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HoCoS: Home Companion Software. A service oriented solution for elderly home accompanying and remote healthcare monitoring

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Abstract — **The age of the population in all societies around the world is increasing. Elderly people prefer to maintain their independence, their autonomy and live at home as long as possible. We propose as a solution to this issue a Home Companion Software baptized HoCoS. This solution aims to help the elderly with daily life by providing an ergonomic and familiar interface. The second purpose is to integrate transparent remote healthcare monitoring service that ensures elderly security without disturbing the ergonomics of the application. We present service oriented architecture that offers extensibility and interoperability between heterogonous systems in order to combine several technologies and operators. We carried out ergonomic tests on this solution to evaluate its comfort and ease of use.**

I. Introduction

OLDER people often face problems of steadiness and loneliness, causing psychological and physiological problems that might seriously threaten their lives[1]. Statistics in [2] show that each year in the U.S., one in every three adults aged more than 65 falls. Falls can lead to moderate to severe injuries, such as hip fractures and head traumas, and can even increase the risk of early death.

In addition, the proportion of elderly people is increasing in all societies around the world. In 2003 there were more than twelve million elderly dependent people in France [3]. It is estimated that that in 2020, 28% of the French population will be over 60 [4].

The traditional solution was the placement of the elderly in specialized centers (retirement homes for example). However, places in these centers are reduced and the independence of patients is not always respected. This justifies the need of keeping the elderly as long as they wish in their homes. In fact, this presents two main advantages:

(i) elderly people usually prefer to stay at home

(ii) it is less expensive to stay at home than in collective accommodation.

Since the idea of home accompanying became a possibility, several studies have been carried out to test the association between social support and cognitive function among the elderly. As proved in [13], the increase of social support and the maintenance of a good life-style promote the cognitive function of the elderly. For these reasons, several research projects have been led to assist the elderly (QuoVADis, CompanionAble, SweetHome). As deduced in [5] and [6], the real challenge of the system is to assure at the same time: social accompaniment, remote healthcare monitoring and ergonomic graphical user interface (GUI).

In order to achieve these objectives, HoCoS implements several services and maintains their accessibility by multiple users, from a unique interface. At the same time, HoCoS manages the technological diversity of the involved services using an abstract layer that enables the exchanges of information and requests between them.

The innovation of HoCoS lies in providing an ergonomic and familiar GUI to elderly while ensuring their security by integration of transparent services for remote healthcare monitoring. In fact, the vital and environmental data of the patient are processed by these transparent services and sent to remote healthcare operators without disturbing the ergonomics of the GUI.

The paper is structured as follows: in the second section, we expose the motivation for adopting a *Service Oriented Architecture* (**SOA**) in this *Remote Healthcare Monitoring* (**RHM**) system. In the third section, we define a service and present the details of its inner design. The fourth section is dedicated to explaining the global SOA of HoCoS. We expose in the fifth section the relevance of our approach. Then we present the service composition of the application we developed in the scope of the QuoVADis project as an example of an service oriented RHM system. In the seventh section some tests results. Finally, we conclude.

II. HoCoS and SOA Architecture

Telemedicine can be defined as the use of telecommunications technology to provide medical services and information [7]. An *Information System* (**IS**) for large-scale RHM involves several operators from various disciplines. It implements diverse autonomous SI interacting to provide monitoring and support capabilities to end users [8].

Service-Oriented architectures today offer a new model to solve this problem [9] [10]. They allow the federation of multiple autonomous IS while ensuring the technical and functional independence between them.

In fact, SOA enables software developers to focus on the fulfillment of the required functionalities at a conceptual level. It provides standardized communication protocol and service management infrastructures [11]. It also enables developers to create the required services from existing ones without being concerned by the barriers caused by heterogeneous operating and hardware systems.

For our telemonitoring solution, we implemented the

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following services:

- Agenda: offers the patient a shared calendar, with an ergonomic interface which can be accessed online by medical staff and teleoperators
- EMUTEM [12]: this service encapsulates a decision support system baptized EMUTEM which analyses the data and generates decisions about the critical situation of the patient. EMUTEM has been previously developed by the ANASON team of LRIT.
- Alarms: sends alert message to the teleoperator to warn him about the critical situation of the patient
- Contacts: this service manages the patient's contacts list
- Videoconference: this service enables the patient to have audio visual calls with his contacts
- Cognitive stimulation: this service offers cognitive tests to the patient in order to evaluate their cognitive abilities. This application has been developed by the AP-HP.
- Diagnosis: this service enables the remote monitoring and healthcare diagnosis of patients by specialists
- Robot: this service supports communications between the companion robot (developed by Robosoft [13]) deployed in the patient home and the teleoperators. The remote command application had been developed by the IBISC laboratory team of UEVE.
- Patient file manager: this service manages the patient file and protects its content. It also synchronizes the patient data with the central telemonitoring server safely
- Network manager: this service manages the discovery, the registration and the connection with the extern services.

Since we have multiple intervenient in this RHM project, we adopted an extensible SOA which enables the combination of heterogeneous systems as multiple cooperating services.

III. Definition and Inner architecture of a service

W3C defines a service as, « an abstract resource that represents a capability of task performance that represents a coherent functionality from the point of view of provider and requester entities » [14].

One of the cornerstones of SOA is the service concept. In a service oriented approach, a service provides actors (human and software) to access one or more business functions [9].

When a client requires a transaction of a service, it sends a message encapsulating the request(Fig. 1). This message is conveyed along a structured communication protocol respected by both sides. The client may receive an acknowledgement message via the same communication protocol [9].

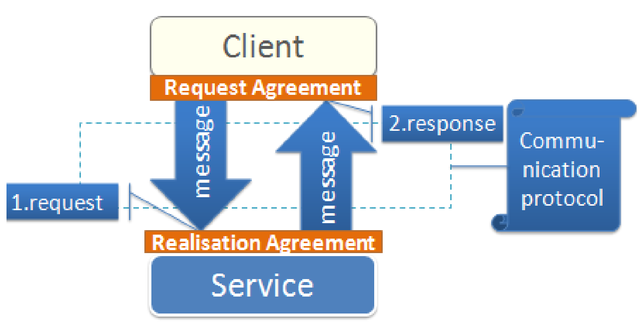

Fig. 1. Message exchange between supplier and service provider

The message structure is described in Table I:

TABLE I
Structure of a service request message

Patient ID	Required service	Client service
date	Priority	Nb Try
options		

The options field consists of several fields depending on the nature of the required business processes.

If the option fields do not match the required service, the service provider tries to find the mandatory fields in the message. If the second try fails, the request is rejected by the service composition layer (see section 4).

A. *Service inner design*

All the services of our solution have been designed according to a uniform design pattern that implements (see Fig. 2):

- One or more private classes which implement the business processes of service (Cursor class)
- A private class of business logic objects (e.g.: event class for Agenda service)
- A private class that handles containers, adding, deleting and career collections of business objects
- Service manager class: represents the Service Gateway to the whole system. It ensures three main tasks:
  - o Organization of the business process execution inside the service,
  - o Publication of the service description and the updating of its availability in the service composition layer,
  - o The discovery of the requested services in the service management layer registry.

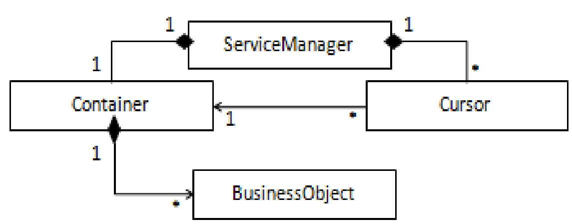

Fig. 2. – Service design pattern.

For example, to display the current week agenda of a patient, the class *Agenda_manager* instantiates the events object (*business_object*) and places them in the week collection of the container class. To make an event become periodic, the periodicity cursor searches for the appropriate objects in the container and makes the necessary instance.

IV. IMPLEMENTATION OF THE SERVICE COMPOSITION LAYER OF HOCOS

Searching for and locating services, in order to identify matches between service requester and provider peers is regarded as a key issue [15]. To build the service composition graph, we opted for the brokered approach. It enables the centralization of the process control while the data can be passed between any service pair directly [16].

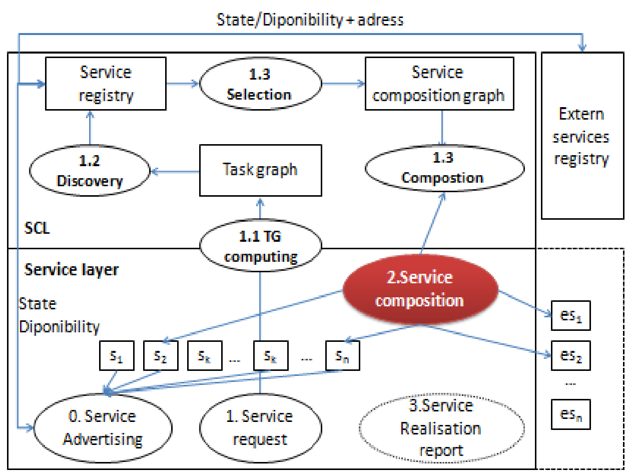

Fig. 3. - HoCoS service composition mechanism.

The brokered architecture we propose is implemented in the *Service Composition Layer* **SCL** (see Fig 3). The service advertising concerns each active service of the system. It consists of posting a state message in the service registry.

When an s_k service makes a service request, 4 main steps are made in the SCL:

- *Task Graph* (**TG**) computing: the SCL transforms the service request into a TG,
- Service discovery: the SCL searches for the available services to execute each task of the TG,
- Service selection: the SCL selects from the available services list those to be involved in the *Service Composition Graph* (**SCG**),
- Service composition: the SCL asks the concerned services to make the requested operations according to the order specified in the SCG.

The external services registry sends the available extern (network) service to the SCL. Once they are registered in the service registry, they may be requested in the service composition just like the local services.

V. RELEVANCE OF HOCOS ARCHITECTURE

The service oriented architecture of HoCoS assures:

- The integration of different technologies in one simple and ergonomic user interface
- The reuse of existent components
- The stability of the system when a service is inactive or unavailable: the guarantee of the non spread of errors from one service to another
- The possibility of adding or removing services immediately (without programming effort) in order to personalize the application services according to final user specifications.

Indeed, the videoconferencing service could establish communication with a RHM center (SAMU-92 in the project QuoVadis) by simply incorporating the same videoconferencing service to the teleoperator's GUI.

Similarly, the diagnostic module installed in the teleoperator GUI can be installed in the patient's home thanks to SOA to take advantage of the home intelligent sensors that are installed. Hence, the patient can be remotely monitored by both teleoperators and medical stuff.

Finally, this architecture enables the transfer of the recorded sounds of distress from smart sensors to the teleoperators.

VI. HOCOS SERVICE COMPOSITION FOR THE PATIENT GUI OF QUOVADIS PROJECT

We choose the services we need to implement based on the functional specification of the client. Once the SCL is established, we obtain a unified GUI for all proposed services. For the tests elaborated in the scope of the ANR_QuoVADis project, HoCoS implemented the services presented in Fig. 4. This GUI is dedicated to the daily accompaniment of the patient at home. For ergonomic reasons and since the patient is the principal user of this GUI, there are only 4 services that appear on the interface which are : Agenda, Contacts, Visio Conferencing and cognitive stimulation (see Fig. 4). The other services running on the background are executing requests for the telemonitoring function.

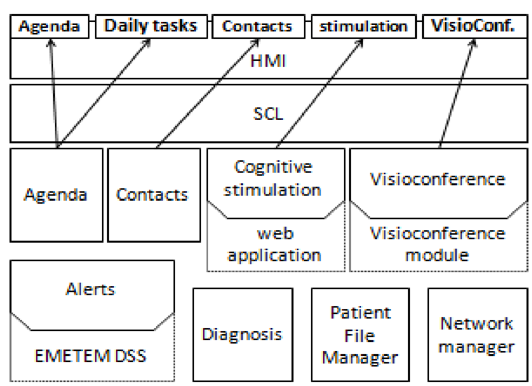

Fig. 4. The implemented services in HoCoS for the QuoVADis project. Some services encapsulate external applications using a special integration class

VII. ERGONOMIC TESTS OF HOCOS GUI

The tests were conducted at the Hospital Broca, Paris. The samples contain 18 persons aged from 72 to 92 years. The average age is "82.07" years. 78.5% from the subjects have no computer experience. The number of schooling years varies between 5 and 18 years. The average number of schooling years is "12.28". Since we aim to provide an intuitive GUI to cognitive disease attained people, the tests were passed without any previous training. The elderly were assisted by the geriatric medicine unit of the hospital. We proposed several tests scenarios, for each one we evaluated the handling and the design of the GUI (a mark from 0 to 5), the number of mistakes and interventions to help the patient and the elapsed time. We note that the difficulty in using the application increases with age (Fig 6 and Fig 7), but it always remains an acceptable difficulty. The number of schooling years and computer experience also interferes in the evaluation on the GUI. We are satisfied by the global acceptance of the tested services. In fact, contrary to one might expect, in 95% of the tests cases, people were pleased to use this GUI and were not afraid of this technology.

TABLE II
Average marks of the tests cases

	handling	help/mistakes	time (s)	design
service access	4,43	0,57	7,57	4,00
service browsing	3,36	2,86	129,71	3,57
data insertion	3,64	4,50	164,05	3,64
data recognition	4,25	1,00	18,13	3,88
data modification	3,63	7,25	179,13	3,50
visual keyboard	4,75	0,75	47,50	4,13
forms use	3,63	8,50	-	4,25
videoconferencing	4,03	3,36	86,99	3,79

TABLE III
Global evaluation of the application

Question	Mark (1 to 5)
Did you like the use of the touch screen?	4.83
Is HoCoS as simple to use as a paper agenda?	3.17
Do you want to have HoCoS at home?	4.08
Do you recommend HoCoS for demented people?	4.23

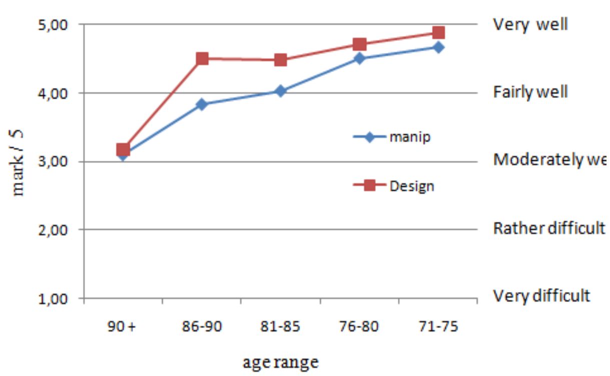

Fig. 6. Age distribution of the average user evaluation of the GUI manipulation and design

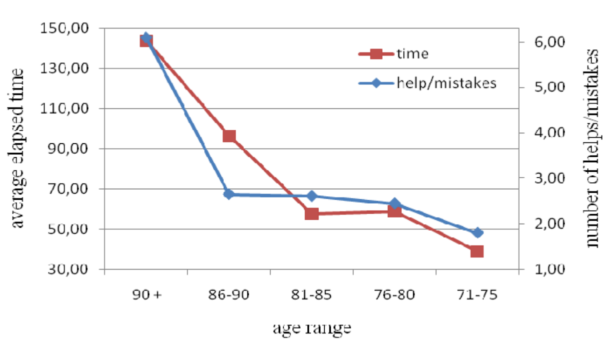

Fig. 7. Age distributions of the average time of realization and the average number of helps and mistakes.

VIII. Conclusion

We chose a service oriented approach to implement out RHM system rather than a classical software design. This multi partner vision makes it possible to combine several technologies with minimal development efforts which allow the system answering current health problems.

The tests led in the scope of research projects have proved to us the acceptability of this new technological solution by elderly people.

Now, to make this solution highly scalable, we have to evolve our services into web service in order to obtain an "in-cloud RHM".

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