Ontology Engineering for Smart Health Insurance Policy

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Ontology Engineering for Smart Health Insurance Policy

A thesis submitted in partial fulfillment of the requirements for the
Degree of Master of Science in
Computer Science

Syed Muhammad Raza Naqvi

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DECLARATION

This thesis is a presentation of my original research work. Wherever contributions of others are involved, every effort is made to indicate this clearly, with due reference to the literature, and acknowledgement of collaborative research and discussions. I also declare that this work is the result of my own efforts, except where identified by references and free from plagiarism of the work of others.

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Thank you,

Syed Muhammad Raza Naqvi

DEDICATION

I would like to dedicate this thesis to my beloved family, teachers and friends.

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ABSTRACT

Due to immense increase in the applications of Internet of Things, our lives have immensely changed technologically. Smart health care is related to such IoT based smart devices, machines, patients, doctors, sensors on the internet. Health care has become an important social-economic concern for health care, health needs and availability, and private care for the particularly elderly class of society. There are various smart health services working on these applications are working as individual services and the need of the hour is to provide a management platform where all these services work as a single unit providing all these facilities to the users. This research focuses on Smart health care systems and proposed model for smart health care insurance policy model using Ontology engineering a knowledge based system developed for health insurance policy.

CHAPTER 1

INTRODUCTION

This chapter presents the background of the smart healthcare systems and particularly insurance policy models in health care Systems in terms of scientific research & in the wake of World Health organization.

Internet of Things is a vital progress in the recent years in ICT that connects genuine entities to internet of things (IoT). These Internet of things devices communicate via wired or wireless sensor network to gather and interchange data and information. Internet of Things has a diversity of applications involving smart healthcare, smart agriculture, smart cities, automation of manufacturing process in industries, transportation etc. Internet of Things plays a vital role when smart decision making is required. Sensors of respective functions and smart things in Internet of Things are used to collect information from different access points, which can be analyzed for better decision making. [1] In this way, smart objects in real world are utilized to unite together information to provide performance on a common basis.

1.1 Background

The terminology of IoT was first devised by Kevin Ashton in 1999. RFID groups make content based on specific communications protocols as a global network of things connected to the internet. It includes traditional systems such as Embedded Systems, Control Systems and Automation, Wireless Sensor Networks, to help Device to Device communication through the Internet. The concept was primary used at the ID center at MIT also, is vital for implementing Internet of things. [2]

IoT is now an emerging paradigm and is at the edge of renovating the existing stationary Internet into a fully incorporated Future Internet. This Internet maturity enabled to the interconnection between people at an extraordinary scale and speed.

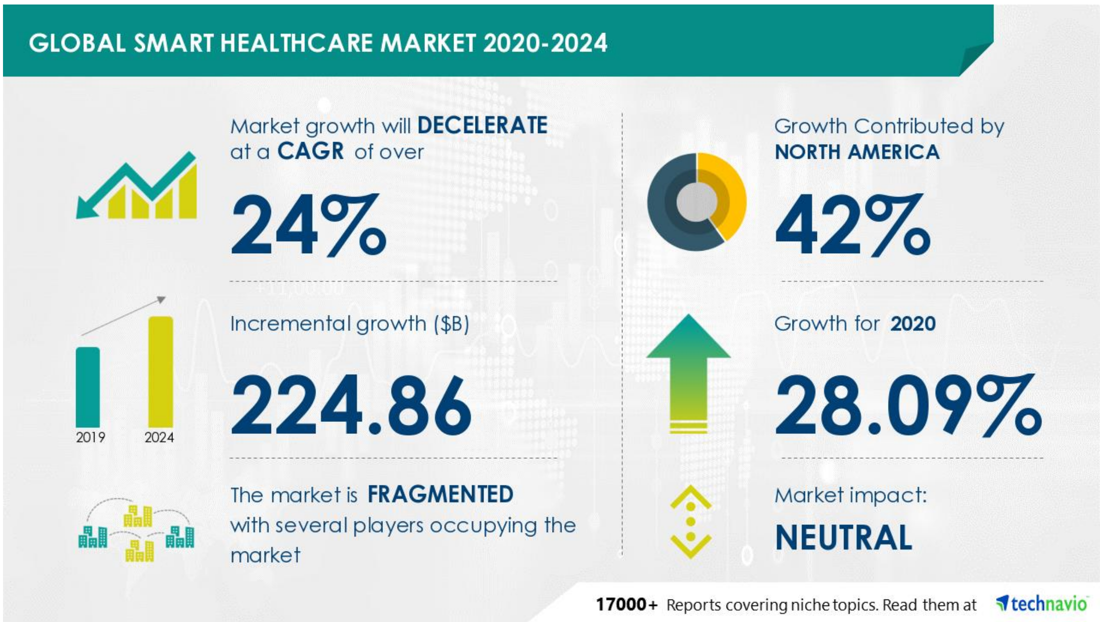


Figure 1: Smart Healthcare Industry Growth

In 2010 the number of connected devices was 12.5 billion while the total population across the globe was 6.8 billion.Connected devices are expected to reach approximately 50 billion in 2020. [3]T

here are many Health applications working in healthcare using 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. Many services that working independently in health sector with their management criteria.

1.2 Problem Statement

Nowadays, healthcare insurance policies are assigned using irrelevant methodologies that depend only on financial aspects, ignoring other important factors such as customer health, medical history and gender. These policies may impose a financial burden on the user or service provider either as government or caregiver. This traditional business model lacks several aspects that could provide better support to meet patients’ and healthcare providers' expectations. Thus, a new adaptive and technologically supported system is needed. Smart Healthcare is defined as a health services system that different wearable devices, IoT, Mobile Internet, big data, and AI to dynamically access relevant healthcare data and actively manages and responds to medical ecosystem needs intelligently. It aims at making healthcare more efficient, affordable, and Manuscript Click here to view linked References personalized. The development of effective smart he.

1.3 Research Questions

RQ1: What are the commonalities and differences among Internet of health things (IoHT)?

RQ2: How can Heath Insurance Ontology can help Smart Health Systems?

RQ3: How can Heath Insurance Ontology can help Insurance Business model for

Decision Making?

RQ4: How the Integration of different Smart Health service will be possible using ontologies?

1.4 Objectives

Our objective of this research is to advance smart health system by developing smart heath care insurance system which conveys the fast changes in smart healthcare The new system has to move from being financial-centric to being customer-centric by setting long term plans and empowering them with new technologies that will sustain and enhance people’s wellbeing and improve the overall healthcare system. The proposed approach is ontology-based based on shared patients’ medical data, building

ontology-based engine, and dynamically develop smart insurance policies to the patients.
Thesis presents two types of research. First, we conduct literature Review to discover the developments and landscapes of the smart healthcare systems and smart health care architectures and find out key areas as well domain Secondly, we also try to work on decorations and trends of smart health systems & integration work in the particular domain also ontologies that have been developed, what tools have been used and purposed Knowledge base system for insurance Policy Management System for Smart healthcare.

1.5 Significance and Contributions

Keen interest in many services integration using (IoT) is discussed by many research scholars, also states that is the it will be highest trending technology in upcoming years [4] According to International Data Corporation IoT will hit the market by a huge amount US$1.7 million by 2020. Another Company namely Gartner estimates 25 billion devices to be connected in the world by 2020.Even the Harvard Business

Review forecasts about 28 Billion smarts objects are linked to the internet [5]. Traditional Healthcare systems are rapidly moving towards the IoT smart solutions. It looks like one of the supreme conspicuous diligence drivers, in the perspective of the internet of things solicitation with health services (e-health) which in scientific community now known as Internet of health things. Internet of things in Healthcare sector is also likely to rapidly take place by 2020.

A company named Markets and Markets predicts that Internet of things in Healthcare sector will worth US$ 163.2 Billion. Business report suggests a spending of $117B on e-Health based on IoT and McKinsey predicts a visible impact of greater than US$ 170B at the market. These effects of Internet of things in Healthcare sector are seen in the form of cost savings, life standard improvement for patients with chronic disease, and real time health monitoring for elderly patients, which saves disease complications to enhance [6]. It is a fact that Internet of things in Healthcare sector will produce an immense social and economic effect in the world.

However, Integration of multiple devices also causes obstacle in carrying out of IoT in the healthcare zone. The reason behind this hindrance is that device manufacturers haven’t agreed upon standard communication protocols and architecture.

If there will be an identical and interconnected health solution it will affect the users and will assist them in more efficient way.

The Significance of our work is to create ontological model which use Reasoning Capacities using SWRL and Droll Engine that transform rapid and automated decision making in Health insurance policy System.

CHAPTER 2

LITERATURE REVIEW

Literature Review Chapter has emphasized on Internet of things and Smart Healthcare Systems how they evolve over the time and how millions of devices get connected over Internet of things. Also we identify according to our research objective to look for Health Insurance ontologies and Methods for ontology Engineering and Integration.

2.1 Smart Health Care Systems

Internet of Things is a concept of a wide network which is composed of any object (thing) that can be inserted into any location with the objective of assessing variables and directing this information through the internet to some other location for storage and/or analysis. The sensors and objects in IoT intelligently gather significant information which in the future is processed and examined for enhanced decision making. This permits the smart objects to link with each other and with the nearby networks to send calculation-based performance. Nowadays the IoT technology is largely seen in industries and commercial sectors. Every object that can be connected will be connected in the upcoming years. The interconnected divergent kinds of smart 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 smart projects i.e. smart cities projects, smart farming projects, and smart homes and this technology is also used in health care. These IoT objects that surround people should know the likes of people, needs of people and wishes, and desire of people without any explicit instruction to these devices. Other than the personal use of these devices IoT devices also serve the community needs such as aiding in surgeries, weather forecasting, identifying animals, and tracking automobiles.

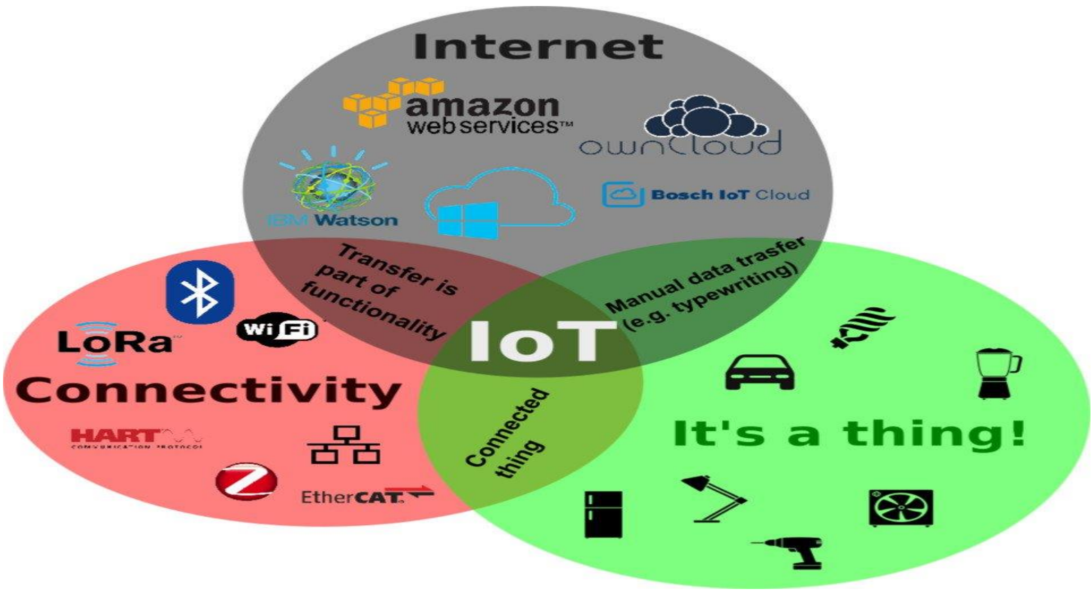


Figure 2: Definition of IoT

Hence, IoT is forming linked network of smart devices, actuators, smart phones and objects implanted with efficient little memory processors connected to the network to collect and tradeoff information to gain anticipated services.

The Internet of Things is also defined as a connected network which lets the communication between human-to-human, human-to-things and things-to-things, in which thing is everything in the universe of discourse by giving a unique IP address to each and every thing.

IoT is a perfect developing technique to positively affect the internet and communication technologies. In other words, the Internet of Things means connecting the living and nonliving things via internet. In the Internet of Things, real life things in the world are seen as objects which are then connected to the internet. [7]

The term IoT is known for nearly a decade, and many researchers and industries have been proud of our expectations for betterment of life and society. When household appliances are connected to the network, they can work together to provide the ultimate service. It is helpful for many real-world applications and services, it applies to Smart Residences, which includes services, such as air conditioner, or can be opened for aviation. It not only makes life easy for human dishabilles, but also provides many types of automatic solutions to rest in many situations.

Internet of things is making computer intelligently and efficiently sense information and process it for the desired purposes.

Probable Internet of things devices and are several and various, dividing into essentially in fields of intelligent systems and applications. Following are some fields where IoT is applicable:

IoT is used in remotely handling different electronic appliances to save energy**.** Refrigerators having display screens showing what's inside and expiry of food. Alarms are generated on the smartphones to buy the vegetables and fruits that are going to be finished soon. Smart washing machines allow monitoring the laundry from anywhere anytime, and. Kitchen ranges like microwave oven can be handled using smartphone app as well. Open-air, climate conditions like moistness, temperature, pressure, wind speed and downpour levels can be seen by IoT

IoT is also used in the field of Transportation. Using IoT smart roads can be built that warns the smart vehicles moving on the roads to avoid the travel during unwanted conditions like heavy snowfall or thunderstorms and it can also help people to avoid going to those roads where there is heavy traffic blockage. Smart Parking can also be enabled using IoT in which availability of parking spaces in the city can be monitored and the make inhabitants able to find and book the closest available spaces.

IoT in industry also plays a vital role. Explosive and Hazardous Gases can be detected using IoT enabled sensors. Gas levels and leakages can be monitored in industry. Monitoring of toxic gas and oxygen levels can help in securing the health safety for the workers in the industries. Maintenance and repair of the equipment can be made easy using IoT due to early estimation on equipment breakdowns and service safeguarding can be spontaneously planned after the actual part failure by planting sensors in the equipment's to be monitored.

Internet of Things also influences the field of agriculture. Green Houses are maintained using IoT to direct miniature environment conditions to expand the development of foods grown from the ground and improve its creation quality. Stickiness and temperature esteems are checked in various yields like horse feed, feed, straw, and so on to keep away from hurtful parasite and other bacterial toxins. Farming is also one of the subcategories of Smart Agriculture in which position and recognition of animals grazing in open location in big strings are observed. Savvy control of developing states of the youthful ones in animal ranches is done to shield its proceeded with presence and wellbeing,

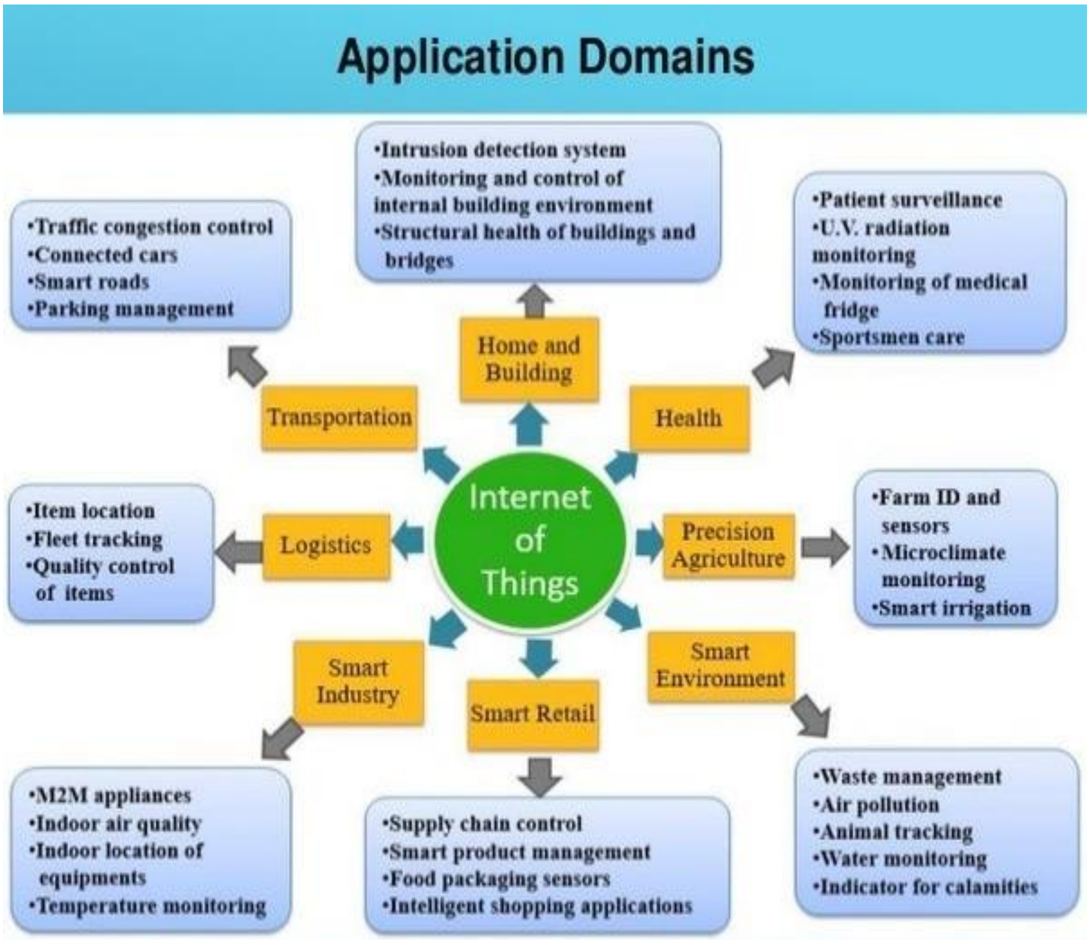


Figure 3: Applications of IoT

IoT also enables us to maintain a smart environment around us. Air Pollution monitoring can be done using IoT in which Carbon Dioxide emissions of factories can be controlled. Pollution released by vehicles and toxic gases produced in fields and factories can be detected. Forest Fire Detection can be smartly handled using IoT such as sensing of burning gases using temperature and smoke sensors. IoT anticipatory fire conditions also help to classify danger areas. Forecasting of weather can also be done in which weather situations such as speed of air, chances of rain, prediction of flood level of humidity in air are monitored. Any natural disaster can be anticipated using IoT techniques for example Earthquake Pre-detection is also possible by implanting sensors in the crust of the Earth. [8]

IoT with the increase in diverse smart applications has changed our lives. IoT enabled Healthcare is one of such a vital IoT application that links smart devices, and different stakeholders to the internet. IoT in healthcare systems has a vital role in serving comfort to doctors and patients. The input data from patients can be gathered with the help of sensors.

This data is processed by applications made for a user terminal, such as computers, smart phones or even a particular embedded device. Such kind of solution empowers sensors to gather detailed bodily information and make use of cloud to examine and store the data and then transmits the processed sensor's data to cloud storage and analyze data interoperable to caregivers for further review. Powerful wireless solutions linked with the IoT. These type of application assists in monitoring the person suffering from chronic disease.

Figure 4: Iot Healthcare

For especially people living in rural side IoT healthcare can be of much assistance as they do not have adequate medical services present there. For the reason that they have to take a trip of miles to visit the doctor, they may start overlooking their health issues. Remotely personal monitoring of the patients lessens reliance on the doctors, 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 emergency situations. Medical expert can also help in the hours of need as much as possible.

The revolution of healthcare, progressing from conventional health management to supplementary custom-made smart healthcare systems, benefits the personal health.

This section describes an overview of the previously done work in the domain of IOT health. This section is categorized in to three parts as disease, Service and res

A. Disease centered IOHT applications.
B. Service centered IOHT applications.
C. Resource centered IOHT applications.

2.1.1 Disease centered IOHT applications

2.1.1.1 Concurrent Heart Attack Mobile Recognition Service

Mobile Edge Computing (MEC) is an advanced architecture that uses cloud computing and mobile networking specifically for less non-functionality of applications [9]. Software-based Network (SDN) is a development groundwater model for network-driven programming, which ensures broad network flexibility and significantly saving costs. The SDN does not make restrictions on the physical structure, but for a specific extent it can be programmed in an application. [10].This means it is established on the supposition that a notable fraction of vehicles will work on IoT based system embed with sensors retaining the prospective of direct real-time communication to other nodes in the network.

Trustworthy testing, road traffic safety and monitoring, and better social connectivity are some of the features of the system. For organization such networks, VANET (Vehicular Ad hoc Network) framework is introduced [11]. VANET is a framework in which smart cars are shown as mobile car nodes in the vehicle's network. This framework is not only used for communication between two vehicles, but also for communication with road-driven units (RSU) and smart vehicles.

Cardiovascular disease is such a chronic illness that is one of the world's most important health problems and is an important cause of death throughout the world.

A Cardiac Auscultation Monitoring system is introduced in which heart sound sensing is done. After obtaining the heartbeat of the patients it is processed. The heart beat segmentation is done which removes the noise from the heart sound. After the heartbeat segmentation is performed to check out the irregularities in the heat sound of the patient. If any irregularities are observed by the medical expert, then a caution message is generated and patient’s heart condition report is sent to the caregivers or doctor for further examination. Bluetooth technology is used for efficient data transmission.

The heart sound data is communicated wirelessly to an Android smartphone for visual display.It is very effective way to monitor the heart disease of elderly patients living alone in a home. [5] This can help in looking after the patients by just considering their heart sound

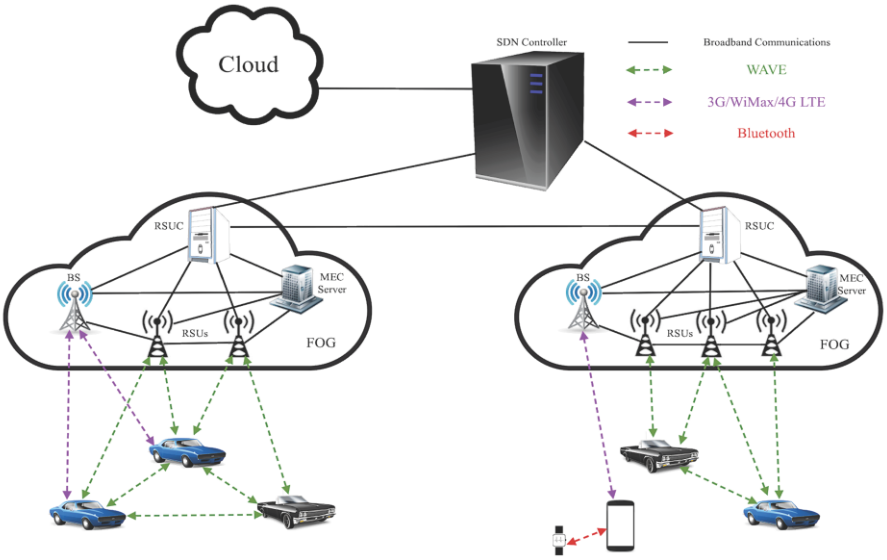


Figure 5: Vehicular Adhoc network(VANET)

.A proficient algorithm for heart attack detection is devised. This system makes use of Data mining technique namely fuzzy c-means. This method works on a mathematical model, which helps to detect minutes of heart attacks before using the fuzzy c-means clustering algorithms. This mathematical model that is being used will foretell unexpected heart attacks in human beings.

This algorithm helps in locating the symptoms of heart attack threats. The fuzzy c-means aids in classifying clusters for precise exposure of probabilities of heart attack to occur. The precision of the result is 82% which is fairly proficient in comparison with present day methods. [12]. Elderly patients can be marked safe if ECG signal patterns are processed in time and action is taken whenever there seems to be any problem in the ECG signal. Heart disorder risk prediction is more important than detection. A system containing a connected sensor is presented which can store heart rate and body temperature. Using the Bluetooth Communication Module, this system collects ECG and body temperature data using a smartphone in the normal environment. This study provides use of ECG signal processing and analysis.

This system also uses machine learning methods for evaluating sensor data for heart attacks and predicts heart attack. This system is useful 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. [13]

2.1.1.2 Chronic Metabolic Disorders

HEALTHIOT 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 who are going through house dialysis. In this proposed system, different vital organic and bodily parameters are provided to the doctor in near-real-time.

Along with biological and physical parameters patient's post processed information is also provided to the doctor so that that medical diagnosis can be done more speedily. IT provides bi-directional communication that means doctor can contact patient and patient can contact doctor whenever required. In this way patient's medical history can be communicated and transmitted between a diversity of medical experts for consultancy.

The purpose of this objective is to include multiple IOT devices for monitoring health care through extracting various basic low-level technologies. It also interferes between diverse devices and offers that access the patient's data to the general data. In addition, a micro-service perspective, which allows HEALTHIOT to be deployed in the cloud system, has been added.

HEALTHIOT works on the layered approach. HEALTHIOT comprises of four layers: Technology Integration Layer, Middleware Layer, Services Layer and Application Layer.

To analyze the patient's health condition, HEALTHIOT uses the disease manager, which applies and regulates various rules after processing data. Such laws have been developed under the instructions of the doctors and these rules should change according to each patient's individual health records. [1]

Diabetes is one of the major chronic diseases which is effecting a number of people around the globe. [14]

A novel framework based on Internet of thigs has been presented for the blood glucose level test in the body. This system has a non-obtrusive Glucometer, a show framework that makes use of an Arduino microcontroller and mobile application(android) [15]. This system makes use of operational intensifiers, an IR LED, a photodiode and LCD Display. Glucose estimation kit and circuit has been accumulated and an application was expected to show the results. In addition, patients are given the results in the user friendly form which is displayed on the mobile phone having an android application of this regard. By monitoring glucose reading, the patient's current condition can be seen. If there is a need for a doctor, caregiver or a relative support, an alarm is generated.

Glucometer with IoT is presented [16] as 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, specific dimension is used by glucose spectroscopy.

A reflective optical sensor is used with finger as a body space for communication and reactions of near infrared (noise) rays. As light transmits the infrared sensor, it will fall on the finger. The reflected light is altered into electrical energy by photo detector and by reflectance spectroscopy. These signal conditioning parts include filters and amplifiers. It is put into the microcontroller for signal modulation. To obtain blood glucose level readings in the body, fingertip is in positioned between NIR light source and NIR image detector.

2.1.1.3 ECG Application

The patient who wears an ECG sensor is accountable for collection of real-time ECG data. The patient's mobile device is another part of the same actor. The ECG data scanned by ECG sensor has been transferred to a nearby mobile device through personal area network communication.

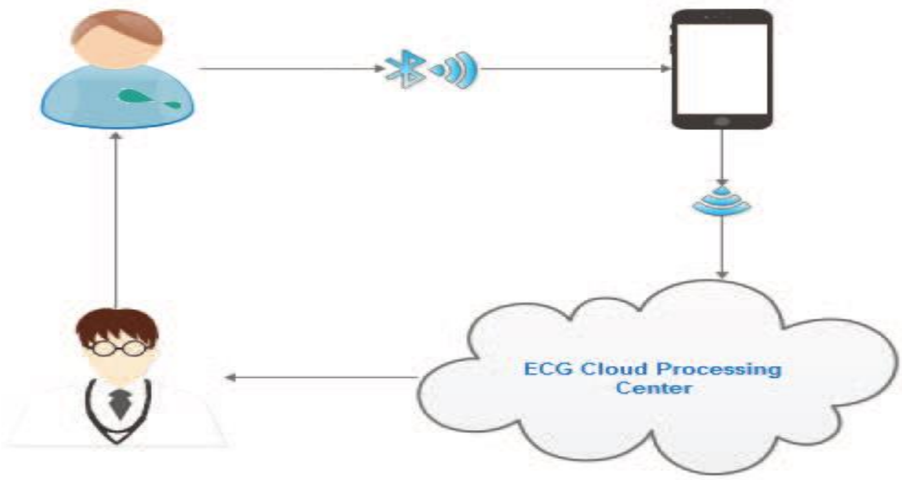


Figure 6: ECG basic flow

Mobile device is responsible for receiving and initial processing of ECG signals. In this particular system the mobile app is responsible for receiving and starting the processing of ecg signals. This device supports ECG signals received as another segment in the EGG Cloud Processing Center. And the other actor is a medical staff who will see the patient's ECG in case of any medical problem. [17]

A procedure for ECG is given for heart disease analysis and processing. This is a diagnostic activity will be helpful for the diagnosis of this particular disease and is based on IoT embedded system. These algorithms suggest a wearable ECG analytic instrument, reasonable for 24 hours constant observing of the patient. Discrete Wavelet Transformation is used for the ECG signal preparing and investigation, and a Support Vector Machine (SVM) classifier for eliminating the commotion in the ECG signal. The best classification accuracy gained after experimentation 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. [18]

2.1.1.4 Smart Asthma Patients care using IoT

A respiratory observing system is developed. According to this system, respiratory rate is estimated on value of temperature. The LM35 temperature sensor is utilized. The respiratory rate is estimated by using LM35 temperature sensor and is observed by the patient’s respiration constantly based on rate of inhaled and exhaled air. These sensors sense the temperature value in near real-time by making use of Arduino microcontroller. NRF24l01 is utilized to communicate the sensor’s data from home to nearby medical center. Then the data is circulated in a webserver by Ethernet wired connection to know the patient’s present condition that is valuable for doctor. And also the data is displayed on a Liquid Crystal Display (LCD) monitor. If any unusual condition is observed, an alarm is initiated and generated showing an emergency alarm message in 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. With the help of this system timely disease detection of patient is possible. [19]

According to a study released by National Health Interview Survey in 2014، 6.3 million children in the United States are almost affected by Asthma.This system is used to check the air saturation so that system can be able to detect smoking and burning events. For this the detection of the concentration of mental matter, carbon dioxide and stable organic compounds should be observed. [20]

2.1.2 Service based IOT Applications

Different monitoring services for different purposes concerning various diseases

2.1.2.1 Monitoring of Patients

For providing a harmless and safe healthy living to the elderly in a smart home, a set of various sensors, ensuring behavioral and environmental conditions, this information is employed additionally to the health devices, used for necessary sign measurement. The configuration and setup of these devices are locatable by a web application designed for particular persons. All the collected information is assembled in a perfectly clear manner by the IoT base coordinated in the home and put away safely in a cloud-based framework, where they are inspected. The aftereffect of the investigation is served to the formal and casual guardians, to give them a choice emotionally supportive network. This aides for the conveyance of a protected environmental factors for older patients. It additionally recommend an advantageous method to set up and test the fixed gear and a choice emotionally supportive network that enables the examination of information which a while later is introduced to the formal and casual parental figures of the older for the compelling observing of their wellbeing and movement status. [21]

Checking constant sickness at home utilizing associated gadgets is conceivable. The point is to screen patients during their everyday life schedule, to save and gather information continually. This sort of checking needs to manage three angles: people, climate and sensors. The center is to gain proficiency with the various relations and connections existing between factors coming from those perspectives. A significant piece of this work contemplates the individual's enthusiastic perspective (stress, bliss, pity) and thinks of them as utilizing the appropriate computerized reasoning devices.

Stress is the main feeling for this framework. It can prompt cardiovascular sicknesses, particularly on account of an ongoing pressure. This response creates both uneasiness and sorrow. It expands pulse and in the long run cardiovascular infection can happen. Having the option to distinguish individual's feeling, group it and dissect its impact on cardiovascular infection, is the target of this framework. This framework screens constant illness patients as well as sound individuals living in a similar climate. [22]

People suffering from chronic diseases need to monitor the vital signs intermittently. An actual medical attendant may miss checking any of patients in the clinic which may bring about wellbeing loss of patient. An ongoing checking crucial indications of a patient is introduced utilizing wearable sensors. Without medical caretaker's assistance, patient knows about the fundamental signs from the sensors and the framework put away the sensor esteem as composed report. These applications produce huge measure of information. This applicable information from the sensor is mined through information mining methods and from this model patient consequently know the indispensable signs information be solid or undesirable. By utilizing information mining draws near, the framework is prepared for fundamental sign information. Patients give their content archive to the framework which thusly they know their wellbeing status with no individual's actual help. This framework ensures that high danger patients are opportune checked and observed occasionally. By utilizing this model, cost is diminished and patients are very much aware of their condition without anyone else without the guide of the medical caretaker. [4]

Pulse Variability (HRV) is a proportion of variety in the time stretch between successive heart beats. Observing of HRV boundaries can assist us with recognizing pre-event of any infection. An ease and effective Remote HRV Monitoring System dependent on the Internet of Things (IoT) innovation for negligible Hypertensive patients is introduced. In this framework, HRV boundaries are acquired utilizing Wireless Zigbee based heartbeat sensor. Arduino moves patient's information to worker utilizing Message Queuing Telemetry Transport (MQTT) convention. The application worker assembles HRV information and plots charts. If there should be an occurrence of a crisis circumstance, the overseer and specialist are reached through Short Message Service (SMS) for giving appropriate clinical assistance. This framework consolidates the double advantages of Zigbee and WiFi innovation. By this, it effectively satisfies every one of the necessities of a far off wellbeing checking framework regarding ease, long reach, security, adequacy and simple to-utilize that serves in saving lives. The framework effectively attempts to screen and give discernments concerning hypertension state of the patients. [6]

A real time remote patient observing and examination using Raspberry Pi 3 is introduced. Raspberry Pi is small sized single board computer that have ARM11 microprocessor working with LINUX operating system. Python language is used in Raspberry Pi for programming it. The system consists of sensors to obtain the physical parameters from the patient’s body and transfer it wirelessly to the web that can be opened by any medical professional across the Globe for diagnosis. Different parameters are maintained in the database and the attained parameters are managed in Pi and it originates a message if there is any irregularity in the parameters. Making use of this technique the patient at home can measure temperature, blood pressure, heart beats and ECG and can send those parameters wirelessly to the web. The medical experts can observe and make recommendations if there is any variation in the parameters. This lessens the cost and time of the patients.

A recovery assistance system has been presented that monitors human's body postures and provides a stress map when the body parts are on the horizontal plane. A cushion shaped sample is implemented to gather data from pressure sensors and then microcontroller make it possible to communicate live with the physician. This prototype is aimed to accomplish different needs, from evaluating an accurate human seat to assess the position to lie on the bed at the time of sleeping. Due to modular design and Wi-Fi availability for connection, this system becomes a low cost and effective model.

2.1.2.2 Remote Prescription and Telemedicine

For monitoring the physical condition of elderly patients, also, to keep them healthy, these two everyday tasks are necessary i.e. near real-time monitoring or predicting critical events. Also inspecting if they are taking scheduled medication according to their prescribed treatment or not, and monitoring if they are taking their recommended medicine on time or not.

An Internet of Things (IoT) based healthcare monitoring system that gathers the medicinal data of a patient is presented. This not only ensures the patient's prescription details but also collects user's health condition data and sends warnings to the doctor concerning his complete health record, serving a consistent and efficient smart healthcare service. With the help of this system the time of both doctor and patient are saved.

Real Time Clock, RFID and sensors tags, that are associated to the raspberry Pi. Readings from the sensors are received by raspberry Pi and it can also be shown on monitor. If the patient's irregular heart condition is not improved in a specific time interval an alarm will send a message using SMS service to the doctor [23].This medication box is of a high technology and it operates on wireless transmission units, I-Med-Box is a trained medicine examiner, which monitors daily intake of medicines of patients. A reader of 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 i-Med-Box 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, as well as other sensors/devices can be attached to iMedBox by different wireless technologies. [24]

If the patients do not take their medicines regularly then they may suffer from the diseases more potentially. There are some diseases like Blood Pressure, if not cured with medicines, can become a cause of heart attack. Chronic disease like osteoporosis cannot be cured by taking medicine once, if patients do not take medicines on regular basis and this might become harmful for the patient's health. So, this issue needs to be addressed. For this purpose, a smart pill box is introduced to help patient follow their medicine intake as directed by the specialist. First of all, the smart pill box is connected to the Internet by Wi-Fi. After this a mobile application is launched for the patient and caregivers in order to check whether patient has taken hi daily dose of medicine or not.

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 ought to be taken and for this reason to be satisfied the update and cautions are created. At the point 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 to take the medication. On the off chance that the patient takes their medication effectively, the framework doesn't impel the alarm work once more. The framework will regularly record the time and change the prescriptions' state. Then again, if 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, on the off chance that weight change is identified, the framework will record this weight and change the status as pill taken.[25]

Architecture for the telemedicine of diabetes management, namely, Saleem is proposed. This exhibits to collect behavioral and response of patients with diabetes. This information is examined and refined to be presented to all the stakeholders who are involved. 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 which can predict medicines depending upon behavioral data obtained randomly by different users. Using this system user may record their eating habits and other attributes. All stored information is maintained and examined in order to display and make suggestions to the doctors and patients. [26]

2.1.3 Resource based IOT Applications

2.1.3.1 Hospitalized Patient Monitoring

Bedridden patients who are under the intense care whether at the hospital or at home and required to be checked very carefully. Solution based on IoT devices are devised, which help us to save the costs of physical monitors providing some Internet connected services. This work describes the integration of Internet of Things (IoT) paradigms and resource ecosystems with a personalized Cloud-oriented device-based environment, by aiming on an e-Health scenario, highlighting monitoring and early treatment of hospitalized patients, by concentrating on Cloud-enabled event detection joined with synchronized reaction. [27]

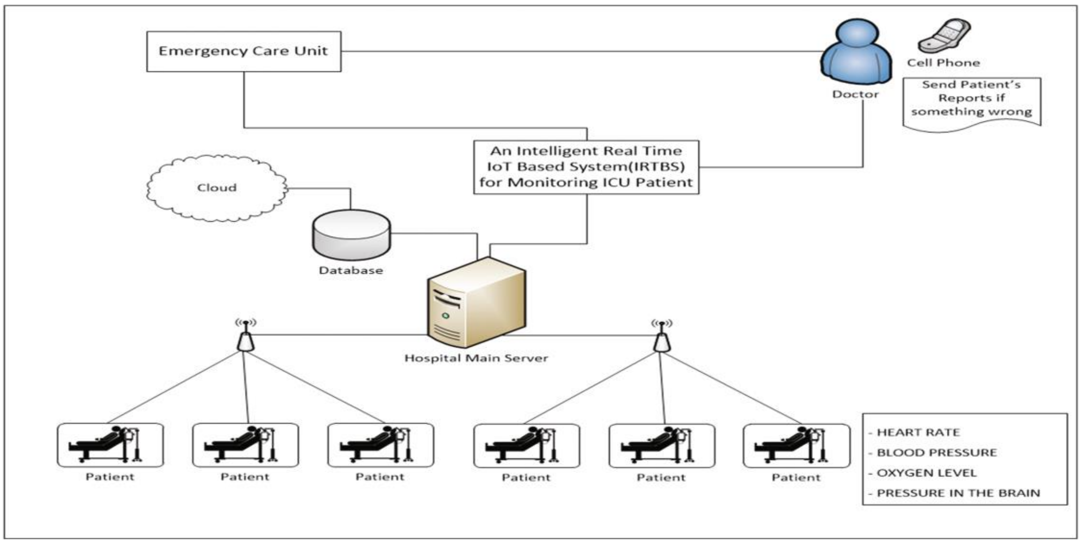


Figure 7: ICU patients monitoring

An IOT-based ICU monitoring system is presented, which can help identify emergency communication and emergency situation and start communication with medical staff and it is also active and quick treatment. In this way help gets started in no time without any delay. [28] This healthcare system remembers the possibility of delay in human errors and communication. At the same time, the doctor also helps to spend more time with the right facts and figures of this subject.

In healthcare, Critical patient are admitted to be treated in Intensive Care Unit. Due to serious condition of patient, health physicians need to continuously monitor the patient. For taking on spot data of residing patient bedside monitors are used. Bedside monitors constantly communicate patient's data i.e. Heart Rate, Blood Pressure, Oxygen Level, Pressure in Brain etc. to local server for the examining purposes. This system makes use of an intelligent real time monitoring system which analyzes the human body parameters. For the purpose of monitoring the bed continuously, patient's data, such as heart rate, blood pressure, oxygen level, brain pressure, etc. for local servers are constantly observed.

2.1.3.2 Internet of Things (IoT) in Smart Ambulance

Patient monitoring and organization of mobile rescue setups can provide noteworthy value in sinking time of patient's recovery and functioning expenditures. Before the introduction of smart ambulance when medical teams were inefficiently interacted, they were effectually aiding in an isolated system not able to connect with the hospital administrative staff.

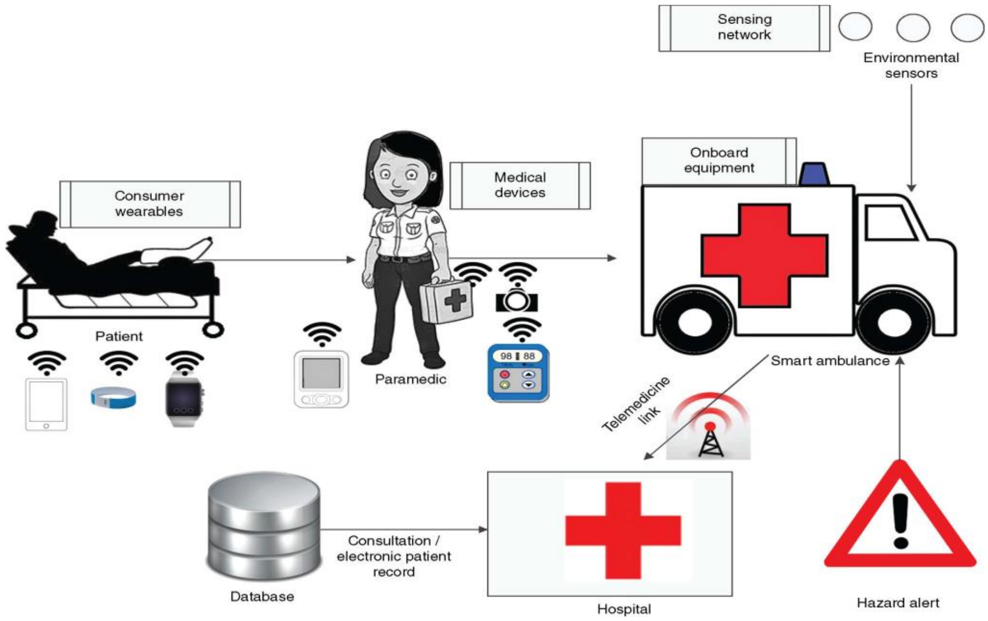


Figure 8: Smart Ambulance

IoT sensing networks assist devising a solution of managing hazard response within an ambulance setting. This makes use of the bio sensing networks for observing and analyzing the physical and vital signs of the patient. Obtaining patient data and incorporating ecological sensing into the ambulance setting can improve on-scene medical rescue as well as reduces patient's recovery time because of in-time response. It will strengthen the use of traditional wireless sensor networks to monitor the patient and also increase the performance of the Emergency Support System. Before the introduction of smart ambulance when paramedics were inefficiently interacted, they were effectually aiding in a closed system unable to connect with the hospital network.

This System is interconnected to other networks of the equipment connected by health devices, sensors, and different parameters required by the smart ambulance and reach the patients' health devices. [29][30] The actual treatment starts when the patient reaches the hospital but in this so much time is wasted and the patient may lose his life.

To stop this incident this framework investigates essential wellbeing boundaries of the patient like pulse, pulse, 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 pre-activity season of doctor guaranteeing to save the patient's life.

2.2 Ontologies for Smart Health Care Insurance System

The vital worry in this exploration is the medical care protection plan of action and ontologies created in the specific space. This part will talk about the current medical care protection plans of action and a depiction of things to come protection plans of action. To characterize medical services protection as referenced in it is an agreement that requires the wellbeing back up plan to pay a few or the entirety of the medical care costs in return for a charge.

Abbas et el. anticipated a cloud-driven protection suggestion framework. The framework is a client driven that suggest the reasonable health care coverage plan relies upon the come in patient data. It looks after the strategy value, approach inclusion advantages, and quality assigns while choosing the client strategy. This framework proposed a normalized medical care protection metaphysics addressing the basic medical care protection strategies and relate XML recovery on utilizing tree coordinating to coordinate between the coming information and the cosmology. [31].

Hedman et al Model works as “Plan of action as characterized in "it depicts the social of how an association makes, conveys and catches esteem" [32].

Authors demonstrate the working of owl Marketing model in detail. It contains concept base tool carrying classes properties and logic of their business [33].

Authors in this paper describes four connected parts of customer as beneficiary its benefits method their customer centered advantages and life cycle [34].

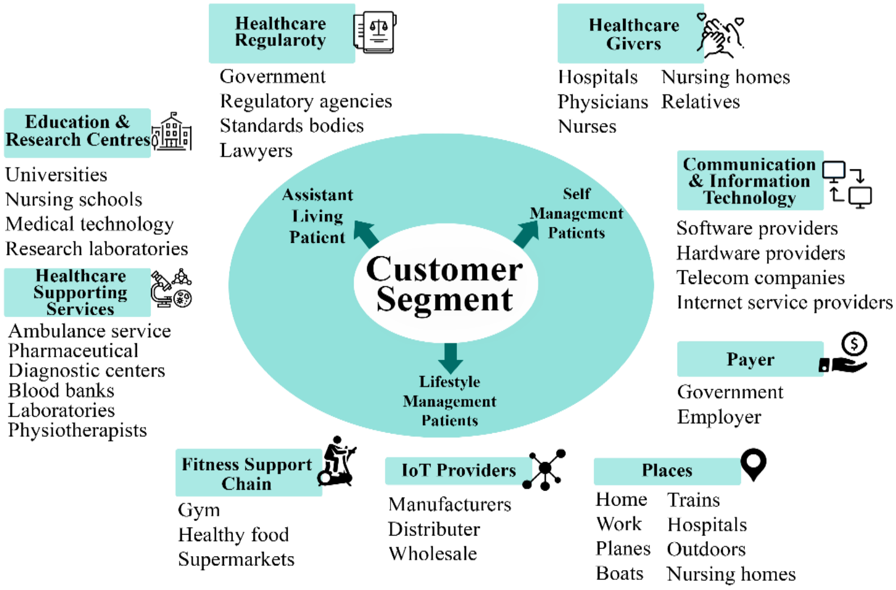


Figure 9: Client Sections and Key Accomplices of Customer Segment

The association ought to distinguish a solid client incentive considering high client worth and lower cost. The benefit recipe is the diagram of the client offer. It characterizes how an association makes the estimation of itself while offering some incentive to its client. Underlying work is the key factor of resource to make the plan to work and meet its objective goals and targets also to the association who wants to achieve certain targets

Their plan is to work on characteristic model to work all around that help the model to work on key factors and merger with the structure of the segments as client sections, incentive, channels, client connections, income transfers, distinct advantages, key exercises, key accomplices and cost structure. [35].

The achievement of an association plan of action relies upon the lucidity of distinguishing these parts The basic current health care coverage plans of action (plans) as referenced in incorporate Reimbursement plan - A kind of clinical arrangement [36].

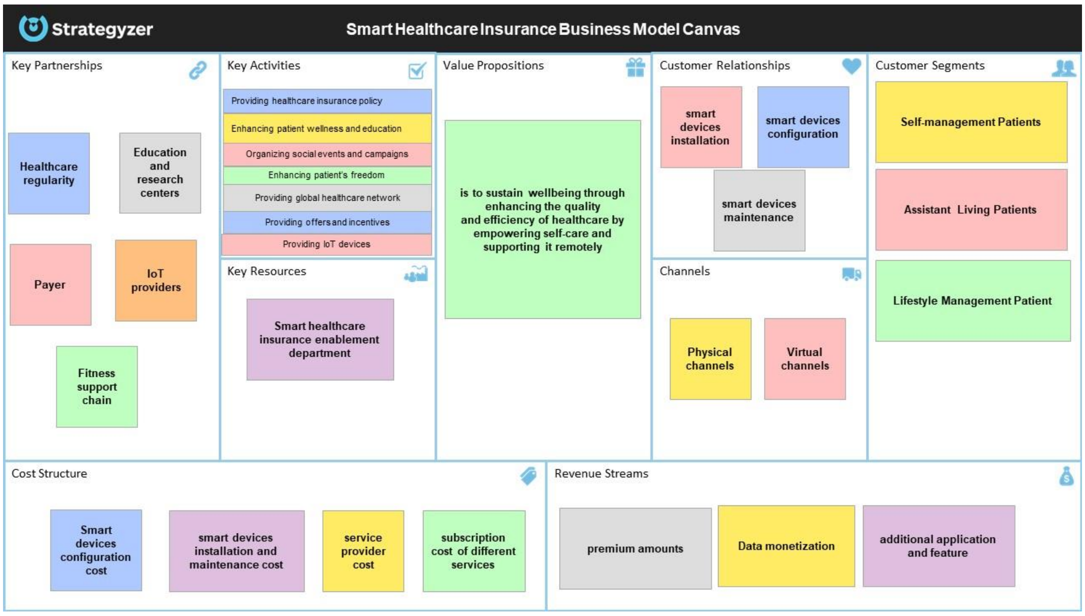


Figure 10: The Inventive Brilliant Medical Care Protection Plan of action Material

Shrewd medical services engineering is a fundamental element of understanding medical care necessities and the framework in general activity [37]. In the accompanying, we will introduce the present status of the craftsmanship design in brilliant medical services.

A cloud-based protection plan suggestion framework proposed by Abbas et al. [38] The framework was client driven that suggested an appropriate medical coverage plan contingent upon the entered patient data. It considered the strategy value, the approach inclusion advantages, and quality assigns while choosing the client strategy. This framework proposed a normalized medical services protection philosophy addressing regular medical care protection arrangements and applied a XML recovery approach utilizing tree coordinating to coordinate with the entered information and the cosmology.

Sahi et al. [39] proposed a keen medical services design comprising of three fundamental layers: Remote Body Territory Organization (WBAN) to gather the patient crucial signs subtleties, the organization layer, and the principle workers to stores medical care data.

Mukhtar et al. [40] proposed a savvy medical services engineering, "haze of things", that consolidated

Authors. [41] create a cloud-driven home climate engineering. It comprised of four layers.

Bansal and Bani [42] proposed a shrewd medical services design that comprised of five parts. The principal part was the body territory organization (Boycott) that gathered patient's essential signs and sent them utilizing the association layer to the subsequent segment, the IoT-based sheets.

Rahmani et al. [45] proposed brilliant medical care design that varied of the past work by updating a haze processing structure's as a moderator between the savvy gadgets and cloud. Additionally, comprised a distant, rationale guardians' stations. Manogaran et al. [46] proposed a comparative keen medical services design that comprised of a mist processing layer between the shrewd gadgets and the cloud. This exploration is based upon work by [47].

2.3 Ontology/Knowledge Engineering

As a branch of philosophy, Ontology is a science to find what is, what kinds and to find the structures of the objects, events, properties, processes and relations in all aspects of reality. Ontology is mostly used by philosophers as an alternative of metaphysics (as a label that literally meaning: "what comes after physics") [48].

This term is used by the Aristotle's early students to refer Aristotle's called "first philosophy" [49]. Word "ontology" could be used in broader sense sometimes, to refer to "metaphysics", study that might exist with the various other possible alternatives of true reality.

In 1721 Ontology word was first recorded by the Oxford Dictionary in English that defines ontology as "an Account of being in the Abstract" [50]. In computer science ontology is a formal categorization of properties, processes and concepts and relations between the concepts.

The ontologies were first developed by Artificial Intelligence researchers [51]. The use of ontologies is to provide machine-process able semantics so that it can be shared among several other software and tools. Ontology is a formal explicit specification of a shared conceptualization. Explicit means that it is represented in machine-readable form with its classes, attributes, and relationships. The word conceptualization refers to an abstract model of the real-world phenomenon [52].

They can be logically reasoned and they can also be shared within a domain [53]. The word shared refers to the concept that they capture consensual knowledge. So, it is accepted by the community or a group and is not restricted to an individual. Therefore, using ontologies, we can formally represent the concepts of a particular domain and also allow automated reasoning among those concepts. The ontologies provide facilitation in the development of domain model in knowledge engineering process. And because ontologies represent consensual knowledge of a domain, often their development is a cooperative work which involves several people from heterogeneous locations.

Some types of ontologies as identified by Guarino [54] are domain ontologies that represent knowledge related to a particular domain, metadata ontologies that represent description of online information sources. Representational ontologies only define objects and entities to represent knowledge and concepts but do not state what to represent. Generic ontologies provide general knowledge of basic concepts around the world so they can be applied in multiple domains. Task ontologies provide terms related to a specific task and method ontologies provide terms for methods and they also provide reasoning support. Because ontologies are shared concepts, therefore, research is also focused on building technology for reuse of these ontologies, worldwide.

WordNet is an online ontology developed by Princeton University and contains 100,000 words meanings in categories of nouns, verbs, adverbs, adjective and function words and a relationship among these words. These relationships can be based on similarity, differentiation, hierarchies, part-of and morphological relationships. Features of WordNet include its huge size and domain independence [55].

But unfortunately, it did not provide a formal semantic representation of those terms and concepts and thus cannot provide automated reasoning. CYC was developed [56] so that the common-sense knowledge can be processed by computer programs. The main barrier in Artificial Intelligence was lack of this common-sense knowledge and reasoning. Therefore, CYC ontology provided formal and executable semantics. There are several other variations of ontologies developed and made available online. The ontologies have also been used in requirements engineering for solving several problems like specifying more accurate and unambiguous requirements, managing requirements knowledge, automating the generation of test cases, domain modeling, and so on [57], [58].

2.4 Ontology Integration and Merging

There is an ever-increasing demand for efficient, automatic, and scalable ontology merging tools for semantic web applications belonging to diverse domains. Although numerous merging tools have been developed so far, still there is a lack of either scalability, customizability, or consistency.

However, CoMerger [59] is a wide-ranging tool that fulfills the standards of compatibility, multiple ontology merging, quality assessment of merged ontology, and inconsistency handling of the result. The overall architecture of the CoMerger is divided into user level and system level. The user-level facilitates the interaction between the users and the tool through a useable interface, whereas, the system level deals with inter-components communication. For a smooth execution, the user needs to input the mappings and their corresponding mappings. Next, the user can select a relevant Generic Merger Requirement (GMR). At this point, the compatibility checker component ensures and determines that all the requirements are met. Followed by suggestions of a compatible subset of GMR. Next, the source ontologies and their mappings are parsed to generate a merged ontology. Subsequently, the merged ontology is evaluated against the user-selected evaluation aspects or via a separate interface.

Among the four significant components of the CoMerger tools are its ability to verify the GMRs that can be met concurrently, merger the source ontologies based on the respective mappings, the evaluator that confirms the quality and correctness of the merged ontology, and the consistency checker that suggests modifications to turn inconsistent amalgamated ontology into a steady one. This disseminated nature of ontology improvement has prompted a connexion between several domains.

Natalya [60] established a set of semi-automatic ontology merging tools that contains iPrompt and AnchorPrompt. iPrompt provides suggestions to the user throughout the merging process based on the decisions in the prior list on the interior structure and the positions in the ontology regardless of their syntax. A successful iteration of iPrompt requires the users to choose from one of the iPrompt's suggestions to stipulate the desired operation.

Next, the iPrompt run the selected operation followed by providing suggestions in case of conflicts. Since iPrompt deals with only the classes and slots that are direct to the input ontology. AnchorPoint deals with ontologies in the non-local context by utilizing simple methods. To achieve the purpose, AnchorPoint analyses the pair of source ontologies traverses the path between the pairs and generates a new pair of semantically close terms. In this way, AnchorPoint suggests a large number of terms that are likely to be semantically analogous. Thus, the tools ultimately allow the users to formulate new ontologies and reuse the previous ones by finding mappings between them and merging accordingly.

Formal idea investigation (FCA) gives a hypothetical setting to getting sorted out, considering, and imagining information, to make further sensible information. M. Priya et al. [61] handled the issue of inefficiency and lack of handling large context in the previous merging methodologies by formulating a pseudo-intent system. The input section accepts any two ontologies as a contribution from either homogenous space or heterogeneous area.

There is no limitation on the kind of philosophy. The proposed system is built using a back-tracking-based FCA-Merger that is capable of merging the desired two ontologies by completing four stages. In the first stage, the decision tree and FCA-Merge are incorporated for the selection of a suitable attribute. Following this, the obtained attributes are saved in a linked list similar to the state-of-the-art framework. Next, the backtracking technique is used to select the perfect relationship between the previous context, based on which the merger is performed. The authors evaluated their system using accuracy, precision, and recall with values 89%, 97%, and 82%, respectively. These results proved to be better when compared with OntEx and FCA-Merge. Semantic Web best practices are chiefly known by the semantic web local area, yet not yet by other networks including IoT (Internet of Things) and WoT (Web of Things).

Amelie et. al [62] conducted research targeting to attain semantic interoperability and effortlessness of integration of the IoT application growth. They proposed a system called PerfectO to classify and reference tools that can support the reusability for semantic interoperability. This exemplifies that it allows to share this information in an inventive manner through mind maps and control for models, and a bunch of intelligent devices to improve furthermore, assess ontologies. The principle advantage is to diminish the expectation to learn and adapt to discovering every accessible device and to facilitate the assignment of the designers to accomplish semantic interoperability. The PerfectO model is accessible and continually refreshed.

The entirety of the instrument URLs and distributions referred to are likewise accessible on the stage in a more intelligent way. Owing to the creation of numerous natural and biomedical ontologies, it has gotten basic to guarantee ontology interoperability and the use of interoperable ontologies for normalized information depiction and combination.

Yongqun et al. [63] developed an "extensible Ontology Development" (XOD) system alongside respective four ideologies. These XOD standards base on the reusability of the existing terms and semantic associations from solid ontologies, create and work on the matured ontology configuration designs (ODPs), and include local area endeavors to help in the improvement of new ontology, advancing normalized and interoperable information and information portrayal and incorporation.

The reception of the XOD methodology, along with hearty XOD device advancement, will extraordinarily uphold philosophy interoperability and hearty ontology applications to help information to be FAIR (Findable, Accessible, Interoperable and Reusable). The Ontoanimal tool handles various onground issues that arise during the development process of ontologies. Each of the contained tool shed light on more than one primary task which collectively support the standards of XOD.

T. Aruna et al [64] developed an ontology evaluation framework by considering factors of ontology properties and technology properties. So in the main case the result of an cosmology apparatus should be checked as for the punctuation definition and in the second case it should be tried utilizing the reference execution. The assessment of consistency was catered by extending the tool to ensure that the outcome of the ontologies was in consistency to the respective semantics. The interoperability is checked by analyzing the several tools that interpret similarly. The feature of representing the outcome in a conventional manner depicts turn around ability.

The performance is evaluated using benchmark tests. While the memory allocation is utilized for handling ontologies. Moreover, scalability is used to analyse the increasing ontologies. The tools considered by the authors are OntoAnalyser, OntoGenerator, OntoClean in WebODE, ONE-T, and S-OntoEval. While OntoAnalyser and OntoGenerator, presents a standard for evaluation criteria, which was shown by evaluating the implementations against the model. OntoAnalyser, ONE-T and OntoClean focus on evaluation of ontology properties, in particular language conformity and consistency. OntoGenerator deals with the evaluation of ontology based gears, according to its performance and scalability.

Siham et al. [65] provided an insight onto the state-of-the-art ontology planning, configuration, and integration tools. Their research enlightened the three significant linguistic incompatibility between ontologies due to syntactic, semantic, and lexical incongruities.

To handle the issues arised due to syntactic mismatches, changes are made onto the respresenting language of one ontology to depict the other one. Lexical mismatches may show up in fours forms: synonyms, homonyms, language difference, and varied version of the words.

This can be handled by defining the association between expressions and entities. Semantic mismatches relating to input ontologies can be handled using the suitable tools such as FCA-Merge, IF-MAP, PROMPT, SMART, PROMPT-Diff, CAIMAN, ONION, Chimaera, and ConcepTool.

Table 1 shows the state-of-the-art features of ontology merging tools.

Table 1: Features of Ontology Merging Tools

Sr#	Title, Author, Year	Features of the ontology tool/ Aim of Research
1	CoMerger: A Customizable Online Tool for Building a Consistent Quality-Assured Merged Ontology, Samira et. al.	1. Compatibility checking of the user-selected Generic Merge Requirements (GMR)s 2. Merging multiple ontologies with adjustable GMRs 3. Quality assessment of the merged ontology 4. Inconsistency handling of the result.
2	Tools for Mapping and Merging Ontologies, Natalya F. Noy.	1. iPrompt provides guidance and recommendations to users during the merging process, recognizing inconsistencies and problems. 2. AnchorPrompt facilitates the iPrompt by graphical representation of correlations between the notions.
3	A novel approach for merging ontologies using formal concept analysis, M. Priya et al., 2020	The pseudo-intent algorithm proposed in the research is featured back-tracking-based FCA-Merge to perform a merger between identified relations.
4	A Survey and Analysis of Ontology-Based Software Tools for Semantic Interoperability in IoT and WoT Landscapes, Amelie Gyrard et al, 2018	The proposed design of PerfectO classifies and references tools to enable the reuse of semantic interoperability.
5	The eXtensible ontology development (XOD) principles and tool implementation to support ontology interoperability, Yongqun et al., 2018	Enables development of extensible ontology through a web-based suite, Ontoanimals.
6	A Survey on Ontology Evaluation Tools, T. Aruna et al., 2011	The proposed framework highlights the ontology properties including language conformity and consistency, and technology properties dealing with interoperability, rotation, performance, memory allocation, scalability, and connectors and interfaces.
7	Survey on the literature of ontology Mapping, Alignment and Merging, Siham et al., 2012	Provides insight of the operations of ontology including translation, reconciliation, coordination, and negotiation between ontologies, and the state-of-the-art tools for ontology mapping, alignment, and merging.

CHAPTER 3

System Architecture & METHODOLOGY

3 .1Methodology

Ontology-based system that facilitates the healthcare insurance domain as part of a smart healthcare system. The Ontology Engineering process includes requirements collection based on specific competency questions, structural design, and implementation Smart Health insurance policy consists of insurance policy packages that consider technological requirements to enhance customers' health and wellness. The proposed insurance policy is customer-centric and consists of packages depending on each customer's parameters retrieved his EHRs. The Healthcare insurance industry needs to adopt more robust and disruptive business models, which embrace new emerging technologies. Smart healthcare is now widely accepted, and there has been ongoing research and developments in this area. Ontologies can play important/critical role in adapting healthcare insurance to meet new advancements in smart healthcare. As discussed in the related work section, ontologies have already been used in different fields, including smart healthcare. However, to the best of our knowledge, ontologies have not been used to support smart healthcare insurance policy selection. Available ontologies focus on representing current healthcare insurance policies and applying XML retrieval approaches using tree matching to match the entered data and the ontology. In contrast, our proposed ontology provides an adaptive healthcare insurance policy that considers the technological requirements according to the customer's available EHRs information.

3.2 Ontology Scope

The ontology scope determines the overall system function and operation. It helps in assigning suitable insurance policy packages. The following functional requirements specify the scope of the ontology-based on ontology competency questions. The ontology captures three main scopes.

Policy Package Functional Requirements
The ontology shall define a basic policy for each age group; child group (0-17), adult group (18-64), and elderly group (65+).
The ontology shall define the policy package based on the health status: healthy, unhealthy, and need to follow up.
The ontology shall specify if the customer requires support treatment.
The ontology shall define the policy package based on a disease affiliated with a certain disease group such as: Heart monitoring group, Vital signs group, Liver parameters group, Body area network & ambient assistant living group.
Disease Monitoring Functional Requirement
The system shall specify the diseases under each disease groups such as: Heart monitoring group, Vital signs group, Liver parameters group, Body area network & ambient assistant living group, Lifestyle management group.
Technology Requirements
The ontology shall specify the technological requirements for each of the following policy packages: Lifestyle management package, Implant heart monitoring package, Wearable Heart monitoring package, Implant vital signs package, Implant vital signs package, Wearable vital signs package, Wearable vital signs package, Wearable vital signs package, Body area network & Ambient Assistant Living package, Appointment management package

Figure 11: Ontology Scope

First, policy package scope which defines basic policy for each group. Second, disease monitoring scope. This scope specifies the different disease groups to monitor. Third, technology scope that specifies technological requirements for each policy package. These scopes will be used in the reasoning engine to create adaptive policy

3.3 Smart Healthcare Insurance Policy

Smart healthcare architecture includes different constituencies that aims at making healthcare efficient and affordable, see Figure 1. Healthcare insurance companies utilize different technologies, such as, IoT, mobile computing, cloud computing, fog/edge computing, and wearable devices, to retrieve patients' data and track medical claims. This research aims to leverage emerging ICTs to develop smart health insurance policy. We focus on the business model customer segment to define a customized knowledge based value proposition

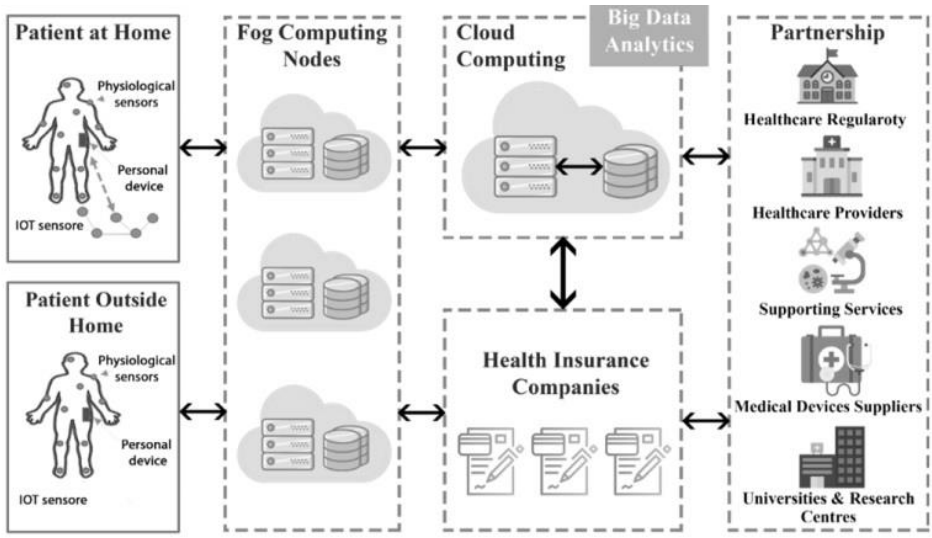


Figure 12: Smart Health Architecture

3.4 Proposed Reasoning Base Model for Health Insurance Policy System

Proposed System is based on reasoning model which automatically assign policy to the specific patient on customer specifications like health requirements age and personal Health Record.

Main focus of this ontological model to reduce the cost and working process of Policy assigning process by creating a model that focuses on customer base health care insurance policy system that contains all packages. The ontological model is created according to the health status age medication record and previous Electronic health record.

Our System is knowledge base which works on OWL, RDF, RDFS, and Semantic web rule Language used to inference our model. All the health related and technical details are collected through literature.

3.5 Work Flow of Reasoning Base Model for Health Insurance Policy System

The Figure Shon below describe working of our ontological model that how our reasoning base model works around ontology SWRL rules Reasoning Engine and Query Engine which connected to user side that is working on the System.

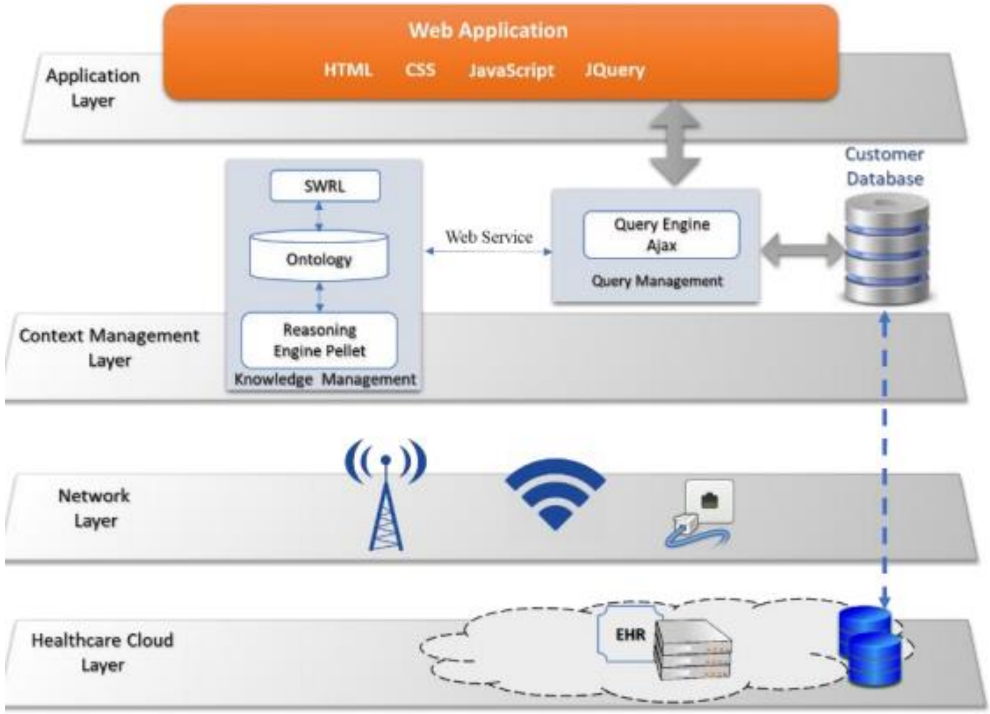


Figure 13: Smart Healthcare Insurance Policy ontological model

3.3.1 Flow Chart of Proposed System

In the figure 15 below shows flow chart of our Ontological model process working as user who is using policy system send request by asking a query which contains Customer ID, customer policy number or personal EHR. Which contains details of the customer.

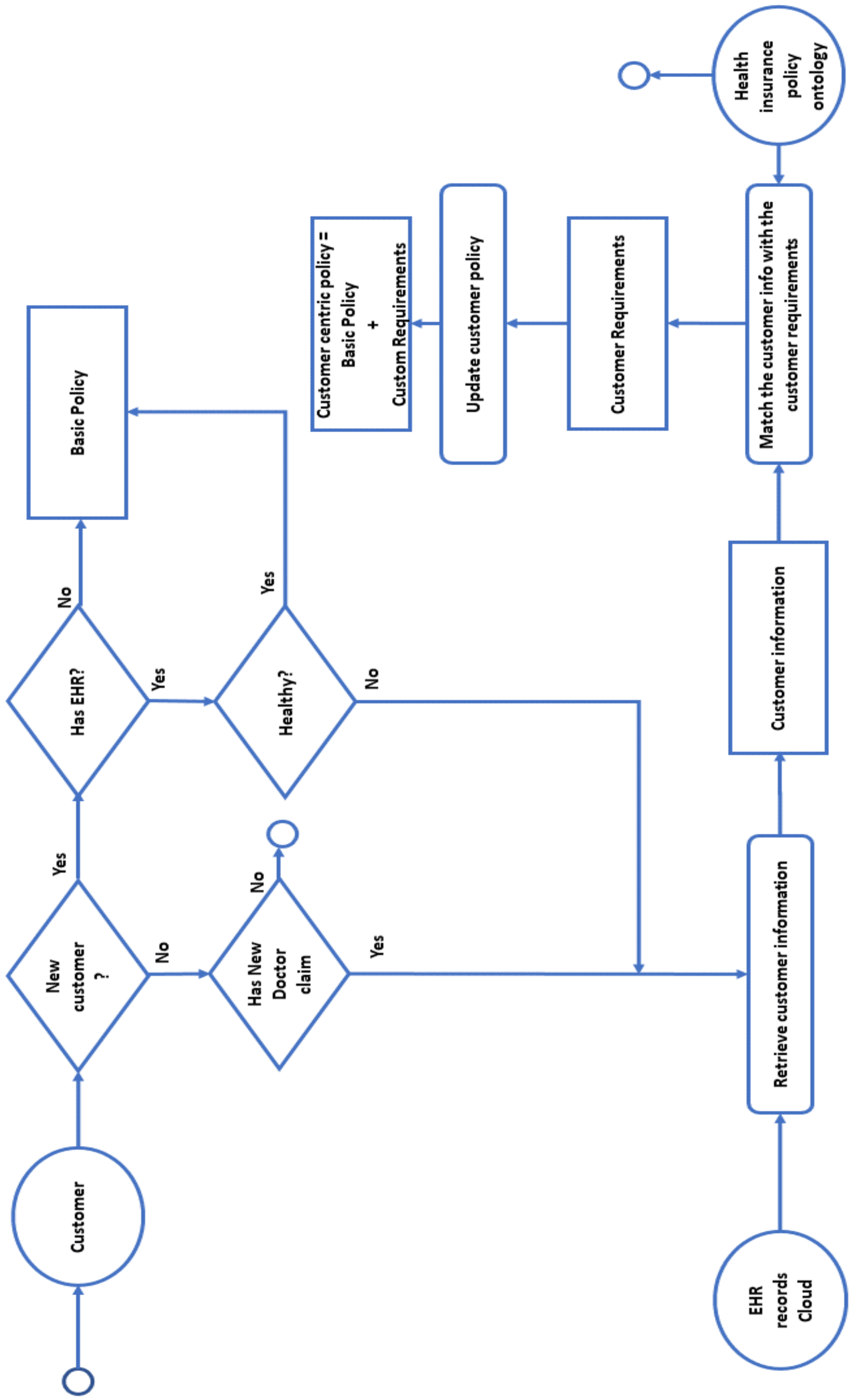


Figure 14: Work Flow

CHAPTER 4

Implementation and Validation

4.1 Ontology

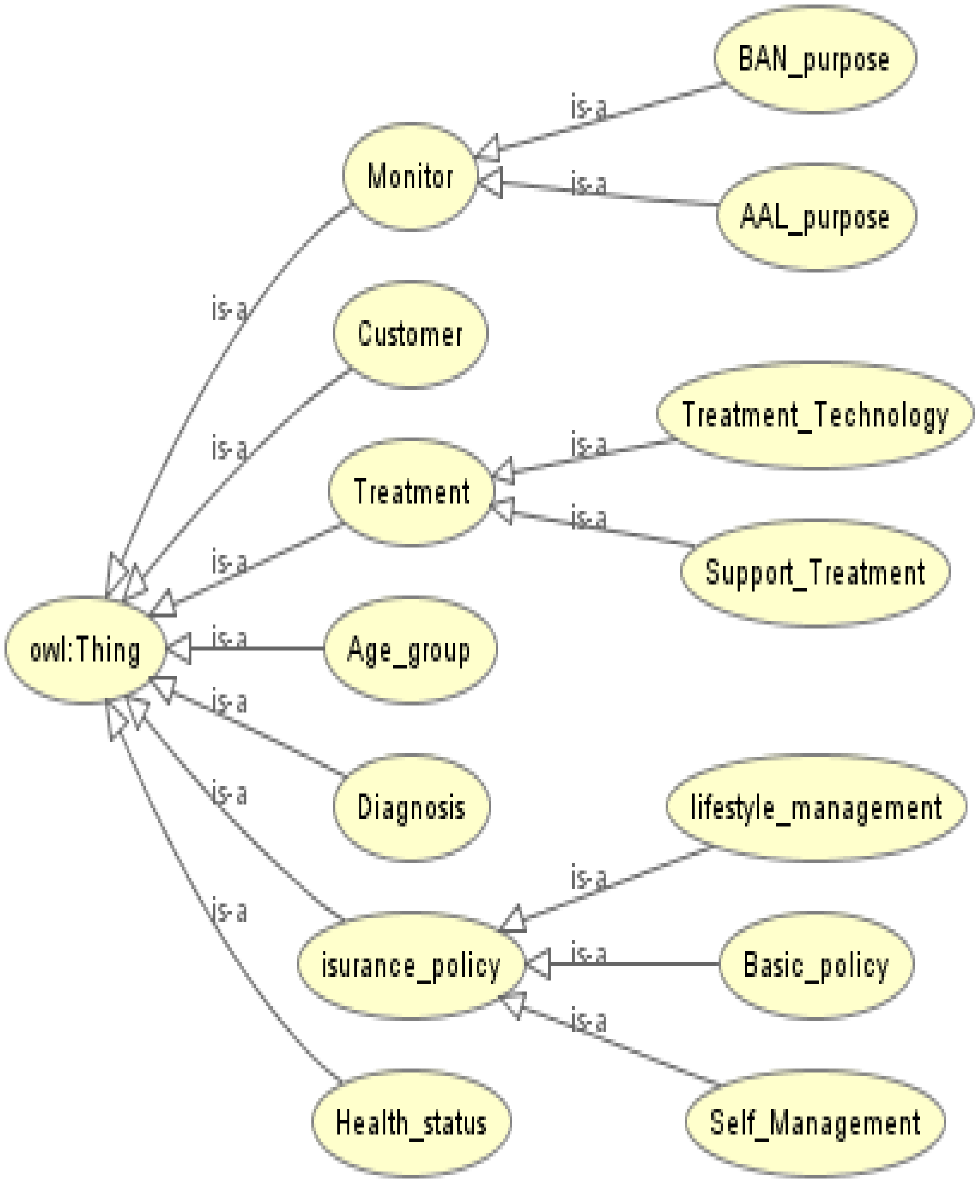


Figure 15: Ontology Classes Diagram

In the Figure 16,17 it shows main classes on our Ontology that how we formalize the concepts as what is health condition of our customer what disease/Health condition customer has and to which age group belongs.

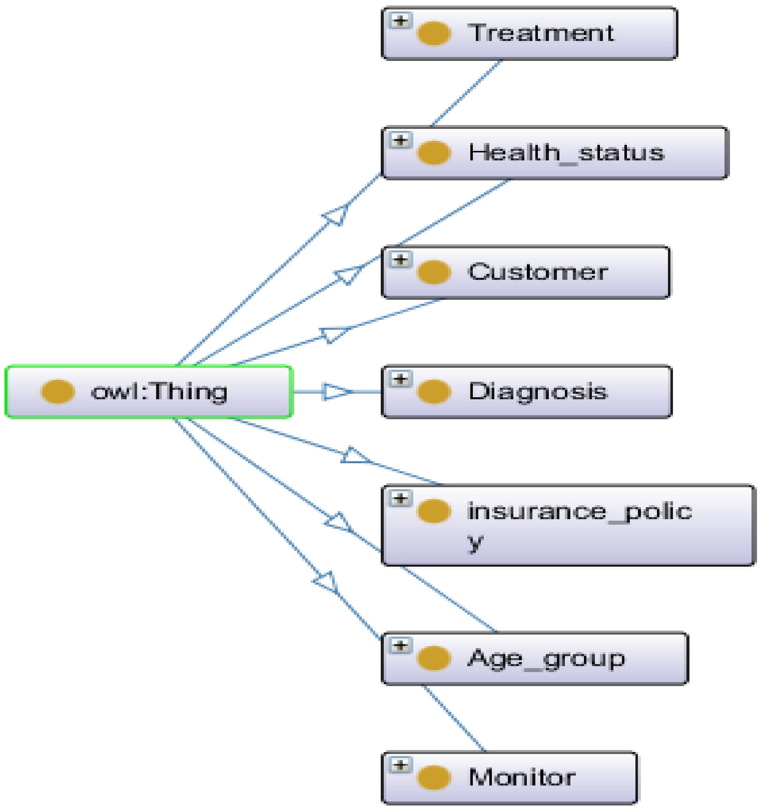


Figure 16: Main Classes of Ontology

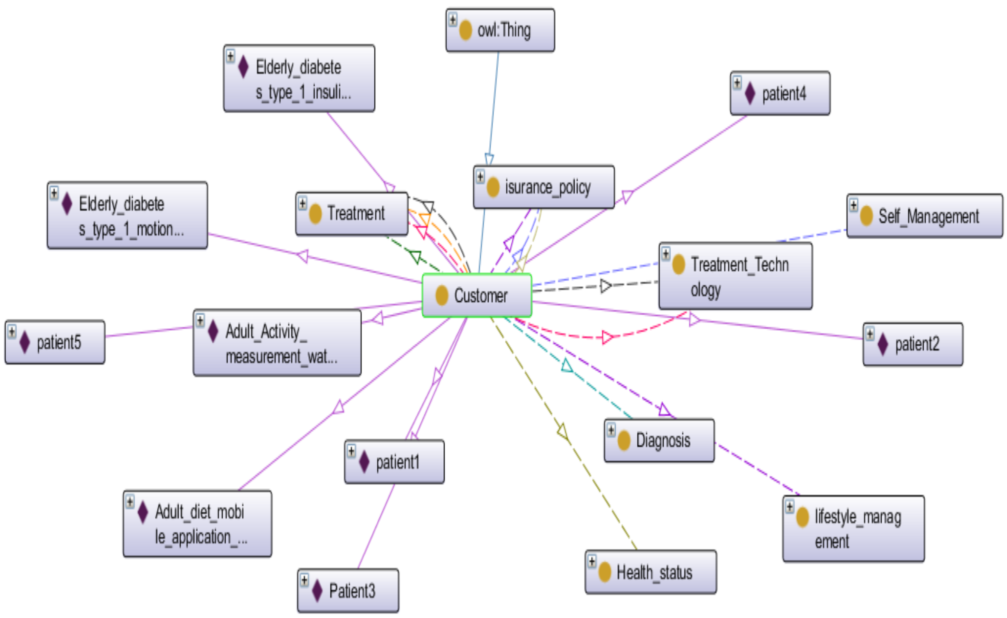


Figure 17: Customer Class Details

In Figure 18 it shows the Customer class interconnected relations with other classes and instance using Object and Data properties.

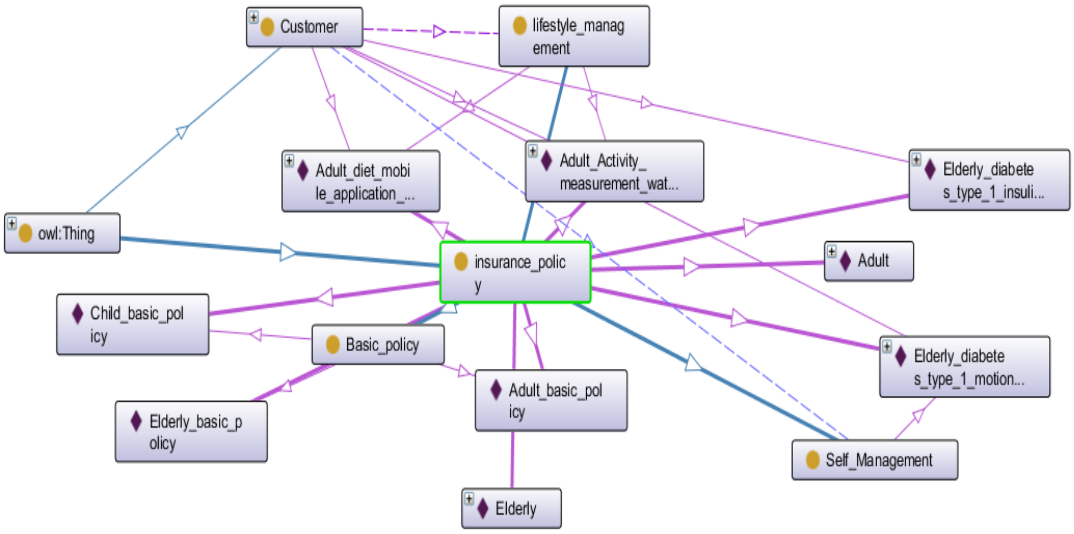


Figure 18: Class Insurance Policy

In Figure 19 it shows the Policy class interconnected relations with other classes and instance using Object and Data properties.

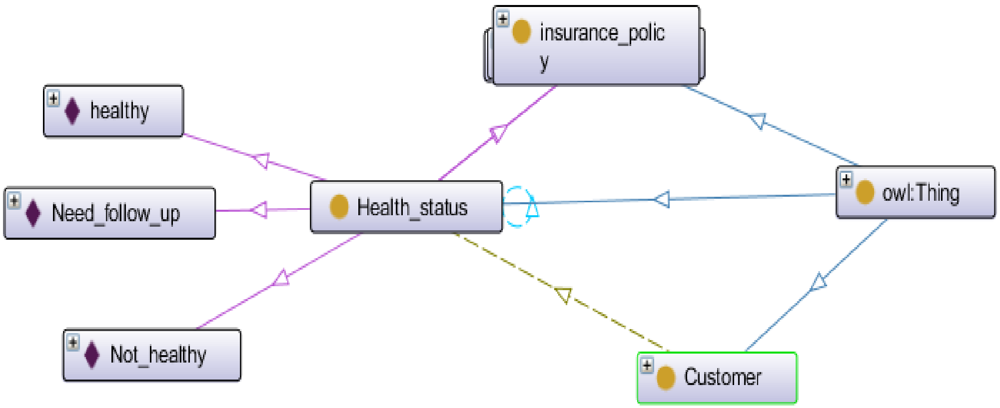


Figure 19: Health Condition Defined in the Ontology

In Figure 20 it shows the Status of user health class interconnected relations with other classes and instance using Object and Data properties.

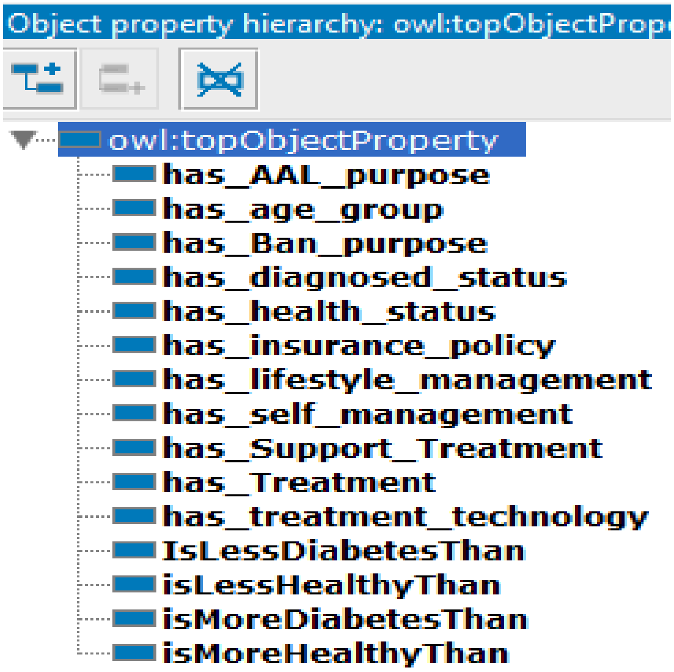


Figure 20: Object Properties

In figure 21 it shows different Object properties relation between classes

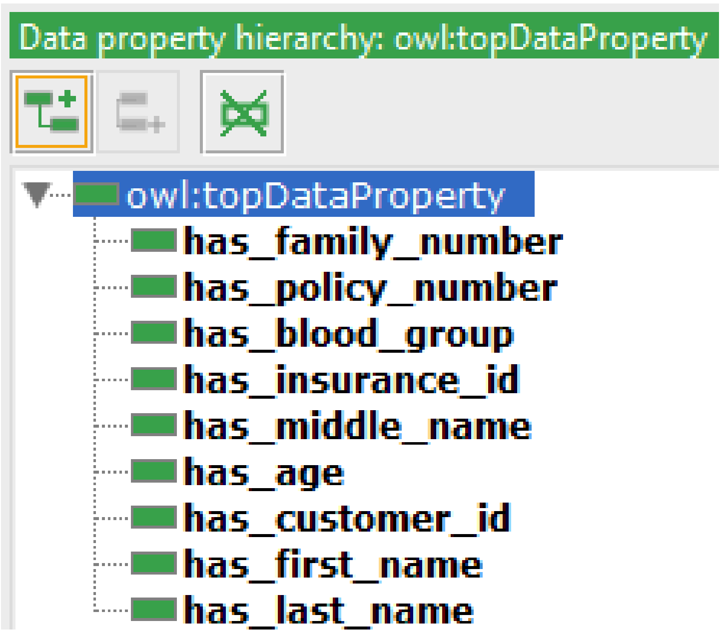


Figure 21: Data Properties

In figure 22 it shows different data properties relation between classes

Figure 22: Individuals of Classes

.

4.2 Semantic Web Rule Language

Following figure 24 shows some of the rules we create to perform inference on our ontological model part which works for assign different age group upon different age different health condition on different health condition and upon all these Insurance policies assigned.

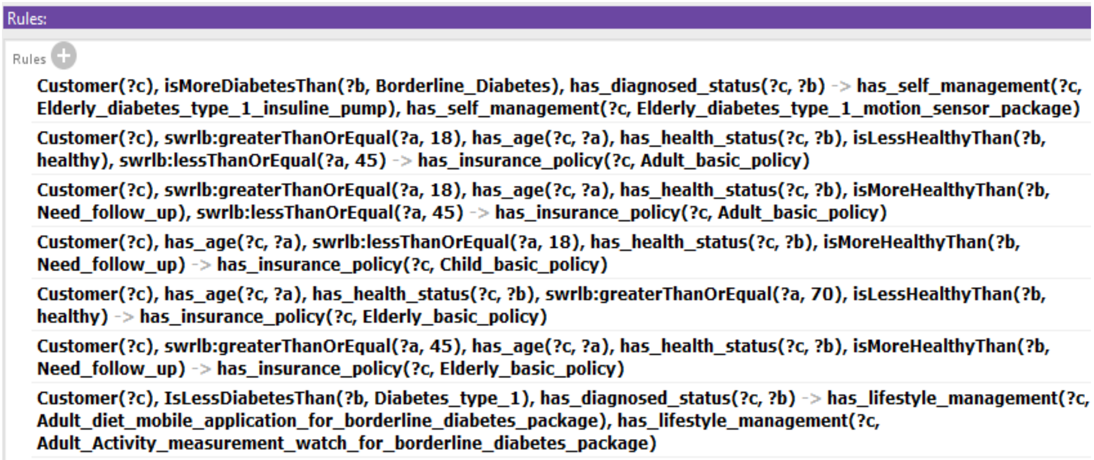


Figure 23: Semantic Web Rule Language (SWRL) for Insurance Policy

4.2.2 Single Rule Evaluation

We use Single Rule Evaluation plugin to check our rules on dummy values to ttest either rule engine is working efficiently before applying on our ontology to inference the knowledge base

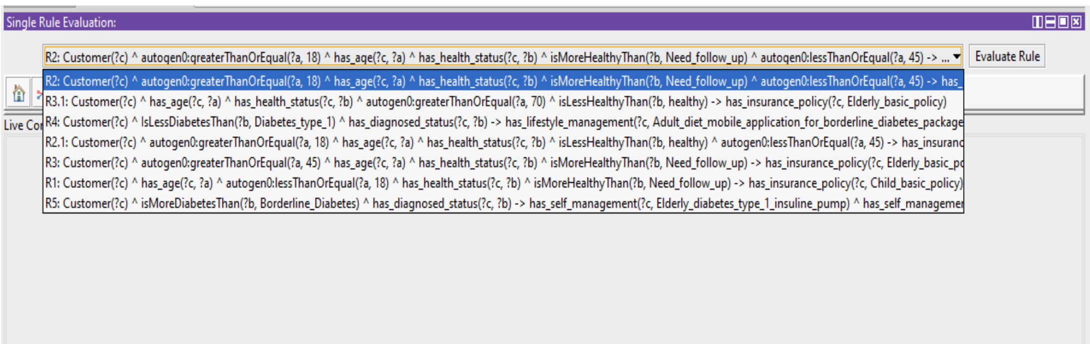


Figure 24: Single Rule Evaluation Plugin

4.2.3 Working Of Semantic Web Rule language with Drools Engine.

In this part we will show the demonstration of working with drools engine step by step and how SWRL Api work with OWL 2 RL-Based reasoner to perform reasoning and inference the knowledge to OWL.

It works in three parts

1. Transfer All OWL +SWRL Rules to Drools Engine
2. Running of the drools Engine
3. Inferencing the Knowledge to OWL Ontology

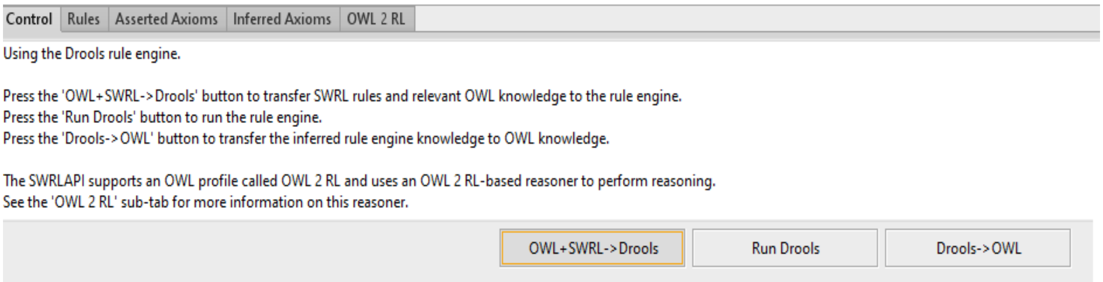


Figure 25: Transfer SWRL to Drools

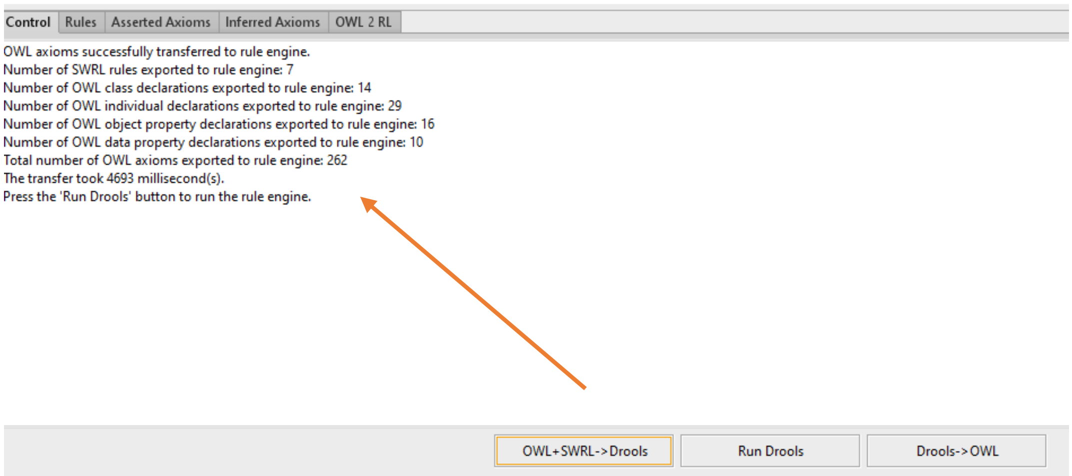


Figure 26: After Transferring the SWRL to Drools Engine

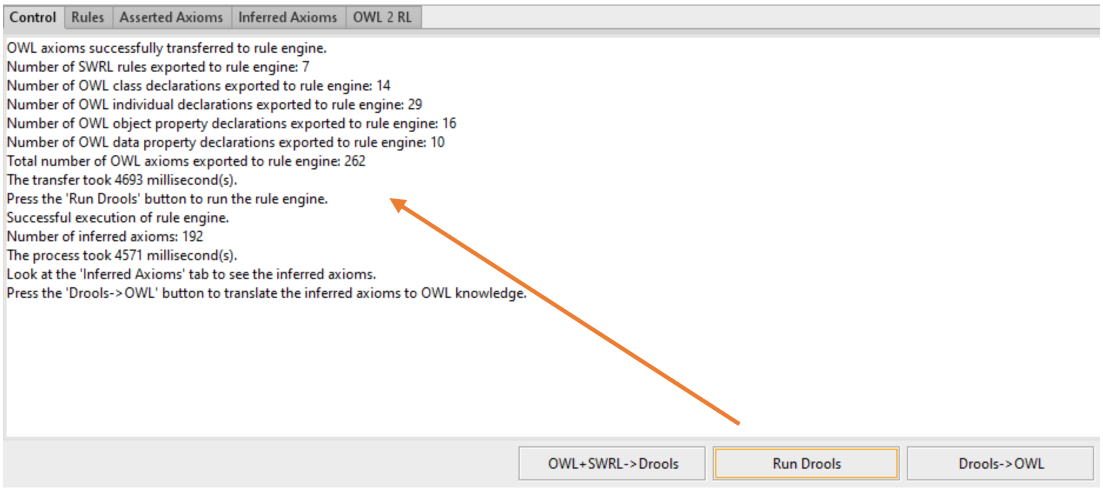


Figure 27: Run Drools engine to inference all the knowledge.

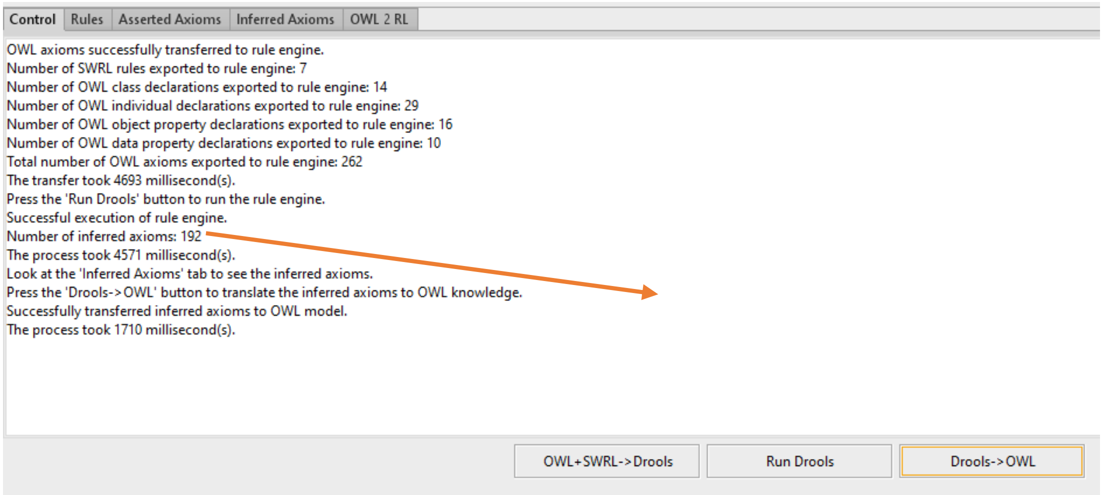


Figure 28: Transfer All the SWRL base inference to Ontology using Drools Engine

4.3 Reasoner Based Validation

Protégé is only a tool not an expert system that only help researcher and ontologist to build ontologies [40]. For the purpose of validayion of ontologies it use plugin,s from different platforms like Pellet, Fact++ and Hermitt.[38]. Reasoner facilitate by providing validation of the Ontology system that have been developed under Protégé by detecting the inconsistency between ontologies Reasoner often mathematical model based as they facilitate with logical inferencing using rule based approach using semantic web rule language. as the mechanism to work is forward or backward chaining [41]. We used Pellet reasoner in our research work also validation thorugh sparql that work with the requiremnet analysis we defined and be reterived accordingly. Now, we will inject such an inconsistency here

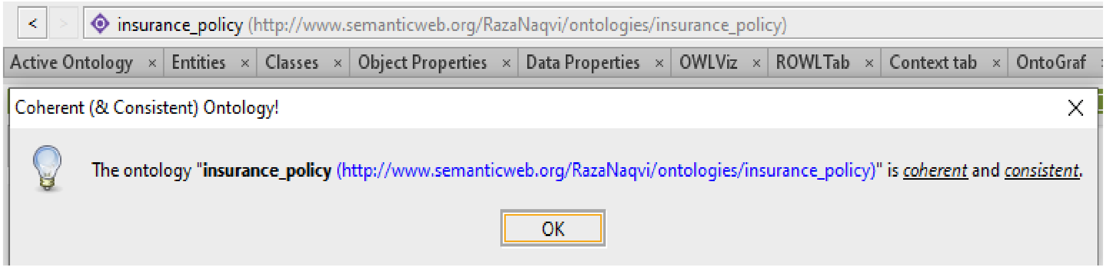


Figure 29: Validation of Ontology Model

4.4 Sparql Based Validation

Sparql is an query language like SQL. The main difference is this used with knowledge engineering and knwoledge modelling to query data over different Rdf triple stores and simulanouesly with the ontology itself. Its also used for validation as we query ontology with using sparql pluigin via protégé or fuseky sever using web interface as protégé web Interface did,nt support sparql.Basic Theory is we made a query to get an reply from ontology or we can say we when we want data stored in ontology reterived we user Sparql.as shown in figure 31 below.

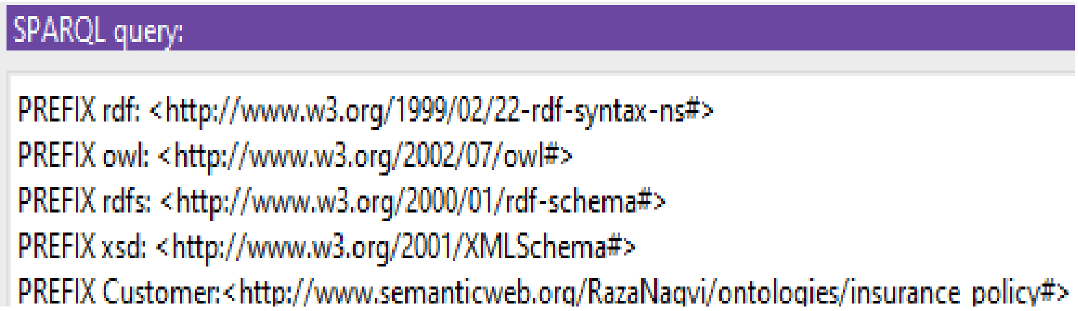


Figure 30: SPARQL interface and prefix Syntax

4.5 Model Testing and Use cases

This part shows working of Reasoning base model on different Use cases that have been defined as following shows 5 Use cases and their results after inference engine does the reasoning part as we discuss the working part of SWRL Working with OWL and Droll Engine in Section 4.5.1 and 4.2.2

4.5.1 Use Case 1

Use Case 1 is where patient age is 6 and Health Condition is healthy.

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#>
PREFIX Customer:<http://www.semanticweb.org/Thesis/ontologies/RazaNaqvi/insurance_policy#>
 DESCRIBE Customer:patient1
```

Subject	Predicate	Object
patient1	has_first_name	"Hussain"@en
patient1	rdf:type	owl:NamedIndividual
patient1	has_age	"6"^^<http://www.w3.org/2001/XMLSchema#int>
patient1	rdf:type	owl:NamedIndividual
patient1	has_health_status	healthy
patient1	rdf:type	owl:NamedIndividual
patient1	rdf:type	owl:NamedIndividual
patient1	has_customer_id	"6661"^^<http://www.w3.org/2001/XMLSchema#int>
patient1	rdf:type	owl:NamedIndividual
patient1	has_last_name	"Ali"@en
patient1	rdf:type	owl:NamedIndividual
patient1	rdf:type	Customer
patient1	rdf:type	owl:NamedIndividual

Execute

Figure 31: Use Case 1 before Inferencing the Knowledge

We defined in rules if Customer is health condition is health and has age less than 18 it should have considered as a child and assign basic package.

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#>
PREFIX Customer:<http://www.semanticweb.org/Thesis/ontologies/RazaNaqvi/insurance_policy#>
 DESCRIBE Customer:patient1
```

Subject	Predicate	Object
patient1	has_first_name	"Hussain"@en
patient1	rdf:type	owl:NamedIndividual
patient1	has_age	"6"^^<http://www.w3.org/2001/XMLSchema#int>
patient1	rdf:type	owl:NamedIndividual
patient1	has_health_status	healthy
patient1	rdf:type	owl:NamedIndividual
patient1	rdf:type	owl:NamedIndividual
patient1	has_customer_id	"6661"^^<http://www.w3.org/2001/XMLSchema#int>
patient1	rdf:type	owl:NamedIndividual
patient1	has_last_name	"Ali"@en
patient1	rdf:type	owl:NamedIndividual
patient1	rdf:type	Customer
patient1	rdf:type	owl:NamedIndividual
patient1	has_insurance_policy	Child_basic_policy
patient1	rdf:type	owl:NamedIndividual

Figure 32: Use Case 1 after Inferencing the Knowledge

After Inferncing performed by drolls engine we can see the exactly according to SWRL Assgined package is Basic one.

4.5.2 Use Case 2

Use Case 2 is where patient age is more than 18 or equal to 18 and Health Condition is healthy.

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#>
PREFIX Customer:<http://www.semanticweb.org/Thesis/ontologies/RazaNaqvi/insurance_policy#>
 DESCRIBE Customer:patient2
```

Subject	Predicate	Object
patient2	has_first_name	"Fatima"@en
patient2	rdf:type	owl:NamedIndividual
patient2	rdf:type	owl:NamedIndividual
patient2	has_customer_id	"6662"^^<http://www.w3.org/2001/XMLSchema#int>
patient2	rdf:type	owl:NamedIndividual
patient2	rdf:type	Customer
patient2	rdf:type	owl:NamedIndividual
patient2	has_health_status	healthy
patient2	rdf:type	owl:NamedIndividual
patient2	has_first_name	"Zahra"@en
patient2	rdf:type	owl:NamedIndividual
patient2	has_age	"30"^^<http://www.w3.org/2001/XMLSchema#int>
patient2	rdf:type	owl:NamedIndividual

Execute

Figure 33: Use Case 2 before Inferencing the Knowledge

We defined in rules if Customer is health condition is healthy and has age more than 18 it should have considered as an adult and assign adult basic package.

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#>
PREFIX Customer:<http://www.semanticweb.org/Thesis/ontologies/RazaNaqvi/insurance_policy#>
 DESCRIBE Customer:patient2
```

Subject	Predicate	Object
patient2	has_first_name	"Fatima"@en
patient2	rdf:type	owl:NamedIndividual
patient2	rdf:type	owl:NamedIndividual
patient2	has_customer_id	"6662"^^<http://www.w3.org/2001/XMLSchema#int>
patient2	rdf:type	owl:NamedIndividual
patient2	rdf:type	Customer
patient2	rdf:type	owl:NamedIndividual
patient2	has_health_status	healthy
patient2	rdf:type	owl:NamedIndividual
patient2	has_first_name	"Zahra"@en
patient2	rdf:type	owl:NamedIndividual
patient2	has_age	"30"^^<http://www.w3.org/2001/XMLSchema#int>
patient2	rdf:type	owl:NamedIndividual
patient2	has_insurance_policy	Adult_basic_policy
patient2	rdf:type	owl:NamedIndividual

Figure 34: Use Case 2 after Inferencing the Knowledge

4.5.3 Use Case 3

Use Case 2 is where patient age is more than 64 or equal to 18 and Health Condition is healthy.

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#>
PREFIX Customer:<http://www.semanticweb.org/Thesis/ontologies/RazaNaqvi/insurance_policy#>
 DESCRIBE Customer:Patient3
```

Subject	Predicate	Object
Patient3	has_customer_id	"6663"^^<http://www.w3.org/2001/XMLSchema#int>
Patient3	rdf:type	owl:NamedIndividual
Patient3	has_age	"66"^^<http://www.w3.org/2001/XMLSchema#int>
Patient3	rdf:type	owl:NamedIndividual
Patient3	rdf:type	Customer
Patient3	rdf:type	owl:NamedIndividual
Patient3	rdf:type	owl:NamedIndividual
Patient3	has_last_name	"Ali"@en
Patient3	rdf:type	owl:NamedIndividual
Patient3	has_first_name	"Hassan"@en
Patient3	rdf:type	owl:NamedIndividual
Patient3	has_health_status	healthy
Patient3	rdf:type	owl:NamedIndividual

Execute

Figure 35: Use Case 3 before Inferencing the Knowledge

We defined in rules if Customer is health condition is healthy and has age more than 64 it should have considered as an Elder and assign Elder basic package.

SPARQL query:

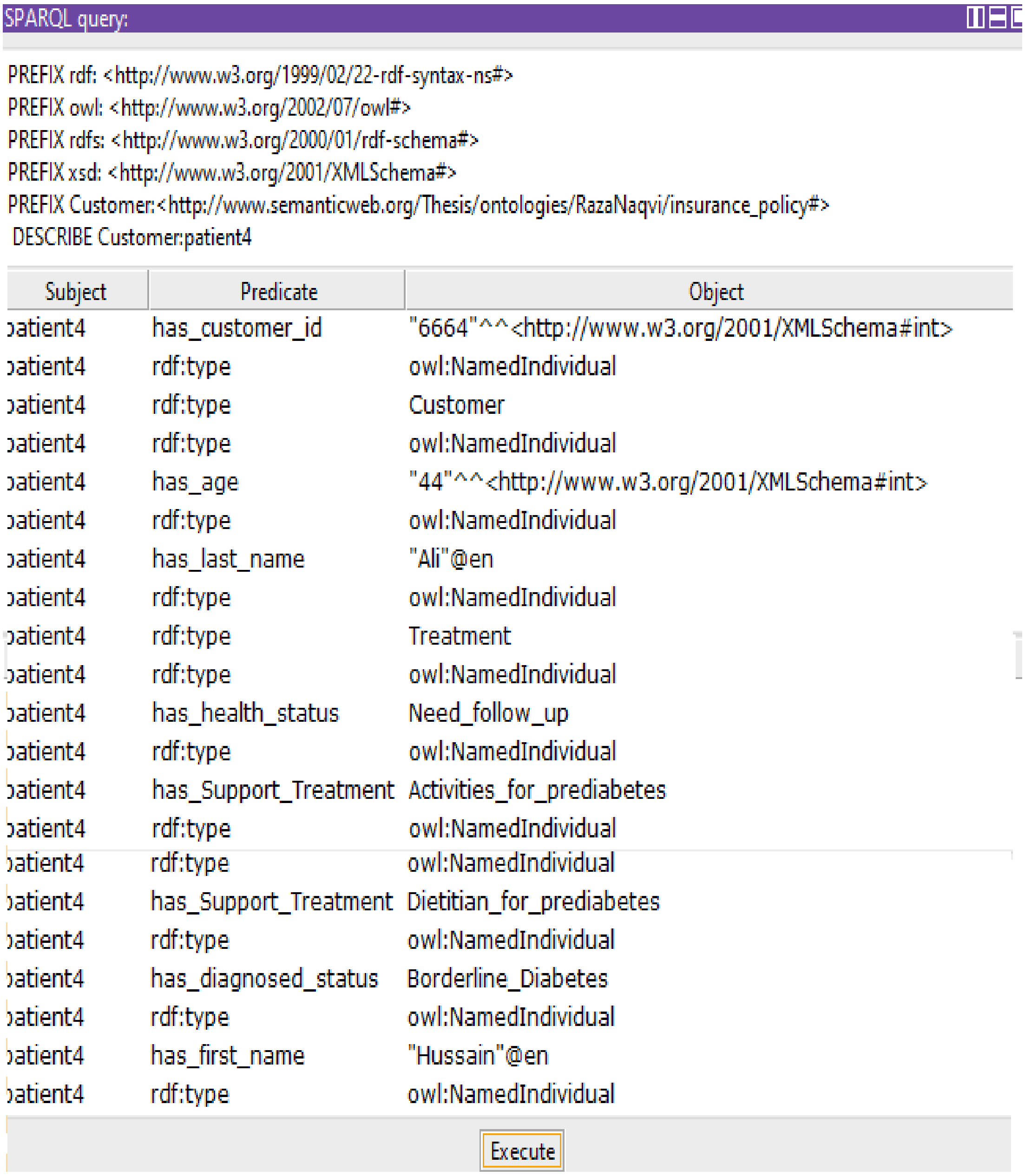
```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX Customer:<http://www.semanticweb.org/Thesis/ontologies/RazaNaqvi/insurance_policy#>
 DESCRIBE Customer:Patient3
```

Subject	Predicate	Object
Patient3	has_customer_id	"6663"^^<http://www.w3.org/2001/XMLSchema#int>
Patient3	rdf:type	owl:NamedIndividual
Patient3	has_age	"66"^^<http://www.w3.org/2001/XMLSchema#int>
Patient3	rdf:type	owl:NamedIndividual
Patient3	rdf:type	Customer
Patient3	rdf:type	owl:NamedIndividual
Patient3	rdf:type	owl:NamedIndividual
Patient3	has_last_name	"Ali"@en
Patient3	rdf:type	owl:NamedIndividual
Patient3	has_first_name	"Hassan"@en
Patient3	rdf:type	owl:NamedIndividual
Patient3	has_health_status	healthy
Patient3	rdf:type	owl:NamedIndividual
Patient3	has_insurance_policy	Elderly_basic_policy
Patient3	rdf:type	owl:NamedIndividual

Figure 36: Use Case 3 after Inferencing the Knowledge

4.5.4 Use Case 4

Use case 4 is where user has age 44 health condition needs to be checked, also has diabetes problem but minor and also on diet.


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#>
PREFIX Customer:<http://www.semanticweb.org/Thesis/ontologies/RazaNaqvi/insurance_policy#>
 DESCRIBE Customer:patient4
```

Subject	Predicate	Object
patient4	has_customer_id	"6664"^^<http://www.w3.org/2001/XMLSchema#int>
patient4	rdf:type	owl:NamedIndividual
patient4	rdf:type	Customer
patient4	rdf:type	owl:NamedIndividual
patient4	has_age	"44"^^<http://www.w3.org/2001/XMLSchema#int>
patient4	rdf:type	owl:NamedIndividual
patient4	has_last_name	"Ali"@en
patient4	rdf:type	owl:NamedIndividual
patient4	rdf:type	Treatment
patient4	rdf:type	owl:NamedIndividual
patient4	has_health_status	Need_follow_up
patient4	rdf:type	owl:NamedIndividual
patient4	has_Support_Treatment	Activities_for_prediabetes
patient4	rdf:type	owl:NamedIndividual
patient4	rdf:type	owl:NamedIndividual
patient4	has_Support_Treatment	Dietitian_for_prediabetes
patient4	rdf:type	owl:NamedIndividual
patient4	has_diagnosed_status	Borderline_Diabetes
patient4	rdf:type	owl:NamedIndividual
patient4	has_first_name	"Hussain"@en
patient4	rdf:type	owl:NamedIndividual

Execute

Figure 37: Use Case 4 before Inferencing the Knowledge

We defined in rules if Customer is health condition is need to checked also have problem with diabetes so should have wearable sensor watch also mobile application.

```
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#>
PREFIX Customer:<http://www.semanticweb.org/Thesis/ontologies/RazaNaqvi/insurance_policy#>
 DESCRIBE Customer:patient4
```

Subject	Predicate	Object
patient4	has_customer_id	"6664"^^<http://www.w3.org/2001/XMLSchema#int>
patient4	rdf:type	owl:NamedIndividual
patient4	rdf:type	Customer
patient4	rdf:type	owl:NamedIndividual
patient4	has_age	"44"^^<http://www.w3.org/2001/XMLSchema#int>
patient4	rdf:type	owl:NamedIndividual
patient4	has_last_name	"Ali"@en
patient4	rdf:type	owl:NamedIndividual
patient4	rdf:type	Treatment
patient4	rdf:type	owl:NamedIndividual
patient4	has_health_status	Need_follow_up
patient4	rdf:type	owl:NamedIndividual
patient4	has_Support_Treatment	Activities_for_prediabetes
patient4	rdf:type	owl:NamedIndividual
patient4	rdf:type	owl:NamedIndividual
patient4	has_Support_Treatment	Dietitian_for_prediabetes
patient4	rdf:type	owl:NamedIndividual
patient4	has_diagnosed_status	Borderline_Diabetes
patient4	rdf:type	owl:NamedIndividual
patient4	has_first_name	"Hussain"@en
patient4	rdf:type	owl:NamedIndividual
patient4	has_insurance_policy	Adult_basic_policy
patient4	rdf:type	owl:NamedIndividual
patient4	has_lifestyle_management	Adult_Activity_measurement_watch_for_borderline_diabetes_package
patient4	rdf:type	owl:NamedIndividual
patient4	has_lifestyle_management	Adult_diet_mobile_application_for_borderline_diabetes_package
patient4	rdf:type	owl:NamedIndividual

Figure 38: Use Case 4 after Inferencing the Knowledge

4.5.5 Use Case5

Use case 4 is where user has age 70 health condition is not well has problem with diabetes, also using treatments and monitors.

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#>
PREFIX Customer:<http://www.semanticweb.org/Thesis/ontologies/RazaNaqvi/insurance_policy#>
 DESCRIBE Customer:patient5
```

Subject	Predicate	Object
patient5	has_AAL_purpose	Motion_sensor
patient5	rdf:type	owl:NamedIndividual
patient5	has_Ban_purpose	Blood_sugar_measurement_sensor
patient5	rdf:type	owl:NamedIndividual
patient5	has_customer_id	"6665"^^<http://www.w3.org/2001/XMLSchema#int>
patient5	rdf:type	owl:NamedIndividual
patient5	rdf:type	Customer
patient5	rdf:type	owl:NamedIndividual
patient5	has_health_status	Not_healthy
patient5	rdf:type	owl:NamedIndividual
patient5	has_Treatment	insulin_intake
patient5	rdf:type	owl:NamedIndividual
patient5	rdf:type	owl:NamedIndividual
patient5	has_first_name	"Ali"@en
patient5	rdf:type	owl:NamedIndividual
patient5	has_last_name	"Reza"@en
patient5	rdf:type	owl:NamedIndividual
patient5	has_diagnosed_status	Diabetes_type_1
patient5	rdf:type	owl:NamedIndividual
patient5	has_self_management	Elderly_diabetes_type_1_motion_sensor_package
patient5	rdf:type	owl:NamedIndividual
patient5	has_Treatment	mosion_monitoring
patient5	rdf:type	owl:NamedIndividual
patient5	has_age	"70"^^<http://www.w3.org/2001/XMLSchema#int>
patient5	rdf:type	owl:NamedIndividual

Execute

Figure 39: Use Case 5 before Inferencing the Knowledge

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#>
PREFIX Customer:<http://www.semanticweb.org/Thesis/ontologies/RazaNaqvi/insurance_policy#>
 DESCRIBE Customer:patient5
```

Subject	Predicate	Object
patient5	has_AAL_purpose	Motion_sensor
patient5	rdf:type	owl:NamedIndividual
patient5	has_Ban_purpose	Blood_sugar_measurement_sensor
patient5	rdf:type	owl:NamedIndividual
patient5	has_customer_id	"6665"^^<http://www.w3.org/2001/XMLSchema#int>
patient5	rdf:type	owl:NamedIndividual
patient5	rdf:type	Customer
patient5	rdf:type	owl:NamedIndividual
patient5	has_health_status	Not_healthy
patient5	rdf:type	owl:NamedIndividual
patient5	has_Treatment	insulin_intake
patient5	rdf:type	owl:NamedIndividual
patient5	rdf:type	owl:NamedIndividual
patient5	has_first_name	"Ali"@en
patient5	rdf:type	owl:NamedIndividual
patient5	has_last_name	"Reza"@en
patient5	rdf:type	owl:NamedIndividual
patient5	has_diagnosed_status	Diabetes_type_1
patient5	rdf:type	owl:NamedIndividual
patient5	has_self_management	Elderly_diabetes_type_1_motion_sensor_package
patient5	rdf:type	owl:NamedIndividual
patient5	has_Treatment	mosion_monitoring
patient5	rdf:type	owl:NamedIndividual
patient5	has_age	"70"^^<http://www.w3.org/2001/XMLSchema#int>
patient5	rdf:type	owl:NamedIndividual
patient5	has_insurance_policy	Elderly_basic_policy
patient5	rdf:type	owl:NamedIndividual
patient5	has_self_management	Elderly_diabetes_type_1_insuline_pump
patient5	rdf:type	owl:NamedIndividual

Figure 40: Use Case 5 after Inferencing the Knowledge

We defined in rules if Customer is health condition as per defined in use case 5 we get the same inference value we defined as per instructions.

CHAPTER 5

CONCLUSIONS

Thesis work based upon three targets that we achieved during this thesis.

First part, literature review of Smart healthcare services and business models using Smart Healthcare Insurance systems. Second part to create Cohesive smart health services ontology and Use cases. The third focuses on reasoning base ontology model for assigning policy packages based on identified parameters through literature.

Our model gets the data from database and chose the policy package according to the parameters defined in the thesis.

5.1 Challenges

The big challenge was to search for the literature and recognize different smart health services and create one cohesive smart services system and create use cases to test the integration also exploring different health ontologies to concrete the argument that there is no Smart Healthcare ontology in the domain of health insurance policy exist.

5.2 Future Work

Our Work meets it targets and research objectives successfully. Other than that we also develop a working web application that works to verify our work. But its works at limited scale and was created with limited resources.

In future we want to mature the reasoning model by creating User centered system to verify user ratification and efficiency and effectiveness of our model in business world

REFERENCES

[1] A. M. Alberti, G. D. Scarpioni, V. J. Magalhaes and S. A. Cerqueira, "Advancing Nova Genesis architecture towards future Internet of Things," IEEE Internet Things J., 2018.

[2] Alok Kulkarni and Sampada Sathe, "Healthcare applications of the Internet of Things: A Review," in (IJCSIT) International Journal of Computer Science and Information Technologies, 2014.

[3] Vandana Sharma and Ravi Tiwari, "A review paper on “IOT” & It‟s Smart Applications," in International Journal of Science, Engineering and Technology Research (IJSETR), 2016.

[4] M.Srinivas, P.Durgaprasadarao and V.Naga prudhvi raj , " INTELLIGENT MEDICINE BOX FOR MEDICATION MANAGEMENT USING IOT," in Second International Conference on Inventive Systems and Control (ICISC 2018), 2018.

[5] Amar Ibrahim E.Sharaf Eldein and Hanny H Ammar,Dale G.Dzielski, "Enterprise Architecture of Mobile Healthcare for large Crowd Events," in 6th International Conference on Information and Communication Technology and Accessibility , 2016.

[6] Samr Ali and Mohammed Ghazal , "Real-time Heart Attack Mobile Detection Service(RHAMDS): An IoT UseCase for Software Defined Networks," in 30th Canadian Conference on Electrical and Computer Engineering (CCECE, 2017.

[7] B. Sobhan Babu, K. Srikanth, T. Ramanjaneyulu and I. Lakshmi Narayana, "IoT for Healthcare," in International Journal of Science and Research (IJSR), 2014.

[8] Keyur K Patel and Sunil M Patel, "Internet of Things-IOT: Definition, Characteristics, Architecture, Enabling Technologies, Application & Future Challenges," in 2016 IJESC, 2016.

[9] S. Nunna, A. Kousaridas, M. Ibrahim, M. Dillinger, C. Thuemmler, H. Feussner and A. Schneider, "Enabling real-time context-aware collaboration through 5g and mobile edge computing," in Information Technology - New Generations (ITNG), 2015 12th International Conference, 2015.

[10] V. Vassilakis, I. Moscholios, A. Bontozoglou and M. Logothetis, "Mobility-aware qos assurance in software-defined radio access networks: An analytical study," in Network Softwarization (NetSoft), 2015 1st IEEE Conference, 2015.

[11] I. Ku, Y. Lu, M. Gerla, F. Ongaro, R. L. Gomes and E. Cerqueira, "Towards software-defined vanet: Architecture and services," in Ad Hoc Networking Workshop (MED-HOCNET), 2014 13th Annual Mediterranean. IEEE, 2014.

[12] Kriti Gupta, Pallavi Kaul and Arashdeep Kaur, "An Efficient Algorithm for Heart Attack," in International Conference on "Computational Intelligence and Communication Technology", 2018.

[13] Yosuf ElSaadany, AKM Jahangir A. Majumder and Donald R. Ucci, "A Wireless Early Prediction System of Cardiac Arrest through IoT," in IEEE 41st Annual Computer Software and Applications Conference, 2017.

[14] M. Sun et al., "Biology Measuring ultra-weak photon emission as a non-invasive diagnostic tool for detecting early-stage type 2 diabetes : A step toward personalized medicine," in Journal of Photochemistry & Photobiology, 2017.

[15] Guruprasad M Bhat and Nayana G Bhat, "A Novel IoT Based Framework for Blood Glucose Examination," in International Conference on Electrical, Electronics, Communication, Computer and Optimization Techniques (ICEECCOT), 2017.

[16] Saina Sunny and S.Swapna Kumar, "Optical Based Non Invasive Glucometer with IoT," in International Conference on Power, Signals, Control and Computation (EPSCICON), 2018.

[17] A. M. Elmisery, S. Rho and D. Botvich, "A fog based middleware for automated compliance with OECD privacy principles in Internet of healthcare things," IEEE Access, vol. 4, no. 8418–8441, 2016.

[18] M. Gusev, A. Stojmenski and A. Guseva, "ECGalert: A heart attack alerting system,"

in Springer International Publishing, 2017.

[19] Hoda Ramin Hossein, "SPHMS : Smart Patient m-Healthcare Monitoring System with NFC and IOT," International Journal of Computer Applications Technology and Research , vol. 4, no. 12, 956 - 959, 2015.

[20] Utkarshani Jaimini, "Multimodal IoT and EMR based Smart Health," in IEEE International Conference on Smart Computing (SMARTCOMP), 2017.

[21] Suriya Begum and Huma Parveen, "U-HEALTHCARE and IoT," International Journal of Computer Science and Mobile Computing, vol. 5, no. 8, pp. 138-142, 2016.

[22] B.Sobhan Babu, K. Srikanth, T. Ramanjaneyulu and I. Lakshmi Narayana, "IoT for Healthcare," International Journal of Science and Research, vol. 5, no. 2, 2016.

[23] S.LAVANYA, G.LAVANYA and J.DIVYABHARATHI, "REMOTE PRESCRIPTION AND I-HOME," in IEEE International Conference on Innovations in Green Energy and Healthcare Technologies(ICIGEHT), 2017.

[24] R.Revathi, S.Vijani and S.Vijanu, "INTELLIGENT HEALTH CARE SERVICES BASED ON IoT," in International Journal of Scientific & Engineering Research, 2015.

[25] Soo Yeon Sohn, Mungyu Bae, Dong-kyu and Hwangnam Kim, "Alarm System for Elder Patients Medication with IoT-Enabled Pill Bottle".

[26] Salem Alelyani, IEEE Member and Abdelrahman Ibrahim, "Internet-of-Things in Telemedicine for Diabetes Management".

[27] S. Distefano, D. Bruneo and F. L, "Hospitalized Patient Monitoring and Early Treatment Using," in Springer Science+Business Media, New York, 2016.

[28] Bharat Prajapati, Satyen Parikh and Jignesh Patel, "An Intelligent Real Time IoT Based System (IRTBS) for Monitoring ICU Patient".

[29] Bernard Fong, 1 A. C. M. Fong and C. K. Li, "Internet of Things in Smart Ambulance and Emergency Medicine," in Inc. Published 2018 by John Wiley & Sons, Inc, 2018.

[30] Omkar Udawant, Nikhil Thombare and Devanand Chauhan, "Smart Ambulance System using IoT," in International Conference on Big Data, IoT and Data Science (BID), 2017.

[31] Abbas, A., Bilal, K., Zhang, L., & Khan, S. U. (2015). A cloud based health insurance plan recommendation system: A user centered approach. *Future Generation Computer Systems*, *43*, 99–109. https://doi.org/10.1016/j.future.2014.08.010

[32] Aruna, T., Saranya, K. and Bhandari, C., 2011, July. A survey on ontology evaluation tools. In 2011 International Conference on Process Automation, Control and Computing (pp. 1-5). IEEE.

[33] Amrouch, S. and Mostefai, S., 2012, March. Survey on the literature of ontology mapping, alignment and merging. In 2012 International Conference on Information Technology and e-Services (pp. 1-5). IEEE.

[34] Mukhtar, M. E. M., Joel, J. P. C. R., Sayed Hassan, A., Shah, S. C., Jalal F., A.-M., & Valery V., Korotaev Victor Hugo C., D. A. (2018). Enabling Technologies on Cloud of Things for Smart Healthcare. *IEEE Access*, *6*, 31950–31967. https://doi.org/10.1109/access.2018.2845399

[35] Pham, M., Mengistu;Yehenew, Ha, D., & Weihua, S. (2018). Delivering home healthcare through a Cloud-based Smart Home Environment (CoSHE). *Future Generation Computer Systems*, *81*, 129–140. https://doi.org/10.1016/j.future.2017.10.040

[36] Bansal, M., & Bani, G. (2018). IoT Based Development Boards for Smart Healthcare Applications. In *2018 4th International Conference on Computing Communication and Automation (ICCCA)* (pp. 1–7). Greater Noida, India: IEEE.

[37] Rahmani, A. M., Gia, T. N., Negash, B., Anzanpour, A., Azimi, I., Jiang, M., & Liljeberg, P. (2018). Exploiting smart e-Health gateways at the edge of healthcare Internet-of-Things: A fog computing approach. *Future Generation Computer Systems*, *78*, 641–658.

https://doi.org/10.1016/j.future.2017.02.014

[38] Manogaran, G., Varatharajan, R., Lopez, D., Kumar, P. M., Sundarasekar, R., & Thota, C. (2018). A new architecture of Internet of Things and big data ecosystem for secured smart healthcare monitoring and alerting system. *Future Generation Computer Systems, 82,* 375–387. https://doi.org/10.1016/j.future.2017.10.045

[39] Lasierra, N., Alesanco, A., Guillén, S., & García, J. (2013). A three stage ontology-driven solution to provide personalized care to chronic patients at home. *Journal of Biomedical Informatics*, *46*(3), 516–529. https://doi.org/10.1016/j.jbi.2013.03.006

[40] Schiza, E. C., Kyprianou, T. C., Petkov, N., & Schizas, C. N. (2018). Proposal for an eHealth Based Ecosystem Serving National Healthcare. *IEEE Journal of Biomedical and Health Informatics*, *PP*(c), 1. https://doi.org/10.1109/JBHI.2018.2834230

[41] Doulaverakis, C., Nikolaidis, G., Kleontas, A., & Kompatsiaris, I. (2012). BIOMEDICAL SEMANTICS GalenOWL : Ontology-based drug recommendations discovery, 1–9.

[42] Alamri, A. (2018). Ontology Middleware for Integration of IoT Healthcare Information Systems in EHR Systems. *Computers*, *7*(4), 51-66. https://doi.org/10.3390/computers7040051

[43] Félix, N. D. de C., Ramos, N. de M., Nascimento, M. N. R., Moreira, T. M. M., & Oliveira, C. J. de. (2018). Nursing diagnoses from ICNP® for people with metabolic syndrome. *Revista Brasileira de Enfermagem*, *71*(suppl 1), 467–474. https://doi.org/10.1590/0034-7167-2017-0125

[44] Bui, V. T., Verhoeven, R., & Lukkien, J. J. (2012). A Body Sensor Platform for Concurrent Applications. *2012 IEEE Second International Conference on Consumer Electronics - Berlin (ICCE-Berlin),* 38–42. https://doi.org/10.1109/ICCE-Berlin.2012.6336468

[45] Hristoskova, A., Sakkalis, V., Zacharioudakis, G., Tsiknakis, M., & De Turck, F.

(2014). *Ontology-driven monitoring of patient's vital signs enabling personalized medical detection and alert*. *Sensors (Switzerland)* (Vol. 14). https://doi.org/10.3390/s140101598.

[46] Shen, Y., Yuan, K., Chen, D., Colloc, J., Yang, M., Li, Y., & Lei, K. (2018). An ontology-driven clinical decision support system (IDDAP) for infectious disease diagnosis and antibiotic prescription. *Artificial Intelligence in Medicine*, *86,* 20–32. https://doi.org/10.1016/j.artmed.2018.01.003

[47] Al Thawadi, Maryam Hasan Abdullah. "Innovative Business Model for Smart Healthcare Insurnce." (2019).

[48] D. Jacquette, *Ontology*. 2014.

[49] B. Smith, "Ontology," in *The furniture of the world*, 2019.

[50] D. Fensel, "Ontologies," in Ontologies, Springer, Berlin, Heidelberg, 2001, pp. 11–18.

[51] T. R. Gruber, "A translation approach to portable ontology specifications," Knowledge Acquisition, vol. 5, no. 2, pp. 199–220, Jun. 1993.

[52] N. Guarino, Formal Ontology in Information Systems. IOS Press, 1998.

[53] G. A. Miller, "WordNet: A Lexical Database for English," Commun. ACM, vol. 38, no. 11, pp. 39–41, Nov. 1995.

[54] D. B. Lenat, R. V. Guha, K. Pittman, D. Pratt, and M. Shepherd, "Cyc: Toward Programs with Common Sense," Commun. ACM, vol. 33, no. 8, pp. 30–49, Aug. 1990.

[55] V. Tarasov, H. Tan, M. Ismail, A. Adlemo, and M. Johansson, "Application of Inference Rules to a Software Requirements Ontology to Generate Software Test Cases," in OWL: Experiences and Directions – Reasoner Evaluation, Springer, Cham, 2016, pp. 82–94.

[56] I. Dubielewicz, B. Hnatkowska, Z. Huzar, and L. Tuzinkiewicz, "Domain Modeling Based on Requirements Specification and Ontology," in Software Engineering: Challenges and Solutions, Springer, Cham, 2017, pp. 31–45.

[57] V. Castaneda, L. Ballejos, M. L. Caliusco, and M. R. Galli, "The Use of Ontologies in

Requirements Engineering,” Global Journal of Research In Engineering, vol. 10, no. 6, Nov. 2010.

[58] Sahi, M. A., Abbas, H., Saleem, K., Yang, X., Derhab, A., Orgun, M. A., … Yaseen, A. (2017). Privacy Preservation in e-Healthcare Environments: State of the Art and Future Directions. *IEEE Access*, *6*, 464–478. https://doi.org/10.1109/ACCESS.2017.2767561

[59] Babalou, Samira, Elena Grygorova, and Birgitta König-Ries. "CoMerger: a customizable online tool for building a consistent quality-assured merged ontology." In ESWC, Poster and Demo Track June (2020).

[60] Noy, Natalya F. "Tools for mapping and merging ontologies." In Handbook on ontologies, pp. 365-384. Springer, Berlin, Heidelberg, 2004.

[61] Priya, M., and Ch Aswani Kumar. "A novel approach for merging ontologies using formal concept analysis." International Journal of Cloud Computing 9, no. 2-3 (2020): 189-206.

[62] Gyrard, A., Datta, S.K. and Bonnet, C., 2018, February. A survey and analysis of ontology-based software tools for semantic interoperability in IoT and WoT landscapes. In 2018 IEEE 4th World Forum on Internet of Things (WF-IoT) (pp. 86-91). IEEE.

[63] He, Y., Xiang, Z., Zheng, J., Lin, Y., Overton, J.A. and Ong, E., 2018. The eXtensible ontology development (XOD) principles and tool implementation to support ontology interoperability. Journal of biomedical semantics, 9(1), pp.1-10.

[64] Aruna, T., Saranya, K. and Bhandari, C., 2011, July. A survey on ontology evaluation tools. In 2011 International Conference on Process Automation, Control and Computing (pp. 1-5). IEEE.

[65] Amrouch, S. and Mostefai, S., 2012, March. Survey on the literature of ontology mapping, alignment and merging. In 2012 International Conference on Information Technology and e-Services (pp. 1-5). IEEE.