Towards Developing Knowledge Management System Framework for managing Chronic Diseases Based on Service Oriented Architecture

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Abstract— **Chronic diseases are type of illnesses that require a continuous monitoring by physicians in order to keep the condition of the patient at the appropriate level. This requires to keep the parameters that have a higher impact on the end results to be within the allowed threshold. In this research a knowledge based system (KBS) is created and then integrated with the electronic health records database (EHR). This is used in order to create a system that is robust and able to predict the condition of any patient based on a certain number of factors that are usually defined by the health authorities. In order to create a model that able to predict a number of chronic diseases, then service oriented architecture (SOA) is used to accommodate these services. This present work deals with creating KBS that participate in the prediction process for diabetes patients.**

Keywords: ***E-Health, Remote monitoring, Smart framework, diabetes, Service Oriented Architecture, Electronic Health Records, Knowledge Based System***

I. INTRODUCTION

E-Health services are bringing a lot of attentions nowadays to the research framework in order to improve the standards of living. Such services include variety of medical and health services which assist the medical sector in tracing, suggested diagnosis and follow up patients. Such services require a framework that has the ability of managing, controlling and monitoring the processes of deploying, discovering and invoking services. Therefore, Services Oriented Architecture is proposed in this research to be the framework for managing the interaction between the users at the top level and resources at the bottom layer. SOA will offer the fabric for health service integration in order to form e-health application as one of the large scale enterprise applications. Such system will improve the current healthcare industry by taking it beyond the scope of one application towards the direction of framework application. The e-health framework application is considered as a platform for implementing, deploying, discovering and invoking different types of healthcare resources from services to infrastructure, such as medical sensors, medical information, medicine information, appointment scheduling, patient history, etc…. This model is required for managing the interaction between the different components of the framework in seamless and smooth way.

Furthermore, in order to monitor and control the operations of the framework, and to insure the integration between services in a way that improves the Quality of Services (QoS), availability, fidelity, maintainability and reliability, the research proposes that three extra layers are required; their main duties are to control and manage the security, manage interaction between layers and knowledge.

Knowledge Based System (KBS) have been used in recent years to represent human knowledge, particularly as the domain problem it represent relates to heuristics. Therefore, such techniques may be considered as an ideal tool that can be used to preserve and then reuse physicians' knowledge that is required to diagnose a specific chronic disease in a specific domain, where the domain could be chronic renal disease, Diabetes, cardiac failure,. . etc. The fact is that if patient condition could be diagnosed through representation of physicians' knowledge, then capturing and then preserving that knowledge held be physicians become very important to repeatedly diagnosing the same or similar conditions that patient report in the future

The Knowledge based system in this research will improve the healthcare industry in the region via offering an on-demand and on-the-fly integration of healthcare resources from services and infrastructure. This, in turn, will have a positive impact on people's health, and then, as a result, on the standard of living in the region of interest. the KBS will be part of the Smart E-Health Monitoring System (SEHMS) will

offer the services of collecting the readings from the patient's side, which can be done remotely (i.e at home via using smart homes, or in a general medical center via using smart medical centers) through a number of medical sensors and services. Knowledge based system is used in order to offer an intelligent service for managing readings, suggesting medical tests and sensors, and anticipating diagnoses for the monitored cases on the fly.

The aim of this research is to create a model that is capable of colleting the data remotely from the patient and then predicting the condition based on certain number of factors. Also, the current proposed model is considered as the bases for predicting other diseases as well as other services. Therefore, SOA is used in order to accommodate these services in future work.

The paper is structured as objectives in section 2, followed by background and brief description to the model. in sections 3 and 4, section 5 and 6 presents a description to the building process of the knowledge based system and then the approach used to integrate it with Electronic Health Records at a nationwide scale. Conclusion is demonstrated in section 7.

II. OBJECTIVES

The research objectives can be summarized in the following points:

- *Improve the standard of living in UAE*: using the smart healthcare framework will improve the healthcare level through providing online and on-demand healthcare services such as smart on-line health monitoring system. Using this system, the doctors can follow the patients 24 hours in their homes based on utilizing a smart system that collects readings and notifies doctors of the current situation of monitored cases.

- *Technology transfer*: applying the technology of "people living independently" based on the use of smart homes and smart medical centers. By accomplishing this task, the patients will be able to be monitored by the doctors remotely.

- *Knowledge framework*: improve the healthcare knowledge framework based on having shared framework for healthcare resources and providers. Hospitals, medical centers, and even doctors from inside and outside the region can share this knowledge framework based on their experiences and knowledge.

- *Improve healthcare Industry*: the research will have positive impact on the healthcare Industry from hospitals, medical centers, medicine companies, medical equipment companies and insurance companies through improving the way of interaction between the patients and healthcare service providers.

- *Building capacity*: the research is aiming to build the national capacity in the field of healthcare informatics, which is required to merge the healthcare and the ICT areas.

III. BACKGROUND

The rapid advancement in both communication and information technologies in recent years has opened a wide doors for researchers the opportunity to use these technologies in order to resolve problems that are associated with different aspects of life. Managing and monitoring chronic disease patients are one of these applications that were benefited from such advancements. Most of research activities are categorized into one of the major ICT, either using body sensors, web based services, or mobile technology.

Omar et al[1-3] proposed a semantic framework that provides an intelligent remote health monitoring service via implementing a method of exchanging information between sensors and actuators in an open standard format.

Black et al[4], where they proposed an automated remote monitoring system that involves patients proactively in the care of their condition by using spoken dialogue technology. Furthermore, Benny et al[5] proposed the use of pervasive sensing technology and wireless communication in order to create the concept of Body Sensing Networks.

As far as the usage of web-based services, Baiet al[6] suggested the building of web-based services information system to aid the activities in diabetic healthcare. Two groups were recognized; healthcare receivers (patients) and various care providers. Mobile-network communication platform for homecare supervision used for preparation prior to face to face diagnoses. Web applications were also used for delivering worthwhile health care services to chronic diseases patients. These web applications were developed in order to support patients in self-managing their diabetes via monitoring their health as well as communicating with their healthcare providers.

IV. MODEL

Service Oriented Architecture (SOA) is used in this proposed research work to offer a generic model for health framework in order to deploy and integrate health services in open

standard format. The model consists of six layers to manage the interaction between the user and the resources. There are other three layers responsible for controlling the security, managing the system and offering ontology for assisting in exchanging information between the layers of the system in an open standard format. The model is shown in figure 1

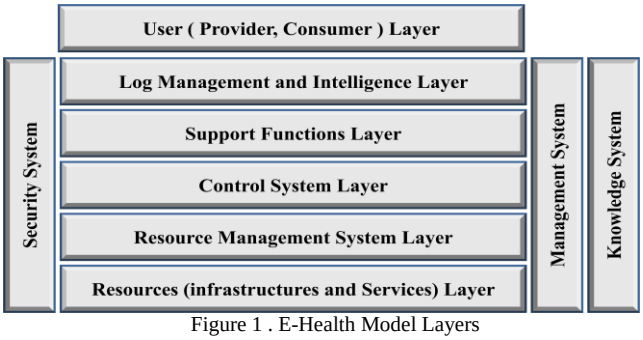

Figure 1 . E-Health Model Layers

A. *Resources Layer*

The **resources layer** consists of three main categories, these are; Services, Computational and Data Process. These categories, however, consist of varieties of components which include range of services types, infrastructures, communication systems, monitoring resources and controlling facilities.

The services resources consist of all types of application and management services that are offered to the customers, such as healthcare services [8], financial services [9], dictionary services, monitoring services and others. The computational category covers the resources that are required for processing tasks requested from the services part in this layer, or other specific tasks that are demanded by the user. The data process resources consist of all the storage system and the access ways to the storage data. This category also includes data processing services like data mining.

The resources layer in the model is proposed to serve huge variety types of applications from financial, research, education, government, healthcare and other fields. Therefore, there is a need to hide the Complexity of integrating resources from the top layer (users). Web Services technology would be an attractive solution for most of the developers due to the broad compatibility that this technology has to offer. This will offer an open standard at resources layer which also requires a standard language for describing resources.

B. *Resources Management Layer*

This layer is responsible for classifying the resources that are deployed by the provider according to the nature, functionality and behavior of resources. Such classification process has been proposed to improve the functionality of the below layer by enhancing the manageability and fidelity of selecting resources. Moreover, this layer is responsible for looking after requests coming from upper layers and find the best services that matches the requests. This layer consist of three main components to accomplish this task; **classification** for classifying resources, **prediction** for predicting the category of resources that may be requested by upper layers and **reasoning** for understanding the requests and interact according to it.

A. *Control Layer*

Control layer is in charge of managing the resources found in the resources layer in a way that offers high reliability, quality of services, availability (fault tolerance) and maintainability. This layer consists of a number of tools and services, which assist in carrying out the task, such as replication, fault tolerance, load balance, mirroring and others.

C. *Support Functions Layer*

This layer is required for managing the processes of **deploying**, **discovering** and **invoking** resources. The deploy function coordinates the deployment of the resources from providers to resources containers in the resources layer, the discovery function manages the process of discovering resources by the users, while invoke function controls and advices the way of accessing the resources in the lower layers by the users..

D. *Log Management and Intelligence Layer*

This layer is responsible for dealing with the users (doctors and patients) through presenting the data in different forms. Also this layer should have the ability to monitor the users' medical activities and record them in a history log in order to provide them to the management and knowledge layers for further processes such as categorize predictions, and others.

E. *User Layer*

The **user layer** represents the consumers as well as applications of the healthcare framework. In this proposed model, the user should interact with the system to improve the operation of the framework through providing the system with experiences, arguments (rules), services specification and other information assists in reconfiguring the framework to give better services. Plus this active user would feed the whole system with a very vital and important ingredient, the Data that would be the main engine to the smart healthcare system.

F. Security Layer

To protect the system, the model consists of **security layer** working with the other layers of the model. The security layer commences by checking the authority of the users, then checking the Service Level of Agreement (SLA) in support function layer. The SLA is required to control and protect the users who have the right and privilege for deploying and using resources from those who do not have. A file system is proposed to be used to record the authority and SLA's for different users, and an encryption mechanism can be very useful to encrypt these files and protected them against sniffing and vandalizing activities. The security at the control layer is to manage the administrator access to control services. At the end, security at the resources layer is to protect the layer from the different types of attacks from outside or inside that can be implemented in sourced or outsourced security systems (virus protection, worms protection applications, etc.…).

G. Management Layer

The **management layer** works in corporation with all layers of the model for managing the healthcare system. This layer consists of numbers of capabilities working together for managing the framework. Such capabilities are framework configuration, optimization, adaption, healing, protection, organizing, and others which assist in improving the operational framework and moving it to on demand framework [10]. All these capabilities should be selected, executed, blocked and destroyed in an automated way. Therefore, autonomic computing [11, 12] is proposed to be used in this case for implementing the self management task. Different services and infrastructures from resources layer will be used in this layer, such as monitoring system, intelligent services (for planning), effectors, and others.

H. Knowledge Layer

The **knowledge layer** in this model is proposed to offer wealthy information to all layers of the system that would assists in efficient usage of the framework. This layer should be attached to all layers of the system for gathering and providing information to each one of them. For example, this layer should collect and provide information regarding the available control services to control layer, the security policies and SLA to security layer, user information, experiences to user interface layer, classification and prediction service to resources management layer, and the available sensors, actuators, loggers and other monitoring resources to the monitoring system,. Furthermore, this layer assists the user in selecting the healthcare services from resources layer based on the information provided by resources management.

Because this layer is involved with all layers, it should use an open standard format that can be readable and understandable by all components. So the existence of such layer would offer a storage and retrieval mechanism for all layers in the framework, and this would facilitate the process of information exchange between layers (not necessarily contiguous layers) in a great way, also it can be a backup for the information found in each layer which will add a precious amount of robustness to the whole system

V. Building the Knowledge Based System

Prior to commissioning the system and placing it into action, there are few steps that are required to be applied. These steps involve the building of a skeleton model followed up by a training that has to be performed in order to form a model that can be used for diagnosing the different cases that are collected from the patient.

Health service providers (Hospitals, medical centers) define the data/parameters that are required to be collected from the patients (depending on the chronic Disease implemented in the system). The parameters are usually similar to those taken from the patient during their medical checkup visit and laboratory tests. By providing such parameters, the medical schema is then created. The latter is then used in order to form the basis for creating the skeleton model

Following the creation of the medical schema, the health providers need to inject a bulk of archive data that are similar to that defined in the medical schema. The system will then take the data provided in order to train the model via using SVM, machine learning and data mining techniques. Applying such techniques to the data provided in order to train the model and to categorize the different cases that can be encountered in real life situations.

The healthcare provider is responsible for providing two important operations that are essential to the success of the model at the first place. First healthcare provider should supply the system with a bulk of archive data that are similar to that already defined as part of the medical schema. The second operation, the appropriate diagnose should be provided along with every records inserted into the model as part of the training process. Following the accomplishing of the above two operations, both an AI and data mining techniques are used in order to train the model and to create a trained model from the skeleton one that was established previously. The results of such training phase leads to the creation of the knowledge based system (KBS) that would anticipate in diagnosing the different cases. The accuracy of the model is

usually proportional to the number of samples and the variety of cases that are given to the model during the training phase and the categorizing methods applied. Figure 2 shows the building process of the KBS.

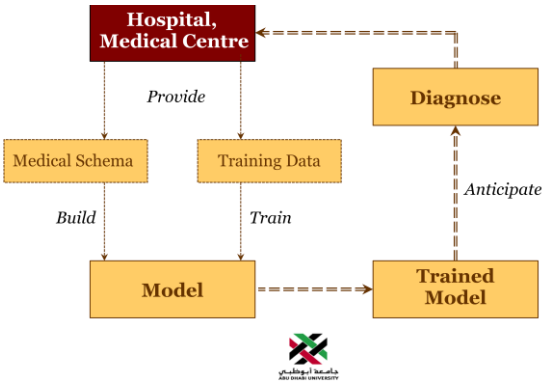

Figure 2 Knowledge Based System building process

VI. INTEGRATION OF KBS AND EHR

The above KBS is integrated and used as part of a wider system where it can anticipate in the diagnoses. Via building an electronic health records Database (EHR) then both patients and hospital can participate in the system [7 - 9]

The proposed system is an on demand system that reacts to the patients stipulate. The management system is usually instigated via issuing a request via providing the appropriate readings that are defined in the medical schema. The data read by the system and provided by the patient is then stored into the patient personal health record (EPHR which is part of the EHR) as shown in figure 3. These readings are inspected by the KBS model in order to analyze the collected data. As a result of analyzing the readings, one of two actions is usually taken depending on the quality of the collected data. In case of any errors detected, then it marks the reading as faulty and issues a new request to the sensor to inject again into the target and to mark the collected data as incomplete. If the readings, on the other hand, are error free, then the system uses the trained model in order to diagnose the case based on the readings and the categorization method used to train the system at the initial stages. It then saves the results into the patient health record, as well as sending the test outcome to the patient.

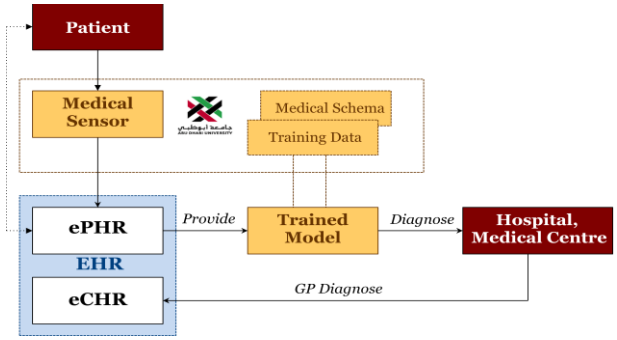

Figure 3 Integration of KBS and EHR

Figure 4, shows the integration of both KBS as well as the HER as part of the proposed national system. The user (patient and health providers) can access the system via a dedicated portals that allow then to communicate with the system effectively.

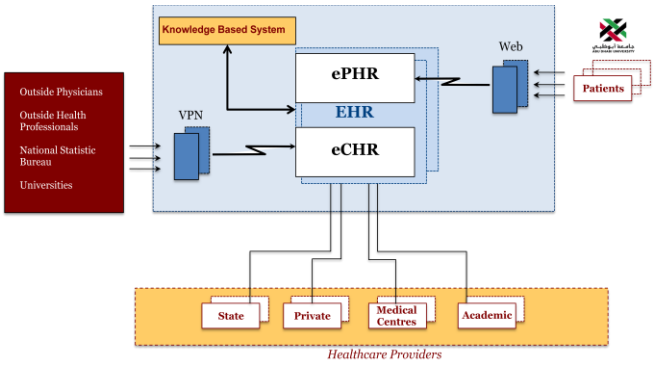

Figure 4 KBS integration with the National Infrastructure

VII. CONCLUSIONS

In this work the creation of a knowledge based system has been identified and a framework was shown. Participation of KMS in the prediction of diagnosing patients that suffer from chronic diseases was also presented. The present research was concentrated on patients with diabetes. The framework shows the integration of both KMS and EHR as part of the national E-Health infrastructure. Future work will take two directions; one direction is to add other chronic diseases to the system and allow the KBS to participate in the prediction process, and add the National Pharmaceutical database to be part of the system. The latter would allow the KBS to be used more widely in the prediction and anticipation of patients diagnose as well as predicting the medicine type and dosage that are required. The latter would add a step towards achieving the optimum goal of implementing the ICT in health sector.

VIII. AKNOWLEDGMENT

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