APPLYING ONTOLOGIES IN THE DEVELOPMENT OF PATIENT MOBILE MONITORING FRAMEWORK

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Abstract — In this paper, patient mobile monitoring enabling framework architecture is presented. To this end, biometric devices (e.g. glucometers, blood pressure meters) are used to send data to the mobile phone via technology such as NFC or Bluetooth among others. These data are updated by the doctor for the patient control. An ontological architecture has been built up to allow the cataloguing of the framework intervening elements. An ontological classification of the patient profile and modules definition are presented. Moreover, and as study case, these ontologies are implemented for Diabetes, regarding the monitoring and control of the convalescent person.
Keywords: *Healthcare, Ontologies, Diabetes, Mobile Monitoring, Mobile Phone.*

1. INTRODUCTION

In order to facilitate people lives, we are working on a mobile monitoring system which allows patients to have a constant control of their diseases as well as direct communication with their doctor. Patient monitoring represents one of the key elements in the progress and control of his illness. This monitoring should offer patient and doctor constant data regarding the disease´s status (vital signs, pulse glucose, etc) so that, the doctor can accordingly readjust the initial treatments and prescriptions. This is our motivation in developing a framework architecture for patient monitoring via mobile phone. Via mobile phone since it characterizes the technologic advance majorly used and which we execute more than a 60% of our daily activities along. An ontological profile classification has been performed as well as for the doctor´s and patient's modules. Through this classification knowledge is extracted. This knowledge is used by the framework when generating the mobile phone's patient application and the doctor's pc one.

2. DEVELOPMENT OF PATIENT MOBILE MONITORING FRAMEWORK

A framework is described at [1] as an abstract object-oriented design for a specific sort of application compounded by an abstract class for each main feature of the design. It will normally contain a library of subclasses that can be used as components of the design.
The framework supports the structure of the domain it belongs to, like a skeleton, and it is those holes that provide the necessary flexibility to adjust the application to our specific interest [2].
A framework can, all in all, be said to be formed by a set of cooperating classes that conform a reusable design for a certain sort of application.
It provides an architectonic guide to divide the design in abstract classes and defining its responsibilities and collaborations [3].
The goal of this work is not to provide a package of general purpose classes, but to create some patterns for the generation of chronic patients' mobile monitoring applications, based on some of the following architectures.
This framework will provide a continuous patient monitoring, to improve the communication between patients and doctor and it will allow generating an automatic architecture for the individual profiles of each patient, self-control and education modules for their condition. This architecture is formed by 3 important elements: patient profile, modules definition, and the communication structure[4].

3. DEFINING ONTOLOGIES IN THE DESIGN OF THE FRAMEWORK

According to Steve´s classification [5], the proposed ontologies in development of a framework belong to a specific domain; this domain is defined for the mobile monitoring of patients with chronic diseases.
Figure 1 specifies the propounded architecture, formed by 3 key elements: PatientProfile, ModuleDefinition, and CommunicationStructure. PatientProfile defines each patient's data, ModuleDefinition elements generated according to each patient's profile and ComunicationStructure define a communication between mobile devices and the framework. Later on explain each of them.

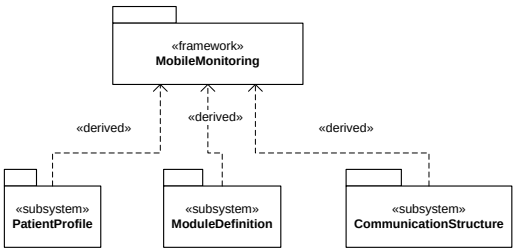

Figure 1. Proposed diagram's structural architecture.

For a better understanding of each of the elements in the architecture an ontological classification of the patient´s profile is presented as well as of the modules definition. This allows us to go into each of the functionalities that compound it in depth.

In figure 2, a classification of the initial proposed diagram [4] is shown, viewed from an ontological perspective that demonstrates the relation among its components.

The doctor and the patient are the actors who interact with the framework. The patient has definite a profile that offers information to the framework (classified under CommonProfile and IndividualProfile ontologies). This individual profile allows the modules definition (MedicateTreatment, ActiveCare and ClinicalSituation ontologies). In addition, the modules definition obtains information of Diseases and Food Ontologies. These ontological elements form the architecture of Mobile Monitoring, which then they will be used for the patterns and relations definition.

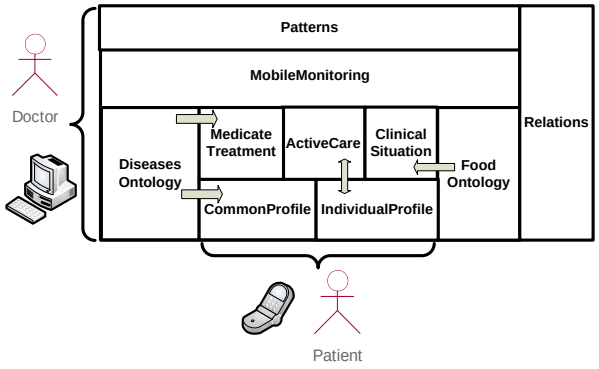

Figure 2. Ontological structure of the initial diagram.

Attending to this classification, each of the elements that compound the definition of a determined module is related to the initial definition of the patient's profile. This definition of the modules let us generate the application´s structure for the doctor as well as for the patient, based on each of these patterns and the relations of the modules definition structure.

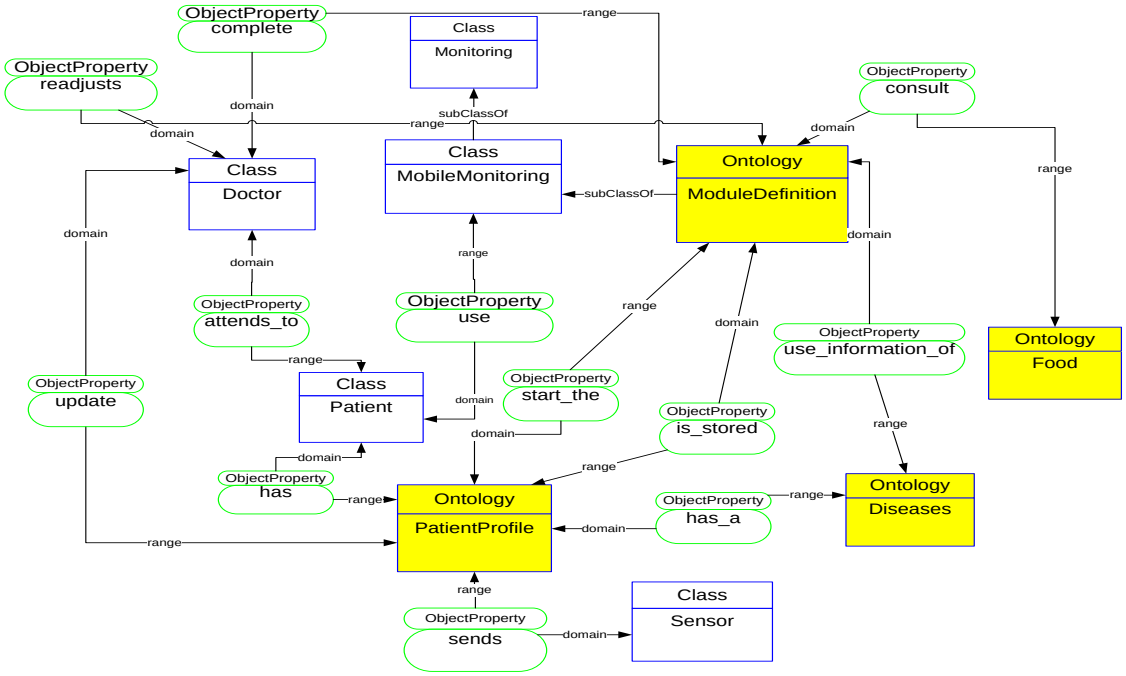

Figure 3. General ontologies diagram for the Patients' mobile monitoring.

The elements that compound our application can be seen in figure 3 and are described below:

Monitoring: is defined at [6] as the patient's vital signs control via monitors. In interest of our application we will focus in the monitoring by means of mobile devices.

Mobile Monitoring: Defines the elements that participate in the mobile monitoring of the patients with chronic diseases. This architecture is formed by three main entities: sensor, patient and doctor. Mobile monitoring enables the follow-up and control under the doctor's supervision via the mobile phone and other communication technologies.

Entities: entities intervening in the patients' mobile monitoring process and which also interact with the framework have been described below:

- ***Doctor***: He or she is the person in charge of the medical activities (i.e. Treatments, diagnosis, evaluation, etc) regarding a patient. Within the architecture, the person to define the patient's profile, and to assign the treatments and activities to carry out.
- ***Patient***: The person with the condition. Furthermore, in the architecture, he or she is the person who feeds the customised data about his disease. This data, which has been gathered by the patient and his doctor from the beginning of the disease, allows the framework the proper generation of the modules customised for the

patient's status.

- ***Sensor***: Any device capable of fetching vital signs of a patient and sending them to the right health personnel for their appropriate interpretation. Within the propounded architecture, a biometric device can be found; this obtains the measures of some of the patient's vital signs (e.g. glucose and blood pressure, obtained via a glucometer and blood pressure meter, respectively) and a mobile phone, which catches the data (through NFC, Bluetooth, etc) and processes and interprets the values of the mentioned measures by means of an embedded application on the device. Additionally, these data will be sent over to the doctor's application (via WiFi, LAN, etc).

The architecture contains the following elements' ontological classifications:

PatientProfile: Defines each patient's data and it is compounded by the CommonProfile and the IndividualProfile.

- **CommonProfile:** The common profile of a patient stores the shared information of a patient for the different diseases he or she might suffer. This information is defined by his/hers personal data, where it is registered the name, address, date of birth, and sex.
- **IndividualProfile:** differing from the CommonProfile, this one has information associated with each diseases of the patient. In addition, it comprises a history where the measures and trends obtained by the sensors are stored.

Diseases: defines a classification range of diseases which our framework can be applied to. In this case, a diseases-classification-ontology has been developed following grouping criteria. They have been classified as follows:

- By the rapidity they show themselves and their duration (Class "ForRapidityandDuration"): Acute, Chronic.
- By the frequency they appear (Class "ForFrecuency"): Sporadic, Endemic, or Epidemic.
- By origin (Class "ForOrigen"): Infectious, Not Infectious.

ModuleDefinition: Elements generated according to each patient's profile. As it can be seen in figure 4, it contains the following information:

- **Care activities (Class "ActivitiesCare")**, it manages the subsequent modules: prevention, education, selfControl, Suggestion and Diet, defined for a pathology particularly for each patient.
- **Clinical State (Class "ClinicalSituation")** defines the typical characteristics of a disease (diseases ontology), and establishes checkpoints for the interpretation of the obtained by the different sensors data.

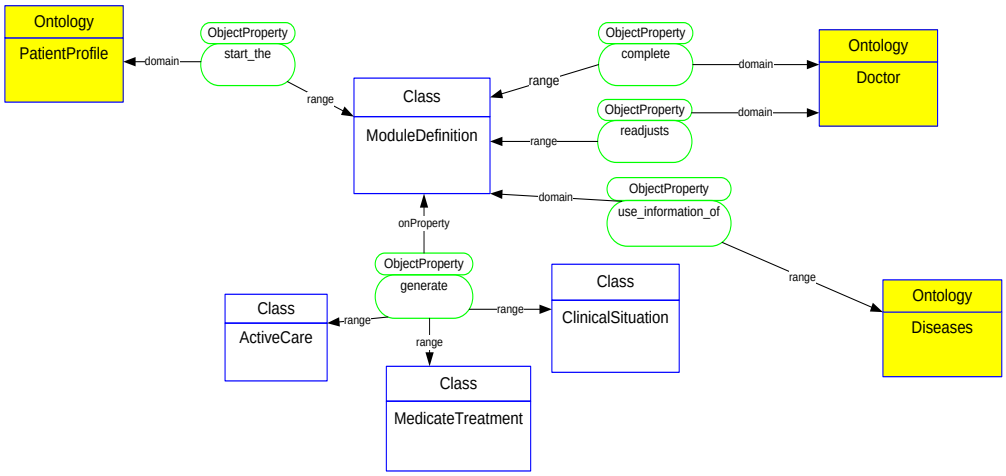

Figure 4. Ontological diagram for Modules definition.

- **Medical Treatment (Class "MedicateTreatment")**, treatments can be of different nature, activity or Pharmacology, always prescribed by a specialist. The latter can be administrated through oral way or be injectable depending on the disease.

Food: defines a classification of the different shorts of food a patient can consume. The ontology proposed by Cantais [7] reflects a food classification for diabetes patients, depending on their energetic content. We use this ontology and complete it with the recommended (ADVISABLE) food component, the forbidden food one and the restricted food section.

These elements define the initial structure and moreover, allow the right definition of the underlying elements in the architecture.

4. ONTOLOGIES IN DIABETES: STUDY CASE

Parting from the generic ontological diagrams, applicable to any condition, in this section we will show how they turn out when applied to diabetes.WHO defines diabetes as chronic disease which can be differed by the treatment or the origin as insulin dependent, not insulin dependent, malnutrition related, etc. Furthermore, it can have other diseases and/or allergies associated and can lead to a series of complication (ophthalmologic issues, renal, neurologic, blood vessel damage, and states of Diabetic Ketoacidosis) [8]. It is showed in figure 5.

It might also be of interest the ontological diagram, showed in figure 6, defining the medical treatment for this disease.

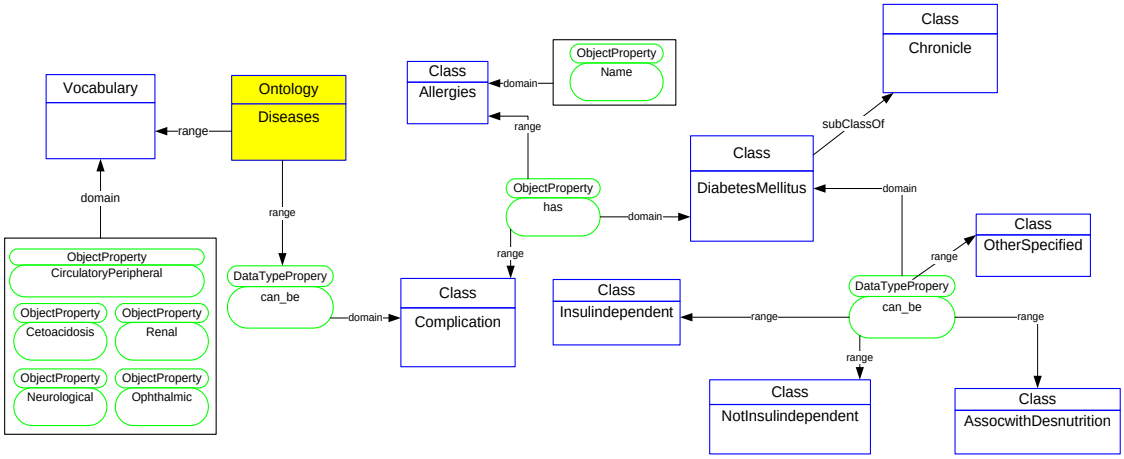

Figure 5. Diagram specification defining diabetes as chronic diseases.

A treatment, generally, as previously explained can be pharmacological of based on a plan of activities (diet, physical exercise, etc). Within the first type, we can make a subsequent classification between medicines orally ingested or injected ones. The earlier ones, in the case of diabetes, are suitable for type-II diabetes, called oral antidiabetic drugs; the inyectable ones are, therefore, meant to treat Diabetes Type-I: injected insulin, where additionally can be made a later categorisation of the sort of insulin according to the speed of its effect (fast or slow).

Another module that can be customised for this condition, and which can significantly impact the life of a person with diabetes, is diet.

In figure 7 it can be seen that the diet module contains data regarding food, which in the case of diabetes, are classified under three groups: forbidden food, recommended (ADVISABLE) food, and restricted food. Inside the first group we can find those one which are harmful, such as fat, sugar, candy, industrial pastry, etc. within the second category, we find food that can be eaten but with quantity restrictions, e.g. dairy products (due to the fat these contain, it is advisable to ingest them skimmed or semi skimmed). At last, the recommended (ADVISABLE) food for a diabetic person's diet, examples of these are vegetables, meat and fishes not with high fat content. Parting from these latter ones, the module generates customised menus for the patient. Equally, ontologies can be adapted to other diseases, when generating patient mobile monitoring applications.

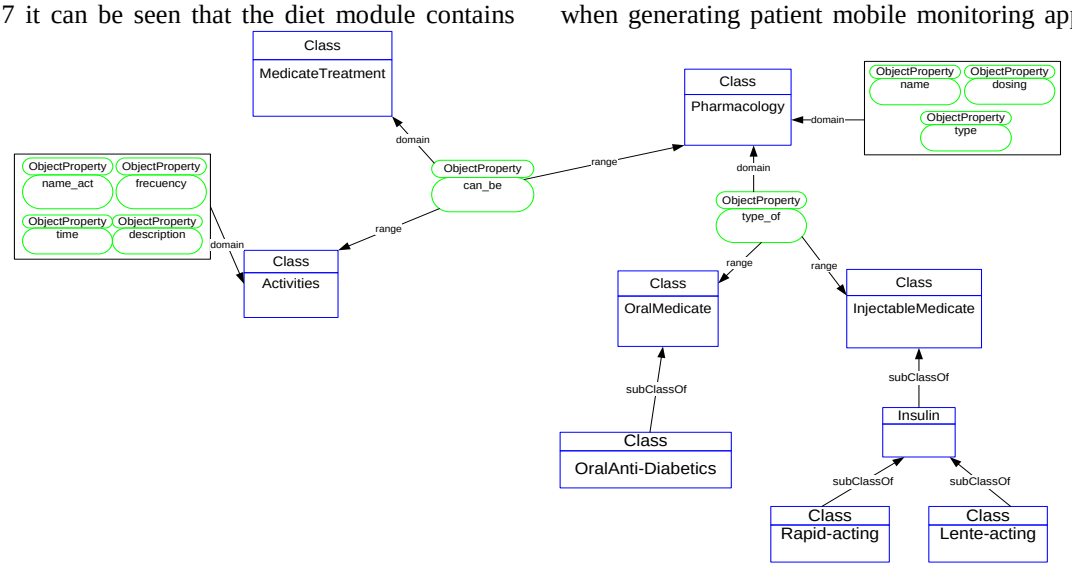

Figure 6. Medical treatment specification for the study case: diabetes.

We have developed a module-based application, divided in two main parts, the specialist and the patient.
The endocrinologist application consists of two modules: The statistics module created to offer the doctor the progress of each patient and the suggestion module, in charge of giving the doctor some pieces of advice based on the statistics of the patient. Of course, this advice is merely a suggestion for the doctor, who of course has the authority to follow it or not, and it is built upon the guidance of a set of endocrinologists.
The patients' application is composed of the following modules: communications, diet and suggestion, all of them profile-dependent. The diet module relays on the profile since it contains the diet restrictions of the patient. Differently, the alert module will store in the profile a record of these for the doctor to bare them in mind when reviewing the patient case. Apart from these, we have the education module, independent from the profile, but fed by the diet module. Once the personal profile has been completed, the application is ready to be downloaded into the patient's device.

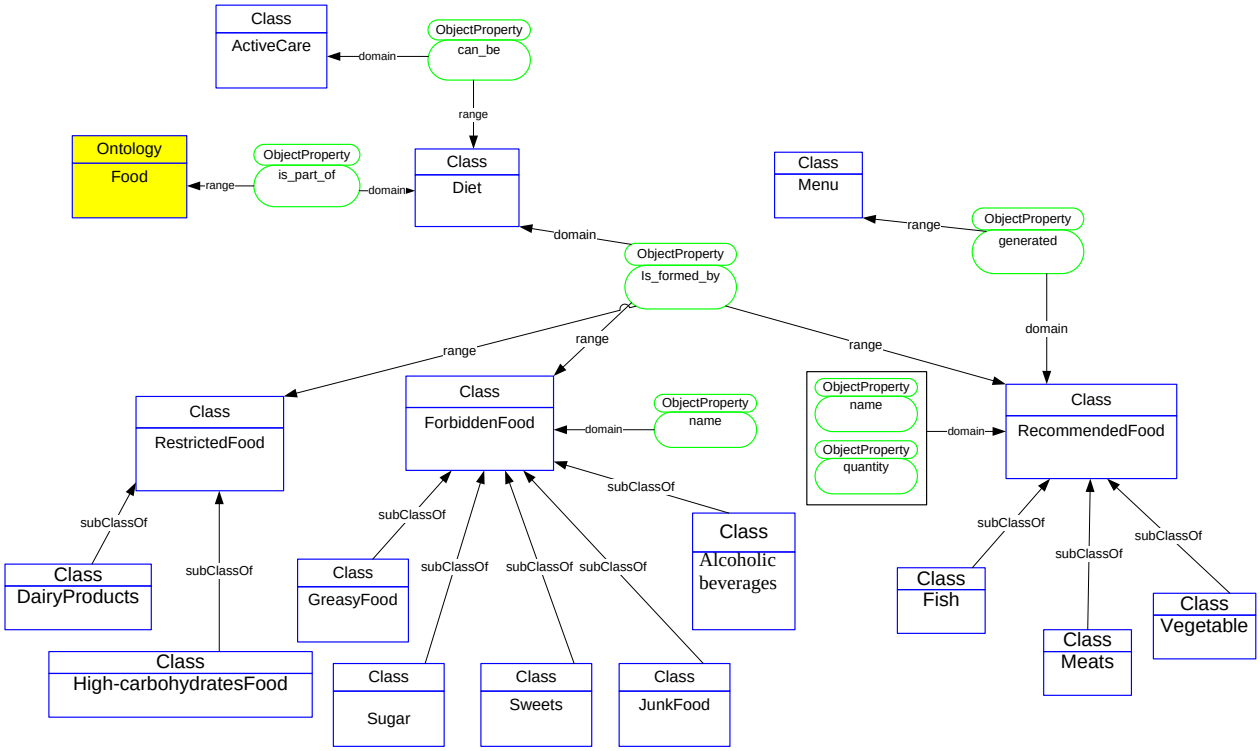

Figure 7. Diet diagram specification for the study case Diabetes.

5. CONCLUSIONS

In this paper, development of a framework is described; this has been developed for the patients mobile monitoring via biometric devices and a mobile phone. A framework intervening elements ontological classification has been built up. These elements are the patient profile, where the personal details of the patient are specified; and the definition of the modules for the mobile phone as well as for the doctor. Diet definition, medical treatment, care activities, patient profile are some of the aspects that have been modelled in the ontologies and that allow the framework an accurate interpretation to generate the right applications.

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