis of a scenario that refers to a couple of frail elderly individuals who have mobility problems caused by arthrosis. Both subjects of care need the provision of health and social care services to treat and control their health status. Moreover, the provision of home automation solutions is taken into account to monitor the individual's life style and to check the safety of the environment they live. The model has been also validated at national level by UNINFO, the branch of the Italian National Unification (UNI) standardization body that tackles the Information and Communications Technology (ICT) activities. In particular, starting from the results of this study a working group has been set up with the aim of "extending the ContSys standard by integrating it with concepts related to social care so as to have a formal description able to define a standard for exchanging the information in social and health care settings". This interdisciplinary group, formed by researchers and professionals belonging to health and social care contexts, has produced a technical norm (i.e., UNI/TR 11802:2020) published by UNINFO²⁵ <http://store.uni.com/catalogo/uni-tr-11802-2020>. At international level, this extension has been proposed to ISO within the planned revision of ContSys given the importance of integrating social services in the provision of territorial healthcare that should include also the individual's social well-being.

The main limitation of the proposed model is that it was conceived starting from the perspective of the Italian national health and social system. In Italy, health and social services are only partially integrated. Moreover, while health is organized and provided by the National and Regional Health Services, social services are mainly managed by municipalities and delivered through private profit or nonprofit accredited care providers. However, the level of abstraction of both ContSys and the proposed integrated model makes it possible to customize it also to other health and social care systems.

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Disclosure statement

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Author's contributions

All authors contributed in the conception of the study as well as in the design of the integrated model. All authors contribute equally in drafting, critically revising and writing the final version of the paper.

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