A Decision Support Resource as a Kernel of a Semantic Web based Platform oriented to Heart Failure

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Abstract - Chronic heart failure (CHF) is a complex cardiovascular syndrome whose management requires a complex clinical program involving, at different levels, several care stakeholders and the integration and interpretation of a number of diagnostic data and information. Within the EU FP6 project HEARTFAID (www.heartfaid.org), an integrated platform of services is being developed to assist CHF stakeholders in their routine workflow and to provide an optimal management of CHF patients, by exploiting the most advanced technologies, compliant to medical standards, advanced instruments for diagnostic data processing, and significant and up-to-date knowledge, suitably formalized. The platform consists in a distributed and heterogeneous infrastructure developed by integrating different and functionally independent components according to the up-to-date service oriented technologies. A Knowledge-based Clinical Decision Support System (CDSS) constitutes the kernel of the platform and is aimed at aiding the decisional processes of CHF care givers. So far, the main functionalities of the platform and of the CDSS have been developed according to an accurate analysis of realistic clinical scenarios. Semantic web technologies are being used as the most advanced tools for formalizing, re-using and sharing medical knowledge, and reasoning on it; while a service oriented approach is being adopted for the integration and easy access to a number of users’ applications. Main results are detailed and discussed in this paper.

Keywords: Decision Support Systems, Heart Failure Management, Semantic Web, Web services

1 Introduction
Healthcare is more and more relying on evidence based medicine delivered by multi-disciplinary, multiparty healthcare teams in a patient-centered approach, which is aimed at providing more effective, personalized clinical diagnoses and treatments. The provision of specialized care regimes depends on the optimization abilities of care professionals to apply the necessary medical knowledge by also integrating the reading of diagnostic test results, medications availability and responses to past treatments. This can be a particularly burdensome task; further delivering patient care with the efficacy, consistency and safety, that the full range of current knowledge could now support [1], may be beyond the mental integration capabilities for unaided healthcare professionals.

To cope with these difficulties, a number of ICT solutions are being developed for aiding care operators in both relieving and making more effective and reliable their work and, at the same time, delivering care programs able to satisfy the evolving healthcare needs of a patient in the continuum of care. E-Health is commonly considered to encompass the broad brand of ICT applications in supporting health care needs, including Electronic Health Record (EHR), health information portals and patient empowerment, remote patient monitoring (tele-care or -monitoring) and telemedicine, medical imaging and sensing with new modalities, Clinical Decision Support Systems (CDSS) and individual care, computer-assisted procedures and virtual surgery. Most of these applications require the advanced and interoperable integration of several healthcare centres, structures and functionalities, which are distributed over broad environments. Service oriented technologies offer an invaluable aid to cope with these aspects, especially Web Services, since based on the most successful information dissemination and sharing apparatus in existence – the World Wide Web [2]. In this framework, Semantic Web Technologies (SWT), not only as an extension of the Web, but as a result of an expanding mix of standards, technologies, and social practices, offer viable instruments for data and service integration, knowledge representation, reasoning and intelligent agents, which are all key issues of e-Health ICT distributed infrastructures.

Within the European STREP project HEARTFAID (“A knowledge based platform of services for supporting medical-clinical management of the heart failure within the elderly population”), starting from all the above mentioned considerations, an integrated platform of services is being developed for aiding clinicians and care operators in the long-term clinical, therapeutic and follow-up care processes for Chronic Heart Failure (CHF) patients [3,4].
CHF is becoming one of the most remarkable global health problems for prevalence and morbidity, with a strong impact in terms of social and economic effects [5]. For example, according to the European Society of Cardiology, at least 10 millions of patients have heart failure. About 78% of the total patients have at least two hospital admissions per year. The impact in other western developed countries is similar. Similarly, according to WHO, in developing countries, cardiovascular diseases will become the leading cause of death by 2010, and, due to an increase in the survival rate after heart attacks or strokes, the incidence of CHF will probably raise as well. So far, several research projects have addressed the problem of CHF patients’ management, by developing automated guidelines systems [6], decision support systems [7], or Machine Learning methods for automated diagnosis [8] or prognosis [9].

A key issue of an effective management of CHF patients is their follow-up, which requires a continuous feedback to assess the patients’ clinical conditions. In the clinical practice, this need is translated in a series of very expensive meetings between physicians and patients. Telemonitoring of the relevant clinical parameters can help health providers to develop a home monitoring program for CHF patients, with a great saving of resources and a better service for them. In particular, the continuous monitoring of patients’ signs and symptoms can help addressing the problem of early detecting their worsening and, then, prevent acute events such as decompensation. Decompensation refers to the heavy exacerbation of symptoms, such as dyspnea, venous engorgement, and pulmonary edema, which requires a prompt hospitalization to re-establish adequate perfusion and oxygen delivery to end organs by adequate therapeutic treatments.

Patients’ telemonitoring is one of the main services of HEARTFAID Platform (HFP) and consists in the collection and processing of data acquired with personalized medical devices in a homecare environment.

In this paper, HEARTFAID Platform (HFP) of services will be introduced by describing its main functionalities and how they are being developed according to a service oriented approach. The kernel of HFP is a Knowledge-based Decision Support System, which is aimed at aiding the decisional processes of HF care practitioners by exploiting and also orchestrating the main functionalities of the other platform components. It has been designed by using SWT for integrating innovative knowledge representation techniques and hybrid reasoning methods, and including advanced tools for the analysis of diagnostic data. Particular attention has been focused on the interpretation of telemonitored parameters by developing dedicated computational methods.

The results, obtained so far in the development of a realistic scenario regarding the telemonitoring service and the early detection of patient’s decompensation, are also presented.

2 The HEARTFAID Platform

HEARTFAID platform of services is aimed at assisting CHF stakeholders in their routine workflows and to provide an optimal management of HF patients, by exploiting the most advanced technologies, compliant to medical standards, advanced instruments for diagnostic data processing, and significant and up-to-date knowledge, suitably formalized. In terms of scientific and technological advances, HFP differs from other research projects since is specifically characterized by the following innovations:

- integration of biomedical data, relevant to the medical domain, of different structure and complexity and coming from different and several sources;
- integration of several approaches for coding the relevant medical knowledge and extract new knowledge: a knowledge based approach (deductive knowledge) for coding the clinical guidelines and the clinical best practice; a data mining approach (inductive knowledge) for extracting new knowledge from the practical clinical experience represented by suitable sets of cases;
- medical decision support level, characterized by functionalities regarding all the clinical management of HF patient: diagnosis, prognosis, therapy planning.

HFP consists of six main technological components able to provide the core platform services, i.e., patients’ data storage and management, homecare data collection with connected alerting service, data analysis and interpretation, clinical decision-making support. More precisely, as shown in Fig. 1, there are:

- a Patients Repository, which is a web-based Electronic Patient Record for insertion, editing, storage and management of patients related demographic and clinical data;
- a Telemonitoring System, which handles the storage and monitoring of observational data acquired by means of homecare sensing infrastructure;
- an Alarm & Alert System, which is in charge of warning the responsible care givers about worsening of patients’ conditions when detected by the interpretation of telemonitored parameters;
- Signal & Image Analysis Toolkits, which consist of methods developed for semi-automated analysis of diagnostic signals, e.g., ECG, and images, e.g., echocardiographic or magnetic resonance images;
- a Clinical Decision Support System, which is a knowledge base system developed for aiding the main decisional processes of CHF stakeholders by interpreting patients’ data, tuning some platform services (e.g., telemonitoring) and providing pertinent suggestions;
- a Web-based User Interface, which provides the access to all the services of the platform.

All these components are integrated by means of an Enterprise Service Bus (ESB): which serves for a loosely coupled, highly distributed and, thus, highly scalable integration network [10].
An ESB is the core component of a standards-based integration structure that combines messaging, web services, data transformation and intelligent routing, and coordinate the interaction of a significant number of diverse applications, across extended enterprises, with transactional integrity.

The routing and transformation mechanisms implemented by the ESB are highly configurable also remotely. Moreover, a big variety of different protocols including their secure implementations has been used to face different heterogeneous entities that are able, in this way, to automatically and dynamically connect to the ESB without requiring necessarily a proxy software.

All the platform components communicate among each other by exchanging messages on the ESB. This way, thanks to the ESB services of message routing and transformation, the burden of implementing these communications at the component level is relieved. Suitable Adapters (see Fig.1) have been included for plugging the application modules to the ESB. The wrapped applications are thus able to loosely interconnect and communicate with the other modules through a message-passing infrastructure based on the ESB.

ESB has been devised by designing and configuring the interactions among the application modules, the data transformations, quality of service, synchronization, workflow specification, life-cycle management and so on, for granting the implementation of the services that want to be exposed at global platform level. Java, workflow and XML messaging based techniques have been selected for implementing the ESB (for implementation details, refer to [11]).

Although technically all the components are connected to the ESB, from a functional viewpoint, the HFP can be considered centred on the CDSS: the most advanced services of the platform require or support, in different modalities, the interventions of CDSS, which can, then, be considered as the core intelligence of the platform.

In the virtualized HFP environment, the CDSS is seen as a resource, able to offer a number of functionalities and to interact with the other resources for performing its tasks. It is activated on the demand, when a request of one of its functionalities is issued and sent via message on the ESB. In the following section, the details of its functioning are reported.

3 The Decision Support Resource

HEARTFAID CDSS has been modeled for processing patients’ related information according to the relevant medical knowledge and providing a valid aid to the decisional processes of CHF care-operators. A strict cooperation with medical partners has allowed for pointing out a number of problems that clinical practitioners usually have to face and that can benefit from the intervention of a computerized support. The severity evaluation of heart failure, the analysis of diagnostic exams, and the early detection of patient’s decompensation are just a few of the most common issues that have been identified regarding diagnosis, prognosis and therapy planning. More precisely, the following CDSS interventions have been envisaged and planned for development:

- assisting the personalization of the telemonitoring service by suggesting the parameters to be observed and the acquisition scheduling;
- interpreting remotely the telemonitored data so as to detect worsening conditions and, in particular, identify the initial signs and symptoms of a decompensation event. When an adverse event is detected or predicted, an alarm or alert should be sent according to the gravity of the situation detected and the consequence risks for the patient;
- assisting clinicians in their routine practice by (i) aiding the identification of the etiology and the nature of HF; (ii) suggesting the severity degree (i.e. the so-called NYHA class [5]) of HF; (iii) proposing diagnostic investigations, such as an echocardiography exams, when additional information is needed, and interpreting their findings; (iv) indicating the most suitable therapeutic plan or changes to current plans, according to patient’s symptoms and intolerance; (v) formulating a prognosis hypothesis.

These functionalities call for the centrality of CDSS within the platform, since they demand for a strict interaction with all the other components: the data acquired by the telemonitoring system have to be validated and interpreted by the CDSS; alarms and alerts are dispatched when suggested by the CDSS; the assistance to clinicians is provided, in the form of suggestions, while they are compiling visit report forms, i.e. while accessing, through the web interface, the Electronic Patient Record.

A careful design process has been performed for identifying the corpus of knowledge necessary for implementing the CDSS. Experts’ know-how and clinical guidelines have turned out as the main sources of knowledge, whose formalization could be compliant to a symbolic representation paradigm. SWT have appeared as viable instruments for implementing the corresponding Knowledge Base (KB). Currently, there is a strong interest on SWT in the clinical decision support community, as testified, first of all, by the rise of several ontology-like formalizations of medical domain, e.g. the Systematized Nomenclature of Medicine (SNOMED) [12], the Unified Medical Language System (UMLS) [13] or the
Medical Subject Heading (MeSH) [14], to name a few. Moreover, a number of systems has been developed by using SWT, e.g. for assisting decision support in breast cancer management [15], or for modelling clinical practice guidelines [16]. Ontologies extended with rules have been, then, selected for formalizing the main explicit, declarative and procedural knowledge of the domain [17], [18]. However, some problems, such as prognosis stratification and the detection of patients’ decompensation, seem still debated in the medical community, due to the lack of validated and assessed evidences and procedures. In these cases, experts’ know-how can be only partially formalizing into a symbolic, inductive KB and should be integrated with computational reasoning models developed by applying Machine Learning techniques to deduce novel knowledge from relevant datasets. According to these considerations, HEARTFAID CDSS was designed for incorporating different reasoning models and according to a multilevel conceptualization scheme for distinguishing among (i) the knowledge level, corresponding to all the information needed by the system for performing its tasks, (e.g. data, domain knowledge, computational decision models); (ii) the processing level, consisting of the system components that are responsible of tasks accomplishment by using the knowledge level; (iii) the end-user application level, including the system components whose functionalities are specifically defined for interacting with the user [3]. This separation assures a high level of flexibility, since any change of the formalized knowledge will not affect the processing level.

In detail, the CDSS architecture consists of the following components (Fig. 3):
- a Domain Knowledge Base, consisting of the domain knowledge, formalized from the European guidelines for the diagnosis and treatment of CHF and the clinicians’ know-how;
- a Model Base, containing the computational decision models, signals and images processing methods and pattern searching procedures;
- a Meta Knowledge Base, composed by the strategy knowledge about the organization of CDSS tasks.
- the Brain, the system component endowed with reasoning capabilities, which has been modelled by functionally separating a meta level, devoted to task accomplishment and organization, and an object level, responsible for actually performing tasks, by reasoning on the computational and domain knowledge. A Strategy Controller has been inserted for performing the meta level functionalities, by orchestrating the two components of the object level, i.e. the Inference Engine and the Model Manager.

When a request is committed to the CDSS, the Strategy Controller, according to what stated in the Meta Knowledge Base, requires the application of the Inference Engine or of the Model Manager. For difficult decisional problems, both inferential and computational reasoning methods can be applied and, thus, the Strategy Controller is responsible for the integration of their results.

Fig. 2 The CDSS architecture

4 A Realistic Scenario: Early Detection of Patients’ Decompensation

The early identification of patients’ decompensation can be considered, by far, as one of the most difficult decision making problems whose solution would assure a great benefit to HF patients’ management in terms of worsening event prevention, therapy optimization and hospitalization cost reduction. Actually, explicit medical knowledge does not exist in medical guidelines for situations like this, and, although medical experts are able to effectively solve them, their tacit knowledge cannot be directly coded into the knowledge base. A viable solution is the application of knowledge discovery or data mining tools to some series of clinically collected data, especially in combination with monitored data, for defining adaptive, computational reasoning models.

Within the relevant clinical protocols and guidelines, a general consensus has not been reached about the definition and assessment of criteria on how to predict when a patient will further decompensate, even though many different evidence based indications are known. In accordance to the suggestions of clinical partners, the variation of some basic parameters have been identified as predictive conditions of patients’ decompensation and have been selected for the home monitoring environment; they are:
- decrease of systolic blood pressure;
- increase of heart rate;
- increase of respiratory rate and width of chest movements;
- increase in the percentage of body water;
- variation of body temperature.

A set of devices has been selected for monitoring these parameters and send their value throughout the data acquisition infrastructure.

A scenario can be described for better explaining the realistic situation that has been envisaged.

<<We considered Patrick Mercy, a 68 years old, retired teacher. His anamnesis reveals he has been a smoker, is suffering of hypertension from several years, and has a post ischemic dilated cardiomyopathy, with a systolic dysfunction. He has been enrolled into HEARTFAID Programme one year ago, during a visit to Dr. Johnson, who recruited him after having checked his medical history, symptoms, signs and diagnostic examinations’ results. At that visit, Dr. Johnson, assisted by the CDSS, planned the pharmacological therapy and chose a set of measurements to be monitored and, then,
according to their availability, a set of devices to be assigned to Mr. Mercy: an oscillometric blood pressure monitor, for acquiring systolic and diastolic blood pressure, as well as respiratory and heart rate; an electronic scale; and a body impedance analyzer for measuring body water. Once selected, these devices are recorded as univocally assigned to Mr. Mercy. The CDSS helped the clinician also in scheduling the acquisition of the measurements. After a proper training and a proper test performed in the office to show and verify the proper use of the devices, Mr. Mercy was provided with instructions on the clinical protocol to follow for the measurement acquisition. In addition, the authorized technical staff took care of performing the necessary installations in his domestic environment, by configuring and testing all of the devices, the hardware, the software tools and the sensor network. At home, Mr. Mercy has followed the protocol conscientiously, taking his medicines, performing the necessary measurements when scheduled, and using HEARTFAID web interface to send the measurements values, answer a questionnaire about his physical conditions (i.e., “Minnesota Living with Heart Failure Questionnaire”) and report his compliance to the therapy. If this had not been the case, an HFP personalized agenda would have remembered him to comply with his protocol. Today, Mr. Mercy signs and symptoms are worsening. The CDSS remote interpretation of the monitored measurements detects promptly the event at its onset, thus inducing an alarm to be sent to the doctor on duty and suggesting to Mr. Mercy to reach a hospital as soon as possible.

Implementing the described scenario has required the formalization of the relevant domain knowledge and the development of computational models for interpreting monitored data. The main functionalities of the other involved HFP components have been set up as well.

4.1 The Domain Knowledge Base

The first step in the development of the KB has been the development of the CHF ontology, which presents the formalized description of concepts for the whole heart failure domain [4]. It includes basic CHF concepts, properties that characterize patients, all relevant diagnostic examinations and tests, and treatment procedures (Fig. 3). CHF ontology provides a formalization of the declarative knowledge of the domain and has been developed in accordance to standard medical ontologies, such as UMLS. Specific concepts have been considered for the telemonitored measurements, i.e., signs and symptoms.

Production rules have been defined for formalizing the procedural knowledge and filling the logical lacks of ontological axioms. They were extracted from the ESC guidelines and elicited from clinicians. More precisely, the rules have been formalized for suggesting alerts or alarms when patient’s signs and symptoms change significantly. Examples of rules elicited in natural language are reported in Table I. The degree of severity of the alerts have been agreed with the clinical partners.

### Table I. Some rules pertaining telemonitoring, formalized in natural language

<table>
<thead>
<tr>
<th>Rules in natural language</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>If Heart Rate differs of 10% from the previous measurement then an alert should be issued</td>
<td>$\Delta P(t) = P(t) - P(t-1), \ for \ t=2,\ldots,N$</td>
</tr>
<tr>
<td>If patient has a pace-maker and his heart rate is lower than 60 beats/min then an alert should be issued</td>
<td></td>
</tr>
<tr>
<td>If heart rate is higher than 80 beats/min and patient is taking Beta-Blockers then an alert should be issued</td>
<td></td>
</tr>
</tbody>
</table>

4.2 The Model Base

Knowledge discovery techniques have been applied to suitably collected datasets in order to define computational reasoning models able to predict patient’s worsening and prevent a decompensation event. A bunch of data has been collected specifically for simulating the monitoring situations by measuring, at different time $t$, the following parameters: systolic blood pressure; heart rate; respiratory rate; body temperature; body weight; and body water.

Both domain experts and some results from preliminary analysis on the available data have suggested that variations between two successive measurements are potentially relevant. Two diverse types of differences have been considered: simple and relative.

A simple difference, on a parameter, between two successive measurements is defined as follows:

$$
\Delta P(t) = P(t) - P(t-1), \ for \ t=2,\ldots,N
$$
while a relative difference as:

$$\Delta P(t) = \frac{P(t) - P(t-1)}{P(t-1)}, \text{ for } t=2,\ldots,N$$

where $P$ is the measured parameter and $N$ is the number of measurements performed for a given patient.

An initial data transformation step has been necessary in order to realize the classification task. First, for each patient, all pairs of measured parameters in two successive measurements have been selected, where the patient health condition at the previous visit was “no decompensation”. This way, two “status transitions” have been considered possible:

- the patient is in “no-decompensation” condition at the previous measurement and remains in the same condition at the current one (marked as negative class cases);
- the patient is in “no-decompensation” condition at the previous measurement but undergoes a transition to “decompensation” at the current measurement (marked as positive class cases).

The analysis of the dataset has started by the application of decision tree and decision list methods, since they are able to extract knowledge in a form understandable by domain experts. The relations extracted from the data have been initially assessed by validation techniques, and then the experts have evaluated the models found most relevant. Finally, methods like Support Vector Machines (SVM) and Radial Basis Function (RBF) networks have been applied in the attempt of obtaining a better prediction accuracy. The learning methodologies have been combined with cost sensitive classification approaches since classes in the dataset are highly unbalanced.

5 Results

The real scenario has been used as basis for the development of the main functionalities of HFP components. For the telemonitoring service, the applications responsible to acquire the data from the medical devices and transmit them to the platform have been built depending on the characteristics of the data acquisition device [18]. In particular, devices have been divided into connectable and non-connectable: the former support some means of connectivity (e.g. by implementing their communication protocol or by exporting their data in a known format), while the latter do not support connectivity, and consequently can be integrated only manually (via the manual completion of the measurements into web forms and the transmission of the data to the platform). In the considered scenario, for instance, patient's temperature and body water measured by the impedance analyzer are measured by non-connectable devices. The acquisition applications have been developed in Java and consist of three main blocks: a GUI used for the interaction with the user, the Data Acquisition module which performs the acquisition of the biomedical data (raw data or data stored in files – depending on the characteristics and communication capabilities of each given device) and the Data Transmission module, which is responsible to transmit the acquired data to the HFP. The transmission of data takes place over HTTP by forming HTTP requests to the platform, containing XML as messages as body.

The domain knowledge base has been developed in accordance to W3C recommendations, i.e., by selecting OWL for defining the ontologies [19] and using Protégé as editor. For realizing the reasoning component, Jena [20] was selected as a Java programming environment that uses OWL, SPARQL [21] and includes a rule-based inference engine. The set of rules elicited from clinicians has been translated into Jena rules defined by using the concepts contained into the ontology.

For developing the computational models for patient’s decompensation, a dataset of 263 instances (8 positive and 255 negative instances, respectively) has been collected with 30 attributes: sex; age; NYHA class; smoke activity; alcohol use; systolic blood pressure (current and previous value, simple and relative variation); heart rate (current and previous value, simple and relative variation); respiratory rate (current and previous value, simple and relative variation); body temperature (current and previous value, simple and relative variation); weight (current and previous value, simple and relative variation); total body water (current and previous value, simple and relative variation); class (decompensation or no-decompensation). Such a dataset has been used for training different computational models, which were tested according to a “leave-one-patient-out” technique. For each patient there is one instance for each pair of patient’s visits relative to one of the two possible “status transitions” mentioned before. In turn all the instances relative to one specific patient are discarded from the dataset, and the remaining examples are used as the training set. After that the trained model is used for the classification of the previously discarded instances. In this way all the information relative to that patient does not influence the training process. This procedure is repeated for every patient in the dataset and the accuracy is computed as the mean value of all experiments. Different binary classifiers were obtained performing the early detection of acute decompensation events, where the results of some of these models are “easy-to-understand” (Decision Trees and Decision Lists) and their consistency was directly evaluated by the cardiologists. Moreover, high percentage of correct classifications (above 85%) was obtained by using leave-one-patient-out validation approach (Decision List 90.11%, Decision Tree 87.83%, SVM with polynomial kernel 85.17% and RBF networks 95.06%).

The symbolic KB and the computational Model Base have been integrating into the CDSS according to a service oriented approach. Currently, the CDSS meta-level has been bypassed and the application of the inferential reasoning as well as of a computational reasoning model has been encapsulated into web services described in WSDL [22]. This is an XML format for describing network services as a set of endpoints operating on messages containing either document-oriented or procedure-oriented information; in practice, it provides information on what a web service is about, where it resides and how it can be invoked.
A web-based user interface has been developed for allowing the end users, i.e., patients and clinicians, to access the HPF services. In particular, a user ontology has been defined for managing users’ authentication, while the interface has been tuned on the specific needs of different types of users. Fig. 4 shows the first page of the interface for clinicians, devoted to patients’ status monitoring, while Fig. 5 shows the page containing the Minnesota Questionnaire that should be filled in by the patients at home.

**Patients Monitor**

<table>
<thead>
<tr>
<th>Name</th>
<th>Status</th>
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<th>Alert</th>
<th>Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pietro Guarnieri</td>
<td>stable</td>
<td>11/04/2008 10:35 01</td>
<td>low</td>
<td>w.s scheduled in one month</td>
</tr>
<tr>
<td>Maria Cuccia</td>
<td>unstable</td>
<td>11/04/2008 10:35 23</td>
<td>low</td>
<td>w.s scheduled in one month</td>
</tr>
<tr>
<td>Gabriele Biondi</td>
<td>stable</td>
<td>11/04/2008 11:36 09</td>
<td>low</td>
<td>w.s scheduled in one month</td>
</tr>
<tr>
<td>Paolo Ross</td>
<td>stable</td>
<td>11/04/2008 10:35 15</td>
<td>low</td>
<td>w.s scheduled in one month</td>
</tr>
</tbody>
</table>

**Not telemonitored Patients**

<table>
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<th>Status</th>
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<th>Alert</th>
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<td>Brindo Benoit</td>
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<td>8</td>
<td>Francesc Forest</td>
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<tr>
<td>9</td>
<td>Giovani Smeri</td>
<td>stable</td>
<td>11/04/2008 10:33 21</td>
<td>w.s scheduled in one month</td>
<td></td>
</tr>
</tbody>
</table>

**Minnesota Questionnaire**

The following questions ask how much your heart fails (heart condition) affects your life during the past month (of weeks). After each question, choose the number from 0 to 5 to show how much your life was affected. If a question does not apply to you, choose the 0 after that question:

1. (0-5) How much does your heart fail affect your ability to...?
   1. (0-5) Have you had any chest pain?
   2. (0-5) Have you been able to do your normal activities?
   3. (0-5) Have you had any signs of congestion?
   4. (0-5) Have you had any dizziness?
   5. (0-5) Have you had any shortness of breath?
   6. (0-5) Have you had any other symptoms?

**Figure 4** The web page pertaining the clinicians context for patients’ monitor.

**Figure 5** Web page pertaining patients’ context, for the Minnesota Questionnaire.

### 6 Discussion and Future Activities

The paper presents the platform of services which is being developed within the EU project HEARTFAID for aiding CHF operators in their activity of care delivery and personalization. The main functionalities of the platform have been introduced and their implementation according to a web services approach has been delineated. Particular attention has been devoted to the CDSS which represents the kernel of the platform since responsible of most of its advanced functionalities. Future activities will consist in finalizing the platform implementation by concluding the realization of the different components. In particular, for the CDSS, additional work is required for the Domain Knowledge Base, the algorithms contained in the Model and Base and the Brain, in particular of its meta level in order to integrate all the object models and the interface.

### 7 Acknowledgment

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### 8 References