A New Web-based E-health Platform

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Abstract—**Nowadays, the development of e-health concept is offering various aspects. In this paper, we present a novel website architecture. Designed for an e-health platform based on a wireless sensor network (WSN), this website offers the ergonomic and multi-functions opportunity for an ambient intelligent hospital. It enables the management of patients' records, real time patient's state monitoring based on remote sensing of biometric signals as well as indoor geo-localization for either in or out patient and professionals. Using architecture based on combined approach, this website presents a part of a big e-health project development.**

Keywords; e-health; website;WSN;remote sensing; localization

I. INTRODUCTION

Can technology make sense without human well being? This is question is behind most humanitarian inventions. People appreciate inventions that facilitates them life but what about medical inventions that decrease the pain level, enhance the body performance and in most times save from death. Telecommunications have always intended to build more comfortable life style. Moreover, it is taking a pioneer role in health care.

E-health is the best example where taking care of ill people is becoming wireless and homely conducted. Nowadays, we usually hear those words "intelligent hospital, automated building, home automation"…and we are seeing more and more applications dealing with this field. E-health as defined by the World Health Organization(WHO) is "the use, in the health sector, of digital data—transmitted, stored and retrieved electronically—for clinical, educational and administrative purposes, both at the local site and at a distance"[1].

The WHO-Regional Office for the Eastern Mediterranean has presented a statistics, on 2005, ranking countries that are more likely to introduce e-health applications. And Tunisia, between 127 countries, was indexed number nine [2]. This is motivating for us to make more and more innovation on the e-health field.

Wireless Sensor Networks didn't miss innovations on e-health. Their application in the e-health field is studied with different aspects. Alemdar et al [3] published a survey presenting the art state of different used technologies (Zigbee, Wi-Fi, RFID…) and prototypes developed by researchers.

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From sensors design [4] and signal processing algorithm to platform design, various works [5, 6] discussed the application and the ease of use on real world conditions of such systems. Furthermore, studies have covered aside patient monitoring as referenced in the survey [7] about the Wireless Body Area Networks (WBAN), patient tracking and localization[8,9]. Additionally, security of medical data and personal health records have been discussed [10]. L. Sun et al. in [11] proposed a cloud computing semantic approach to control access on e-health applications. Some works presented an integrated system [12] combining monitoring of patient's state and the indoor localization concept without describing the Human-Machine Interface (HMI) architecture.

However, few works on e-health system design have developed the Graphical User Interface (GUI). In this paper, working on a multi-functions and ergonomic website is the challenge. Some sites were dealing only with managing medical records [13]. The Swiss website "Swisscom", using its application "evita"[14] provides, in addition of that, an e-Alarm system that provides emergency calls. However, it doesn't give either localization of the patient or real time signal monitoring. On the other hand, the "Isansys"[15] system which offers real time monitoring of the patient vital signals and many interesting services doesn't offer mapping and localization for out-patient (patient not resident in the hospital).

In this work, the developed website intends to communicate e-health to not only the in-professional (professional working in the care center) and the in-patient (patient resident in the care center) but also offers services to out-professionals (professionals from outside the care center like: Private doctors, Pharmacist, Radiologist,…) and out-patient by providing statistical reports for researchers and mapping for any new service demander, guiding him to the desired direction.

This paper is organized as follows: Section 2 presents the general functioning and the use case diagrams. Section 3 illustrates the proposed application architecture. In Section 4, we present the implementation details and some developed interfaces. Section 5 concludes the paper.

II. APPLICATION OVERVIEW

The e-health platform is a whole independent system which carried various functionalities. Allowing, not only monitoring patient's records but also gives real time vital signals processing and positioning of in-patient. Thus such platform includes various actors and validates different needs inside a care-center.

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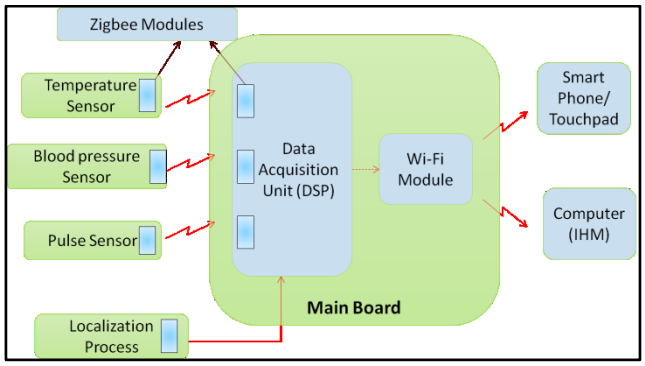

Figure 1. Main Board for e-health platform

Based on Wireless Body Area Network (WBAN), this platform uses gathered data from portable biosensors of the patient. Remote sensing leads to identify his position.

As shown in Fig.1, using a Zigbee modules, sensors communicate with the main board and the Data Acquisition Unit allows the processing of those signals. Thus, it calculates the location of patients besides of physiologic data tele-monitoring.

The protocol Zigbee is based on IEEE 802.15.4 standard. The choice of this protocol was taken relatively to various criteria. First, IEEE 802.15.4 offers data rates at 250kb/s at ISM (Industrial, Scientific and Medical) 2.4GHz band which satisfies healthy environment conditions and acceptable rates. Second, Zigbee is characterized by its scalability, which perfectly responds to the high number of communicating modules in the hospital scenario. Besides, this technology is known with its battery autonomy (years), hence reducing the maintenance cost of the platform. And finally, its coverage (up to 10-20m) is sufficient to let patients freely moving under continuous supervision.

The main board uses in the other side Wi-Fi modules to transmit processed results to the final terminals.

This system allows interaction between various actors: Hospital administrator, In-healthcare professionals (Doctors, nurses, caregivers), Out-healthcare professionals, in-patients, out-patients.

In this paper, we will present the development of the "Human-Machine Interface" (HMI). Called "E-health Center", the developed website transforms the results processed by the platform. Thus, it acts as the ergonomic interface of the wireless sensors network.

A. *Use case diagrams*

This website gives three main functionalities:

- To manage patients records: Add/ delete and modify diagnostics for existent health file.
- To follow the vial signals progress of patients (Temperature, blood pressure and cardiograph pulses) in real time.
- To localize patient and professionals and mapping service for out-patient

Thus, for each actor a use case diagram was established. Fig.2 presents the global use cases including actors and general related tasks without the communication details between them.

B. *Scenarios:*

Different scenarios are developed to enhance the website diversity. Corresponding to each use case diagram, special scenarios were established. In this paper, we will present some scenarios as examples.

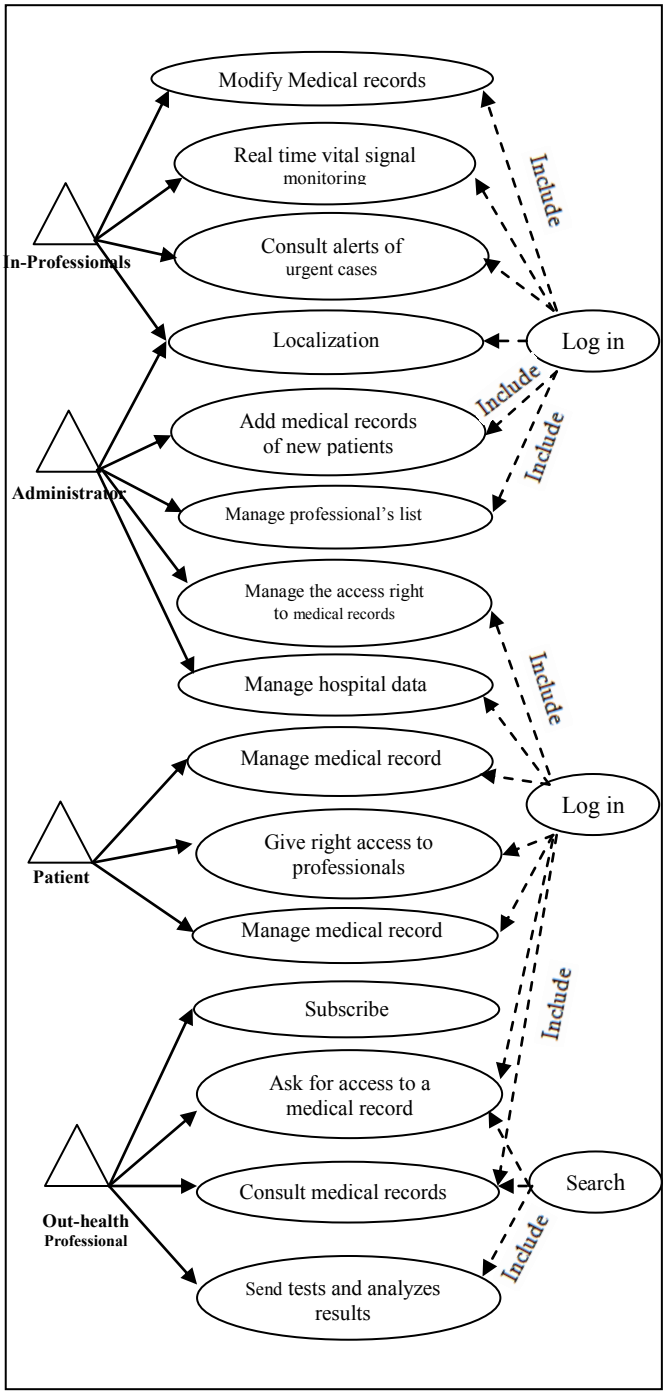

Figure 2. General use cases Diagram

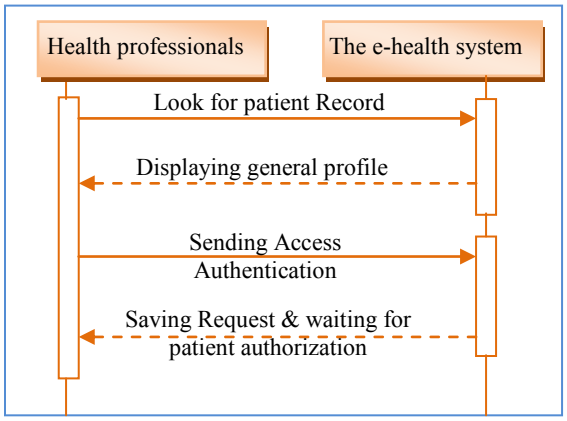

Figure 3. Sequence diagram of the use case : professional access request

To guarantee the secured functioning of our website, the access right management was made based on access priority. The following diagram shows the behavior of the system when an access request is received. The system can not authorize the professional access without the patient acceptation. Fig.3 illustrates the protocol of communication between the professional and the system.

Furthermore, to simulate the communication between the wireless sensors network for patient's supervision and the professionals, the system has to get back the recorded data in the real time database as presented in Fig. 4. If any anomaly is detected, the system alerts the professional in charge of its information.

For the patient, fig. 5 describes the access validation process to his record.

III. PROPOSED SYSTEM ARCHITECTURE

A. N-tier architecture and MVC model

1) N-tier architecture:

Among various manners to structure architecture, best included and mastered in computing is the approach multi-layering. A layer is a logical, horizontal division of the system

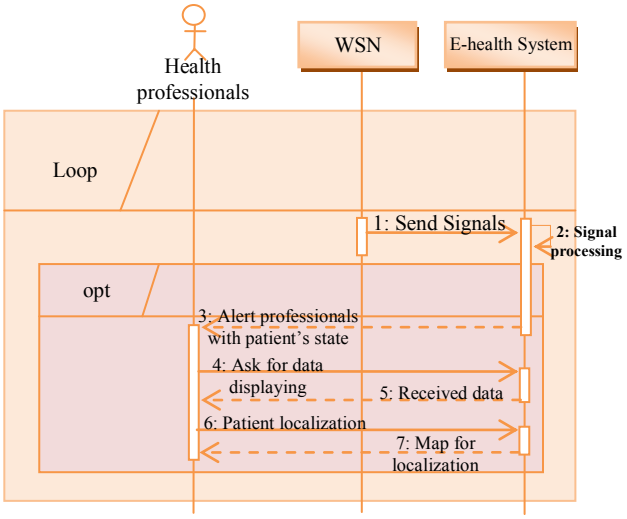

Figure 4. Sequence diagram of the use case: "patient vital signal monitoring and localization"

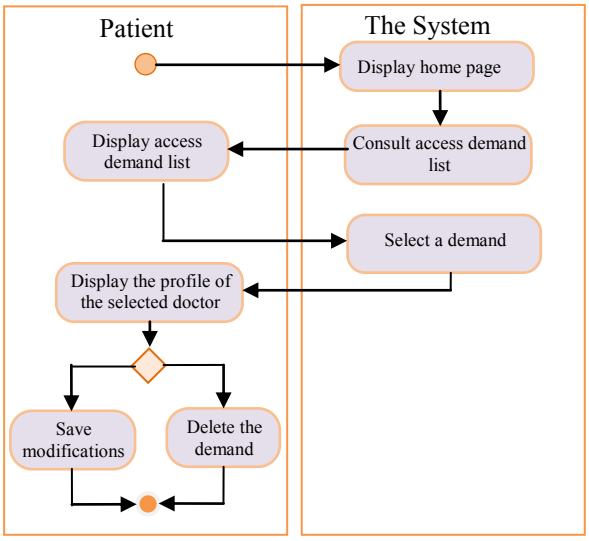

Figure 5. Sequence diagram for patient access validation

which supplies a particular abstraction of the system to the top layers.

Every layer possesses specific roles. In a structuring by layers, the lower layers offer a basic functioning for top layers, allowing afterward abstracting the implementation of these basic services. So, we adopted a division in five layers. Such architecture also allows obtaining a good level of re-use and reconfiguration. Those layers are as follow:

a) Presentation layer: This layer contains the e-health platform components which have to interact with the user of the application, as the web pages, the forms, as well as validation patterns that manage the behavior of the user interface.

b) Application layer: Its main purpose is to supply specific services in the Presentation layer. These services correspond to the business rules defined during the analysis phase. It manages different control aspects of the use cases described partly in the previous section. The communication with the top layer is made through managed-beans.

c) Services layer: This layer receives the requests of the application layer and process the business logic contained in these requests. It is a package which contains the requested classes, on one hand, to guarantee the semantic validation of the business information, and on the other hand, to manage the interaction with the database. The communication with the Application layer is made through the services interfaces.

d) Domain layer: This layer is certainly one of the most important. Here are the basic features which allow creating, searching, modifying and deleting the business entities respecting the transactional properties. It is also in this layer that the mechanisms of conversion object/relational partially take place.

e) The Persistence layer: This layer is responsible of the physical storage of data. It insures the transactional support. As regards to our system, this layer will be based on the relational model.

2) MVC Model2 :

The Model-View-Controller organizes the Human-machine interface of the software application in a model (business object, data model), a view (presentation, user interface) and a controller (control logic, events management), each having a precise role in the interface. This pattern design imposes the separation between the data, the presentation and the processing, what gives the three fundamental parts:

a) The Model: It describes or contains the recorded medical data and the registered measures of the sensors. It offers updating methods to data (insertion, deletion, values change) of the database. It also provides methods to get back these data. The results sent back by the model are divested of any displaying. It is the model which contains all the business logic of the application.

b) The View: It presented the data sent by the model.besides, It receives the user tasks and transmit them to the controller. The view doesn't proceed to any processing, it is just displaying the model's results.

c) The Controller: It analyzes the customer request and contents with calling the adequate model and with sending back the view corresponding to the demand. The MVC2 model integrates a front controller which role is to distribute actions to a specialized subcontroller.

In this work, we combined the two patterns in the same architecture in a way that the user action is got back by the View which asks the Controller for the adequate action. The Controller reaches the business rules on the application layer to have access to the logic of the application. The business part can have access to the data of the database or other one through the data part. Thanks to this processing, the Controller can then format the Model via the data of the business part and sends it to the View. Thus, we have the MVC model within the Presentation layer of the n-tier architecture.

B. Diagram design:

To highlight the static architecture of our application, we will begin by a general illustration of the solution through the packages diagram. Then, the diagram of classes.

a) The packages diagram:

Fig. 6 illustrates the logical architecture showing the various packages and the relations between them.

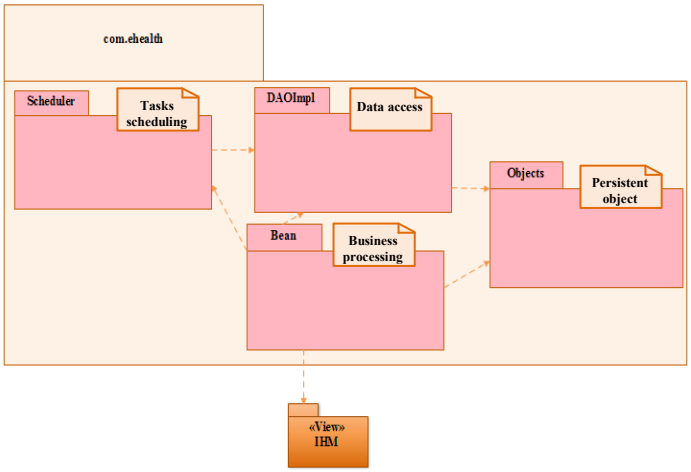

Figure 6. Packages diagram

All the application classes are included in the package 'com.ehealth'. We organized the system in packages detailed in Table 1 to better structure it and facilitate the understanding of its features.

b) Components diagram:

We decomposed the e-health platform on 4 sub-systems explained in the diagram of Fig.7.

TABLE I. ROLES OF DIFFERENT PACKAGES

Packages	Role
Package IHM	It describes the relations between the actors of the system and the engine. Indeed, two actors of the system, the researcher and the administrator have the possibility of contacting the engine through a page of welcome or indexation for the researcher, or page of administration for the administrator.
Package Bean	It contains the classes of businesses processing and of data manipulations given by the user via the IHM and those transferred from the database by the DAOImpl package.
DAOImpl package	It allows the manipulation of the database. It offers the basic features which allow creating, searching, modifying and deleting business objects components in the database.
Objets package	This package contains persistence classes and the mapping files which are XML files that allow Hibernate to make the link between the Java objects and the database.
scheduler Package	It contains the classes which check the sensors values got back by the DAO package in real time every 5 minutes. It calls in the Bean package for the alert when anomalies affecting patients is detected.

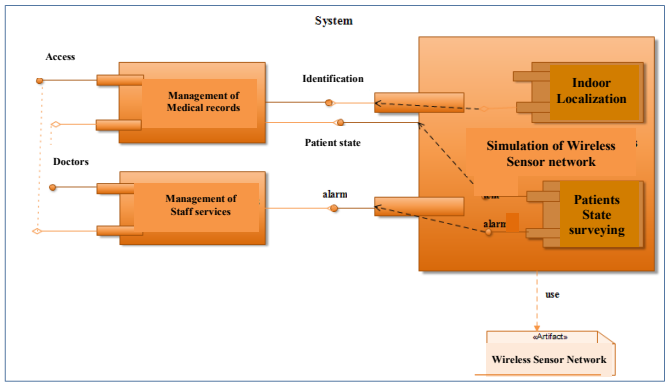

Figure 7. components Diagram

Figure 8. The homepage of the E-health plateform

c) Classes diagram

Fig.9 below illustrates the classes diagram represented under package "com.ehealth.objects". The package contains javabeans used to save data. The latter assure the communication with the various tables of our database. Every class of this package contains a set of attributes similar to the existing fields at the level of the bases's table. These classes also contain the methods setter and getter relative to every attribute which allow the modification and the recovery of the attributes values.

IV. IMPLEMENTATION DETAILS

A. *Software configuration:*

The technological choice was based on rapidity, interoperability and ergonomic criteria. Thus, the development of our application leans on the platform J2EE (Java2 Enterprise Edition), JSF, Hibernate and Quartz.

B. *Human-Machine Interface (IHM):*

In this part, we present some French interfaces of the realized work. The homepage in Fig.8 includes all links towards all uses cases such as connection, registration, search….

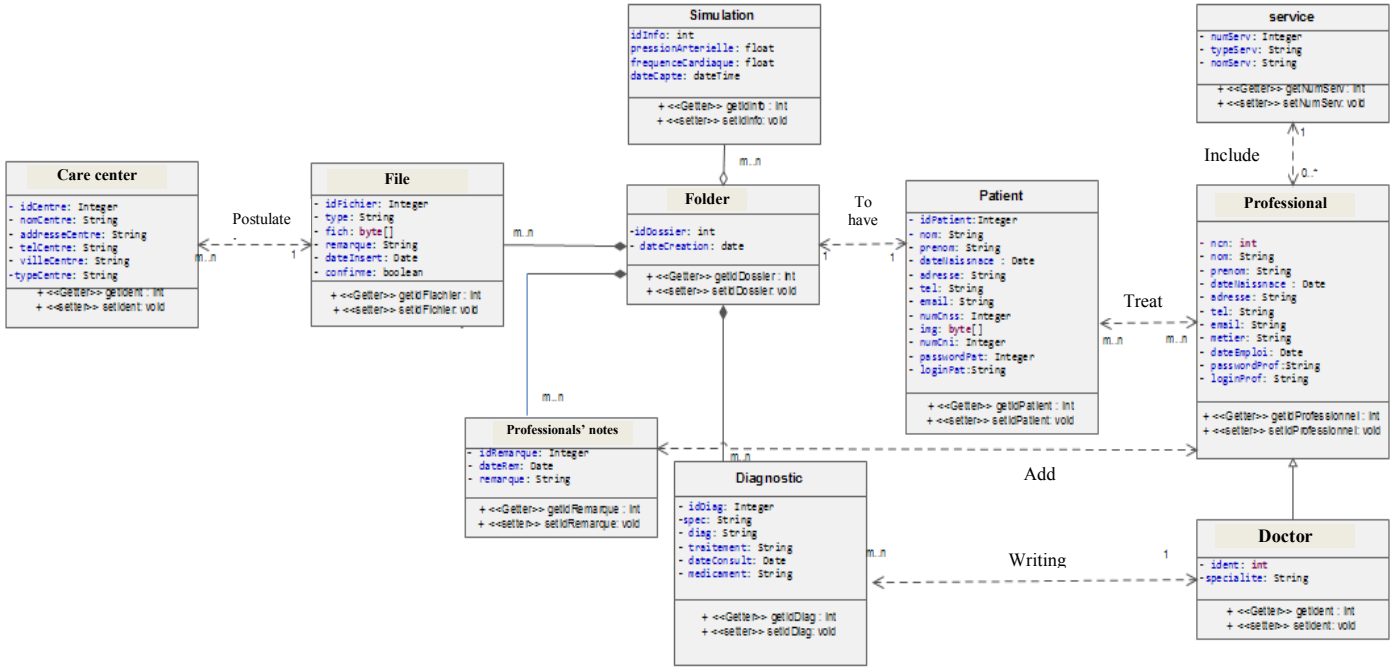

Figure 9. Classes diagram

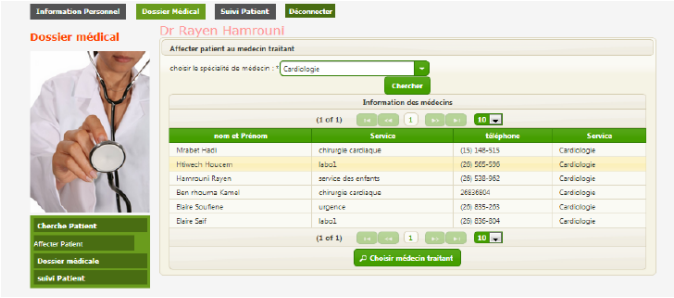

Figure 10. The affectation interface of doctors

In Fig.10, the page includes a form containing all the information necessary to save in the table professionals of our database.

V. CONCLUSION

This work presents a new web-based e-health application. The technological choices, in addition of providing various functionalities to different actors (in and out-patients, in and out-professionals) make the originality of this ubiquitous platform regarding existing platforms. Also, the integration of indoor geo-localization of either patients or professionals is based on an intelligent algorithm that processed the signal strength collected from patient sensors. The developed application uses combining architecture (n-tier and MVC2 model) which makes it extendible and ergonomic. The system is under development (not all hardware is acquired, so it is hard to talk about comparative results till its implementation in real hospital environment.

Future works intend to optimize different algorithms including security and legal data fusion and clustering. Besides, it is crucial to consider the improvement of the indoor geo-localization package (tracking, guiding and mapping) taking into consideration the specific hospital environment constraints (signal propagation problems: reflections, multi-path, geometric similarity and medical machines sensitivity to radiations...).

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