ABSTRACT
Nowadays ICT is more and more used in e-health domain to give support to diagnosis and treatment of diseases. However, because of the diversity of diseases and their particularities a plethora of ad-hoc system has been created for monitoring particular diseases. This paper presents an adaptive and configurable system based on a generic design model which allows developing systems that support health monitoring and diagnosis of a set of related diseases. The system manages the vital signs of the patient and context information, in order to assess objectively the state and evolution of the patients ensuring the ecological validity of data. It is intended to detect the influence of the environment on the state of health of the patient. To accomplish this goal, the proposal makes use of services, whose design is based on components in order to be able to adapt a same solution to several diseases with some common disorders, specific equipment, and environmental situations of the patient. The component based design of the services allows the modification of their behaviour to adapt it to a situation in a given moment.

Categories and Subject Descriptors
C.1.3 [Other Architecture Styles]: Adaptable architecture; H.3.4 [Systems and Software]: User profiles and alert services; K.4.2 [Social Issues]: Assistive technologies for persons with disabilities; J.3 [Life and Medical Sciences]: Health

General Terms
Design, Human Factors, Management, Measurement

Keywords
ehealth, health care, monitoring, adaptive, Service Oriented Architecture (SOA), wearable, Systemic Lupus Erythematosus (LES), Fibromyalgia

1. INTRODUCTION
The social problems such as limited financial resources, the population projection [8] and the diverse range of diseases to be treated have a strong impact on the health sector. The use of ICT could help to cover the shortcomings caused by these adversities, and it allows the development of alternative proposals to traditional ones in order to improve patient care.

One of the main problems is the wide range of diseases, their characteristic, symptoms and treatment pose many challenges from the software engineering perspective. Moreover, the design and development of systems is largely dependent on the particular application domain, the specific functionality and end-users who will use them. Moreover, to monitor these diseases different equipment can be used, such as wearables, mobile devices, environmental and physical sensor networks, etc. Also, the equipment have different characteristic (parameters, sampling frequency, set of data and transfer, etc.) and limitations [12]. Therefore, a challenge is to identify features for these systems in order the developers can detect advantages from their commonalities and to address the integration of software and hardware elements in a system by taking into account specific requirements for each disease. This implies an economic effort and time that could be minimized by implementing the philosophy followed by adaptive systems [3].

These problems are especially prominent when the diseases to be treated present an unknown or uncertain etiology. For example, Systemic Lupus Erythematosus (SLE) disease does not present specific factors to consider for monitoring and diagnosis. Therefore, the medical tests appropriate for study and the adjustment of the characteristics of the devices, require changes in short periods of time. Nowadays, the affected population in the world is between 0.02-0.07% [11] and there is a prevalence in woman compared to men on a scale 9-1. Also, it is important to emphasize that the LES is not an isolated disease, commonly there is a high prevalence of Fibromyalgia. Additionally, there is a high prevalence of sleep disorders in people affected by LES [2, 1] and Fibromyalgia [9].

This work presents an adaptive and configurable system to monitor patients with SLE, Fibromyalgia or other related diseases. The system manages the vital signs of the patient and context information, in order to contrast information usually obtained subjectively and thus achieve a more ob-
The following difficulties:

- Monitoring and diagnosis systems developments usually presents the information collected. Moreover, it is unknown at this time the existence of a system for monitoring and diagnosis.

2. RELATED WORKS

New social trends encourage the incorporation of the technologies into the everyday life of the people. These technologies provide the necessary capabilities to improve the hospital care and the continuous monitoring of the patients, even outside of the medical facility. Therefore, it is required the design and development of new systems that support these new needs. Dem@Care [4] monitors and diagnoses people who suffer dementia. It allows doctors to manage the progression of the patients, and to adjust the treatment based on their trends. From the information sensed by the wearables, it detects unusual events and situations of interest for a future analysis. REACTION [10] is platform that aims to improve the management of the diabetes in the long-term. It uses a Body Area Network and environmental sensors. The platform includes data-processing, monitoring and alarm services. Moreover, it provides information about the patient’s state to friends and relatives. Mobihealth [13] offers a monitoring system focused on the mobile device of the patient. This allows monitoring the patient outside and inside of his/her house. The data are gathered by a set of sensors and centralized in the mobile device. It transmits them externally through GPRS and UMTS connections.

However, the proposal presented in this paper is intended to overcome the following limitations: the systems are designed to monitor a specific disease, therefore this lack of generalization makes difficult their reuse, increasing the development effort; moreover, the most systems do not contemplate the influence that environmental factors could have in the patient’s state; and they do not analyse the ecological validity of the information collected. Moreover, it is unknown at this time the existence of a system for monitoring and diagnosis of a group of related diseases: LSE, Fibromyalgia and Sleep Disorders.

3. CONFIGURABLE AND ADAPTIVE DESIGN MODEL FOR MONITORING AND DIAGNOSIS OF RELATED DISEASES

Monitoring and diagnosis systems developments usually presents the following difficulties:

- The disease is unknown and its causes are not clearly defined.
- The patients can react differently to certain symptoms, therefore it is required a personalized attention.
- Depending on the disease can be complex to determine user profiles that show similar features.
- Continued progress in research help to incorporate new diagnosis methods and treatment.
- The incorporation of new devices, usually with heterogeneous features.

These aspects generally require the development of specific and static systems, that could not endure through time and provoking early aging software problem.

In this section is presented the system for the monitoring and diagnosis of diseases. The system developed on the base of a generic design model which streamlines the software development with specific requirements, and facilitate the integration and management the necessary hardware equipment. The proposed model seeks to address how and when a system developed must be adapted and it must allow modify its configuration. Its design focuses in the requirements and characteristics of various related diseases such as SLE, Fibromyalgia or Sleep Disorders. It is important identify similarities between the diseases such as patient information, context environment, diagnostic process and patient assistance. After identifying these aspects it has been possible to design component-based services that perform specific tasks. The components can cooperate and improve the quality health care, due to that the system could offer alternative services in a continuous way for monitoring and diagnosis.

The details of the system structure are presented in Figure 1. It is important to consider the representation the vital signs and context, because the relations between them at a given moment can help to determine the causes the alterations in the state of the patients (vital signs) or the occurrence of specific symptoms (frequency of arousals, time intervals, sleep quality, corporal indisposition, insomnia, etc.). Also, this information allows experts to determine if it is guaranteed the ecological validity. In Figure 2 are presented a
sample of the components that integrate the system: (1) the generic components are required for the execution of the service. (2) The specific components encapsulate the logic related with the analysis of a specific disease and the remaining elements that are implied in the communication of the service with the equipment (wearables, mobile devices, sensor networks, communication protocols, etc.). The main entities of the system can be divided into three main groups:

3.1 Users
The system can be used by two kinds of end-users (doctor and patient). The doctor has the possibility of configure the system, stating what kind of monitoring is required and what information (vital signs and context) needs to be sensed for a specific patient. The collaboration of the patient, or even of a relative, during the tests is considered favourable in order to obtain a complete diagnosis. Sometimes, patients must perform actions or activities during the monitoring period, for instance, record when an event occurs, or to fill in a form to gather subjective information of the patient about what happened, what it was doing or where it was in a given moment. These actions are supported by the application.

3.2 Equipment
The system integrates ergonomic sensors, computing devices for capturing vital sings and environmental context information accurately and an application. The sensors used to capture vital signs are two wristbands. In this case the parameters collected are actigraphy measurement, heart rate, blood volume pulse and electrodermal activity. Also, during the monitoring and diagnosis of specific diseases could be necessary take into consideration different kinds of context [5]. It is considered context as all of those external factors that may have any impact in the patient. That factors could be environmental (e.g., temperature, luminosity, atmospheric pressure, etc.), personal factors (e.g., interpersonal relations or people that are in the same place that the patient), factors relating with the location (e.g., a known or strange place) and factors relating with the activity that a patient could be performing in at a given moment (e.g., he/she is watching the TV while also filling a form). In this case, the context parameters collected by system are related with the environment (noise, temperature, luminosity, atmospheric pressure and humidity) and the parameters are captured with a mobile device. The relations between the parameters are established through timestamps. Moreover, the system requires computational device with the necessary computational capacities to host the applications and/or needed services for monitoring a specific disease.

3.3 Services
The system is composed by four main services that enclose the storage and the logic of the system. The logic of the system includes processing, analysis and provision results of the information gathered from the patient. This functionality is obtained by composition of the components of each service. The subcomponents can be combined modifying their structure (automatic adaptation) because their elements (operations, conditions, parameters, etc.) are different according to the disease under study. The elements are designed to be interchanged dynamically before and during the execution of the system, in order to address the following objectives:

1. Monitoring Service. It monitors the information recorded by the sensors that the patient uses in each time. It is in charge of carrying out the following functionalities: (1) the management of mechanism to establish the communication between the sensors and the system; (2) mapping, normalizing, and discretizing the information gathered by the sensors; (3) information preprocessing in order of reducing the volume of the information generated; and (4) encrypting the information before temporary storage or send it to the Storage Manager service.

2. Storage Manager service. It stores the information received from the Monitoring service. This service uses synchronization mechanism [7] in order to guarantee the consistency of the information.

3. Vital Signs and Context Data Manager Service. It analyses the patient’s vital signals and environmental information, which is storages by the Storage Manager service, and collected by the sensors. The stored information consists of a value for a measure and a timestamp. This service will process the information in order to allow doctors and other medical staff to
know about the state of the patient in each time. Furthermore, it allows detecting any influence of the environment in the patient’s state. The main functionality encompasses query response, generation of reports, and provision of elaborated information to other services. The elaborated information corresponds to a set of specific operations (e.g., maximum values, variance, critical values, number of occurrences, etc.). The service is designed to generate selective reports (e.g., medical staff require a kind of specific report).

4. Diagnostic Assistance Service. It applies specific data classification mechanisms on the information required to the Vital Signs and Context Data Manager service. The information received is elaborated information that considers the features that each specific disease can present (e.g., main symptoms, value ranges, environmental influences on the patient state, etc.).

4. CONCLUSIONS
In this work an adaptive and configurable system for the monitoring and diagnosis of SLE, Fibromyalgia and diseases related has been presented. The system developed on the basis of a generic design model which streamlines the software development with specific requirements, and facilitate the integration and management the necessary hardware equipment. One of the main keys of the design has been found coincidences between the diseases under study, in order to design specific components of processing and management. The devised approach, which is focused on a service-oriented architecture, promotes the composition, service reusability and integration with others systems, and development more complex systems.

The proposal includes the use of ergonomic sensors and mobile devices to capture vital signs and context information during the daily life of the patients. This information can be managed and processed by the services, in order to contrast information and assess the state and evolution of the patients and to know the influence of external factors in a given moment. Moreover, in this kind of scenarios it is crucial ensure the ecological validity of the data.

Finally, the system developed it is being used in a clinical study. In the literature, there are no studies combining both types of information, therefore, until now it was unknown the influence of the environment. Also, it is unknown the existence of a system for monitoring and diagnosis of LSE, Fibromyalgia and diseases related.

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6. REFERENCES