

## Ontological Model for Cohesive Smart Health Services Management

Muhammad Raza Naqvi<sup>1</sup>, Muhammad Waseem Iqbal<sup>2,\*</sup>, Syed Khuram Shahzad<sup>3</sup>, M. Usman Ashraf<sup>4</sup>,  
Khalid Alsubhi<sup>5</sup> and Hani Moaitiq Aljahdali<sup>6</sup>

<sup>1</sup>Le Laboratoire Génie de Production de l'École Nationale d'Ingénieurs de Tarbes (LGP-INP-ENIT), Université de Toulouse, CEDEX, Tarbes, 65016, France

<sup>2</sup>Department of Software Engineering, Superior University, Lahore, 53700, Pakistan

<sup>3</sup>Department of Informatics & Systems, University of Management & Technology, Lahore, 54000, Pakistan

<sup>4</sup>Department of Computer Science, University of Management and Technology, Sialkot, 51310, Pakistan

<sup>5</sup>Department of Computer Science, King Abdul-Aziz University, Jeddah, 21577, Saudi Arabia

<sup>6</sup>Faculty of Computing and Information Technology, King Abdulaziz University, Jeddah, 21577, Saudi Arabia

\*Corresponding Author: Muhammad Waseem Iqbal. Email: waseem.iqbal@superior.edu.pk

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**Abstract:** Health care has become an essential social-economic concern for all stakeholders (e.g., patients, doctors, hospitals etc.), health needs, private care and the elderly class of society. The massive increase in the usage of health care Internet of things (IoT) applications has great technological evolvement in human life. There are various smart health care services like remote patient monitoring, diagnostic, disease-specific remote treatments and telemedicine. These applications are available in a split fashion and provide solutions for variant diseases, medical resources and remote service management. The main objective of this research is to provide a management platform where all these services work as a single unit to facilitate the users. The ontological model of integrated healthcare services is proposed by getting requirements from various existing healthcare services. There were 26 smart health care services and 26 smart health care services to classify the knowledge-based ontological model. The proposed ontological model is derived from different classes, relationships, and constraints to integrate health care services. This model is developed using Protégé based on each interrelated/correlated health care service having different values. Semantic querying SPARQL protocol and RDF query language (SPARQL) were used for knowledge acquisition. The Pellet Reasoner is used to check the validity and relations coherency of the proposed ontology model. Comparative to other smart health care services integration systems, the proposed ontological model provides more cohesiveness.

**Keywords:** Ontology; internet of things; smart health; services integration



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## 1 Introduction

IoT is a concept of a vast network composed of any object that can be inserted into any location to some other place for storage and analysis. The sensors and things in IoT intelligently gather essential information processed and examined for enhanced decision-making. This permits the intelligent objects to link with each other and with nearby networks to send calculation-based performance [1]. Nowadays, IoT technology is primarily seen in industries and commercial sectors. The interconnected divergent kinds of intelligent gadgets vary from simple wearable devices, household devices, and appliances to large machines. These objects contain chips that are used to inspect and pursue facts. This technology is used in many intelligent projects, i.e., intelligent cities projects, innovative farming projects, and smart homes and this technology is also used in health care [2,3].

With the increase in diverse smart innovative applications, IoT has changed our lives. IoT enabled health care is such a vital IoT application that links intelligent devices, and different stakeholders to the internet. IoT in health care systems robust has a critical role in serving comfort to doctors and patients. The input data from patients can be gathered with the help of sensors [4]. This data is processed by applications made for a user terminal, such as computers, smartphones or even a particular embedded device. Such a solution empowers sensors to gather detailed bodily information and use kind-collect physical the cloud to examine and store the data and then transmit the processed sensor's data to cloud storage and analyses data interoperable to caregivers for further review [5]. Robust wireless solutions linked with the IoT. This type of application assists in monitoring the person suffering from chronic disease [6].

For especially people living in rural areas, IoT health care can be of much assistance as they do not have adequate medical services side assistance to help adequate good. Because they have to take a trip of miles to visit the doctor, they may start overlooking their health issues [7]. Remotely personal monitoring of the patients lessens reliance on the doctors and sustains quality of life-preserving privacy of patient data. Due to this ease of communication, one can save himself from the wastage of time, especially in situations and emergencies. A medical expert can also help in the hours of need as much as possible. The revolution of health care, progressing from conventional health management to supplementary custom-made smart health care systems, benefits personal health.

### 1.1 *Lacking in Smart Health Services Standardization*

Smart health care Systems are hard to define formally because most systems lack standardization of architecture by doing a literature review of different IoT based healthcare systems. We have known shared concepts in other innovative health systems working in isolation. These shared concepts can be represented using ontologies, the help of which are not only able to define smart health care systems formally but also find the commonalities and differences among these systems. By finding the shared concepts between these systems and ontologies, we merge them into a cohesive health care management system. That leads us to the standardization of smart health care systems.

### 1.2 *Motivation*

Recently, a variety of smart health care services have been available to facilitate the users in a diversity of interaction styles and modes on a separate individual basis. These distinct units of health care services create frustration by providing inadequate modules, specific remote patient features, limited diagnostic structures, poor treatment of diseases and high costs. These types lack the motivation to create a management platform of smart health care services where they work as a single unit to facilitate the users. Although, in the last few years, a lot of research has been done to reduce

users in smart health care services. This research proposes an ontological model for cohesive smart healthcare services management smart innovation presented. This model is provided smart health care survives management platform in a single unit and is part of the continuation of the author's previous work [8]. It is to keep all the context in terms of health care services properly to facilitate the users.

## 2 Literature Review

Ontologies arrange the items or concepts of data in such a way that it creates meaning among them. The vocabularies and taxonomies become more meaningful by using the relations and restrictions among the data terms and concepts. Therefore, by using ontologies, we can formally also represent particular domain's concepts and allow automated reasoning among those concepts. Worldwide ontologies are used for defining terms in the field and relationships among them because ontologies are shared and ideas and provide a standardized solution. These defined concepts in the field are termed classes and arranged in a hierarchy in the form of sub-classes. Object properties and data properties are assigned to these classes.

Following is an overview of the previously done work in the domain of IoT health care applications as we categorized it into three parts such as i) disease based, ii) service based, and iii) resource based.

### 2.1 Disease Based IOHT Applications

#### 2.1.1 Concurrent Heart Attack Mobile Recognition Service

Mobile edge computing (MEC) is an advanced architecture that uses cloud computing and mobile networking specifically for more minor non-functionality applications [9]. Software-defined networking (SDN) is a development groundwater model for network-driven programming, ensuring broad network flexibility and significantly saving, which provides overall costs. The SDN does not make restrictions on the physical structure, but to a specific extent, it can be programmed in an application [10]. Trustworthy testing, road traffic safety & monitoring, and better social connectivity are some of the system's features. For organizations such networks, the Vehicular ad hoc network (VANET) framework is introduced [11]. VANET is a framework in which smart cards are shown as mobile car nodes in the vehicle's network. This framework is not only used for communication between two vehicles cars but also for communication with Restricted stock units (RSU) and intelligent vehicles. Cardiovascular disease is a chronic illness that is one of the world's most important health problems and is a significant cause of death across the globe. A proficient algorithm for heart attack detection is devised [12].

Elderly patients can be marked safe if Electrocardiogram (ECG) signal patterns are processed in time and action is taken whenever there seems to be any problem in the ECG signal. This system also uses machine learning methods for evaluating sensor data for heart attacks and predicts heart attacks. This system is helpful for the elderly patient monitoring and is also likely to detect heart disease in patients with adults, adolescents and heart disease patients or physical restoration patients.

#### 2.1.2 Chronic Metabolic Disorders

Health IoT for personalized monitoring of patients with chronic metabolic illness is presented. Two types of patients are targeted in this system, i.e., diabetic patients and patients going through house dialysis. To analyze the patient's health condition, Health IoT uses the disease manager, which applies and regulates various rules after processing data. Such laws have been developed under doctors' instructions, and these rules should change according to each patient's health records [13]. A novel

framework based on IoT has been presented for blood glucose level tests in the body. This system has a non-obtrusive glucometer, a show framework that uses an Arduino microcontroller and mobile application (android) [14]. This system uses operational intensifiers, an Infrared light-emitting diode (IR LED), a photodiode and a Liquid crystal display (LCD) display. The glucose estimation kit and the circuit has been accumulated, and an application was expected to show the results.

Glucometer with IoT is presented [15] as the purpose of this system is to use blood glucose levels, which is painful for patients, rather than tobacco prices by optical and IT technology using non-technology. To achieve blood glucose levels, a specific dimension is used by glucose spectroscopy.

### *2.1.3 ECG Application*

In this particular system, the mobile application is responsible for receiving and starting the processing of ECG signals. This device supports ECG signals received as another ECG cloud processing center segment. And the other actor is a medical staff who will see the patient's ECG in case of any medical problem [16]. Discrete wavelet transformation (DWT) is used for the ECG signal preparation and investigation, and a Support vector machine (SVM) classifier eliminates the commotion in the ECG signal. After experimentation, the best classification accuracy is 98.9% for a feature vector of size 18 and 2493 support vectors. Various executions of the algorithm on the Galileo board help demonstrate that the computational budget is such that the ECG analysis and classification are real-time systems [17].

### *2.1.4 Smart Asthma Patients Care Using IoT*

A respiratory observing system is developed. According to this system, respiratory rate is estimated on the temperature value. The LM35 temperature sensor is utilized. The respiratory rate is calculated using an LM35 temperature sensor and is observed by the patient's respiration constantly based on the based continuously rate of inhaled and exhaled air. These sensors sense temperature values in near real-time by using an Arduino microcontroller. NRF2401 is utilized for communicating the sensor's data from home to a nearby medical Centre [18]. Then the data is circulated in a webserver by Ethernet wired connection to know the patient's present condition, which is valuable for the doctor. Data is useful for the doctor also data is also displayed on an LCD monitor. If any unusual situation is observed, an alarm is initiated and generated, showing an emergency alarm message in the web browser. Then the data is then analyzed and processed by utilizing different data mining ways like data clustering and data classification to recognize the health status of patients without any outside help [19].

## **2.2 Service Based IOT Applications**

### *2.2.1 Monitoring of Patients*

For providing a harmless and safe healthy living to the elderly in a smart home, various sensors ensure behavioral and environmental conditions; this information is employed in addition to the health devices, used for necessary sign measurement. The aftereffect of the investigation is served to the formal and casual guardians to give them a choice emotionally supportive network. These aids convey protected environmental factors for older patients [20].

Checking constant sickness at home utilizing associated gadgets is conceivable. The point is to screen patients during their everyday life schedules to save and gather information continually. This sort of checking needs to manage three angles: people, climate and sensors. The Centre is to gain proficiency with the various relations and connections between factors coming from those perspectives.

A significant piece of this work contemplates the individual's enthusiastic attitude (stress, bliss, pity) and considers them as utilizing the appropriate computerized reasoning devices [21]. People suffering from chronic diseases need to monitor their vital signs intermittently. This framework ensures that high danger patients are opportunely checked and observed occasionally. By utilizing this model, the cost is diminished, and patients are very much aware of their condition without anyone else without the guidance of the medical caretaker [22]. Small heart rate variability (HRV) monitoring system dependent on the IoT innovation for negligible hypertensive patients is introduced. This framework, HRV boundaries are acquired using a wireless Zonal intercommunication global-standard (ZigBee) heartbeat sensor in this framework. Arduino moves the patient's information to the worker using the Message queuing telemetry transport (MQTT) convention. The framework effectively attempts to screen and discern the hypertension state of the patients [23].

### 2.2.2 Remote Prescription and Telemedicine

Real-time clock, Radio frequency identification (RFID) and sensor tags are associated with the Raspberry Pi. Raspberry Pi receives readings from the sensors, and they can also be shown on the monitor. If the patient's rare heart condition is not improved in a specific time interval, an alarm will send a message using SMS service to the doctor [24]. This medication box is of high technology. It operates on wireless transmission units; I-Med-Box is a trained medical examiner who monitors the daily intake of medicines of patients. A reader of a specific frequency, Wi-Fi, a Zig bee receiver, and a tablet having additional ports are implanted into the closure. A weight bridge sensor having a high resolution is joined in the bottom of the Intelligent medicine box (iMedBox) to keep an eye on the weight changes of the medication contained in the iMedBox, and based on this, the dose; the medicine intake of the patient can be estimated. Wearable medical sensors, e.g., Bio Patch, intelligent medicine packages, and other sensors/devices, can be attached to iMedBox by wireless technologies [25].

If the patients do not take their medicines regularly, they may potentially suffer from the diseases. There are some diseases like Blood Pressure, if not cured with treatments, which can become a cause of heart attack. Chronic illnesses like osteoporosis cannot be fixed by taking medicine once; if patients do not medico regularly, this might become harmful to their patient's health. So, this issue needs to be addressed. For this purpose, an intelligent pillbox is introduced to help the patient follow their medicine intake as directed by the specialist. First, the smart pillbox is connected to the Internet by Wi-Fi. After this, a mobile application is launched for the patient and caregivers to check whether the patient has taken his daily dose of medicine or not [26]. A confirmed client can enter the patient's data, the endorsed medication, time and time in every supper into the application and append headings about how every pill should be taken. For this reason, to be satisfied, the update and cautions are created. When the time has come to take their medication, a notice is set off on the portable application with a voice caution and vibrates, directing them to take medicine. If the patient takes their medication effectively, the framework doesn't propel the alarm to work once more. The framework will regularly record the time and change the prescriptions' state. Then again, if the weight of the jug isn't changed, the framework will accept that the patient has not taken their medication and start the alarm work in the subsequent stage. In the wake of running the alarm work, if the weight changes are not spotted once more, the framework will change the status as not taken. However, if weight change is identified, the framework will record this weight and change the group as a pill taken [27].

The architecture is proposed for the telemedicine of diabetes management. This exhibits to collect of behavioral responses of patients with diabetes. This information is examined and refined to be presented to all the involved stakeholders. Thus, decisions are reinforced by the data. Visualization layer as mined data to patients and doctors. Based on this data, a prediction layer can be made

to predict medicines depending upon behavioral data obtained randomly by different users. All stored information is maintained and examined to display and make suggestions to the doctors and patients [28].

### **2.3 Resource Based IOT Applications**

#### **2.3.1 Hospitalized Patient Monitoring**

Bedridden patients under intense care must be checked very carefully, whether at the hospital or at home. Solutions based on IoT devices are devised, which help us save the costs of physical monitors by providing some Internet-connected services. This work describes the integration of IoT paradigms and resource ecosystems with a personalized cloud-oriented device-based environment, aiming at an e-Health scenario, highlighting monitoring and early treatment of hospitalized patients, and hospitalizes concentrating on cloud-enabled event detection joined with synchronized reaction. An IOT-based Intensive care unit (ICU) monitoring system is presented to help identify emergency communication and emergency and start communication with medical staff. It is also an active and quick treatment. In this way, help gets started without any delay [29].

#### **2.3.2 Internet of Things (IoT) in Smart Ambulance**

Patient monitoring and organization of mobile rescue setups can provide significant value in the sinking time of patients' recovery and functioning expenditures. Before introducing the innovative intelligence when medical teams were inefficiently interacting, they were effectually aiding in an isolated system unable to connect with the hospital administrative staff [30]. IoT sensing networks assist in devising a solution for managing hazard response within an ambulance setting. This uses the bio sensing networks to observe and analyze the patient's physical and vital signs. It will strengthen the use of traditional wireless sensor networks to monitor the patient and also increase the performance of the Emergency support system (ESS). Innovative ambulance, when paramedics inefficiently interacted, they were effectually aiding in a closed system unable to connect with the hospital network [31]. This system is interconnected to other equipment networks connected by health devices, sensors, and different parameters required by the intelligent ambulance and reach the patients' health devices. The actual treatment starts when the patient gets to the hospital, but so much time is wasted, and the patient may lose his life.

To stop this incident, this framework investigates essential well-being boundaries of the patient like pulse, pulse, and internal heat level in the emergency vehicle in ceaseless stretches itself and guides it to the medical clinic's information base while in transit to the medical clinic. Keeping in see this information, the emergency clinic specialists will understand what kind of treatment should be given to the patient. This can save the pre-activity season for doctors guaranteeing to keep the patient's life [32].

### **3 Ontology Engineering**

Ontologies arrange the items or concepts of data to create meaning among them using relations and restrictions among the data terms and ideas so that vocabularies and taxonomies become more meaningful. The use of ontologies provides machine-process able semantics to be shared among several other software and tools. Ontology is a clear explanation of common conceptual interests [33].

Ontological engineering is a combination of therapeutic development works for particular domains. Ontologies are used for defining terms in the field and relationships among them. Explaining

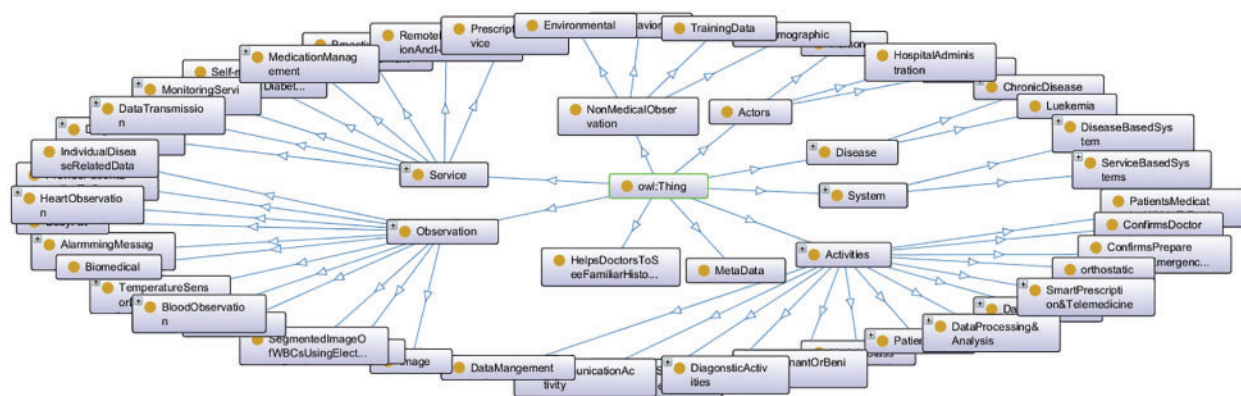


concepts in the environment is termed classes. These concepts are arranged in a hierarchy in the form of sub-classes. Object properties and data properties are assigned to these classes [34].

Smart health care systems are hard to define formally because most systems lack standardization of architecture [35]. By doing a literature review of different, IoT-based healthcare systems, we know that there are concepts that have been shared and other systems working in remoteness. We use 101 methodology and already ideas given in OBO<sup>1</sup> Foundry has been used. With the help of which, we will be able to define innovative health systems formally and find the commonalities and differences among these systems. By finding the shared concepts between these systems and describing them in ontologies, we can merge them into a cohesive system [36,37].

### 3.1 Taxonomy Building

Some classes and subclasses are defined, and different stakeholders are available in the industry shown in Fig. 1.



**Figure 1:** Taxonomy of classes and subclasses of a cohesive system

Diverse relations are Shown in Fig. 2 is, representing class service and subclasses. These classes are derived from our literature survey.

Fig. 3 represents the class of disease and subclasses in relation to subclasses diagnostic services and diagnostic activities and actors involved.

Fig. 4 represents the class activities and subclasses, like data acquisition, diagnostic activities, communication activities, patient care, smart prescription & telemedicine, patient medication with IoT enabled pill box, data processing and analysis.

<sup>1</sup><https://obofoundry.org>

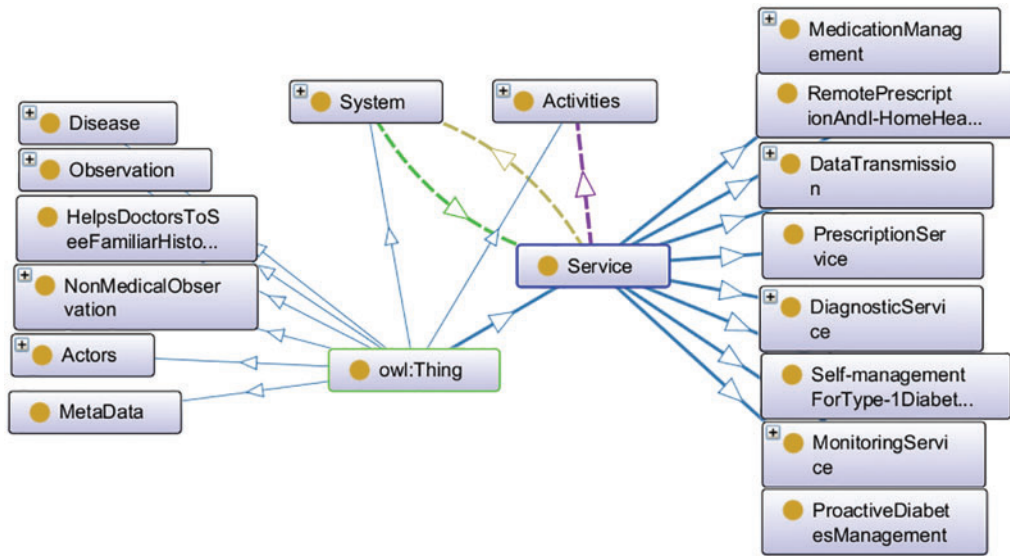


Figure 2: Classification of service class

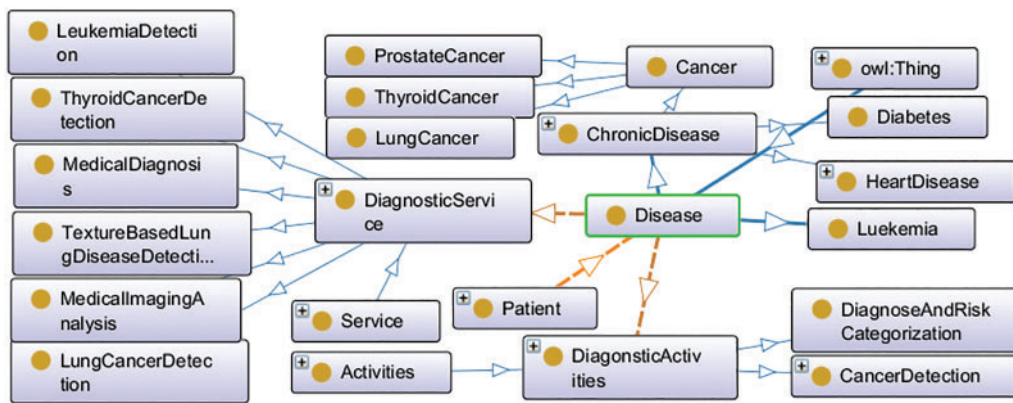


Figure 3: Taxonomy of disease class

Fig. 5 represents class observation and subclasses like blood observation, heart observation, etc. and their relation with services, data acquisition, data processing and analysis.



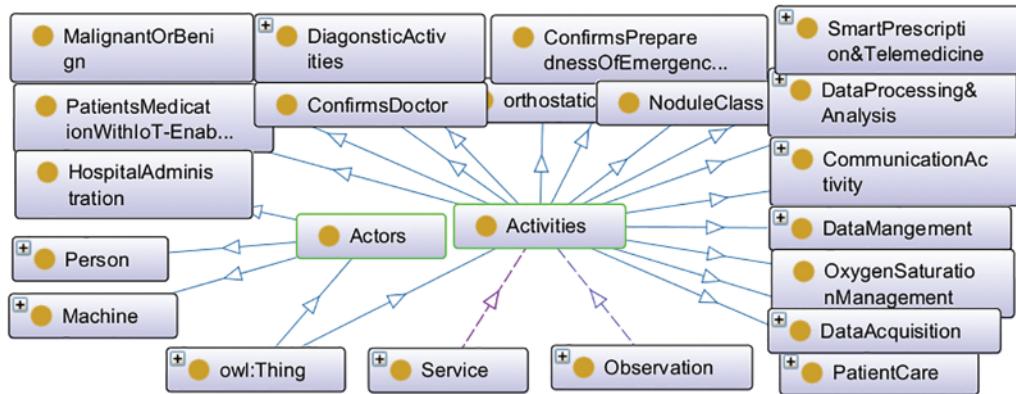


Figure 4: Taxonomy of activities class

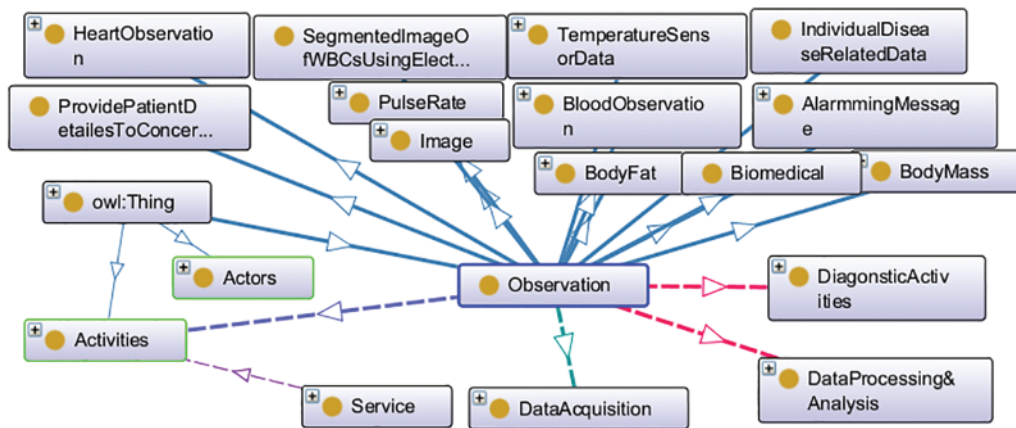


Figure 5: Taxonomy of class observation and its subclasses

### 3.2 Semantic Relations

The linking of two classes by using some predicates represents the semantic relation. An ontology represents the metadata schemas used to integrate different services under one system. These semantic relations form with the help of vocabulary. The following Fig. 6 illustrates the Object property relations between other individuals and different concepts.

In Tab. 1, semantic relations concerning Fig. 6 are discussed in detail with the domain range of each reference concerning object property by mentioning semantic relations.

Following relations have been created in the knowledge model by defining object properties between the classes and explaining the domain range between the types.

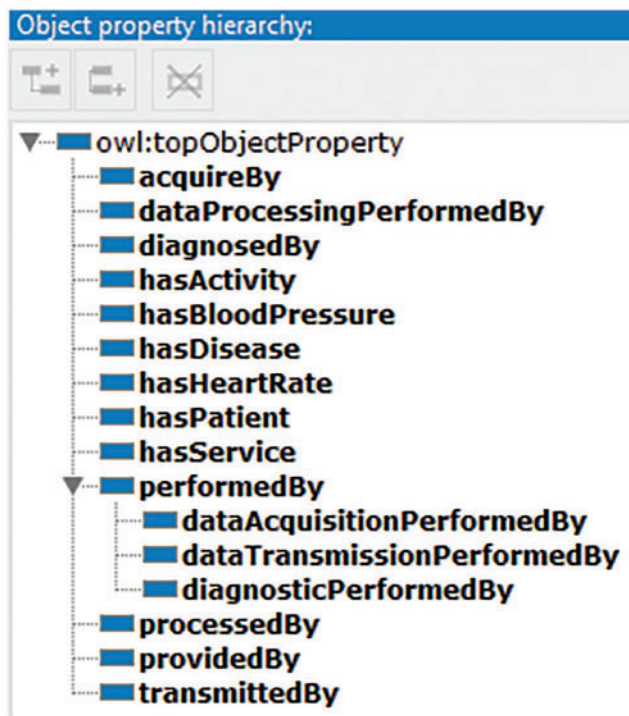


Figure 6: Object property hierarchy

Table 1: Semantic relations between class

Semantic relations between classes	Object property	Domain	Range
Observation acquire by data acquisition	Acquire by	Observation	Data acquisition
Disease diagnosed by diagnostic activates and services	Diagnosed by	Disease	Diagnostic activates diagnostic services
Service has activities	Has activity	Service	Activities
The patient has blood pressure	Has blood pressure	Patient	Blood pressure
Patient has disease	Has disease	Patient	Disease
The patient has heart rate	Has heart rate	Patient	Heart rate
System has patient	Has patient	System	Patient
System has service	Has service	System	Service
Observation processed by diagnostic activities and data processing and analysis	Processed by	Observation	Diagnostic activities and data processing and analysis
Service provided by system	Provided by	Service	System
Observation transmitted by activities	Transmitted by	Observation	Activities
Observation performed by activities	Performed by	Observation	Activities
Observation data processing performed by activities	Data processing performed by	Data processing & analysis	Data processing unit
Observation Data Acquisition Performed By activities	Data acquisition performed by	Data Acquisition	Machine person

(Continued)

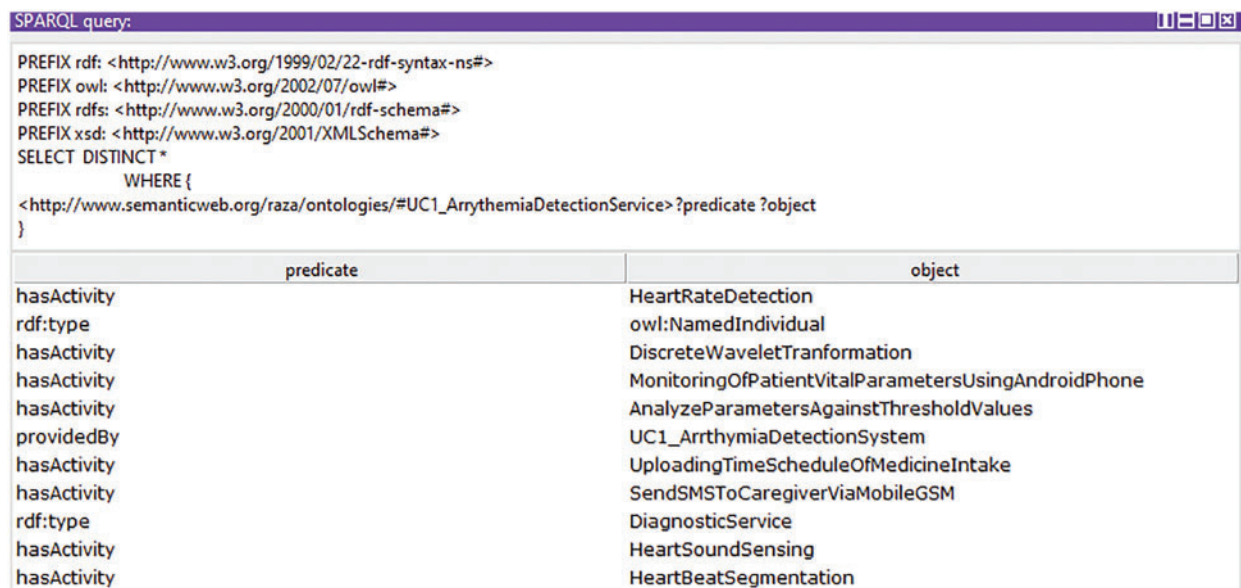
**Table 1:** Continued

Semantic relations between classes	Object property	Domain	Range
Observation data transmission performed by activities	Data transmission performed by	Data acquisition	Machine person
Observation diagnostic performed by activities	Diagnostic performed by	Diagnostic activities	Doctor data processing unit

## 4 Validation and Results

### 4.1 SPARQL Query for Validation and Retrieval

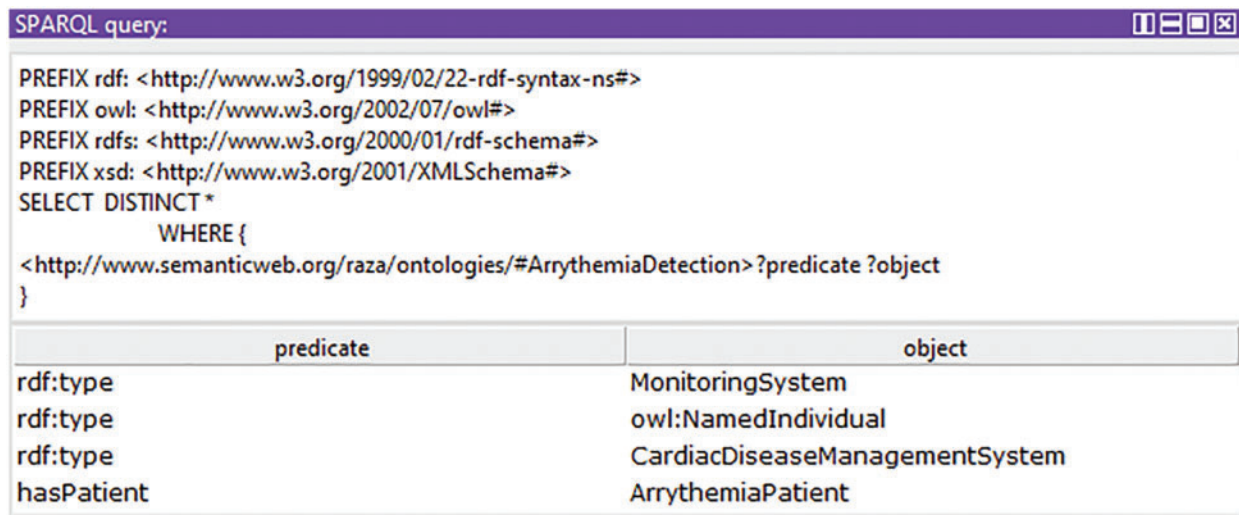
SPARQL is a query language like SQL, which is used with knowledge engineering and knowledge modelling to query data over different RDF triple stores and simultaneously with the ontology itself. It is also used for validation and query ontology using the SPARQL plugin via Protégé or Foskey server using Web interface because the Protégé Web interface did not support SPARQL. The basic theory is to make a query to get a reply from ontology. In Fig. 7, the SPARQL query for arrhythmia detection service is performed.



**Figure 7:** SPARQL query of arrhythmia detection service

Fig. 8 shows the query in which different properties of the arrhythmia detection system are used. This system belongs to the monitoring system and cardiac disease management system. The arrhythmia detection system has patients of type arrhythmia patient.

Fig. 9 shows the query in which the arrhythmia detection service possesses different services with corresponding object properties. The arrhythmia detection service is a diagnostic type service. It has the activity of heartbeat segmentation, SVM classification, ECG filtering and DWT.



SPARQL query:

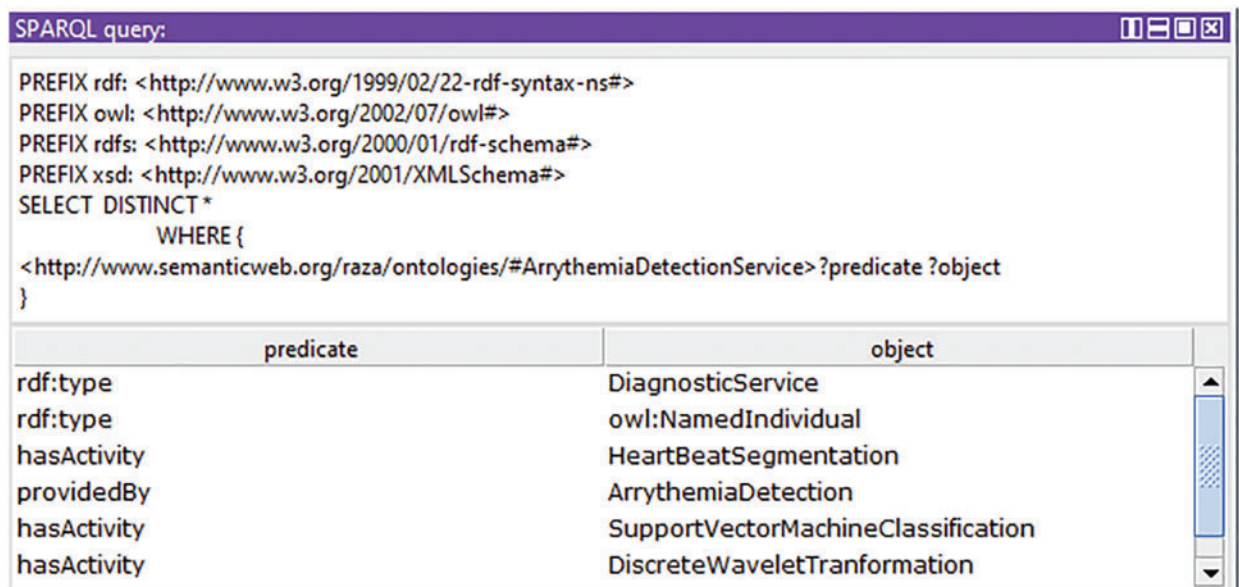
```

PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
SELECT DISTINCT *
  WHERE {
    <http://www.semanticweb.org/raza/ontologies/#ArrythmiaDetection>?predicate ?object
  }

```

predicate	object
rdf:type	MonitoringSystem
rdf:type	owl:NamedIndividual
rdf:type	CardiacDiseaseManagementSystem
hasPatient	ArrythmiaPatient

**Figure 8:** SPARQL query of arrhythmia detection



SPARQL query:

```

PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
SELECT DISTINCT *
  WHERE {
    <http://www.semanticweb.org/raza/ontologies/#ArrythmiaDetectionService>?predicate ?object
  }

```

predicate	object
rdf:type	DiagnosticService
rdf:type	owl:NamedIndividual
hasActivity	HeartBeatSegmentation
providedBy	ArrythmiaDetection
hasActivity	SupportVectorMachineClassification
hasActivity	DiscreteWaveletTranformation

**Figure 9:** SPARQL query of arrhythmia detection service

Fig. 10 shows the query in which heart disease monitoring services possess different services with corresponding object properties or data properties. It comes under the monitoring services category. A heart disease monitoring system provides a heart disease monitoring service. Heart disease monitoring service has the activity of heart rate detection, blood pressure detection and data storage on the cloud.

Fig. 11 shows the query in which ECG signals have different data or object properties. This observation is processed by ECG filtering activity. DWT and SVM Classifications Activities also process this. Heart Rate Detection Activity acquires ECG signals.



SPARQL query:

```

PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
SELECT DISTINCT *
  WHERE {
<http://www.semanticweb.org/raza/ontologies/#HeartDiseaseMonitoringService>?predicate ?object
}
    
```

predicate	object
hasActivity	HeartRateDetection
rdf:type	owl:NamedIndividual
rdf:type	MonitoringService
hasActivity	DataStorageOnCloud
hasActivity	BloodPressureDetection
providedBy	HeartDieaseMonitoring

Figure 10: SPARQL query of heart disease monitoring service

SPARQL query:

```

PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
SELECT DISTINCT *
  WHERE {
<http://www.semanticweb.org/raza/ontologies/#ECGSignals>?predicate ?object
}
    
```

predicate	object
processedBy	ECGFiltering
rdf:type	owl:NamedIndividual
processedBy	SupportVectorMachineClassification
acquireBy	HeartRateDetection
processedBy	DiscreteWaveletTranformation
rdf:type	ECG

Figure 11: SPARQL query of ECG signals



Fig. 12 shows the query in which the heart rate value has different data or object properties. The heart rate value is of type heart rate. The heart rate value is processed by analyzing parameters against threshold values activity. The heart rate value is acquired by heart rate detection. The heart rate value is also processed by DWT and heartbeat segmentation activities.

predicate	object
processedBy	AnalyzeParametersAgainstThresholdValues
rdf:type	owl:NamedIndividual
rdf:type	HeartRate
acquireBy	HeartRateDetection
processedBy	HeartBeatSegmentation
processedBy	DiscreteWaveletTranformation

Figure 12: SPARQL query of heart rate value

Fig. 13 shows the query in which the heart sound value has different data and object properties. Heart sound value belongs to the type of heart sound. Heart sound value is processed by DWT and heartbeat segmentation activities. Heart sound value is acquired by heart sound sensing activity. Analyses parameters against threshold values activity also process heart sound value.

#### 4.2 Using Reasoner for Validation

Protégé is only a tool, not an expert system, that helps researchers and ontologists to build ontologies. It uses plugins from different platforms like Pellet, Fact++, other, and Hermit to validate ontologies. Reasoner facilitates by providing proof of the ontology system that has been developed under Protégé by detecting the inconsistency between ontologies. Reasoner is often a mathematical model-based tool as it facilitates logical inferencing using a rule-based approach and semantic web rule language. Pellet Reasoner is a frequently used tool in research for validation. In our study, Pellet Reasoner is also used for verification through SPARQL work with the requirement analysis and has retrieved accordingly.

```
SPARQL query:
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
SELECT DISTINCT *
  WHERE {
    <http://www.semanticweb.org/raza/ontologies/#HeartSoundValue>?predicate ?object
  }
```

predicate	object
processedBy	DiscreteWaveletTranformation
rdf:type	owl:NamedIndividual
processedBy	AnalyzeParametersAgainstThresholdValues
acquireBy	HeartSoundSensing
processedBy	HeartBeatSegmentation
rdf:type	HeartSound

Figure 13: SPARQL query of heart sound value

## 5 Conclusion

Diverse, innovative healthcare frameworks are contemplated, giving various smart healthcare services. These services are made out of a different number of activities. These services perform explicit assignments under the particular help. For instance, a demonstrative framework has diverse recognition and observing benefits. In these services, various exercises are underlined for performing the conclusion of the patient. Discovering the shared characteristics and distinctions among the administrations of the different framework is an enormous concerning issue for astute wellbeing.

These frameworks of various medical care applications are arranged in three kinds. These services work in a disengagement way to engage clients in the explicit issue. The harmony of these well-being applications is absent. Every one of these applications deals with its stream and design. This research remembers discovering particular distinctions and shared traits for the independent utilization of IoT health care. Contingent on these shared traits and contrasts, coordinated engineering of various IoT wellbeing applications can be created. This robust design will give clients an assortment of health services applications and a variety under one system.

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