Smart Health Architecture Integration Model

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Abstract— **Smart environments are changing our lives with their growing interactive applications. Smart Health Care is such a type of IOT-application providing smart service through their sophisticated devices interconnected for collective knowledge sharing and intelligence. There has been devised many solutions focused for specific disease, service or patient care. All these smart healthcare solutions provide very much disintegrated architectures. Though these facilities have to run under unified health providing and management facility as a hospital or healthcare system. This research aims to provide an integration model for these disjoint solutions. Ontological modeling and merging techniques is used to unify the systems over their commonalities and difference. The systems services, disease, actors and data observations are joined under respective classes. The model is tested to hold the all semantic relations and constraint of individual solution with abilities to introduction of hybrid solution as well.**

Keywords-component; Internet of Things (IoT), Smart Healthcare, Ontologies, E-Health, Knowledge Merging.

I. INTRODUCTION

Internet of Things (IoT) is one of the main communication developments in current time that connects the internet with every day sensors and working devices for IP-based architecture. These electronic devices interact with wired or wireless channels for data collection and conversion. Smart systems are based on IoT with capabilities of intelligent information processing and decision making.

Smart health systems comprise of many sensing device, data storage and data processing units. Such a system correctly measures, monitors and examine a multiplicity of health status indicators. The observations can contain basic vital health signs such as pulse rate, heart rate, oxygen or glucose level in blood and blood pressure. Smart sensors can be integrated into medicines and pills that are associated to a network internet care, smart cities, hospital automations or various interconnected health applications where the decision making is difficult. The observations made by sensing devices and IoT objects can be processed later after collecting. Thus sensation and related information, analyzed to make better decisions. In this way allows physical objects in the real world to connect with one another to provide performance on a common basis.

The Internet of Things (IoT) has been widely recognized, in which potential solution to mitigate the pressure on healthcare systems, and in such a way the recent research has been given. The Internet of Things (IoT) in health care plays an important role in facilitating patients and doctors [1]. Data from patients can be collected through input sensors and processed by applications formed for a user terminal, such as computers, smart phones, smart watches and embedded device. This type of solution apply sensors to gather comprehensive information and use gateways and cloud to analyze and collect the information and then send the examined data wirelessly for additional examination and review. Powerful wireless solutions linked through the Internet of Things (IoT) are now making it probable for observing the patients. The influence of Internet of Things (IoT) for health and medical services are bound by smart sensors (microcontroller and a sensor) which and can create alerts about whether the patient has taken his listed amount of medication or not [11].

Internet of Things (IoT) permits us to form an intelligent connections and effective health care system. Best opportunities are presented by Internet of Things (IoT) to modernize e-health system. Internet of Things (IoT) permits us to form an intelligent connections and effective health care system. Best opportunities are presented by Internet of Things (IoT) to modernize e-health system. The healthcare Internet of Things (IoT) have many applications as well as remote monitoring, elderly care, chronic disease management, early

prevention, health treatment for institutionalized patients etc. For people specifically in rural areas Internet of Things (IoT) health care can be of much benefit as they do not have enough medical amenities available. They may start ignoring health because they have to travel miles checkup. Remote monitoring of the patients decreases reliance on the doctors, keeps quality of life maintaining privacy of patient data.

The time of doctor and patient saved in any emergency case, doctors can help the patient as much as possible. Outcome of the project is to give appropriate and well-organized medical services to patients by collecting and connecting information through health status monitors that's include patient's heart rate refers an emergency alert to doctor with his present status and complete medical information [1].

There are many Health applications working in healthcare using Internet of Things (IoT). Some applications involve wearable sensors (temperature sensor, Pulse rate sensor, oxygen stability sensor, glucose level checking sensor) while some use onsite physical devices, some involves the direct involvement of a Doctor while some use a trained system for patient's assistant, some handle emergency situations providing ambulance service while some don't have emergency situation handling, some involve patient during the monitoring while some monitor patient on the basis of his activities. All these Health services are working independently on their respective management criteria. The

II. Related Work

This section describes an overview of the previously done work in the domain of IOT health. This section is divided into three categories.

i) Disease based IOT applications include Heart or cancer monitoring or detection specific systems

ii) Service based IOT applications provide health-care service specific applications including monitoring services, remote prescription and telemedicine.

iii) Resource based IOT applications contain health resource management applications like ambulance management or health care staff management

A. Disesase Base Solutions

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1) Real-Time Heart Attack Mobile Detection Service

Software Defined Network and Mobile Edge Computing technologies are used to offer a novel Internet of Things (IoT) e-health service. Real time heart attack mobile detection service works through voice control and gesture control by smart watches. Real time heart attack mobile detection service targets to better the response time of emergency service for heart attack patients in vehicular networks. [1]

A cardiac acquisition monitoring system takes the advantages of wireless technology, implemented via Bluetooth technology, and computational methods of diagnosis of heart physiology. With the application of the Internet of Things (IoT), the users or doctors can get the instant status of heart and take clinical interference before an emergency. The major contribution includes the novel hardware devices with the peripheral devices wirelessly, which can access data remotely, facilitate seamless connectivity between users and clinical physiology, and provide data analysis for clinical decision support. It is suitable for the home environment, predicting cardiac wellness of an inhabitant through the auscultation sound monitoring of an inhabitant. [2]

2) CHRONIC METABOLIC DISORDERS

Health Internet of Things (HIOT), a novel distributed software infrastructure for remote monitoring of i) patients with diabetes disease (type 1 or type 2 diabetes) and ii) patients undergoing house dialysis is presented. It integrates different off- the-shelf Internet of Things (IoT) devices for healthcare monitoring and performs analysis on patient's health conditions. To perform such analysis, HEALTHINTERNET OF THINGS (IOT) includes in its core a Disease Manager, which works on predefined rules. Such rules have been developed following the requirements given by doctors (both dialectologists and nephrologists) and they are customizable according to personal medical records of each patient. [3]

3) ECG Mobile Application

The general architecture of an Internet of Things (IoT) solution for a time critical monitoring on mobile devices is composed of the following two actors the first actor is the patient who wears an ECG sensor responsible for collection of real-time ECG data. The patient's mobile device is another segment of the same actor. ECG data scanned by the ECG sensor is transmitted to a nearby mobile device via personal area network communication. The mobile device is responsible for receiving and initial processing of the ECG signal. This device is used to upload the received ECG signal to the ECG Cloud Processing Center, as another segment. And second actor is the medical staff. [4]

An algorithm for ECG is given for the analysis and classification for heartbeat diagnosis, and implements it on an Internet of Things (IoT)-based embedded platform. This algorithm is the proposal for a wearable ECG diagnosis device, suitable for 24 -hour continuous monitoring of the patient. This makes use of Discrete Wavelet Transform (DWT) for the ECG analysis, and a Support Vector Machine (SVM) classifier. The best classification accuracy achieved is 98.9%, for a feature vector of size 18, and 2493 support vectors. Different implementations of the algorithm on the Galileo board help demonstrate that the computational cost is such, that the ECG analysis and classification can be performed in real-time. [5]

4) IoT based Asthma Patient Care

A respiratory monitoring system is proposed for both inpatients and outpatients. The respiratory rate is calculated based on temperature value. The LM35 temperature sensor is

used. For calculating respiratory rate, two LM35 temperature sensors are needed. Then sensed the temperature value in real-time by using Arduino microcontroller. And then the value is displayed in a web browser using Ethernet wired connection. If any abnormal condition is reached, trigger an alarm and generate an alarm message in web browser. Then the data is analyzed by using data mining techniques to identify the health status of patient's without any external help. With the help of this system early disease detection is possible. [6]

B. Service Base Solutions

Following are examples of different monitoring services for different purposes concerning various diseases

1) Smart-Home Infrastructure for Independent Elderly Resident healthcare

For supporting the independent living of older adults in their living environments and providing perceived safety, a set of heterogeneous sensors, able to provide behavioral and environmental condition information, was utilized in addition to health devices, used for vital sign measurement. This helps for the provision of a safe environment for elderly patients. It also provides a mechanism for easy setup and testing of the installed equipment and a decision support system that offers advanced data analytics and visual analytics mechanisms to the formal and informal caregivers of the elderly for the efficient monitoring of their health and activity status. [7]

2) Monitoring Chronic Disease at home Using IoT

The main objective is to monitor participants during their daily routine life, to record and to collect data continuously. This health care monitoring is a case of study of system of systems engineering within it we manage interactions between three aspects: humans, environment and sensors. The idea, then, is to study the different relations and correlations existing between variables coming from those aspects. An important part of this work takes into consideration the participant's emotional aspect (stress, happiness, sadness, among) and analyze that using the appropriate artificial intelligence tools. Being able to detect participant's emotion, categorize it and analyze its impact on cardiovascular disease is the main goal of this work. [8]

3) IOT based Classification of Chronic Disease Vital Signs

This service gathers raw data from medical sensor and using these sensors a model is built. Any real time data may be given to the model and the model returns the response that whether this real time data is either healthy or unhealthy which is very useful for the precautions of chronic diseases to monitor their vital signs periodically. For every periodic instance, with the help of nurses in hospital, patient knows their status. This is time consuming process. So, a model is built and the sensor value will be given to the model and the model gives the health condition of a patient. By using this model, cost is reduced and without nurse help patient know their condition. [9]

4) HRV Monitoring System for Hypertensive Patients

The system monitors the HRV parameters for Hypertensive patients through a web application. The application monitors the HRV parameters and provides results as graph. In emergency case, the system sends SMS to care taker and doctor to provide immediate medical help. The observation conclude that there is decrease in HRV time domain parameters beneath the normal range for hypertensive patients compared to normotensive person and more deviance from normal seen in concentrated graphs of hypertensive patient specifying the bigger risk for stroke mortality and cardiac mortality. The system effectively functions to monitor and provide perceptions regarding hypertension condition. [10]

5) IOT based Real-time Patient Monitoring and analysis

A real time remote patient observing and examination using Raspberry Pi 3 is introduced. Raspberry Pi is credit card sized single board computer that have A-R-M-11 microprocessor have LINUX. Open source programming language Python is used in Raspberry Pi. The system includes sensors to obtain the biological parameters from the patient's body and convey it wirelessly to the webs that can be opened by any medical expert across the Globe for diagnosis. Different parameters are kept in the database and the acquired parameters are managed in Pi and generate a message if there is any irregularity in the parameters. By using this technique the patient at home can measure, temperature, blood pressure, heart beats and ECG and can convey those parameters wirelessly to the web. The medical experts can examines and make recommendations if there is any dissimilarity in the parameters. This reduces the cost and time of the patients. [11]

6) Remote Rehabilitation Monitoring using IoT

An embedded system is designed to track improvements of people doing physical reintegration. The main advantages provided by the design are the unobtrusiveness of the supple substrate hosting sensors that can fit on different supports the low power and the large autonomy on batteries of the complete information system plus also the constant streaming of data through Wi-Fi interface [12]

C. Remote Prescription and Telemedicine

1) Remote Prescription and iHome Healthcare

The system is an Internet of Things (IoT) based health monitoring system that gathers the medical data of a patient plus his blood pressure, heart rate and ECG and issue warnings to the doctor regarding his complete medical information, providing a reliable and fast healthcare service. With the help of this system the time of both doctor and patient are saved and doctors also help in emergency case. A medical box is also introduced, it will helps to family members and doctor to check either they are following their recommended treatment on time by Real Time Clock ,RFID and sensors tags ,which are connected to the raspberry and sends message to the patients, their doctors and family members if there is any anomalous behavior happened. [13]

2) Intelligent Healthcare Service

I-Med-Box is fully functional as a medication inspector, and an on-site examiner for daily monitoring. An ultra-high frequency reader, a high frequency reader, Wi-Fi, a Zig bee receiver, and a tablet with extension ports are embedded into the lid. A high resolution weight bridge sensor is combined in the bottom of i-Med-Box to track the weight variation of the medicine stored in the box, and based on which the dose of

medication taken by the patient can be calculated. Wearable medical sensors e.g. Bio Patch, intelligent medicine packages, as well as the sensors/devices from third parties can be connected to i-Med-Box via various wireless technologies. The i-Med-Box can serve as an in-home healthcare gateway to gather patients information and it deliver a variety of services such as health social network, on-site analysis, ,emergency, medication management services and telemedicine. [14]

3) Patient's Adherence to Medicine InTake Schedules

A smart pill box is introduced to help patient follow their medicine intake as prescribed by the doctor. First of all, the smart pill box will connect to the Internet via Wi-Fi. Then, the mobile application can be set by the patient and also by caregivers which can communicate with the patient and remind the patient to take their medicine. An authorized user can enter the patient's information, the prescribed medicine, time and time in each meal into the application, and attach instructions about how each pill should be taken the reminder and alerts are generated. When it is time to take their medicine, a notification pops up on the mobile application with a voice alarm and vibrates advising to take the medicine. If the patient takes their medicine correctly, the system does not activate the alert function again. The system will automatically record the time and change the medications' state. On the contrary to this, if weight changes are not detected, the system will assume that the patient did not take their medicine and activate the alert function in the next step. After running the alert function, if the weight changes are not detected again, the system will change the status as not taken. But if weight change is detected, the system will record this weight and change the status as pill taken. [15]

D. Resource base Smart Health Solution

1) Hospitalized Patient Monitoring and Early Treatment Using IoT & Cloud

This work describes the integration of Internet of Things (IoT) paradigms and resource ecosystems with a tailored Cloud-oriented device centric environment, by focusing on an e-Health scenario, featuring monitoring and early treatment of hospitalized patients, by focusing on Cloud-enabled event detection coupled with coordinated reaction. [13]

2) Intelligent Real-Time IoT based ICU Patient Monitoring System

An IoT based ICU monitoring system is proposed, which can help to fast communication and identifying emergency and initiate communication with healthcare staff and also helps to initiate proactive and quick treatment. This health care system reduces possibility of human errors, delay in communication and helps doctor to spare more time in decision with accurate observations. Bedside monitors are devices which are continuously reading patient data. The system is designed to get health information of bedside patients. Devices are available, which can gather the data from patients' body and display it. This facility is extended to pass this information to communicate further and process it in desired way. [14]

3) Smart Elderly Monitoring with Nearest Ambulance Detection System

The key idea is to provide timely help to the patient and elderly people in critical situation. An alert message about patient's condition is sent to the caregiver for immediate help. A prototype of the system has been successfully designed and tested [15]

4) Smart Ambulance and Emergency Medicine

Backups, aggregate, filtering, and data from the health system, arrest, aggregate, and data sharing in any emergency, there is a challenge and promise of medical internet, where the Internet view where patients are directly linked to national health care system. Telemedicine allows the Internet to track the things in remote and demanding locations through remote ambulances. Ambulance Gateway provides complete duplicate data transfer and storage to data filtering and overall hospitals.

Contains a network of woven apparel equipment networked by medical devices, sensors, and parameters depending on the smart ambulance and reaches the patients' health devices of patients. Internet stuff platforms work as a bridge in which parameters connect to both patients and hospital networks, to get remote support for providing treatment related to the date of privacy history for the patient's medical history. Provide support. [16]

5) Android based Smart Home and Nurse Calling System

The development of an intelligent Android based wireless system is done to help the default person differently, so that the room environment needs to be controlled and call the attendance when needed. For this purpose, the voice-based and secure application software has developed a nurse using a zip communication interface and using Bluetooth-based wireless communication. The user's voice commands will provide the required verbal signal for the actuators at the end of receiving / received at the end. [17]

III. ONTOLOGY ENGINEERING

Complete ontology engineering process is followed for development of integrated ontology.

A. Requirement Analysis

There has been study of 26 smart health research applications selected from each category that need to ne integrated in one smart health solution. Different kinds of cancer and heart diseases have been major concern in the studies. In services, monitoring, diagnostic, prescription and communication services are selected for the base ontology.

B. Vocabulary

Vocabulary of the system consisted of all the concepts presented in the studied smart health systems. These concepts have been generalized to parent categories. The top level concepts include Systems, Services, Disease, Actors and medical observations.

C. Taxonomy

The taxonomy of the system provides the super and subclass hierarchy developed for the concepts in the system's scope. The System class is further specialized in Service-based,

Disease-based or Resource Management based Systems. Services offered by the systems are also subdivided in same fashion. Services can be monitoring, diagnostic, smart prescription and communication. The Disease are sub categorized in chronic disease and nonchronic disease like emergency service.

Figure1 to Figure 5 represent the taxonomy and semantic relations among all the unified concepts of various smart health application systems.

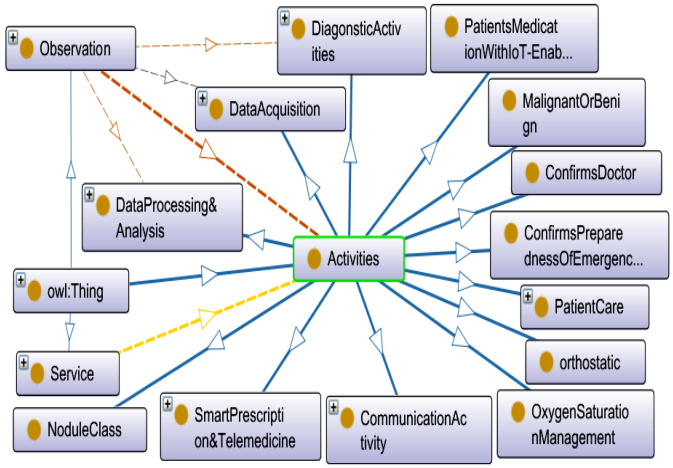

Figure 1. Taxonomy & Semantic Relation Activties

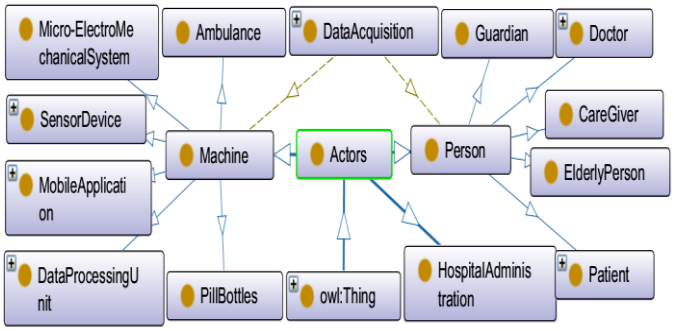

Figure 2. Taxonomy & Semantic Relation Actors

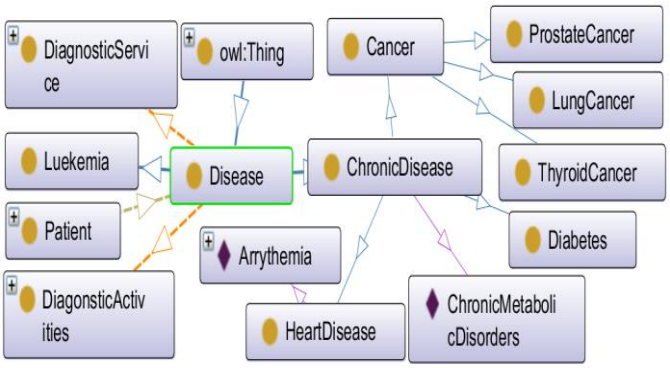

Figure 3. Taxonomy & Semantic Relation Disease

D. *Semantic Relations*

The semantic relations are defined according to the protocols and architectures defined in the studied systems. Semantic relations include Systems providing the services, service composed of activities, activities performed by some actors, services acquiring, processing or transmitting the observations and observation belonging to the patient.

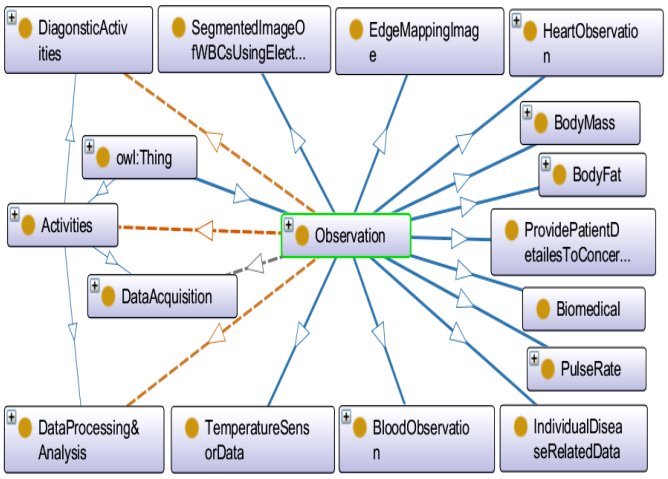

Figure 4. Taxonomy & Semantic Relation Observations

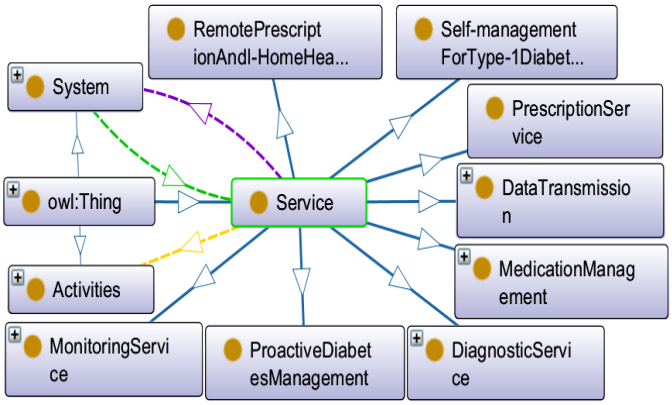

Figure 5. Taxonomy & Semantic Relation Services

E. *Constraints*

System constraints provide the limitations and binding by the protocols. Majority of the constraints include activities that are not allowed be performed by some actor roles like diagnostic activities cannot be performed by patient.

IV. Experimentation & Results

Studied system and some hybrid system are defined using the integrated ontological model to verify working of individual system and collaborative solutions.

A. *Reasoner based Validation*

Reasoning algorithms implement by Fact++ and Hermit [1.3.8.413] are used to validate the consistency of the model. It also validates the instantiation of studied individual services and collaborative solutions.

B. SPARQL Querying

SPARQL queries are used for knowledge extraction in terms of model and its instances. The query are based on the given system to present its provided service and set of activities performed to accomplish the service objectives.

V. CONCLUSION

The research here targeted the integration mechanism of various health services provided as a health-care facility like a hospital. Furthermore it was also required by public or community structure monitoring the healthcare within a Smart City. Different insurance and other healthcare financing organization are interested to have an interconnected health facility due to shared resources. The most vital shared entity of all system is the patient. The research here concluded with the ontological modeling of various smart healthcare systems and their integration with ontology merging. The merging is based on commonalities, differences and dependencies of activities performed for various healthcare services. These relations and constraints are semantically defined through ontologies verified by reasoning software. The resultant ontological framework required to be populated by health care system details that can be added as integrated smart healthcare knowledge.

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