11-2019

Innovative Business Model for Smart Healthcare Insurnce

Maryam Hasan Abdullah Al Thawadi

United Arab Emirates University

College of Information Technology

Department of Information Systems and Security

INNOVATIVE BUSINESS MODEL FOR SMART HEALTHCARE INSURANCE

Maryam Hasan Abdulla Al Thawadi

This thesis is submitted in partial fulfilment of the requirements for the degree of Master of Science in Information Technology Management

Under the Supervision of Dr. Farag Sallabi

November 2019

Declaration of Original Work

I, Maryam Hasan Abdulla Al Thawadi, the undersigned, a graduate student at the United Arab Emirates University (UAEU), and the author of this thesis entitled "*Innovative Business Model For Smart Healthcare Insurance*", hereby, solemnly declare that this thesis is my own original research work that has been done and prepared by me under the supervision of Dr. Farag Sallabi, in the College of Information Technology at UAEU. This work has not previously been presented or published or formed the basis for the award of any academic degree, diploma or a similar title at this or any other university. Any materials borrowed from other sources (whether published or unpublished) and relied upon or included in my thesis have been properly cited and acknowledged in accordance with appropriate academic conventions. I further declare that there is no potential conflict of interest with respect to the research, data collection, authorship, presentation and/or publication of this thesis.

Student's Signature: Maria Date: 19 / 11 / 2019

Approval of the Master Thesis

This Master Thesis is approved by the following Examining Committee Members:

1) Advisor (Committee Chair): Farag Sallabi
   Title: Associate Professor
   Department of Computer and network engineering
   College of Information Technology
   Signature ______________________ Date 14/11/2019

2) Member: Mohammed Mehedy Masud
   Title: Associate Professor
   Department of Information Systems and Security
   College of Information Technology
   Signature ______________________ Date 14/11/2019

3) Member (External Examiner): Ashraf M. Elnagar
   Title: Professor
   Department of Computer science
   Institution: University of Sharjah, UAE
   Signature ______________________ Date 14/11/2019

This Master Thesis is accepted by:

Dean of the College of Information Technology: Professor Khaled Shuaib

Signature ______________________ Date 26/12/2019

Dean of the College of Graduate Studies: Professor Ali Al-Marzouqi

Signature Ali Hassan Date 16/1/2020

Copy 1 of 5

Abstract

Information revolution and technology growth have made a considerable contribution to restraining the cost expansion and empowering the customer. They disrupted most business models in different industries. The customer-centric business model has pervaded the different sectors. Smart healthcare has made an enormous shift in patient life and raised their expectations of healthcare services quality. Healthcare insurance is an essential business in the healthcare sector; patients expect a new business model to meet their needs and enhance their wellness. This research develops a holistic smart healthcare architecture based on the recent development of information and communications technology. Then develops a disruptive healthcare insurance business model that adapts to this architecture and classifies the patient according to their technology needs. Finally, and implementing a prototype of a system that matches and suits the healthcare recipient condition to the proper healthcare insurance policy by applying Web Ontology Language (OWL) and rule-based reasoning model using SWRL using Protégé.

Keywords: Smart healthcare, smart healthcare insurance, ontology, business model.

Title and Abstract (in Arabic)

نموذج اعمال مبتكر للتامين في الرعاية الصحية الذكية

الملخص

أسهمت ثوره المعلومات ونمو التكنولوجيا إسهاما كبيرا في تقليل النمو المتزايد للتكاليف وتمكين العملاء. إضافة إلى ذلك فقد ساهمت هذه الثورة في تدمير معظم نماذج الاعمال في الصناعات المختلفة. وقد انتشر نموذج الاعمال المرتكز على العملاء في مختلف القطاعات. حققت الرعاية الصحية الذكية تحولا هائلا في حياه المريض ورفعت توقعاته بجوده خدمات الرعاية الصحية. التامين الصحي هو عامل أساسي في قطاع الرعاية الصحية وحيث أن القطاع الصحي متأثر بالثورة المعلوماتية فإن توقعات المرضى تتطلع إلى نموذج عمل جديد لتلبيه احتياجاتهم وتعزيز حالتهم الصحية. تتناول هذه الدراسة تصميم نظام الرعاية الصحية الذكي القائم على التطور في تكنولوجيا المعلومات والاتصالات. كما تم تصميم نموذج أعمال مبتكر للتامين الصحي يتماشى مع نظام الرعاية الصحية حيث يتم تصنيف المريض وفقا لاحتياجاته التقنية. إضافة إلى إنشاء نظام يعمل على إصدار بوليصة تأمين مخصصة لكل مريض وفقاً لحاجاته الصحية والالكترونية. يعتمد هذا النظام على استخدام خاصية Ontology Web Language إضافة إلى تطبيق القواعد باستخدام لغة SWRL لتشكيل بوليصة تأمين خاصة بكل مريض.

مفاهيم البحث الرئيسية: الرعاية الصحية الذكية، التأمين للرعاية الصحية الذكية، أنتولوجيا، نموذج الأعمال.

Acknowledgements

I would like to thank my committee for their guidance, support, and assistance throughout my preparation of this thesis, especially my advisor Dr. Farag Sallabi. I would like to thank the chair and all members of the College of Information Technology at the United Arab Emirates University for assisting me all over my studies and research, especially Dr. Adel Serhani and Ms. Maryam Almandhry.

My thanks go to the examining committee members (Prof. Ashraf M. Elnagar, Dr. Mohammed Mehedy Masud) for thier valuable comments that empower my thesis.

Special thanks go to my Bahraini and Emirati families, parents, aunties, sisters (Haya, Hend, Fatima) and brothers who helped me along the way. I am sure they suspected it was endless.

In addition, special thanks to all my friends in Bahrain Noora, Moody, Luma, Mahmood, Farrah and my special sisters in UAE Maryam, Nuha. Thanks a lot, I really appreciate your unlimited support all the time.

Special thanks to my supportive manager Prof Alaa and my supportive colleagues in Bahrain Aysha, Ebtisam and Noor.

Finally, my colleagues especially Henry, Noora, Alreem, Haya and everyone contribute to the success of this journey.

May Allah bless you all.

Dedication

To my beloved parents and family

To Dr. Ahmad AlNobi "may he rest in peace"

Table of Contents

List of Tables

List of Figures

List of Abbreviations

2G	2 Generation of Broadly Cellular Network
3G	3 Generation of Broadly Cellular Network
4G	4 Generation of Broadly Cellular Network
AAL	Ambient (or Active) Assistant Living
AI	Artificial Intelligent
ASA	American Society of Anesthesiologists
B2B	Business to the Business Model
BAN	Body Area Network
BMI	Body Mass Index
CMP	Chemical Mechanical Planarization
DSS	Decision Support System
ECG	Electrocardiogram
EHR	Electronic Health Record
EPO	Exclusive Provider Organization
FMA	Foundational Model of Anatomy
FOAF	Friend of a Friend Ontology
GDP	Gross Domestic Product Rate
GPS	Global Positioning System
HMO	Health Maintenance Organization
ICD	International Classification of Diseases Ontology
ICNP	International Classification for Nursing Practice
ICT	Information and Communication Technology
IoMT	Internet of Medical Things

IoT	Internet of Things
IP	Internet Protocol
IPA	Individual Practice Association
ISP	Internet Service Providers
IT	Information Technology
OGS	Open Geospatial Consortium
PD	Personal Device
PHO	Physician-hospital Organization
POS	Point-of-service
PPO	Preferred Provider Organization
RFID	Radio Frequency Identification
SensorML	Sensor Model Language
SNOMED-CT	Systematized Nomenclature of Medicine - Clinical Terms Ontology
SOSA	Sensor, Observation, Sample and Actuator
SPARQL	A Semantic Query Language for Databases
SSN	Semantic Sensors Network
SWL	Semantic Web Language
SWRL	Semantic Web Rule Language
W3C	World Wide Web Consortium School
WBAN	Wireless Body Area Network
WHO	World Health Organization
Wi-Fi	Wireless Fidelity
WSSN	Wireless Semantic Sensors Network
XML	Extensible Markup Language

Chapter 1: Introduction

1.1 Overview

The significant goal of World Health Organization (WHO) is to build a better, healthier future for people over the world (WHO, 2018). One of the methods for achieving this goal is to establish effective healthcare systems. An effective healthcare system as defined in (WHO, 2018b) is the system with the ability to provide healthcare services to all people in the place and the time they need. Healthcare system has three main goals include preserving people health, providing sickness therapy and supporting families to avoid financial ruin from medical bills (PNHP, 2016).

There are three levels of healthcare services (HIC, 2018) including primary healthcare, secondary healthcare, and tertiary healthcare. The primary healthcare is the first place that the patient will reach to get a healthcare service including doctors, dentist, nurse, health professional or pharmacists. The secondary level is provided by a professional and specialist in healthcare. In most cases, secondary healthcare services are provided for the patient after the primary healthcare level referral. This level of healthcare services is provided in hospitals and includes ongoing services such as physiotherapy. The highest level of healthcare is tertiary services. This level provides complex and surgical procedure services by highly specialized healthcare professionals. The patient may be transferred to the secondary or the tertiary levels depending on the patient health situation and the healthcare services needed.

The gross domestic product rate (GDP) of healthcare is growing over the years in all countries. As registered in the world health organization global health expenditure database of The World Bank that the total health expenditure GDP percentage has growth from 8.6% in 2000 to 10% in 2016 (World Bank, 2019). A statistics for the U.S. national health expenditure as a percent of GDP from 1960 to 2019 shows that in 1960 the GDP was 5% only and reached 17.5% in 2019 (Statista, 2019).

Recent advances in Information and Communication Technology (ICT) increased patient expectation regarding healthcare services. Future doctors will not only provide patients with prescriptions but also with advice and healthcare monitoring devices and facilities to improve health and lifestyle. Healthcare providers including governments, private sectors, insurance companies must collaborate to tame runaway cost inflation using digital health and focus on the delivered value instead of providing drugs and devices. These reasons are the main motivation for this research.

1.2 Statement of the Problem

Healthcare is an imperative field in the whole world to maintain the main capital in any country which is the human, and at the same time, it needs to control the huge financial spending on it. From this point, healthcare should provide the best services at the lowest financial cost. Recalling some other concepts from other fields will facilitate achieving this goal. The innovative business model from the business perspective and the emerging technology trends (like IoT, cloud computing, mobile...etc.) can be applied in the healthcare field to enhance its efficiency (Hwang & Christensen, 2008). On the other hand, the change in healthcare has a direct relation to healthcare insurance policies. Nowadays, healthcare insurance policies are assigned using the irrelevant methodology that depends on the financial terms only, ignoring most of the important factors. It is selected by the customer or the provider (government or employer) which may cause financial ruin for either the customer of the insurance company. Indeed, this business model will be disruptive because it is not supporting the patients’ expectations and the smart healthcare system.

The main objective of this research is to develop an innovative Healthcare Insurance Business Model that convey the accelerated changes and satisfy the market and customer needs.

This research was built upon the hypothesis that combining the innovative business model concept and the available trend technologies will create a new business that can enhance the healthcare services and achieve the goals of WHO. This business model will manage the relationship between the different healthcare parties including the government, private sector, and healthcare insurance companies.

1.3 Relevant Literature

This section discusses three parts namely, smart healthcare architecture, smart healthcare insurance and smart healthcare ontologies.

1.3.1 Smart Healthcare Architecture

Smart healthcare architecture is an essential part to understand the healthcare requirements and it has several designs (Sahi et al., 2017). This part discussed five different smart healthcare architecture in the latest researches.

Sahi et al. (2017) proposed a smart healthcare architecture that consists of three main layers. Body area network (BAN) used to collect the patient vital signs details and send them using the network layer mainly the Internet to the users (such as physicians, pharmacist, healthcare insurance provider etc.) and the main network that consists of the servers to stores healthcare information.

Mukhtar et al. (2018) proposed a smart healthcare architecture that combines

IoT and cloud computing and called it “cloud of things”. The first layer is IoT devices that are connected using a wireless body area network (WBAN). The collected data is transferred to the medical servers in the cloud for the analysis and storage purpose using a communication medium. The users mainly physicians can access the cloud to get information.

Pham et al. (2018) proposed a cloud-based home environment architecture. It consists of four layers. The first layer is the smart home environment includes body area sensors, environmental sensors and a robot. The second layer is the communication layer which is mainly the Internet. The third layer is the caregiver remote station and that access the private cloud for data analysis and storage.

Bansal & Bani (2018) proposed a smart healthcare architecture that consists of five components. The first component is the body area network (BAN) that collect the patient vital signs and send it using the connection layer to the second component which is the IoT based boards. These boards are responsible for data processing. The processed data has two different destinations depends on patient status. In the case of emergency, the data will be sent to the doctor remote station which is the fourth component. Otherwise, the data is sent to the cloud for storage which is the fifth component.

Rahmani et al. (2018) proposed an architecture of smart healthcare that differ from the previous research by adding fog computing layer as an intermediate between the cloud and the smart devices. It also consists of remote and logic caregivers’ station.

Manogaran et al. (2018) proposed a similar smart healthcare architecture that consists of fog computing layer between the smart devices and the cloud.

With respect to the architecture mentioned above, they miss the holistic overview of the smart healthcare architecture by focusing on the technology components and ignoring smart healthcare partners. We focus on this issue in chapter 2 by proposing a holistic smart healthcare architecture.

1.3.2 Smart Healthcare Ontologies

An ontology is a conceptual model consists of classes, properties and the relations between the classes within a specific domain. Each class represents a concept and the properties represent the attributes of the concept (Lasierra et al., 2013; Riaño et al., 2012). The ontologies represent knowledge in a semantic and interoperable model that encourage knowledge reuse and simplify problem-solving in various fields. Medicine is one of the complex fields that benefit from applying ontologies and there are various types of medicine ontologies (Doulaverakis et al, 2012). Medicine ontologies can be divided into three groups according to the knowledge used (Zhang et al., 2017). The first group represents the standard medicine terminologies that aim to achieve consistency in various medicine information systems such as international classification of diseases ontology (ICD) (Bioportal, 2019c), Systematized Nomenclature of Medicine - Clinical Terms ontology (SNOMED-CT) (Bioportal, 2019d), the Foundational Model of Anatomy (FMA) (Bioportal, 2019a) and the International classification for nursing practice (ICNP) (Bioportal, 2019b). The second group represents the declarative knowledge related to constant concepts and the relationship within a medical organization or medical research field such as Actor profile ontology that identifies positions and responsibilities in healthcare. The third group represents the procedural knowledge that identifies the terms, decisions and processes of managing the clinical workflow such as the instruction ontologies evidence-based clinical decision support.

The standard medicine terminologies ontologies are the most used ontologies in research fields. Some of the commonly used ontologies are ICD, SNOMED-CT, FMA and ICNP (Alamri, 2018). ICD consists of the general health situation including diseases and its symptoms and other health problems related to other variables such as health status influencing factors. ICD mainly used in smart diagnosis systems and it has 11 version until now. SNOMEC-CT consists of the core terminologies in the health record. It aims to enhance the effectiveness of clinical data recording. FMA is the Foundational Model of Anatomy that represents the declarative knowledge of body anatomy (Foundational Model of Anatomy, 2019). ICNP includes the terms and definitions of the nurses' statements that considered the patient diagnosis. Nursing science has a significant contribution to healthcare services since nurses' statements are important in systemizing and prioritizing healthcare services (Félix et al, 2018).

The integration of the wearable and implant body sensors represents the medical body area network which records the different human body functions and environmental factors for certain purposes either medical or sports track or even computer games (Bui et al., 2012). Currently, the available sensors ontologies can be combined to serve the body sensors projects.

The W3C Semantic Sensors Network (SSN) is one of the most important ontologies used in describing sensors and it describes the sensors capabilities, actuators observation and the related concepts (Alamri, 2018; Nachabe et al, 2015). Wireless SSN (WSSN) is the extended SSN version that includes the wireless communication data policy. Sensor, Observation, Sample and Actuator (SOSA) is the lightweight core of SSN that provide general-purpose specification model for interaction between sensors. SOSA doesn’t replace SSN but it expands the targeted audience in the semantic web community by providing a flexible framework and easy to use vocabulary (Janowicz et al., 2019). The Open Geospatial Consortium (OGS) Sensor Model Language (SensorML) describes the sensors, observation and measurement syntactically using XML. OntoSensor (Nachabe et al., 2015) was built on the idea of OGS SensorML and it extended the observation data to include the geographical location and the observed data accuracy.

The previous ontologies need to be integrated and altered to suit body sensor networks since none of them is integral to obtain such purpose (Nachabe et al., 2015). MyOntoSens is an example of a proposed ontology for body area network (BAN) that was extracted from OntoSensor, SSN, WSSN and SensorML. MIMU-Wear ontology is another example of an ontology that extended SSN to create a comprehensive ontology for the purpose of building wearable sensors that recognize the human body activities (Villalonga et al., 2017).

The patient plays the most important role in medical researches and defining patients’ profile is a mandatory process in such projects. General ontology can be used to declare patient profile and empower this process. FOAF (Friend of a Friend) is a general ontology which became the standard ontology for declaring person profile in different fields such as health, finance, law, etc. (Emre & Ozgu, 2018). FOAF classes describe a person, his activities and his relations in general. It has four main categories including basic information such as name and title etc., personal information such as age and interests etc., online accounts such as bank account and Yahoo account, and documents and image such as personal photo and logo (Kalemi & Martiri, 2011).

Ontologies are broadly used in several fields and ontologies integration is a useful process for implementing new ontologies. Ontology integration is the process of combining two or more general ontologies to create a new ontology for the purpose of enriching the available ontologies or combining ontologies from different fields in a new ontology that used to solve certain problems (Liu et al., 2019). This research work, Do-care, is based on one composed ontology containing different valid ontologies including ICNP (International Classification Nursing Practices) as a medicine ontology, SSN/SOAS ontology as a sensor network ontology and FOAF as a personal profile ontology.

Healthcare reasoning techniques may include rule-based reasoning, case-based reasoning and hybrid-based reasoning. Kumar et al. (2018) proposed a system for monitoring and diagnosing series diseases using IoT devices and cloud computing in data collection and fuzzy rules algorithm in the diagnosis process. Case-based reasoning is the best option for complex disease prediction (Malathi et al., 2019). Gómez-Vallejo et al. (2016) proposed a case-based reasoning system called InNoCPR for nosocomial infections detection and classification. Nosocomial infections referred to the infections that infected the patient from the hospital environment during the patient treatment in the hospital. InNoCPR system provides an automatic nosocomial infection diagnosis using case-based reasoning and classifies any new potential nosocomial infection.

Hybrid-based reasoning is a combination of two or more reasoning methods. Malathi et al. (2019) proposed a disease prediction support system using hybrid reasoning based methodology. It is a combination of fuzzy set theory, k-nearest neighbour and case-based reasoning to enhance the prediction of the disease. Moreover, applying reasoning methods for ontologies is used widely in healthcare systems, Ali et al. (2018) proposed an IoT based system for monitoring the patient health and recommend diet including food and medicine for chronic diseases patient. The system applied semantic web language (SWL) rules and fuzzy logic on the ontology to automate the recommendation process and (SPARQL) queries are used to evaluate the ontology.

Zhang et al. (2017) proposed an ontology-driven decision support system to monitor and follow up chronical disease patients outside the hospital to provide a continuous assessment and chronic disease management. The proposed ontology adopted SNOMED-CT and consists of three knowledge type: patient data, medical domain knowledge and patient assessment criteria for chronic diseases. The decision support system was adopted to automate the selection of a patient's assessment program. DSS collect required data from different sources such as patient electronic health record, patient mobile application and medical devices that represent a patient database. The framework was applied for type 2 diabetes and achieved 99.93% accuracy and 95 completeness. Also, Shen et al. (2018) proposed an ontology-driven clinical support system (IDDAP) for infectious disease diagnosis and antibiotic prescription to help the patient in infection diagnose and prescribe the related antibiotic as first-line therapy. It specifies the infection based on the patient's self-description about body temperature, symptoms, complications, antibacterial spectrum, contraindications, and drug-drug interactions and then proposed the appropriate infection therapy. The system consists of 507 infections and their therapy and the proposed infection ontology is considered as the most completed ontology compared to the others. The weakness of these systems is the miss of applying IoT technology in data collection that will enhance the collected data and the accuracy of the results.

Hristoskova et al. (2014) proposed an ambient intelligent framework to monitor a congestive heart failure patient. The novelty of the framework is personalizing the real-time monitoring process of the patient health status and risk stage and sending an alert to the specialized physicians according to the patient health status. Moreover, it considers the physicians' location and intervention time in emergency cases. The framework was validated using the scenario methodology. The architecture of the framework consists of wireless medical devices, sensors network to specify the location of the physicians, patient monitoring application and an ontology for congestive heart failure reasoning. The framework is a combination of IoT application and ontology concept which empower it, but it is limited for congestive heart failure patients.

Rhayem et al. (2017) proposed an ontology-based system for patient monitoring with connected objects that consist of three modules. The first module is connecting and managing object using Health IoT ontology, the second module is diagnosis and detection that allow doctors assist patients remotely, and the third module is an alert distribution for the patient with their status and a list of their medical prescription. Using ontology in this system is limited to IoT and medical devices only while the vital signs analysis and decision-making need doctor intervention. The doctor can assist his patient remotely, but this process is not automated which may affect the treatment response time

Ahmed (2017) proposed an intelligent healthcare system to monitor elderly vital signs in daily life using IoT for data collection, rules-based reasoning and case base reasoning for patients diagnose. The system works by collecting vital signs data from IoT and sending them to a cloud that apply the rules and case base reasoning to return the patient diagnosis from the worldwide cases available from different doctors and physicians. The weakness in this system is the miss of applying ontology concept that is significant for solving the heterogeneous issue of collected data.

1.3.3 Healthcare insurance Ontologies

Abbas et al. (2015), proposed a cloud-based insurance plan recommendation system. The system is a user-centric that recommend the suitable health insurance plan depends on the entered patient information. It considers the policy price, the policy coverage benefits, and quality designates while selecting the customer policy. This system proposed a standardized healthcare insurance ontology representing the common healthcare insurance policies and apply XML retrieval approach using tree matching to match between the entered data and the ontology.

This thesis proposed a health insurance policy system that followed the same purpose of the previous research by defining the customer-centric policy but using a different methodology. The proposed system creates a customized policy consists of policy packages related to the customer health status and other parameters as discussed in Chapter 4.

Chapter 2: Smart Healthcare Architecture

Generally, the new trends of technology like IoT, big data, cloud computing, and robotics has a significant influence on healthcare. New concepts appear like smart healthcare, E-health or healthcare technology. They share the same goal by using ICT to enhance healthcare services (WHO, 2019). The application of ICT in healthcare started by creating digital records for the patient that can be viewed and shared within the county using an integrated database system. Nowadays, the mobile and social media platforms allow the physicians to follow up the patient health and get real-time information which leads to providing suitable healthcare for the patient remotely (EY, 2015). On the other hand, the huge amount of real-time data which can be considered as big data revolution can be stored in cloud computing. It provides the service of the store, maintains and backs up big data of personal health information using cheap and more effective technique (Rouse, 2012). IoT is the technique of creating smart objects. It could be used to address pediatric and elderly care, chronic disease supervision, private health, and fitness management (Islam et al., 2015). This application of smart healthcare is a significant incitement to create an innovative healthcare insurance business model.

This chapter presents a holistic smart healthcare architecture as depicted in Figure 1. The goal is to provide different services to various stakeholders by considering state-of-the-art technologies. Farahani et al. (2018) presented the architecture of IoT healthcare ecosystem. The architecture is patient centric IoT healthcare ecosystem, which consists of three layers namely, device layer, fog computing layer, and cloud layer. In our work, we add two more layers to the architecture to make it suitable for a smart healthcare business model.

2.1 Smart Healthcare Device Layer

This layer consists of IoT devices that monitor and collect patient and ambient data. These devices include Wireless Body Area Network (WBAN) and Ambient sensors. WBAN consists of sensors and a Personal Device (PD). Sensors are either attached to the body or implanted inside the body with an invasive operation. WBAN sensors collect patient-related data to monitor health status and send them to the PD for initial filtering and pre-processing. The PD sends all collected data to the fog computing nodes for further processing. Ambient devices measure the environmental parameters such as humidity, temperature, smoke, water flow sensors, video cameras to detect unusual patterns, etc. (Firouzi et al., 2018; Uddin, 2018). These sensors usually are deployed nearby the patient and can be attached to the patient when the patient leaves the house. Smart healthcare services are realized by developing software applications for remote patient monitoring, diagnostics, and consultation.

2.2 Network Layer

The network layer is the backbone that connects all other layers. Different layers may use different network technologies to connect to the Internet. The device layer gateway, a proxy that connects the healthcare devices to the Internet, may use Wi-Fi, 3G, 4G or even 5G if available. Other layers are connected to the Internet with the underlying connections deployed at the corresponding premises. The network layer is usually provided and managed by local ISPs. Due to the sensitivity of smart healthcare services, the network layer should provide reliable and secure connections.

2.3 Fog Computing Layer

This layer is usually hosted by the hospital, the insurance company or as part of the smart city. It should be within the same city/town of the care recipient to minimize the latency between the patient and the caregivers. All health data should be directed to fog nodes before being sent to the cloud. In a smart healthcare architecture, fog computing is used for processing time-sensitive data to allow just-in-time decision and avoid any delay that put the patient at risk. Conserving the network bandwidth is another issue solved by using fog computing. Some devices like ECG generate a massive amount of raw data during the day for just one patient. This amount of data could be processed, analyzed, filtered and compressed using a fog node and then the results are sent to the cloud.

2.4 Cloud Computing Layer

The cloud layer has two components, backend infrastructure, and user interface. The backend infrastructure facilitates data storage, analytics, mining, and decision making (Firouzi et al., 2018). It captures the data from different sources and in different data types and stores them securely. Cloud captures data from fog nodes and other sources like doctors' comments, e-prescription, and the patient electronic health record. Collected data could be made available to different stakeholders. Big data analytics plays a significant role in cloud computing based on smart healthcare architecture. It aims to extract effective insights into decision making. Data mining, rule-based, auto reasoning based, AI, machine learning algorithms are applied in this layer. The User Interface allows the patients and authorized partners to monitor the patient health status. Physicians can monitor, diagnose and contact the patient remotely. This layer is responsible for data visualization and presentation of analyzed data for the users using desktop or mobile applications.

2.5 Partnership Network Layer

This layer includes key healthcare insurance partners in the smart healthcare ecosystem. These partners may include:

2.5.1 Healthcare Regulatory

Healthcare regulatory is presented by the Ministry of Health and responsible for healthcare service availability to society members and for defining policies, rules, regulations and monitoring the quality of healthcare services country wide (Schiza et al., 2018).

2.5.2 Healthcare Providers

Healthcare providers are responsible for providing healthcare services to the patient directly including hospitals, clinics and all the members of these centers such as doctors, nurses, and physicians.

2.5.3 Healthcare Support Services

Healthcare support services are responsible for providing support services including ambulance, pharmaceutical, laboratories, physiotherapists, diagnostic centers, and blood banks.

2.5.4 Medical Devices and Equipment Suppliers

Medical devices and equipment suppliers are the manufacturers, distributors, and wholesalers of medical devices and supplements responsible for providing all required equipment and medicine for hospitals and health centers.

2.5.5 Universities and Research Centers

Universities and research centers are using the collected healthcare data for research purposes and introducing new medications, treatments or preventing disease outbreaks.

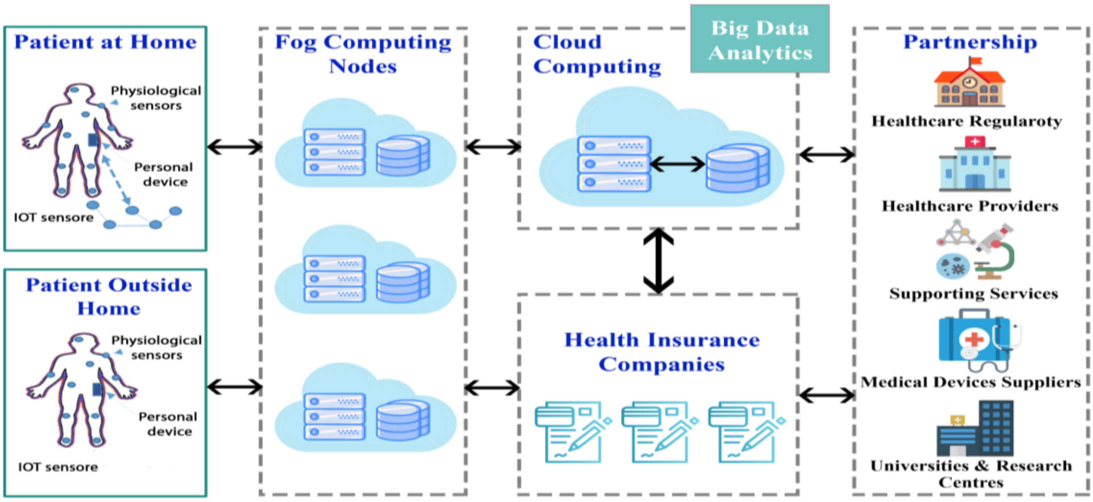


Figure 1: Smart Healthcare Architecture

Chapter 3: Innovative Smart Healthcare Insurance Business Model

The current healthcare insurance business model will be disrupted by the emerging smart healthcare technologies. The business model is a strategic concept used in the different organizations' fields including both traditional and electronic business fields. It presents the big picture of any business by identifying the main elements in it and the interrelationship between them to enhance the organization competition power in the market. Business model as defined in (Hedman et al., 2003), "it describes the relational of how an organization creates, delivers and captures value". To identify the business model in-depth as mentioned in (Osterwalder et al., 2005), it is "a conceptual tool containing a set of objects concepts and their relationships with the objective to express the business logic of a specific firm". The business model consists of four interlinked components including customer value proposition, profit formula, key resources, and key processes (Osterwalder & Pigneur, 2010). The organization should identify a reliable customer value proposition considering high customer value and lower cost. The profit formula is the blueprint of the customer value proposition. It defines how an organization creates the value of itself while providing value to its customer. Key resources are the main assets used to make the business model works properly and meet its purposes. While key processes include the operational and managerial processes that contribute to the success of delivering the organization. The business model has a well-defined canvas model that helps and facilitates the identification of the key components. It includes nine building blocks that build the main four components and they include customer segments, value proposition, channels, customer relationships, revenue streams, key resources, key activities, key partners and cost structure (Osterwalder & Pigneur, 2010). The success of an organization business model depends on the clarity of identifying these components.

The pivotal concern in this research is the healthcare insurance business model. This part will discuss the current healthcare insurance business models and a description of the future insurance business models. To define healthcare insurance as mentioned in (Healthcare, 2018) it is a contract that requires the health insurer to pay some or all of the healthcare costs in exchange for a premium.

3.1 Current Healthcare Insurance Business Model

The common current health insurance business models (plans) as mentioned in (EY, 2015) include Indemnity plan - A type of medical plan that reimburses the patient and/or providers of the incurred expenses. Conventional indemnity plan - An indemnity that allows the participant the choice of any provider without effect on reimbursement. Preferred provider organization (PPO) plan - An indemnity plan where coverage is provided to participants through a network of selected health care providers (such as hospitals and physicians). Exclusive provider organization (EPO) plan - A plan under which employees must use providers from the specified network of physicians and hospitals to receive coverage; there is no coverage for care received from a non-network provider except in an emergency situation. Health maintenance organization (HMO) - A health care system that assumes both the financial risks associated with providing comprehensive medical services (insurance and service risk) and the responsibility for health care delivery in a particular geographic area to HMO members, usually in return for a fixed, prepaid fee. Financial risk may be shared with the providers participating in the HMO. Group Model HMO - An HMO that contracts with a single multi-speciality medical group to provide care to the HMO's membership. The group practice may work exclusively with the HMO, or it may provide services to non-HMO patients as well. The HMO pays the medical group a negotiated, per capita rate, which the group distributes among its physicians, usually on a salaried basis. Staff Model HMO - A type of closed-panel HMO (where patients can receive services only through a limited number of providers) in which physicians are employees of the HMO. The physicians see patients in the HMO's own facilities. Network Model HMO - An HMO model that contracts with multiple physician groups to provide services to HMO members; may involve large single and multispecialty groups. The physician groups may provide services to both HMO and non-HMO plan participants. Individual Practice Association (IPA) HMO - A type of health care provider organization composed of a group of independent practising physicians who maintain their own offices and band together for the purpose of contracting their services to HMOs. An IPA may contract with and provide services to both HMO and non-HMO plan participants. Point-of-service (POS) plan - POS plans resemble HMOs for in-network services. Services received outside of the network are usually reimbursed in a manner like conventional indemnity plans. Physician-hospital organization (PHO) - Alliances between physicians and hospitals to help providers attain market share, improve bargaining power and reduce administrative costs. These entities sell their services to managed care organizations or directly to employers. Medigap Supplemental Plans - Medigap pays the Medicare deductibles, copayments, and other expenses that beneficiaries are typically required to pay as a means of spreading the cost burden and reining in unnecessary use of services.

The current healthcare insurance business model provides basic policies with different specifications and prices for customers who choose a policy that suits their financial status (IBM, n.d.). In most basic policies, the healthcare provider sends a claim to the insurance company which endorses or rejects it according to the customer's policy's terms and conditions (Punke, 2018). The insurance company covers most of the claims and its administrative costs by investing premium amounts in interest-generating assets that contribute to the main revenue stream of the company (Rose, 2018). This model ignores a significant value proposition related to enhancing customer wellbeing and focuses only on financial factors.

The current health insurance business model is a financial centric model and has short time plans. In brief, the current healthcare business model aims to share the payment of healthcare services and drug cost with its client ignoring any health enhancement or improvement processes.

3.2 Innovative Smart Healthcare Insurance Business Model Canvas

This section presents a disruptive smart healthcare business model based on the business model canvas (Osterwalder et al., 2010). It presents a strategic overview of enabling trend technologies in smart healthcare. This model assumes that the insurance company is part of the smart healthcare ecosystem.

3.2.1 Customer Segment

Healthcare insurance is a fundamental human right that enables the United Nation Sustainable Development Goal No.3 to ensure health and wellbeing for all society members (Papa et al., 2018; Johnson et al., 2018). The customer segment in the proposed smart healthcare insurance business model includes all kinds of patients, the elderly, children, special needs, and normal healthy people in a society. There are important vital signs that specify patients' health status for different customer segmentation to be monitored (Farahani et al., 2018; Care, 2018). Wearable healthcare devices are a combination of technologies used to monitor human vital signs at the activity level and medical level for extended periods (days/weeks) and it was introduced as a concept in the late 1990s. They are divided into two main areas, activity area, and medical area, as shown in Figure 2. The Activity area is concerned with fitness, wellbeing, and non-medical application. The Medical area is concerned with prediction, anomaly detection, and diagnosis support. Prediction is for recognizing the occurred event and providing medical advice to avoid chronic problems. Anomaly detection is for recognizing the unusual pattern that does not harmonize with the expected behavior. Diagnosis support is for clinical decision depending on collected knowledge. Table 1 lists these vital signs and their wearable devices (Dias, 2018).

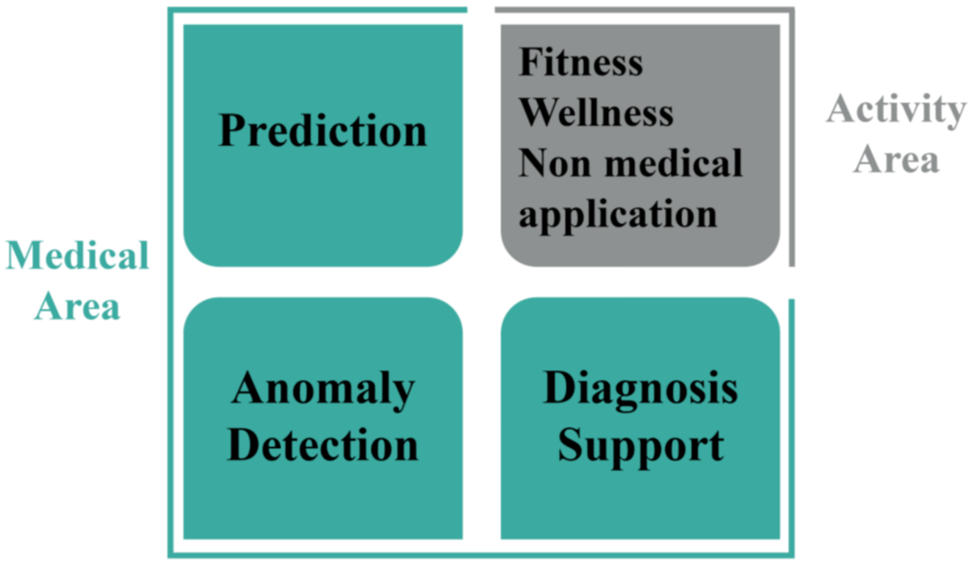


Figure 2: Wearable Health Device Categories

The customers are segmented according to the healthcare requirements into three types, namely self-management patient, assistant living patient, lifestyle management patient.

3.2.1.1 Self-management Patient

Self-management patients are suffering from one or more chronic diseases and need to be educated to manage their illness and make daily decision to enhance their life quality (Bodenheimer & Lorig, 2020). Self-management has a particular process and activities to control the disease and avoid health relapse (Dadgar & Joshi, 2018). These activities are classified into three groups. The first group is activities that focus on the disease needs including drug management, symptoms management and communication with healthcare givers. The second group is resources that support attaining a healthy lifestyle including human resources (family members, friends, healthcare providers members, etc.) and community resources (transportation, spiritual, social, etc.). The third group is activities for coping with suffering from chronic disease including the management of psychological consequences (depression, negative emotions, stress, etc.) and lifestyle reorganization (diet, physical activities, etc.).

According to the U.S National Center for Health Statistics, chronic disease has continuous symptoms for more than three months that cannot be treated by medication (Dadgar & Joshi, 2018). Chronic diseases can be prevalent in different age segments including children, adults, and the elderly. These diseases range from chronic pain like a migraine to complex chronic health conditions like strokes. Moreover, disabilities are considered as a chronic disease since it is a chronic condition (Jones et al., 2018). A chronic disease patient requires permanent and continuous physicians care.

Primarily, in the case of children the parents, teachers, and physicians are engaged in this process. Permanent monitoring has a high cost for governments, parents, and relatives (Sendra, et al., 2018). Self-management enhance the patient ability to control illness and wellness and enhance patient life quality (Dadgar & Joshi, 2018). It will contribute to cost reduction and hospitals dependencies. AI, smart devices, sensors, RFID, GPS, and IoT devices are needed for self- management enablement (Sendra et al., 2018).

Table 1: Common Vital Signs Wearable Devices

Vital sign	Wearable health device	Category
Heart Rate	Inertial sensors	Activity, Anomaly, Diagnosis
Blood pressure	Microelectromechanical sensors BP watch	All
Respiration Rate	dielectric active polymer	Prediction
Blood Glucose	GlucoWatch, EyeSense, Scout	Prediction
Body temperature	sensor a battery-less RFID thermometer	All
Skin conductance	epidermal-based sensors Fabric/flexible plastic-based sensors	Diagnosis
Sleep pattern / Capnography	electrochemical electrode sensors, oximetry sensors	Prediction
Electrocardiogram (ECG)	Ag/AgCI electrodes	Diagnosis
Blood Oxygen Saturation	photoplethysmography sensors	Anomaly
Motion sensors	inertial sensors (accelerometers, magnetometers, and gyroscopes), electromyography electrodes, shoe force sensors	All

3.2.1.2 Assistant Living Patients

Assistant living patients are the elderly who live alone or in the preferred environment and needs real-time health and environment monitoring (Uddin, 2018; Marcelino et al., 2018). This patient needs two main wireless networks, Ambient (or

Active) Assistant Living (AAL) and Body Area Network (BAN).

Assistant living patients amount is in growth, based on the World Health Organization (WHO) expectation, the elderly (over 65 years old) population will be higher than the children (under 14 years old) population by 2050 (Majumder et al., 2017). In numbers, elderly people will reach 2 billion by 2050 (Hemairy et al., 2018).

This research ignoring the patient group and consider the patient need instead. Any patient who required ambient assistant living to enhance patient wellness or health considered as an assistant living patient.

3.2.1.3 Lifestyle Management Patient

Lifestyle management patients are normal healthy patients. American Society of Anesthesiologists (ASA) physical status classification system defined the normal healthy patient as the fit person (BMI under 30), nonsmoking and doing an accepted range of exercise (Doyle & Garmon, 2019). Lifestyle management patients need advice and education to maintain their health status and prevent lifestyle diseases. Lifestyle disease is defined as the disease related to the way a person or group of people live and how they are acting daily (Medicinenet, 2019). Lifestyle diseases have different dangerous rates ranging from sleep disorder to diseases that lead to death like heart diseases. According to (Taylor, 2019) lifestyle diseases may include:

- Heart disease.
- Stroke.
- Obesity.
- Type 2 Diabetes.
- Osteoporosis.

- Kidney and liver disease.
- Asthma.
- Metabolic syndrome.
- Depression.
- Some types of cancer

There are two types of lifestyle diseases pathogens, controlled and non-controlled. The controlled pathogens are the person's bad attitude, actions, and habits. While the non-controlled are age, gender, and heredity. Applying lifestyle diseases management require wearable devices and smartphone. Wearable devices and sensors are used to monitor the patient's vital signs. While the smart device is to receive the comments, advice and viewing a dashboard showing the health status.

3.2.2 Value Propositions

The value proposition of the proposed smart healthcare insurance business model is to sustain wellbeing by enhancing the quality and efficiency of healthcare by empowering self-care and supporting it remotely (Care, 2018). This goal can be achieved by enabling a customer-centric model and long-term premiums.

Patients will be provided with the consultation and needed advice during their normal daily activities and they can travel to any country safely since the insurance company has a global health givers network (Mukhtar et al., 2018).

The policy will be assigned to the patient according to health factors specified by the doctors. These factors are retrieved from the patient EHR stored in the cloud and matched to the ontology. The policy will be customized according to the patient's needs and include the basic policy. The basic policy is assigned to the new customer who does not have health records or a healthy patient. It covers the basic health needs that do not need continues monitoring and health management. The current or the customers with health record are two categories including patients' who need health monitoring and lifestyle management to avoid the disease (borderline patients) and the unhealthy customers who suffer from a disease or more. Each customer will have a collection of packages according to his/her needs that represent the custom health insurance policy. The smart healthcare insurance policy updates after each doctor's claim to cover the customer need and avoid the company loses.

The packages include all the customer's segment mentioned earlier and consider the age groups. These packages are specifying the customer' technological needs such as body area network (BAN), ambient assistant, smart devices etc..

3.2.3 Channels

This work proposes two types of channels namely, physical and virtual channels. Physical channels are the vehicle used for IoT devices delivery process. While Virtual channels are the mobile applications, voice over IP, video conferencing and social media which are the ideal environment for marketing campaigns.

3.2.4 Customer Relationship

The insurance company provides new services for their customers to enable smart healthcare services that depend on smart devices installation, configuration, and maintenance. For example; in the event of a device malfunction, the company provides the following sequence of services to patients:

- The device is checked remotely by the insurance company specialist and guides the patient to solve the problem;

- If the problem is not solved, the specialist arranges a maintenance visit to the patient place;
- If the problem is not solved, the specialist places a device maintenance request to the device provider;
- Else the insurance company replaces the defected device.

3.2.5 Revenue Stream

The main revenue stream in this work is investing premium amounts that differ according to patient health and condition. Customizing the insurance policies according to the patient collected data will reduce the risk ratio of spending more than earning. In addition, the business model aims to enhance wellness and prevent diseases; this will reduce spending amounts for provided healthcare services. Another source of revenue is to provide customers with an additional application and feature like pregnancy management for a subscription with additional fees.

Data monetization is a source of revenue for smart healthcare insurance companies by selling the collected data to other entities (EY, 2015), like marketing companies, research centres, universities, and health service providers. In this case, the company should have a clear privacy policy with its patients.

3.2.6 Key Resources

This section presents the key resources needed to support the value proposition policies. Other resources that support day to day business activities are not mentioned.

- Business analyst: combines business and IT knowledge and responsible for meeting the devices' suppliers, negotiating the needed features and selecting the appropriate providers among available bids.

- IoT specialist: responsible for installing, monitoring and maintaining IoT or IoMT devices and providing remote assistance for customers to solve problems.
- Data scientists: responsible for extracting knowledge from the big data collected by IoT and other sources (doctors' comments, medicines prescription, etc.).
- AI specialist: responsible for creating AI algorithms and apply them to the extracted knowledge to enhance decision making. The AI algorithms will be used to update policy options, send customized advice to the patient and predict the patient's behavior and needs.
- Mobile application specialist: responsible for building and maintaining mobile applications like patient and doctor's dashboards, doctor's notifications or advice and communication with healthcare givers on different platforms.
- Social media specialist: responsible for a marketing campaign and providing patients with important information about wellness. Also, social media is an affordable data source (Yenkataraman; & Kothamasu, 2017).
- Network Management: manage end-to-end connections and make sure that the network is reliable, secure and scalable.
- Biomedical Doctors: responsible for creating the business scenario and specifying required technology for each patient depending on his doctor indication.
- Healthcare insurance policies developer: responsible for identifying and legislating the rules and policies that suit the smart healthcare insurance enablement which differ from the current situation.

- Logistics relations specialist: create a global network of healthcare providers for the tourist patient who will be directed to the nearest center in a foreign country.

The mentioned jobs can be an organizational unit called Smart healthcare insurance enablement department, or it can be outsourced depending on different criteria provided by the Insurance company.

3.2.7 Key Activities

This section presents the main key activities of an insurance company using the proposed business model.

- Providing healthcare insurance policy: the core key activity of the insurance company which will customize the policy according to the patient's health information, electronic health records and will be updated according to the IoT data collected and analyzed. The premium price may increase or decrease depending on the patient's behavior and habits. Moreover, the claim endorsement process will be disruptive since the customized policy will cover all patient's needs even health support services like a body massage.
- Providing IoT devices: the responsibility of insurance company, IoT and IoMT devices differ depending on the customer segment and the customer needs.
- Enhancing patient wellness and education: to prevent new diseases by customizing patient activities and advises for each patient based on his health status and lifestyle. Moreover, it will enhance patient education about health and suggest healthy products which will contribute to deploying a healthy culture within the community.
- Enhancing patient's freedom: by tracking the patient's health status remotely

during his normal daily life both patients and doctors will get a detailed report about patient health.

- Providing global healthcare network: of healthcare givers around the world to motivate the tourist patient to travel safely and comfortably avoiding preparing emergency plans related to health concerns (Almobaideen et al., 2017).
- Organizing social events and campaigns: to stay close to the customers, get their feedback, and perceive their future needs. Social events and campaigns can be a significant source for patients’ data, opinion, and experience. This type of data cannot be collected using sensors and devices and such campaigns can be arranged in social media to deploy wellness and health information insurance company.
- Providing offers and incentives: will motivate the patient to enhance his health status and wellness and motivate the patient to follow the proposed healthcare program leading to a healthy life and disease prevention. Providing a priced feature for free is an example of an offer.

3.2.8 Key Partnerships

The proposed smart healthcare business model needs wider relations to sustain and achieve its value proposition.

- Healthcare regularity: is the government represented by the ministry of health, regulatory agencies, lawyers, etc. and responsible for defining related policies, laws, and regulation for the different smart healthcare insurance aspects. Long term policies programs which require economic and financial regulation related to taxes or other payments (EY, 2015).
- Payer: is the government or the employer depending on the beneficiary. The

government provides payment services for retired people and their families while the employer provides payment services for employees and their families. In this case, the smart healthcare insurance company applies business to the business model (B2B) in term of contract and premium payments.

- IoT providers: include manufacturers, distributors, and wholesalers of IoT and IoMT communication devices.
- Fitness support chain: provide the patients with offers and discounts. The purpose of providing such offers is to enhance the patient's behavior and involve healthy habits within his/her daily routine.
- Education and research centers: include all universities' research centers, nursing schools, medical technology, and research laboratories which need collected data for research purposes. In addition, the insurance company may have a direct relation with healthcare service providers, healthcare supporting services and communication and information technology providers to enable its role properly. Customer segments and key partners are the main networks of the insurance company; Figure 3, presents the customer segments and the key partners in the proposed smart healthcare insurance model.

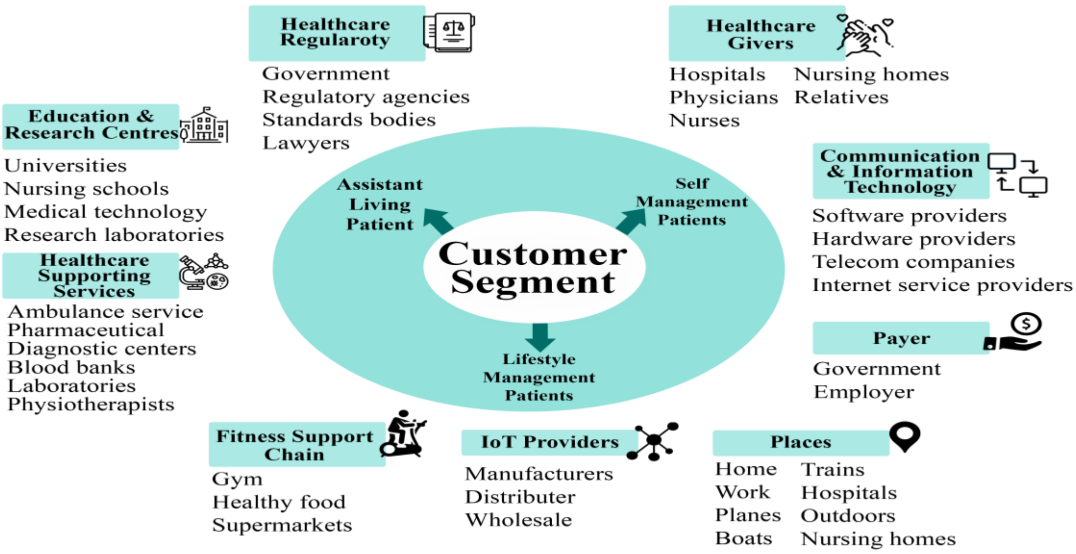


Figure 3: Customer Segments and Key Partners of Disruptive Smart Healthcare Insurance Business Model

3.2.9 Cost Structure

The proposed smart healthcare insurance business model will add additional cost to the current healthcare insurance model due to the smart healthcare enablement. Smart devices configuration, installation and maintenance cost and service provider cost includes the subscription cost of different services like the Internet, Cloud computing, fog computing, and application license. Figure 4 presents the business model canvas of the innovative smart healthcare insurance business model.

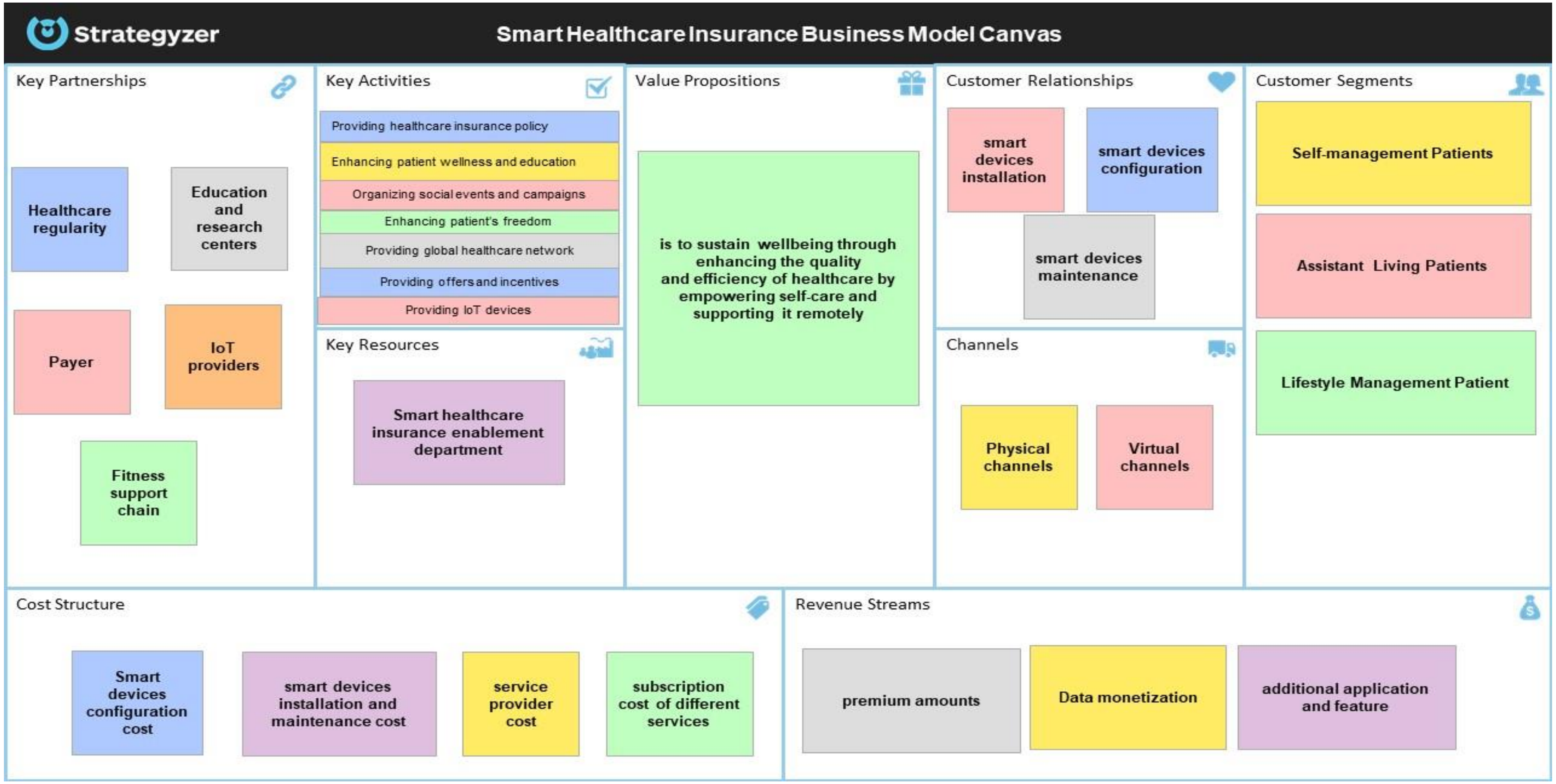


Figure 4: The Innovative Smart Healthcare Insurance Business Model Canvas

3.2.10 Smart Healthcare Use-Case

This section presents a Use Case summaries the interaction between the customer and the insurance company.

Use Case: A man has been recently diagnosed with diabetic Type 2, and he is at risk of developing diabetic Type 1. He works at an international consulting company and his work requires frequent travel to different countries. Instead of prescribing medicine at this stage, his doctor recommends lifestyle change (food, exercise, stress, sleep). The doctor requests to monitor the blood sugar level at intermittent times during the day including certain events; e.g., after meals and exercise for one year. The monitor request is forwarded to the insurance company. The company also coordinates with the hospital to have the blood glucose monitor implanted in the man's body. The monitor is a sensor that is implanted under the skin through a simple surgical procedure. The implanted sensor communicates with a receiver that the man carries or a gateway at home. The insurance company installs a gateway at the man's home and connects it to the Internet through a Wi-Fi router. The insurance company sets up two end-to-end connections. One connection carries the sensor data to the backend server at the hospital and saves it locally in the electronic health records. The other connection carries the management data to the backend server owned by the insurance company and saves the data in the configuration management database. The company installs another gateway at the workplace and sets up a service to connect the gateway at work to the hospital directly or through the home gateway. The insurance company also provides the man with a device that logs the sensor data while the man is travelling or on the airplane. The insurance company arranges with other ISPs in the other countries to connect the man to his home network. The insurance company also arranges for any emergencies the man might face during travel. A mobile application is installed on the man's mobile. The data will be analyzed, and all rules will be applied. The customized meals and physical activities are available in the application daily and the statistics of blood sugar level. The insurance company updates the man's policy and changes the premium amount according to the patient's behavior and attitudes. Figure 5 presents the Use Case model and Table 2 summarizes the Use Cases. Figure 6 presents the logistic setups, while Figure 7 presents patient monitoring.

Table 2: Use Case Summary

Use Case	Summary
Diagnose	Physician diagnoses treatment to the patient based on symptoms, labs, etc.
Prescribe Treatment	Based on the patient condition, the physician can prescribe different treatment plans, such as drugs, lifestyle, or mixed.
Change Lifestyle	A physician determines different patient's lifestyles and activities be conducted and monitored. This is subject to Insurance approval.
Setup Logistics	Install blood sugar device for monitoring. Insurance Co. installs gateways, mobile App, and networking devices to enable remote monitoring.
Update Policy	Insurance Co. upgrades the insurance policy of the patient according to the new treatments prescribed by the physician.
Record Management Data	Manage collected data.
Monitor Blood Sugar	The sensor starts collecting data which is forwarded over the gateway to the hospital. Mobile conducts an analysis of the sugar level of the patient and recommends meals and lifestyle activities.

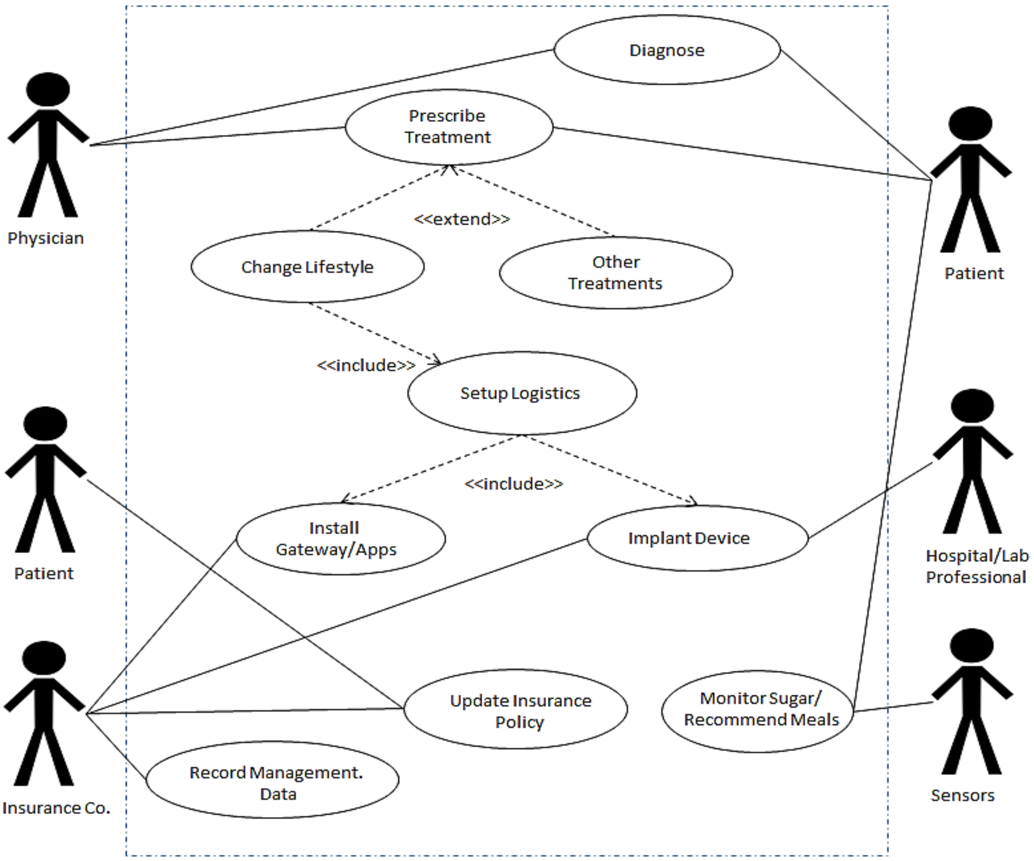


Figure 5: Use Case Model

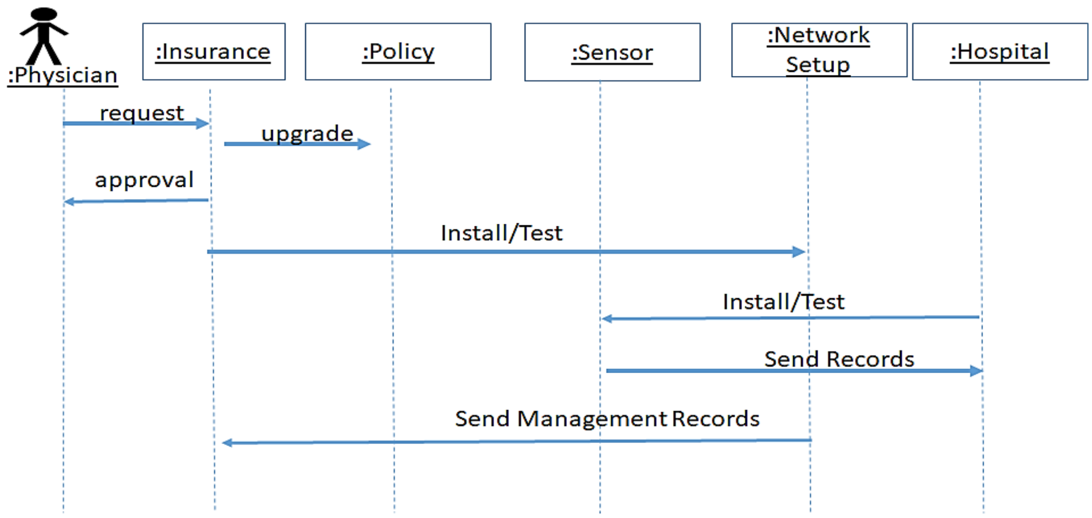


Figure 6: Logistic Setup

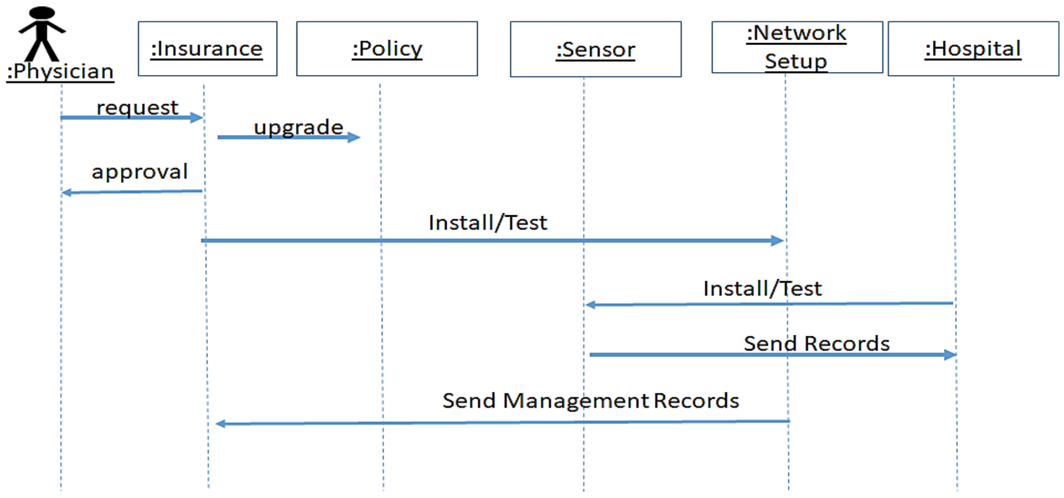


Figure 7: Monitor Patient

Chapter 4: Proposed Smart healthcare Insurance Policy System

The proposed system is designed to support assigning the insurance policy to the customer automatically according to the customer electronic health record (EHR) information. The main purpose of this system is to optimize the cost spending of the insurance company and its customers by designing a smart customer-centric healthcare insurance policy that includes all the required healthcare packages. These packages are specified according to the customer's health status and requirements. In this case, the insurance company covers all customer's health requirements, while adapting a proper premium insurance amount. The policy will be updated automatically according to the customer health status and doctor's claims. It focused only on defining technical requirements in terms of package that create a customized centric policy. The system is an application-based and used by the insurance's company customer service. The policy names and details are selected based on our assumptions for the testing purposes. The following sections present the system architecture, design, and workflow.

4.1 System Architecture and Design

The system architecture, as shown in Figure 8, consists of four layers, namely, healthcare cloud layer, network layer, content management layer (implemented layer) and application layer.

4.1.1 Healthcare Cloud Layer

As mentioned earlier, the healthcare insurance company is a component of smart healthcare architecture and it retrieves the customer data from the shared database of the smart healthcare system in the cloud. This system assumed that the

EHR consists of all required data that determine healthcare insurance. EHR consists of patient basic details, health status, diagnose, treatment technological requirements and other attributes that will be presented in the following sections.

4.1.2 Network Layer

The network layer provides all communication means between the different layers in the smart healthcare system.

4.1.3 Context Management Layer

This layer consists of four main components namely, query engine, data retrieving engine, knowledge manager and customer database. These components are discussed as follows:

4.1.3.1 Query Management Engine

The query engine is the middleware between the application layer and data retrieving model. The main role of this layer is to receive the customer ID from the application layer and send it to the data retrieving model that requests the customer information including all the EHR attributes.

4.1.3.2 Data Retrieving Engine

This layer responsible for retrieving the EHR of the required customer from the healthcare cloud.

4.1.3.3 Knowledge Management Engine

This layer consists of the ontology-based context model and the rules for specifying the centric customer health insurance policy. This layer is discussed in detail in Section 4.2.

4.1.3.4 Customer Database

This layer is the data warehouse of the insurance company and it consists of the customer data and the insurance policy details. It is the source of updating the patient insurance policy of healthcare database stored in the cloud.

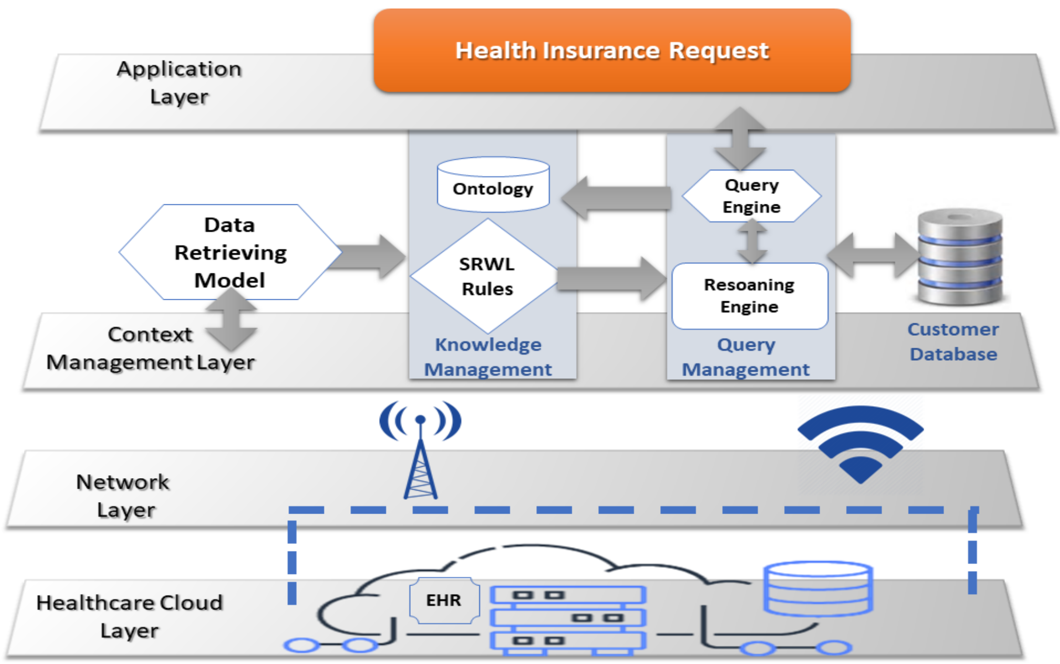


Figure 8: Smart Healthcare Insurance Policy System Architecture

4.1.3.5 System Workflow

This section presents the system workflow as shown in Figure 9 and summarized in the following steps:

1. Customer requests healthcare insurance policy.
2. The insurance company enters the customer ID in the system.
3. If the customer is new, either newborn or doesn't have an EHR, the basic policy is assigned to the customer.
4. If the customer already exists and has an EHR, the system will check if there is a new doctor claim to update the policy otherwise, the insurance policy remains is the same.
5. If there is a new doctor claim the system requests the customer's new technical requirements from the cloud, then retrieve the required package as a result of running the ontology rules and update the customer record.

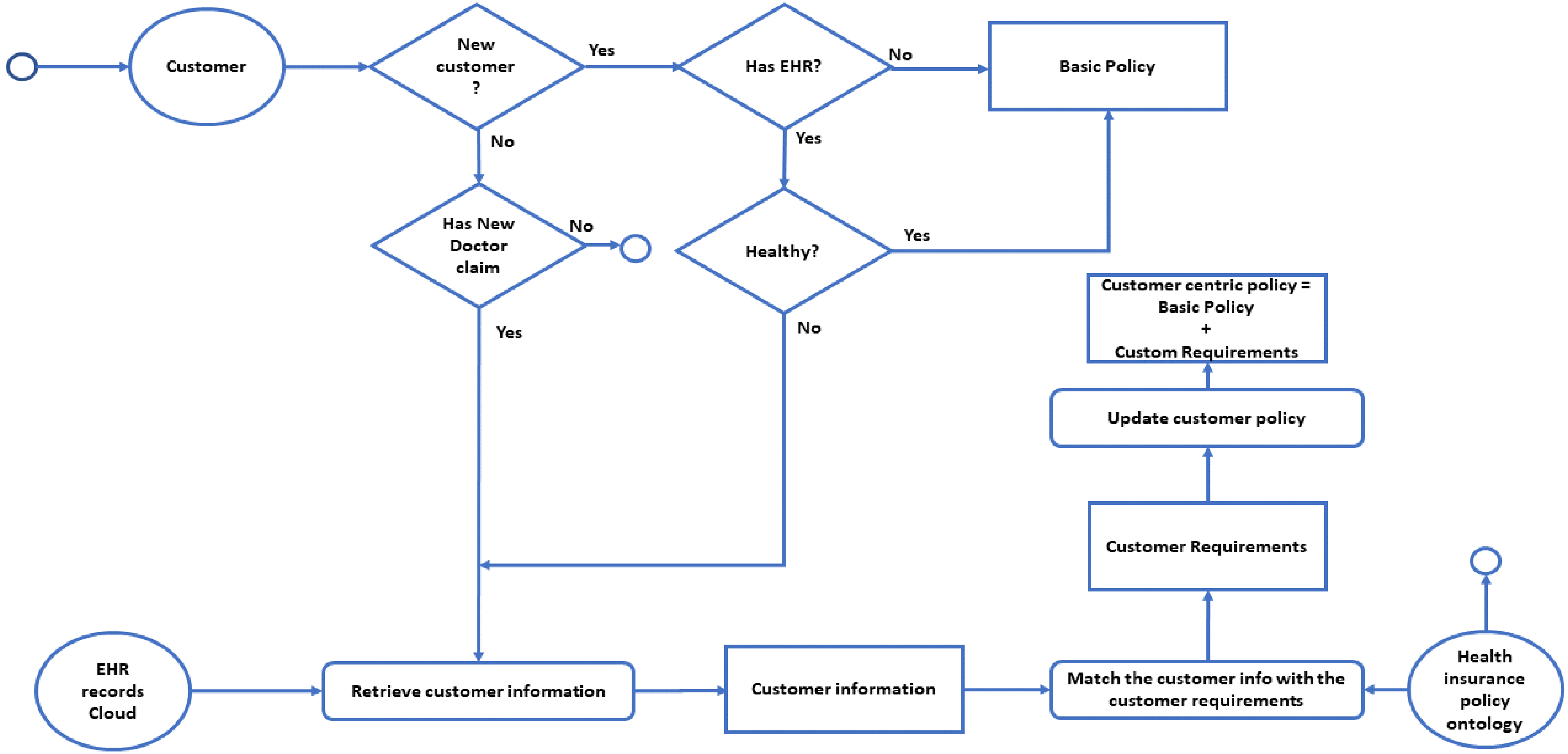


Figure 9: Smart Healthcare Insurance Policy System Workflow

4.2 Ontology-Based Context Model

This section describes the ontology-based context modelling approach. The ontology was built in Protégé environment using the built-in reasoner Pellet (incremental), SWRL rules were used for policy matching process and SPARQL was used to present the results.

The ontology consists of two main classes, customer class and insurance policy class, where each patient has an insurance policy. Figures 10-12 present the ontology components including the classes, object properties, data properties, individuals and their data types.

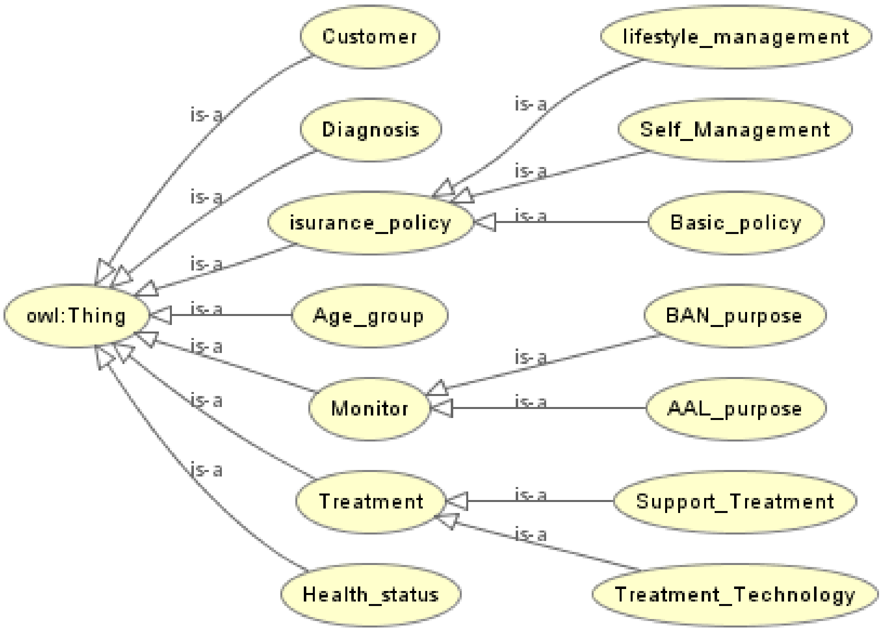
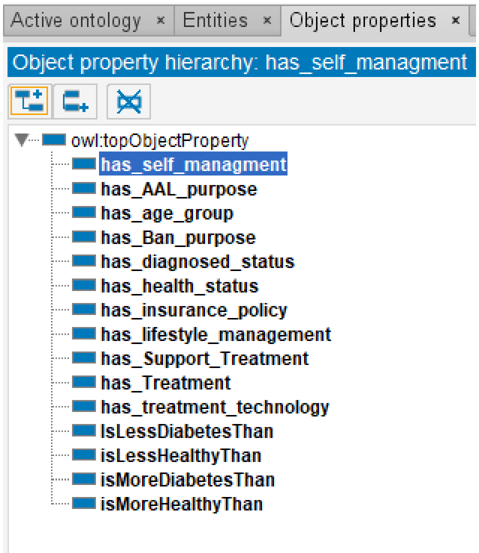


Figure 10: Ontology Classes Diagram



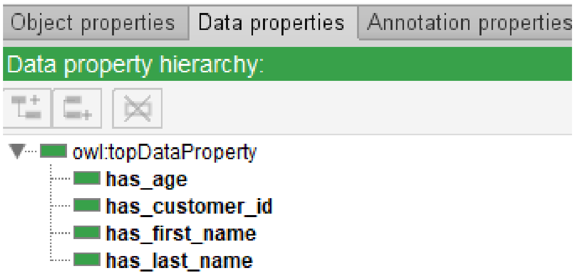


Figure 11: Ontology Classes Diagram

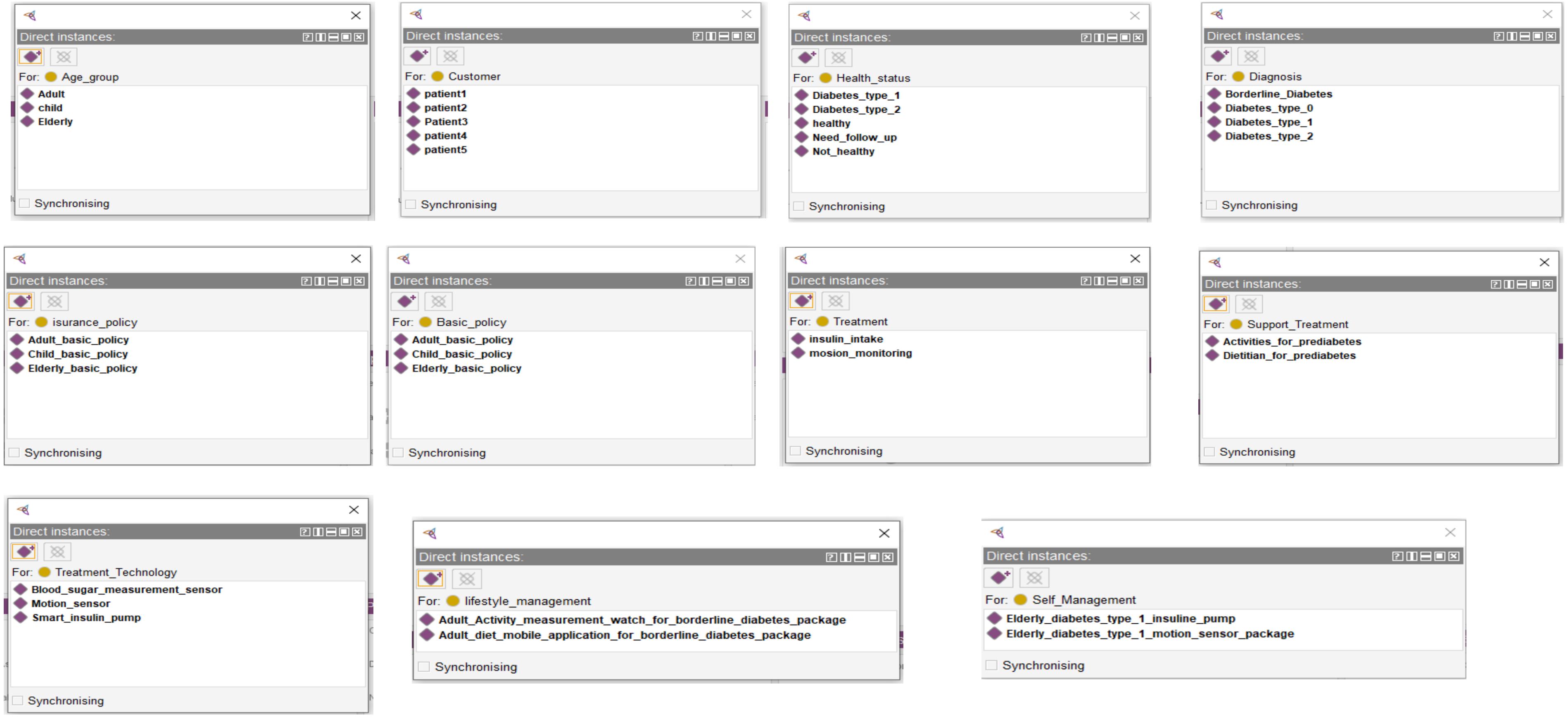


Figure 12: Individuals of Classes

4.2.1 Classes Description

This part presents a general description of the ontology classes and sub-classes and their relation to the customer segmentation defined in the smart healthcare insurance business model.

Class: Customer

This class represents the customer profile that includes EHR data. The customized policy will be selected based on these details. This research is not focusing on the regular treatment only, but it considers the support treatments that have a direct relation in improving the customer's health such as dietitian program or activity programs and their related technologies.

Class: Insurance Policy

This class consists of four subclasses namely, Basic policy, lifestyle management policy and self-management policy.

- Basic policy: This subclass provides packages for the customer with "Healthy" health status. It will be differentiated from one customer to another according to the age group. It consists of child basic policy, adult basic policy and elderly basic policy.
- Lifestyle management: This policy provides packages for the customer with "need follow up" health status. In this case, the customer is not suffering from any disease but has some indicators that warn of having a disease. The customer needs support treatment to change the lifestyle for the purpose of avoiding this disease. This class should include all these types of pre diseases situation and the required support treatments packages for each age group

(child, adult and elderly). This research has considered two diseases with estimated values for the purpose of proofing the concept.

- Self-management: This class provides packages for the customers with “unhealthy” health status. This customer is already suffering from one or more chronic diseases that need at least six months of treatment and healthcare to be in a healthy status. It also includes patients with permeant diseases who need long life treatment. This class should include all chronic diseases and the required treatments packages for each age group (child, adult and elderly). This research has considered two diseases with estimated values for the purpose of proof of concept.

The other classes were built to maintain the relationship between the previous classes.

Chapter 5: Implementation and Evaluation

The proposed system aims to provide a smart healthcare insurance policy that adapts to customer's information provided by the EHR. The policy is dynamic and changes to meet customer health requirements and cost. It will be updated according to the doctor claim. Moreover, the technological requirement will be provided as part of the treatments and will be covered by the insurance policy as depicted in the use case in Section 3.2.10. The main aim of adding technological requirements is to enhance customer health and wellness, reducing the demand for caregivers and eliminate the treatment process and cost.

As mentioned in Chapter 4, the system consists of four layers and this research assumed that the healthcare providers are connected and integrated and have a consistent data warehouse where are the customer information are stored. Moreover, it is assumed that the EHR stored in the cloud contained the needed information for customizing the policy and it is the main source of data. This research focused on designing ontology components.

The implementation of this system required different platforms and tools to meet its purpose. Including Protégé to build the ontology, Pelet (Incremental) to verify the ontology structure and SWRL to build the matching rules between the customer and policy classes. SPARQL query engine to retrieve and manipulate data stored in the ontology.

5.1 SWRL Rules

This part presents the SWRL rules that are used to match between the customer and the related patient. There are seven rules written in SWRL syntax (Figure 13).

Rule1: Customer(?c) ^ has_health_status(?c, ?b) ^ isMoreHealthyThan(?b, Need_follow_up) ^ has_age(?c, ?a) ^ swrlb:lessThanOrEqual(?a, 18) -> has_insurance_policy(?c, Child_basic_policy)
RULE2: (?c) ^ has_health_status(?c, ?b) ^ isMoreHealthyThan(?b, Need_follow_up) ^ has_age(?c, ?a) ^ swrlb:greaterThanOrEqual(?a, 18) ^ swrlb:lessThanOrEqual(?a, 45) -> has_insurance_policy(?c, Adult_basic_policy)
RULE3: Customer(?c) ^ has_health_status(?c, ?b) ^ isLessHealthyThan(?b, healthy) ^ has_age(?c, ?a) ^ swrlb:greaterThanOrEqual(?a, 18) ^ swrlb:lessThanOrEqual(?a, 45) -> has_insurance_policy(?c, Adult_basic_policy)
RULE4: Customer(?c) ^ has_health_status(?c, ?b) ^ isMoreHealthyThan(?b, Need_follow_up) ^ has_age(?c, ?a) ^ swrlb:greaterThanOrEqual(?a, 45) -> has_insurance_policy(?c, Elderly_basic_policy)
RULE5: Customer(?c) ^ has_health_status(?c, ?b) ^ isLessHealthyThan(?b, healthy) ^ has_age(?c, ?a) ^ swrlb:greaterThanOrEqual(?a, 70) -> has_insurance_policy(?c, Elderly_basic_policy)
RULE6: Customer(?c) ^ has_diagnosed_status(?c, ?b) ^ IsLessDiabetesThan(?b, Diabetes_type_1) -> has_lifestyle_management(?c, Adult_Activity_measurement_watch_for_borderline_diabetes_package) ^ has_lifestyle_management(?c, Adult_diet_mobile_application_for_borderline_diabetes_package)
RULE7: Customer(?c) ^ has_diagnosed_status(?c, ?b) ^ IsLessDiabetesThan(?b, Diabetes_type_1) -> has_lifestyle_management(?c, Adult_Activity_measurement_watch_for_borderline_diabetes_package) ^ has_lifestyle_management(?c, Adult_diet_mobile_application_for_borderline_diabetes_package)

Figure 13: Rules in SWRL Syntax

5.2 SPARQL Query

This part presents the SPARQL query that retrieves the result of the previous SWRL rules. This research provides one query to retrieve the result as shown in Scheme 1.

```
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/mariam/ontologies/2019/9/insurance_po
licy#>
DESCRIBE Customer:patient1
```

Scheme 1: SPARQL Syntax

5.3 System Evaluation and Scenarios

This section presents scenarios for evaluating the system and show the results of applying the SWRL rules. The table presents the patient information followed by the required policy and a screenshot of the result before and after applying the rules (Figures 14-23).

- Customer 1

Patient ID	First Name	Last name	Age	Health status
6661	Ahmad	Alkaabi	6	healthy

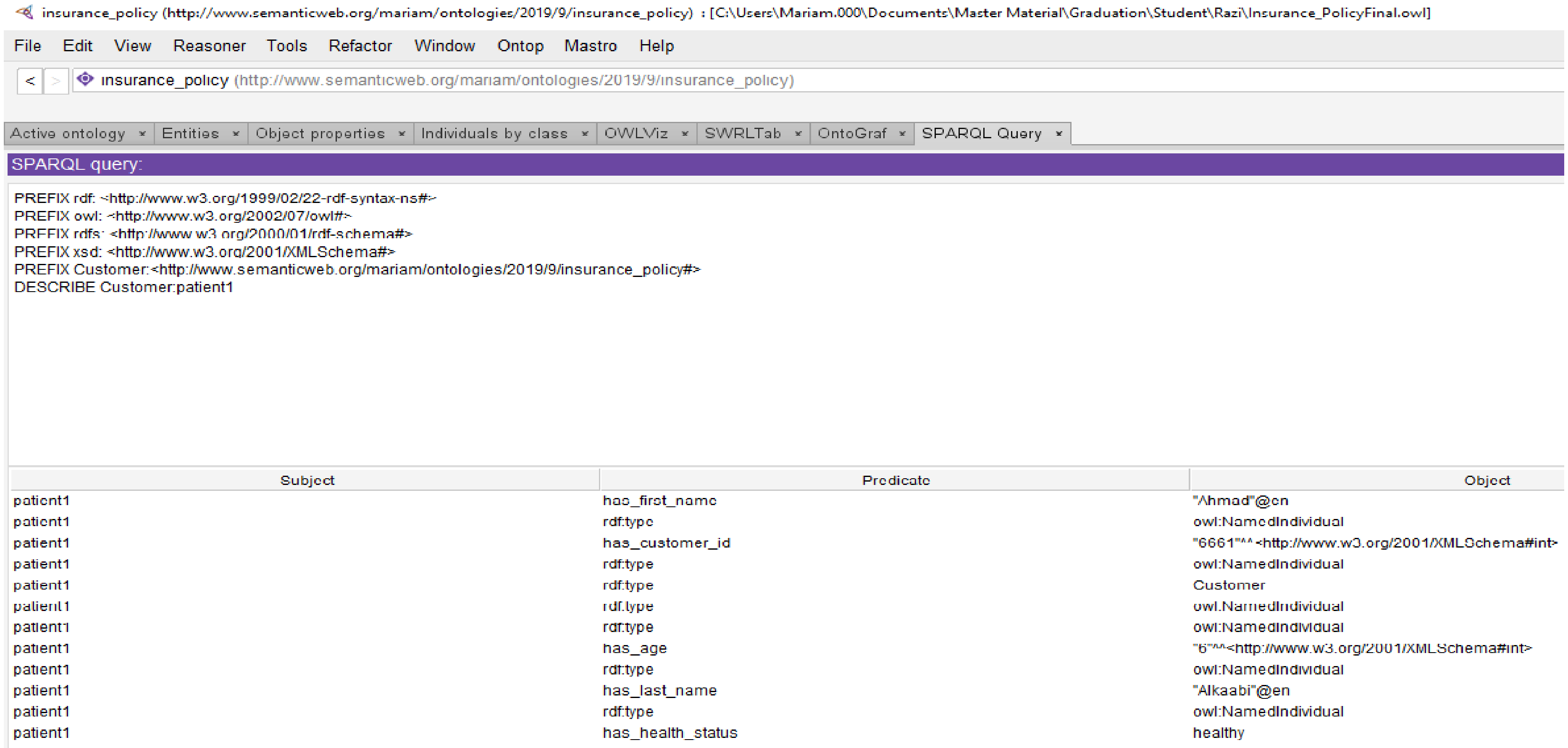


Figure 14: Customer 1 Record before Applying the SWRL Rules

According to the customer information the assigned policy should be “Child Basic Policy”.

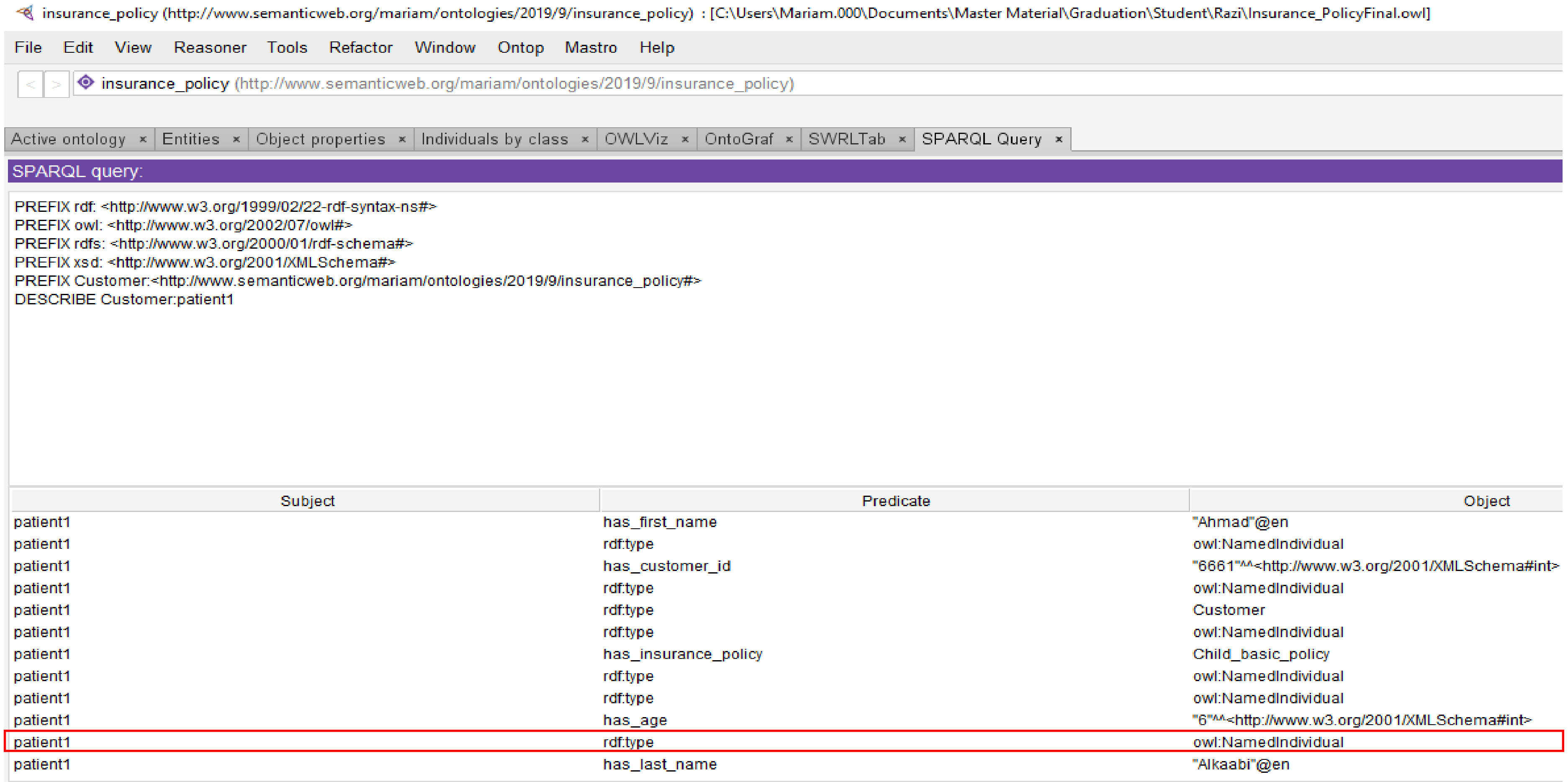


Figure 15: Customer 1 Record After Applying SWRL Rules

- Customer 2

Patient ID	First Name	Last name	Age	Health status
6662	Maryam	Alboloshi	30	healthy

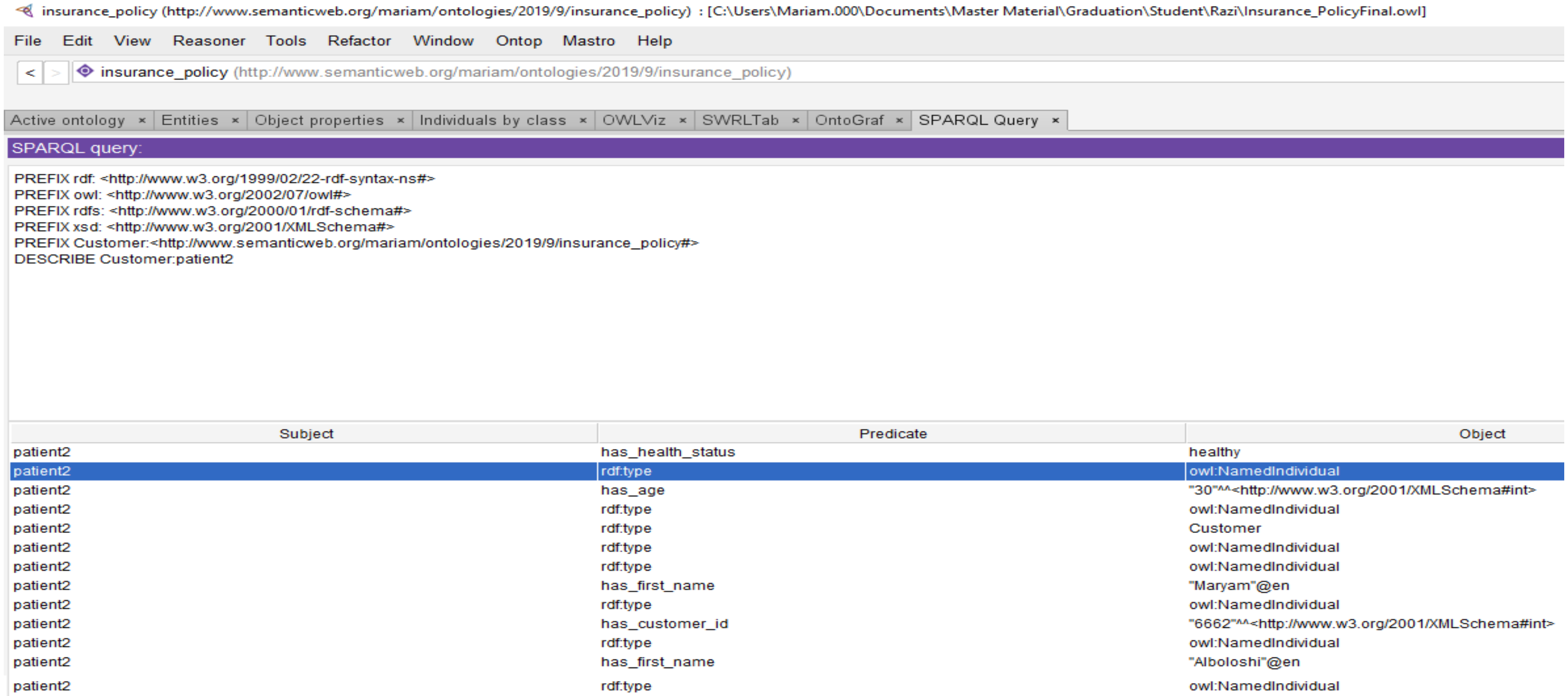


Figure 16: Customer 2 Record before Applying the SWRL Rules

According to the customer information the assigned policy should be “Adult Basic Policy”

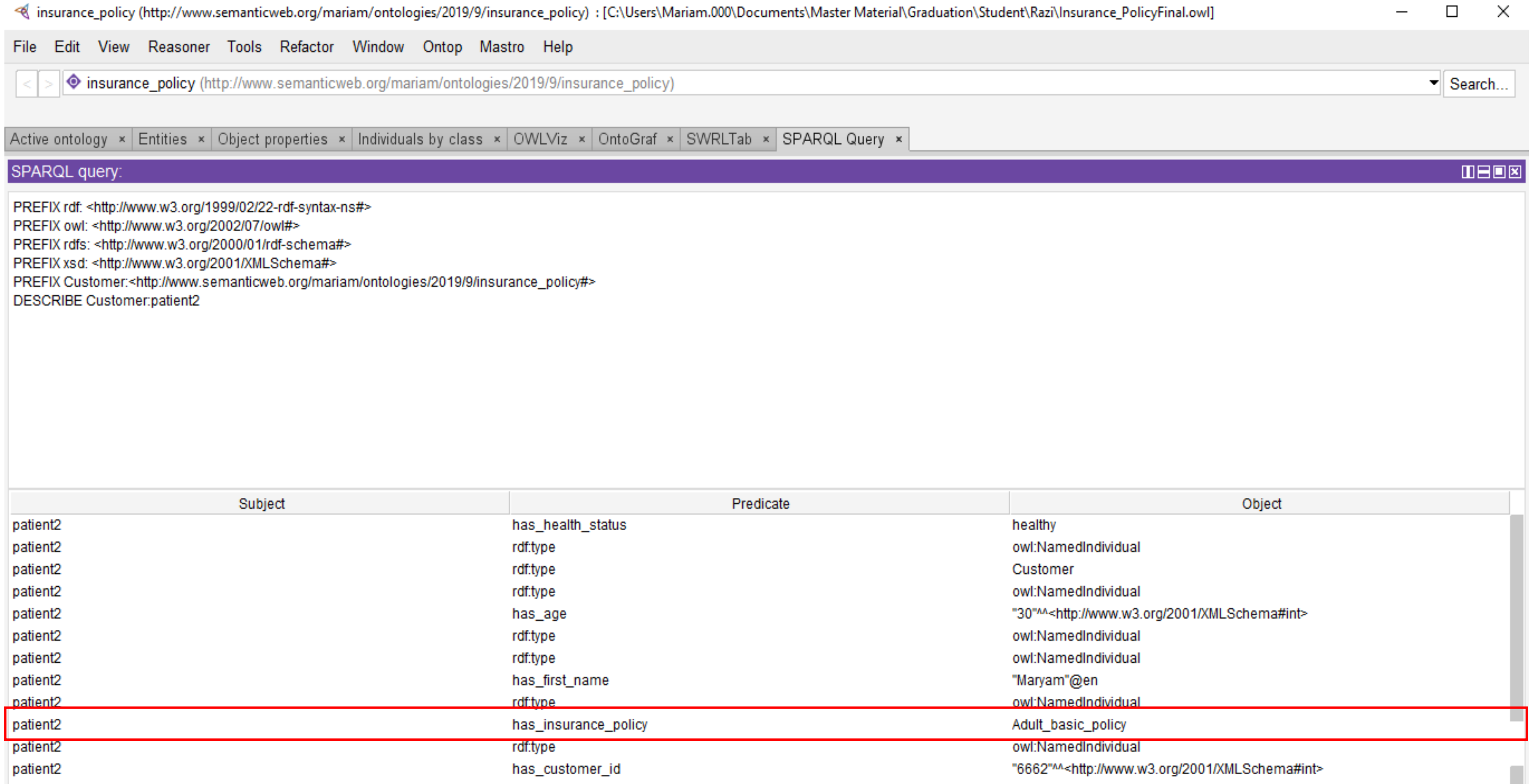


Figure 17: Customer 2 Record After Applying SWRL Rules

- Customer 3

Patient ID	First Name	Last name	Age	Health status
6663	Salem	Ali	66	healthy

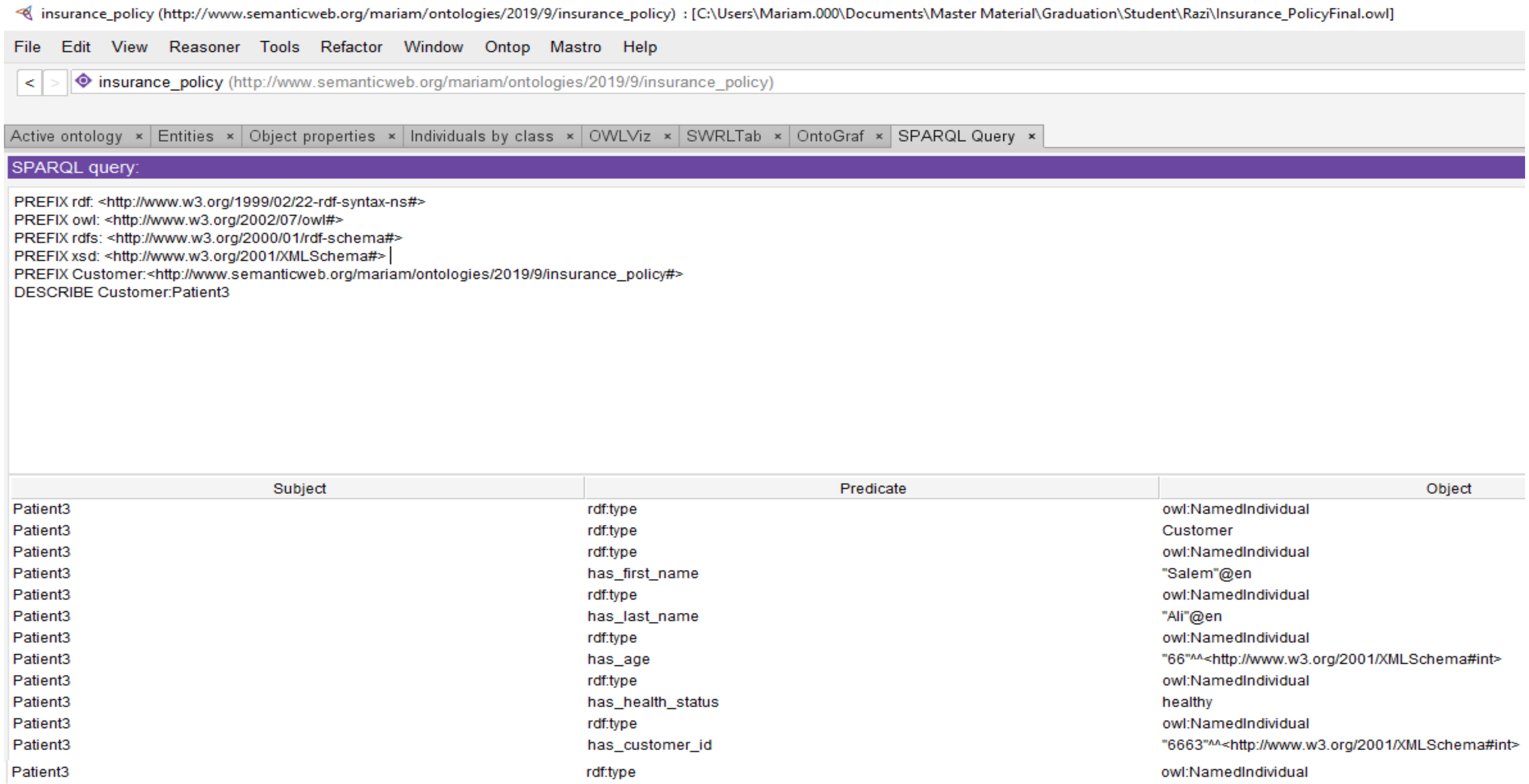


Figure 18: Customer 3 Record before Applying the SWRL Rules

According to the customer information the assigned policy should be “Elderly Basic Policy”.

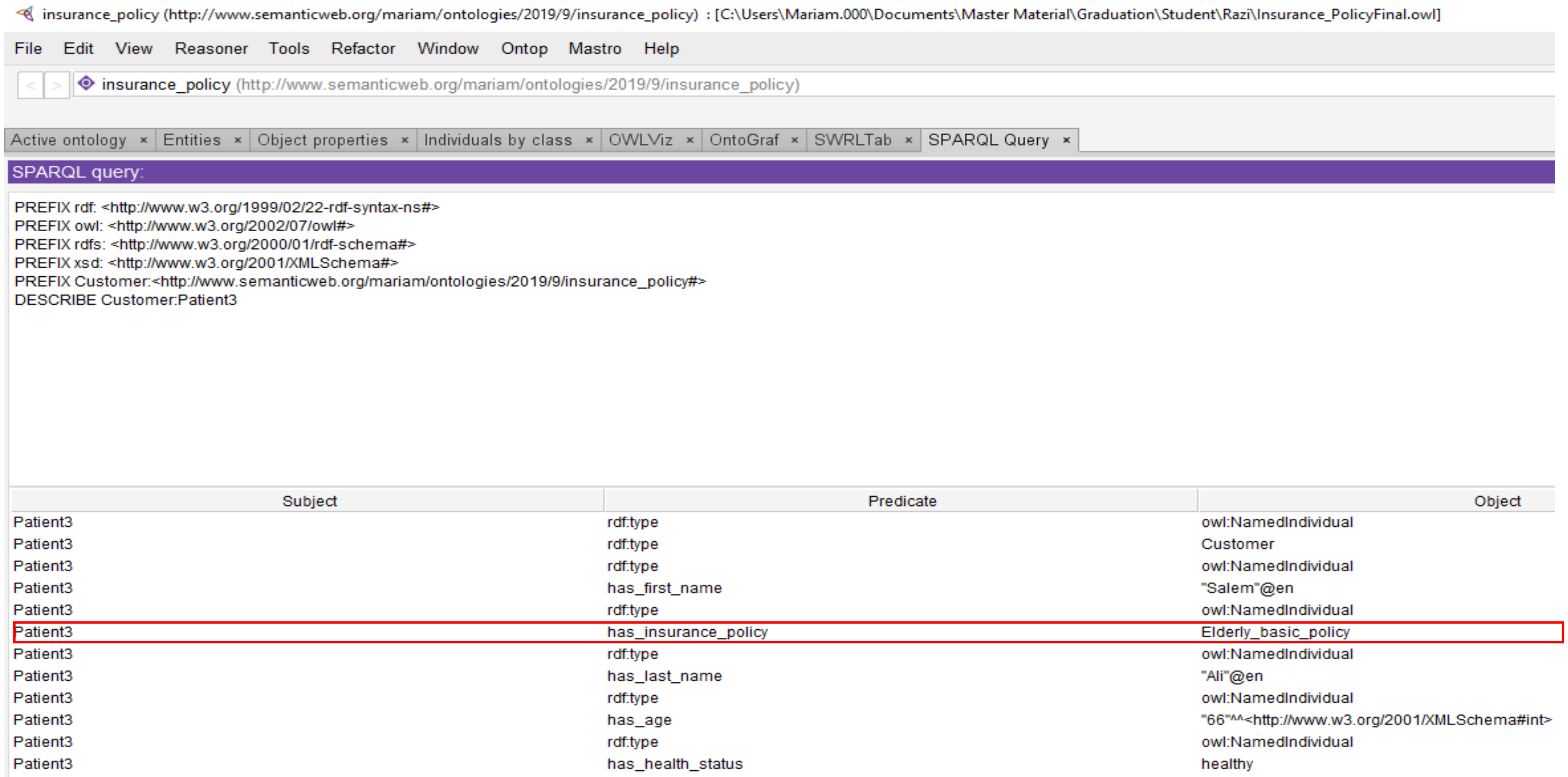
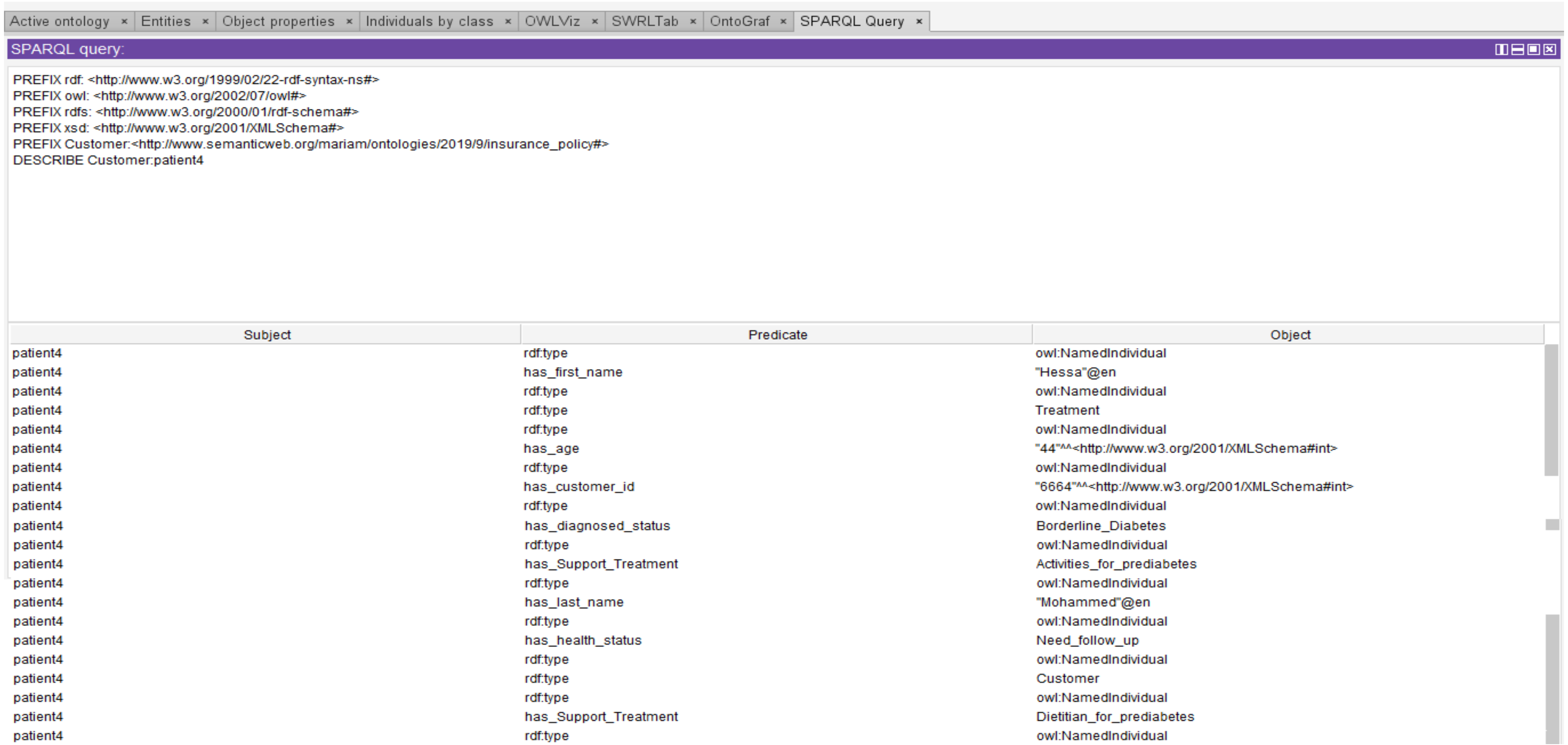


Figure 19: Customer 3 Record After Applying SWRL Rules

- Customer 4

Patient ID	First Name	Last name	Age	Health status	Diagnose	Support treatment
6664	Hessa	Mohamed	44	Need follow up	Borderline Diabetes	-Activities for prediabetes -Dietitian for prediabetes

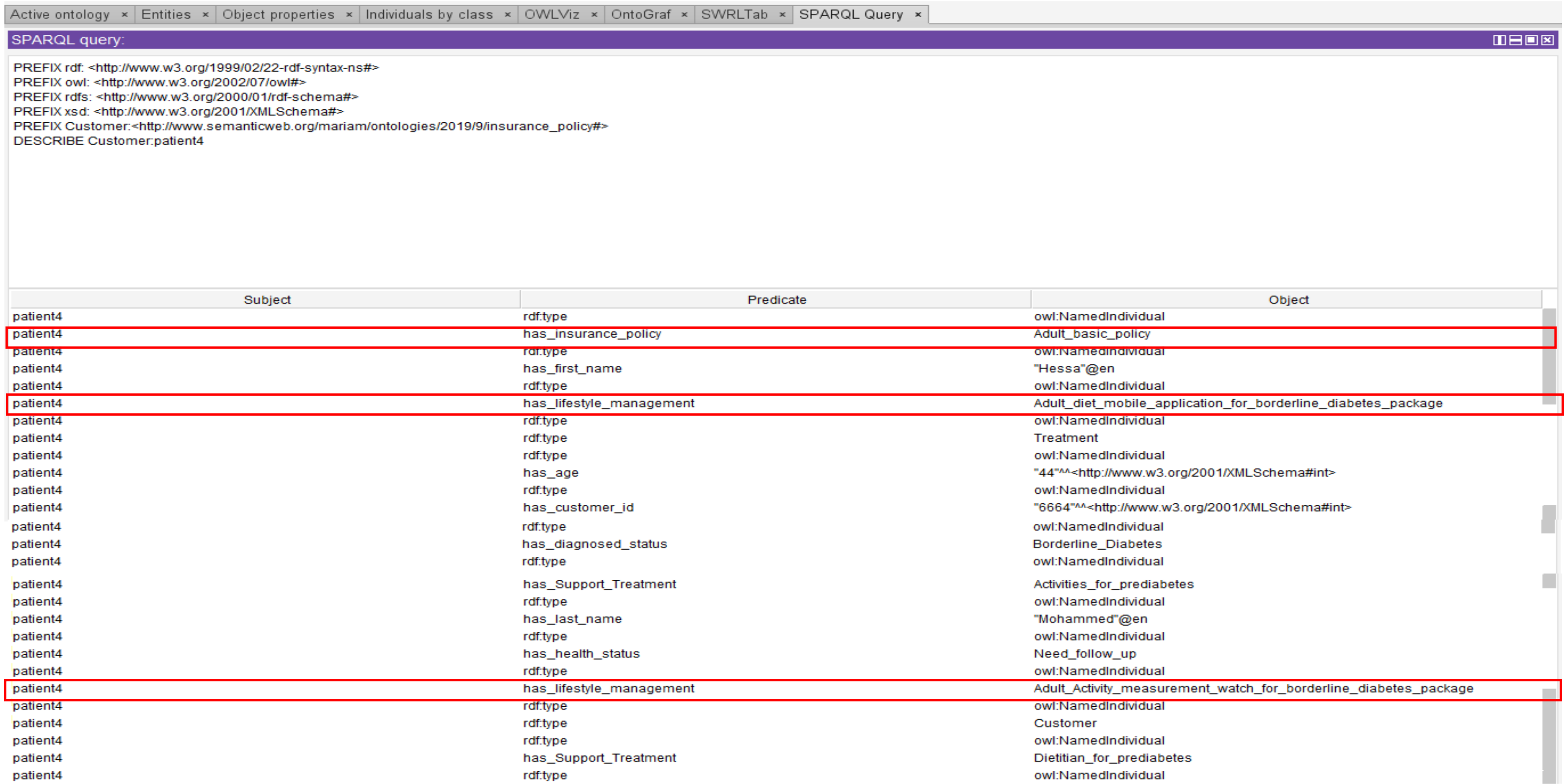



```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX Customer:<http://www.semanticweb.org/mariam/ontologies/2019/9/insurance_policy#>
DESCRIBE Customer:patient4
```

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

Figure 20: Customer 4 Record before Applying the SWRL Rules

According to the customer information the assigned policy should be “Adult Basic Policy + Adult Activity measurement watch for borderline diabetes package + Adult diet mobile application for borderline diabetes package”.



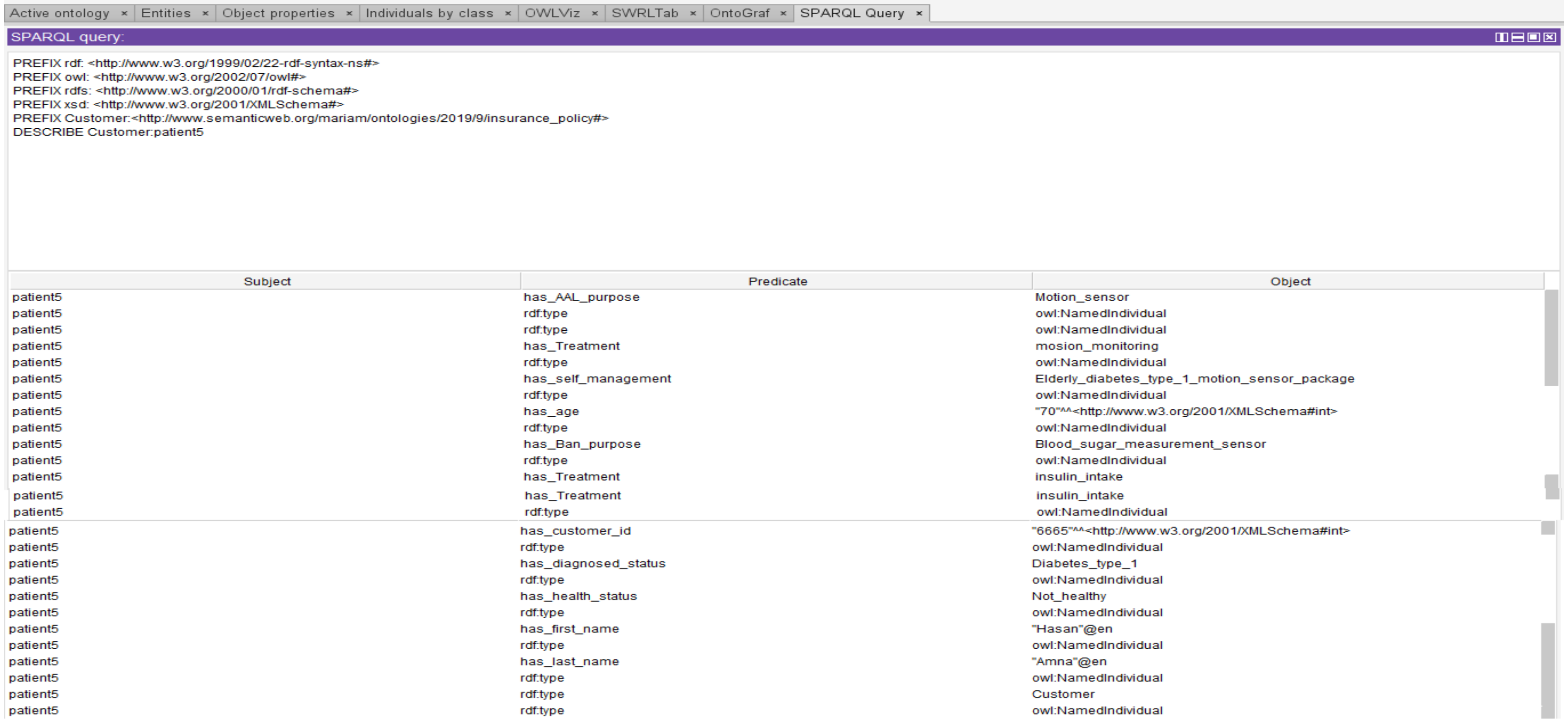

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX Customer:<http://www.semanticweb.org/mariam/ontologies/2019/9/insurance_policy#>
DESCRIBE Customer:patient4
```

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

Figure 21: Customer 4 Record After Applying SWRL Rules

- Customer 5

Patient ID	First Name	Last name	Age	Health status	Diagnose	Treatment	Support treatment	BAN purpose	AAL purpose
6665	Amna	Hasan	70	Not healthy	Diabetes type1	Insulin intake	Motion monitoring	Blood sugar measurement sensor	Motion sensor



Active ontology × Entities × Object properties × Individuals by class × OWLViz × SWRLTab × OntoGraf × SPARQL Query ×

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/mariam/ontologies/2019/9/insurance_policy#>
DESCRIBE Customer:patient5
```

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

Figure 22: Customer 5 Record before Applying the SWRL Rules

According to the customer information the assigned policy should be “Elderly Basic Policy + Elderly diabetes type 1 insulin pump package + Elderly diabetes type 1 motion sensor package”

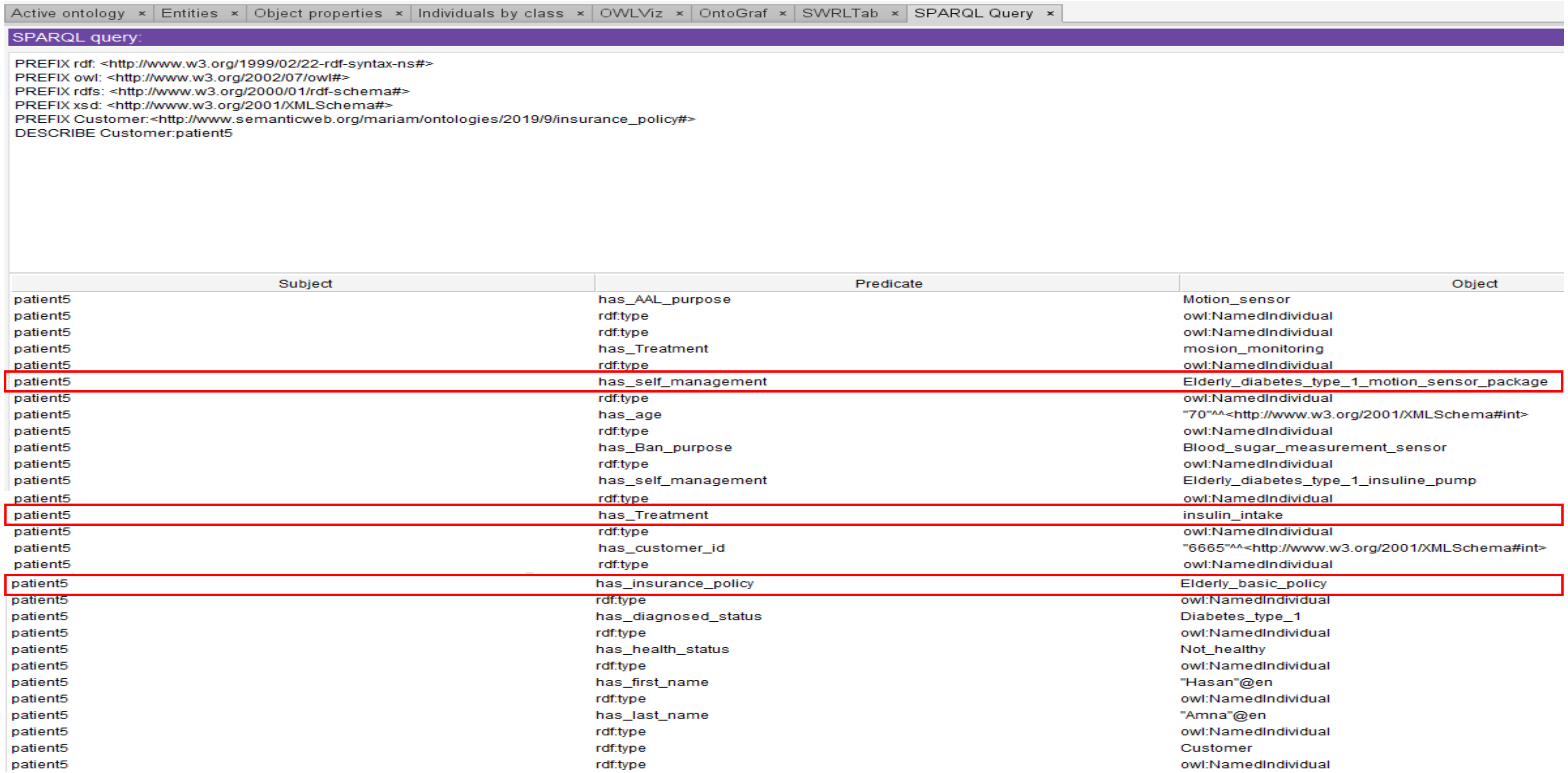


Figure 23: Customer 5 Record After Applying SWRL Rules

Chapter 6: Conclusion

This research contained three main contributions. The first is a holistic smart healthcare architecture that consists of all the components that contribute to the healthcare services. The second contribution is an innovative smart healthcare insurance business model that can adapt to the technology change in this field and maintain this business. The third contribution is building an insurance policy ontology that aims to assign a customer-centric policy depends on the customer requirements. This model retrieves the customer data from EHR and selects the required packages according to the customer health status, age and the technological requirements to maintain the customer health and wellness.

6.1 Research Implications

This research meets its hypothesis by getting the benefit of combining the innovative business model concept and the available trend technologies successfully and satisfy its objectives comprehensively.

6.2 Challenges

This main challenge was building the ontology part because it required a considerable amount of time to find the proper and related references since this area is still not matured and there is a limited number of experts in it.

6.3 Limitation and Future Work

This research meets its goals and objectives successfully. On the other hand, the insurance policy system was partially developed as a prototype that presented a limited number of cases and was built using basics tools as a reason for time limitation.

The future work will focus on data collection to build the smart healthcare insurance ontology and use related tools to extract and match the customer requirements with the insurance packages to create a customer-centric policy.

List of Publications

Althawadi, M, Sallabi, F, Awad, M, Shuaib, K, “Disruptive IoT-Based Healthcare Insurance Business Model”, The 17th IEEE International Conference on Embedded and Ubiquitous Computing (IEEE EUC 2019), New York, USA, August 1-3, 2019

References

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

Ahmed, M. U. (2017). An Intelligent Healthcare Serviceto Monitor Vital Signs in Daily Life – A Case Study on Health-IoT. *International Journal of Engineering Research and Applications*, *07*(03), 43–45. https://doi.org/10.9790/9622-0703024345

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

Ali, F., Islam, S. M. R., Kwak, D., Khan, P., Ullah, N., Yoo, S. jo, & Kwak, K. S. (2018). Type-2 fuzzy ontology–aided recommendation systems for IoT–based healthcare. *Computer Communications*, *119*, 138–155. https://doi.org/10.1016/j.comcom.2017.10.005

Almobaideen, W., Krayshan, R., Allan, M., & Saadeh, M. (2017). Internet of Things: Geographical Routing based on healthcare centers vicinity for mobile smart tourism destination. *Technological Forecasting and Social Change*, *123*(March 2016), 342–350. https://doi.org/10.1016/j.techfore.2017.04.016

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.

Bioportal. (2019a). Foundational Model of Anatomy. Retrieved September 9, 2019, from https://bioportal.bioontology.org/ontologies/FMA

Bioportal. (2019b). International Classification for Nursing Practice. Retrieved September 8, 2019, from https://bioportal.bioontology.org/ontologies/ICNP

Bioportal. (2019c). International Classification of Diseases, Version 10. Retrieved June 21, 2019, from https://bioportal.bioontology.org/ontologies/ICD10/?p=summary

Bioportal. (2019d). SNOMED CT. Retrieved from https://bioportal.bioontology.org/ontologies/SNOMEDCT

Bodenheimer, T., & Lorig, K. (2020). Patient Self-management of Chronic Disease in Primary Care. *Innovations In Primary Care*, *288*(19), 2469–2475.

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

Care, S. H. (2018). Everything You Wanted to Know About Smart Health Care. *IEEE Consumer Electronics Magazine*, *7*(january), 18–28. https://doi.org/10.1109/MCE.2017.2755378

Dadgar, M., & Joshi, K. D. (2018). The Role of Information and Communication Technology in Self-Management of Chronic Diseases : An Empirical Investigation through Value Sensitive Design, *19*, 86–112. https://doi.org/10.17705/1jais.00485

Dias, D. (2018). Wearable Health Devices—Vital Sign Monitoring, Systems and Technologies. https://doi.org/10.3390/s18082414

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

Doyle, D. J., & Garmon, E. H. (2019). American Society of Anesthesiologists Classification (ASA Class). Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK441940/

Emre, O., & Ozgu, C. (2018). Extending FOAF and Relationship Ontologies with Consent Ontology. In *3rd International Conference on Computer Science and Engineering* (pp. 6–10).

EY. (2015). the Future of Health Insurance: A Road Map Through Change. Report number EYG No. GC0008. URL: https://www.ey.com/Publication/vwLUAssets/EY-the-future-of-health-insurance/$FILE/EY-the-future-of-health-insurance.pdf (Accessed March 2017).

Farahani, B., Firouzi, F., Chang, V., & Badaroglu, M. (2018). Towards fog-driven IoT eHealth : Promises and challenges of IoT in medicine and healthcare. *Future Generation Computer Systems*, *78*, 659–676. https://doi.org/10.1016/j.future.2017.04.036

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

Firouzi, F., Rahmani, A. M., Mankodiya, K., Badaroglu, M., & Merrett, G. V. (2018). Internet-of-Things and big data for smarter healthcare : From device to architecture , applications and analytics. *Future Generation Computer Systems*, *78*, 583–586. https://doi.org/10.1016/j.future.2017.09.016

Gómez-Vallejo, H. J., Uriel-Latorre, B., Sande-Meijide, M., Villamarín-Bello, B., Pavón, R., Fdez-Riverola, F., & Glez-Peña, D. (2016). A case-based reasoning system for aiding detection and classification of nosocomial infections. *Decision Support Systems*, *84*, 104–116. https://doi.org/10.1016/j.dss.2016.02.005

Healthcare. Health Insurance. (2018). Retrieved May 1, 2018, from https://www.healthcare.gov/glossary/health-insurance/

Hedman, J., & Kalling, T. (2003). The business model concept: theoretical underpinnings and empirical illustrations. *European Journal of Information Systems*, *12*(1), 49–59.

Hemairy, M. Al, Serhani, M., Amin, S., & Alahmad. (2018). *Technology for Smart Futures*. (M. Dastbaz, H. Arabnia, & B. Akhgar, Eds.). Switzerland: Springer International Publishing AG. https://doi.org/10.1007/978-3-319-60137-3_6

HIC. (2018). Understanding our health care system. Retrieved March 16, 2018, from http://healthissuescentre.org.au/consumers/health-care-in-australia/understanding-our-health-care-system

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

Hwang, J., & Christensen, C. M. (2008). Disruptive innovation in health care delivery: A framework for business-model innovation. *Health Affairs*, *27*(5), 1329–1335. https://doi.org/10.1377/hlthaff.27.5.1329

IBM. (n.d.). Define customer segments in the Insurance sample. Retrieved April 11, 2019, from https://www.ibm.com/support/knowledgecenter/en/SSCJHT_1.0.0/com.ibm.swg.ba.cognos.pci_oth.1.0.0.doc/c_pci_pm_insur_cust_seg.html

Islam, S. M. R., Kwak, D., Kabir, H., Hossain, M., & Kwak, K. (2015). Concomitant headache in acute ischaemic stroke: Relation with ct angiography and ct perfusion characteristics. *International Journal of Stroke*, *10*, 217–708. Retrieved from http://www.embase.com/search/results?subaction=viewrecord&from=export&id=L72034289%5Cnhttp://dx.doi.org/10.1111/ijs.12479

Janowicz, K., Haller, A., Cox, S. J. D., & Le, D. (2019). Web Semantics : Science , Services and Agents on the World Wide Web SOSA : A lightweight ontology for sensors , observations , samples , and actuators. *Web Semantics: Science, Services and Agents on the World Wide Web*, *56*, 1–10. https://doi.org/10.1016/j.websem.2018.06.003

Johnson, J., Hall, L. H., Berzins, K., Baker, J., Melling, K., & Thompson, C. (2018). Mental healthcare staff well-being and burnout: A narrative review of trends, causes, implications, and recommendations for future interventions. *International Journal of Mental Health Nursing*, *27*(1), 20–32. https://doi.org/10.1111/inm.12416

Jones, M., Morris, J., & Deruyter, F. (2018). Mobile Healthcare and People with Disabilities : Current State and Future Needs. https://doi.org/10.3390/ijerph15030515

Kalemi, E., & Martiri, E. (2011). FOAF-Academic Ontology : *2011 Third International Conference on Intelligent Networking and Collaborative Systems*, 440–445. https://doi.org/10.1109/INCoS.2011.94

Kumar, P. M., Lokesh, S., Varatharajan, R., Chandra Babu, G., & Parthasarathy, P. (2018). Cloud and IoT based disease prediction and diagnosis system for healthcare using Fuzzy neural classifier. *Future Generation Computer Systems*, *86*, 527–534. https://doi.org/10.1016/j.future.2018.04.036

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

Liu, J., Li, Y., Tian, X., Sangaiah, A. K., & Wang, J. (2019). Towards semantic sensor data: An ontology approach. *Sensors (Switzerland)*, *19*(5), 1–21. https://doi.org/10.3390/s19051193

Majumder, S., Aghayi, E., Noferesti, M., Memarzadeh-Tehran, H., Mondal, T., Pang, Z., & Deen, M. J. (2017). Smart Homes for Elderly Healthcare—Recent Advances and Research Challenges. *Sensors*, *17*(2496), 1-32. https://doi.org/10.3390/s17112496

Malathi, D., Logesh, R., Subramaniyaswamy, V., Vijayakumar, V., & Sangaiah, A. K. (2019). Hybrid Reasoning-based Privacy-Aware Disease Prediction Support System. *Computers and Electrical Engineering*, *73*, 114–127. https://doi.org/10.1016/j.compeleceng.2018.11.009

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

Marcelino, I., Silvana, G., Domingues, P., Gómez-Meire, S., Fdez-Riverola, F., & Pereira, A. (2018). Active and Assisted Living Ecosystem for the Elderly. *Sensors*, *18*(1426), 1–18. https://doi.org/10.3390/s18041246

Medicinenet. (2019). Medical Definition of Lifestyle disease. Retrieved April 4, 2019, from https://www.medicinenet.com/script/main/art.asp?articlekey=38316

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

Nachabe, L., Girod-genet, M., & Hassan, B. El. (2015). Unified Data Model for Wireless Sensor Network. *IEEE Sensors Journal*, *15*(7), 3657–3667. https://doi.org/10.1109/JSEN.2015.2393951

Osterwalder, A., & Pigneur, Y. (2010). Business Model Generation - A handbook for visionaries, Game Changers and challengers striving to defy outmoded business models and design tomorrow's enterprises. *The Medieval Ous: Imitation, Rewriting, and Transmission in the French Tradition*, 5, 45–58. https://doi.org/10.1523/JNEUROSCI.0307-10.2010

Osterwalder, A., Pigneur, Y., Smith, A., & Movement, T. (2010). *Business Model Generation*. Canada: John Wily & Sons, Inc.

Osterwalder, A., Pigneur, Y., & Tucci, C. L. (2005). Clarifying Business Models: Origins, Present, and Future of the Concept. *Communications of the Association for Information Systems*, *16*(July), 1–25. https://doi.org/10.17705/1cais.01601

Papa, A., Mital, M., Pisano, P., & Del, M. (2018). Technological Forecasting & Social Change E-health and wellbeing monitoring using smart healthcare devices : An empirical investigation. *Technological Forecasting & Social Change*, (September 2017), 0–1. https://doi.org/10.1016/j.techfore.2018.02.018

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

PNHP. (2016). Health Care Systems - Four Basic Models. Retrieved March 15, 2018, from http://www.pnhp.org/resources/health-care-systems-four-basic-models

Punke, H. (2018). Why Doctors Review Health Insurance Claims. Retrieved March 23, 2019, from https://www.makingthehealthcaresystemwork.com/2018/10/23/why-doctors-review-health-insurance-claims/

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

Rhayem, A., Ahmed Mhiri, M. Ben, Salah, M. Ben, & Gargouri, F. (2017). Ontology-based system for patient monitoring with connected objects. *Procedia Computer Science*, *112*, 683–692. https://doi.org/10.1016/j.procs.2017.08.127

Riaño, D., Real, F., López-Vallverdú, J. A., Campana, F., Ercolani, S., Mecocci, P., … Caltagirone, C. (2012). An ontology-based personalization of health-care knowledge to support clinical decisions for chronically ill patients. *Journal of Biomedical Informatics*, *45*(3), 429–446. https://doi.org/10.1016/j.jbi.2011.12.008

Rose, S. (2018). What is the main business model for insurance companies? Retrieved April 6, 2019, from https://www.investopedia.com/ask/answers/052015/what-main-business-model-insurance-companies.asp

Rouse, M. (2012). Healthcare Cloud. Retrieved April 1, 2018, from http://searchhealthit.techtarget.com/definition/health-care-cloud

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

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

Sendra, S., Parra, L., Lloret, J., & Tomás, J. (2018). Smart system for children ' s chronic illness monitoring, *40*, 76–86. https://doi.org/10.1016/j.inffus.2017.06.002

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

Singh, B. (n.d.). IOT based Smart Healthcare Applications for People with Disabilities, *IV*(2350).

Statista. (2019). U.S. national health expenditure as percent of GDP from 1960 to 2019. Retrieved October 26, 2019, from https://www.statista.com/statistics/184968/us-health-expenditure-as-percent-of-gdp-since-1960/

Taylor, J. (2019). Lifestyle Disease. Retrieved April 4, 2019, from https://www.habitsforwellbeing.com/lifestyle-diseases/

Uddin, Z. (2018). Ambient Sensors for Elderly Care and Independent Living : A Survey, 1–32. https://doi.org/10.3390/s18072027

Villalonga, C., Pomares, H., Rojas, I., & Banos, O. (2017). Neurocomputing MIMU-Wear : Ontology-based sensor selection for real-world wearable activity recognition. *Neurocomputing*, *250*, 76–100. https://doi.org/10.1016/j.neucom.2016.09.125

WHO. (2018a). About WHO. Retrieved March 31, 2018, from http://www.who.int/about/en/

WHO. (2018b). Health systems. Retrieved March 15, 2018, from http://www.who.int/topics/health_systems/en/

WHO. (2019). eHealth. Retrieved April 14, 2018, from http://www.who.int/ehealth/en/

World Bank. (2019). Current health expenditure (% of GDP). Retrieved October 26, 2019, from https://data.worldbank.org/indicator/SH.XPD.CHEX.GD.ZS?end=2016&start=2000&view=chart

Yenkataraman;, S. S. K., & Kothamasu, R. (2017). *Top 10 Technology Trends in Health Insurance : 2018 What You Need to Know*.

Zhang, Y. fan, Gou, L., Zhou, T. shu, Lin, D. nan, Zheng, J., Li, Y., & Li, J. song. (2017). An ontology-based approach to patient follow-up assessment for continuous and personalized chronic disease management. *Journal of Biomedical Informatics*, *72*(2017), 45–59. https://doi.org/10.1016/j.jbi.2017.06.021