Lappeenranta-Lahti University of Technology LUT

School of Engineering Science

Software Engineering

Master's Programme in Software Engineering and Digital Transformation

Seyedehhanieh Mortazavi

A proposed architecture for the integration of IoT and Cloud Computing

Supervisor 1: Kari Smolander

Supervisor 2: Professor Sergey Viktorovich Zykov

ABSTRACT

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Nowadays, with the use of pervasive environments, environments that provide human needs at any time and place, information technologies and artificial intelligence in the field of machine-to-machine interaction have evolved at an unprecedented rate of speed. These technologies have evolved synergistically. However, data storage and data processing holes and challenges are on IoT. On the other hand, cloud computing technology can play an important role in storage holes with the ability to store and process cloud data. With the centrality and interoperability of the IoT space that comes with the Cost-saving, automation of service and control; the exploitation, implementation and maintenance of organizational structures of this technology is improving all around the world. Therefore, it is necessary to implement this technology and considering the model. Optimization, implementation of the technology has been a major challenge in the field of computing (In Lee, Kyoochun Lee. 2015). in this thesis, we have tried to understand the concepts of new technologies such as cloud computing and the Internet of Things and have studied the weaknesses and strengths of the architectures by examining them. And then the synthetic IoT and cloud computing model in the infrastructure layer for processing and storage straws in order to improve the challenges and holes have been provided based on existing (internal and external) research studies.

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1 Introduction

1.1 Background

Today, the concept of the Internet of Things can be achieved either by establishing an interactive platform between things or the machine, through the Internet or the Intranet, has been able to collect, process and analyze data by making timely decisions on human needs in the medical field, health, industry, and etc (Waseem, Mazhar. 2015). On the other hand, the use of cloud computing technology with the ability to store cloud data generated by its Internet is indispensable and necessary. The integration of IoT and cloud computing has always had advantages such as cost reduction, timely decision making and reliability (Aazam et al, 2016). Utilization and implementation of IoT technology is expanding in public or private organizations and companies. Therefore, there is a need to implement this technology in the world, and considering the lack of knowledge in the integrated IoT and cloud computing, implementation is a major challenge in the field of processing and storage and it requires a smart decision making.

Main problem in this research study is , with the expansion of Internet of Things technology and lack of data in integrated Internet of Things and cloud computing model, we will provide an architecture of processing and storage bottlenecks based on existing research.

Nowadays, with the use of pervasive environments, environments that provide human needs at any time and place, information technologies and artificial intelligence in the field of machine-to-machine interaction have evolved at an unprecedented rate of speed Dillon, (Tharam, et al. 2010). these technologies have evolved synergistically. On the other hand, cloud computing technology can play an important role in storage holes with the ability to store and process cloud data.

Consequently, the need to implement such a technology is vital and considering the lack of data in an optimal processing model, implementing this technology has serious and critical challenges and bottlenecks.

Internet of Things is a system consisting of, related computing devices, mechanical and digital machines and Things with a specific and unique ID that has the ability to transmitting data over an object or a network without the need of interaction between human-human and human-things (Aazam et al, 2016).

In general, with the development of IoT technology and the lack of optimal model in the integration of the two IoT and cloud computing technologies, providing a Synthetic model of these two technologies has been the main topic of this research.

The integrated model of Internet of Things and cloud computing, is designed by studying the reference architectures for the purpose of decreasing the challenges, holes and, bottlenecks of the existing architectures.

As it was mentioned before, the integrated model of Internet of Things and cloud computing considering the processing and storage challenges, associated with this technology and the provision of computational solutions can enhance the processing power and timely response in utilizing the IoT technology (Ahmad et al, 2017). Also, by specifying different components and tasks of IoT and cloud computing according to the existence standards in the proposed model, we can decrease the processing challenges and crisis of IoT.

Today, with the pivotal capability of Internet of Things, which always comes with many benefits, implementation and exploitation of this technology is improving so fast. The lack of optimal processing model has always been a concern and challenge for organizations and even a hindrance to the rapid expansion of this technology.

Also, by utilizing IoT technology in high-priority tasks such as healthcare, industry, and…, which always an immediate and prompt response plays an important role, the lack of efficient processing model adds processing time and as a result, lack of responsiveness, when it comes to using IoT technology and therefore, renders problems for organizations. (Gubbi, et al, 2013.)

In order to address the current state of how cloud computing and IoT are related it was necessary to made my research based of several sources. Most of the material that has been studied consist on academic researches and papers, however some conferences were taken as well into account.

Most of the aforementioned sources were devoted to the topic of combining the two technologies of cloud computing and IoT, for example in areas such as health, education, home and so on.
The following are some of the articles studied.

The main Idea on my research consist of the combination of IoT and cloud computing. When it comes to analyze the current state of the academia in this regard, the article "IoT and Cloud Computing in Automation of Assembly Modeling Systems" written by Chengen Wang, Zhuming Bi and Li Da Xu was very useful. The challenges and bottlenecks in the production of complex product assembly programs are widely discussed in this paper. In fact, the proposed IoT and cloud computing architecture have the importance of upgrading to an advanced modeling system, capable of dealing with complexity and automatic changes. According to the authors, in order to achieve this, the recommended system has innovations such as 1) Modular Architecture System which provides a reliable, strong, flexible and, upgradable System. 2) Integrated object-oriented templates to facilitate interfaces and reuse the system. 3) Automated algorithms to retrieve assembly matrix Frequency, assembly scheduling relationship, aircraft engine assembly modeling is used as an example to illustrate the effectiveness of the system.

Another important aspect of my research is how the development of IoT and its integration with cloud computing has taken place. On "Cloud of Things: Integrated Internet of Things and Cloud Computing and the Issues Involved" written by Mohammad Aazam and Imran Khan the authors analyze how this integration of the both technologies has led to reaching advanced services to the user. Moreover in the paper it is also discussed the optimization of the resources.

As Mr. Aazam and Khan State, this integration of technologies, called Cloud of Things, is intended to address a number of key issues such as protocol overhead, resource allocation, identity management, service discovery, data storage, security and privacy. It also deals with the storage of data generated from specific devices. Accordingly, the solution is to consider both devices, providers and gateways should have the ability to stop to produce data. This also helps to optimize the use of electricity. To this end, IoT devices need to have more operational capabilities for short-circuit processing, data transmission over the Internet, and even the cloud.

These two realities (IoT and cloud computing technologies) has been envisioned as an application enabler. In “On the Integration of Cloud Computing and Internet of Things”, (written by Alessio Botta, Walter de Donato, Valerio Persico, Antonino Pescape) address the fact that with the concentration on cloud integration and IoT, CloudIoT has been introduced.

The combination of IoT and Cloud Computing is very important now a days since it provides countless possible applications. As Yu Liu, Beibei Dong and Benzhen Guo state on “Combination of Cloud Computing and Internet of Things in Medical Monitoring Systems”, one very interesting example of it is the advance that thanks to this technologies has taken place in the medical monitoring systems. In this regard, the analysis of the used architecture model of remote monitoring medical information technology, shows the superiority and efficiency of the combination of these two technologies.

Furthermore, it was necessary to research about the cloud capabilities in cloud computing technologies. As Mrs. Pritee Parwekar affirms on “From Internet of Things towards Cloud of Things”, it is fundamental to integrate the concepts of IoT and cloud computing.
Mrs. Parwekar defines this challenge as: 1) Establishing an accurate and practical definition of the concept of the Internet of Things and the increasing number of specific objects 2) Providing cloud-based services available on the Internet of Things, such as recognition services, information sharing services 3) Expressing the ultimate benefits of Cloud Computing like security, unlimited data Storage and, business aspects of integration with IoT.

Another challenge in the current state of IoT is to present an architecture for scalability of the IoT cloud based protocol (CoAP) based on user interface, designed primarily for small, low cost and, systems of IoT devices. In “Californium: Scalable Cloud Services for the Internet of Things with CoAP”, Matthias Kovatsch indicates that this architecture utilizes three-stage architecture of multi-core resources. Along with this system architecture systematically evaluates the performance of the new web protocol in the cloud. The CoAP framework provides not only low-cost web technology devices on IoT, but also significantly improves the scalable services for several number of devices.

Something that is worthy to consider in the studied literature reviews is, failure to address the issue of processing layer in the combination of IoT and cloud computing technology, on the other hand, a suitable model and algorithm that can improve both processing time and response time by combining these two technologies has not been provided. Given the importance of processing and response time in IoT technology, the need for an optimal model for combining cloud computing and IoT in the processing layer is increasingly felt.

1.2 Research Questions:

1. What is the optimal model to reduce the crisis in the integration services of IoT and Cloud Computing?
2. What is the concept and structure of IoT and Cloud Computing?
3. What are the processing challenges of IoT?
4. How the synergies of cloud computing and IoT emerge?
5. What are the strong and weak points in IoT and Cloud Computing technologies?

1.3 Definition of Concepts and terms:

1. Technology: Technology can be all knowledge of commodities, processes, tools, methods and, systems that are used to create and construct goods and provide services. Technology is a tool by which we can achieve our goals. Technology is the practical implementation of knowledge. It is a set that comes with the help and effort of humans. (Wiley, 2014;)
2. Information Technology: It is a set that studies the design, development, support or management of computer-based information systems, especially computer software and hardware.
3. Model: Modeling, or in other words, architecture is an all-encompassing design and structure of an entity that has properties such as complexity and dynamics, preparation and maintenance that requires special attention to the integrity of flexibility and interactivity.
4. Cloud Computing: Cloud computing is a concept in which a set of virtualized resources based on distributed systems is provided to consumers by service-level agreements (SLA) and is paid for by consumers. (Truong, Dustdar, 2015)
5. Internet of Things: Internet of Things, or in short, IoT, refers to the communication between different living things and inanimate objects, whatever is capable of connecting patches that can do activities and sharing information without human intervention. The interaction of these networks will result from interconnected objects which called the IoT. (Keyur et al, 2019)
6. Fog computing: Fog computing, also known as cloud networking, is a decentralized computing infrastructure that distributes computing resources and service software at the most logically efficient location anywhere along the chain of data sources. The purpose of Fog Computing is to improve the efficiency and reduce the amount of data that needs to be transferred to the cloud for data analysis and storage. This is often done for productivity but also for security and compliance reasons. (Yi et al, 2017)

2 Theoretical framework:

2.1 Internet of Things

The term Internet of Things was first used by Kevin Ashton in 1999 to describe a world in which anything, including inanimate objects, has a digital identity and allows computers to organize and manage the Internet. Internet now connects all people, but with the Internet of Things, we can connect all things. (Bassi et al, 2018)

First, here's a look at some of the different definitions of the Internet of Things.

- The Internet of Things, or IoT for short, refers to the connection between the different objects of living things and inanimate objects and anything that can connect tags without human intervention and activity. Also these tags will share their information, and as a result of the interaction of these connections, a network of interconnected objects will emerge, which will be called the Internet of Things. (Asemani et al, 2019)
- Internet of Things technology is a new concept in the world of technology and communications. This phrase refers to the specific and unique interaction of the sensors of the calculators. In short, the Internet of Things is a state-of-the-art technology that allows any entity to send data through communication networks (Smart Grid). These interactions may have spread through intelligent objects and the network of these connections (Bassi et al, 2018). In this technology, objects can be controlled and managed by applications on smartphones, tablets, etc. Also, one of the phrases that has received a lot of attention on the Internet of Things is cloud computing, which has made it possible to process huge amounts of information and data. (Aazam et al, 2016)

The process of sending data in IoT technology is such that each device provides a unique identifier and an Internet Protocol (IP) sends the necessary data to the relevant database. One of the areas that is very close to the Internet of Things is the issue of machine-to-machine communication. In the literature in this field, many researchers consider the concept of machine-to-machine communication to be synonymous with the Internet of Things, and many consider machine-to-machine communication to be from the Internet of Things. In other words, the Internet of Things requires the connection between objects with objects and machine with machine. (Sethi, et al, 2017)

2.1.1 The features of Internet of Things:

The basic features of IoT technology are as follows:

- Connectivity: Due to the existence of Internet of Things technology, all objects are able to communicate with global information and communication infrastructure. (Shan, Yaqoob. 2016)
- Heterogeneous: Devices on the Internet of Things are different based on hardware and networking platforms, but in this technology they are able to connect to different devices with different networks. (Asemani et al, 2019)
- Dynamic nature: Mode of devices is dynamically changing, for example, sleeping and waking, connection or disconnection, as well as device information that includes location and speed, all of which can be changed dynamically. In addition, the number of devices can also change (Asemani et al, 2019).
- Scale: The number of devices that need to be managed and connected to each other is much higher than the number of devices connected to the current Internet, and most importantly,

the ability to manage data generated by devices and process data for different applications (Asemani et al, 2019).

- Safety: Security Features Related to Virtual Security Threats Safety depends largely on the structure of the tools and areas used. It is also usable so that no safety threats occur while working with IoT tools and applications (Lee, Kyoochun. 2015).
- Sensing: Easy and direct use is important for accepting IoT applications. Internet of Things programs should ideally be aware of the field of work and match the skills of users of the situation and environmental aspects (Shah, Yaqoob. 2016).
- Integration capability: Easy integration in information technology and the prospect of the process is necessary and may lead to decisions about the use of IoT solutions (Shah, Yaqoob. 2016).

2.1.2 IoT Challenges:

There are several challenges for the Internet of Things that are still in the research stages of these challenges.

1. The amount of information collected for each object
2. Communication between system hardware

The figure 1 shows a more specific category of these cases.

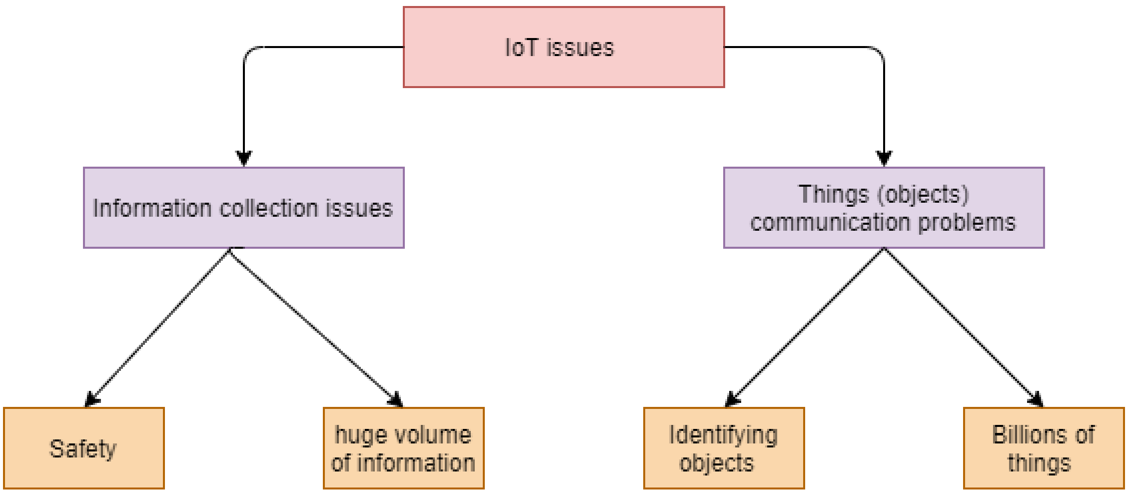


Figure 1: IoT challenges Category

Data collection:

The contents of this section can be divided into two main categories. First, a large amount of information is extracted, which is extracted by a very large number of objects connected to the IoT system. The second is the issue of security and privacy of information, which should be considered due to the wireless transmission of information. (Wang, et al, 2018)

IoT systems must connect billions of objects, and each object must publish information about itself. This information must be collected in places to be exploited. Due to the large number of IoT objects, the amount of information collected is very large, so we will face many different problems in collecting this information. (Hossain, Hasan. 2015) These problems include:

1. Data transfer: A large amount of information must be transferred instantly, which is not necessarily guaranteed. The most important reason for this is the bandwidth limitations.
2. Storage: This is important because of the large amount of information that needs to be stored and backed up.
3. Processing: The collected information of objects must be processed and controlled by web applications to determine the control activities for objects. The control process must be done immediately and requires computational power.

Security and privacy:

It is clear that data is transmitted wirelessly between IoT objects, so security and privacy are very important and should be carefully considered. There are several reasons why security is compromised on the Internet of Things. These reasons include: (Wang et al, 2018)

1. Physical Layer Attacks: A hacker can extract or delete or change information inside Internet of Things devices because these devices are often left in the environment. (Sethi, Sarangi. 2017)
2. Wireless Attack: An attacker may be able to obtain information before it reaches the recipient. There are many different security issues in this area and it is a big challenge.
3. Low defense capability: Most IoT devices may not be able to accept security packages for reasons such as processing power consumption, cost, and other savings. (Sethi, Sarangi. 2017)

Privacy is an important issue in everywhere. Privacy means that the provider of information (with a user) can only be identified by observing the use of the system (and at least its detection must be very difficult) (Ahmad et al, 2017) Data mining is done in Internet of Things systems, and the reason for this is the existence of different ways in IoT systems, such as (home resource control system), so to ensure the privacy of personal information, there are three main issues that we have to consider:

1. Who collects personal information?
2. How this information is collected?
3. How long does the collection process last?

In addition, it must be ensured that the information collected by authorized persons is used and stored in authorized services. Also, everyone should know what information about their privacy is provided to the authorized people and all this process should be done with the knowledge of their permission and consent.

Communication of objects:

Issues related to the relationship between objects on the Internet of Things are divided into two categories. The first category is answering object problems, and the second category is RFID issues in reading, writing, and transferring object information. In the following, we will examine the communication issues of objects. (Chen, Wan. 2014)

Billions of objects in the Internet of Things:

When it comes to the relationship between a large numbers of objects, many issues appear, including the following:

1. What is the hardware?
2. What hardware is needed to connect these massive objects?
3. What is the ideal addressing method for each object in the system?
4. Can compatibility between a large number of hardware be a communication factor or not?

How to identify objects:

Focusing on the Internet of Things system, two ambiguous issues emerge:

1. How each object is defined
2. Get all kinds of information

These issues can be answered with RFID technology. But the technology has many problems, such as privacy, breaches and incompatibilities in updating information. In addition, the definition of this technology will not be easy on all objects in the world. The most important challenge of this solution is instant control. Immediate control means that communication between system objects (viewing, analyzing, and extracting information) must be immediate. (Jia, et al, 2012)

2.2. Cloud Computing:

Just as the Internet created information in the cultural environment of the revolution, cloud computing has revolutionized information and communication technology. Cloud computing represents a model repair in the movement of resources and services that has provided many benefits for both cloud providers and users (Marinescu, 2017). Cloud computing is changing the perspective of information and communication technology on how to build and use IT systems it is up to the organization and shaping of information technology resources. (Rittinghouse, Ransome 2016)

Here's a look at some of the different definitions of cloud computing:

- Cloud computing is a paradigm in which a set of virtualized (service-oriented) resources are distributed based on distributed systems and provided to consumers by suppliers in accordance with the Service Level Agreement (SLA) payments are made. (Parfait, Satyarayana, 2020)
- (Peter Mell and Tim Grance)'s team from the National Science and Technology Organization (NIST) have compiled definitions of cloud computing in a credible review. They describe cloud computing as a developing model and define it as follows.

“It is a model for providing easy and fast network access to variable computer resources (such as network, server, storage resources, software and services) that provide minimal transaction management. The service can be created and moved quickly.”

2.2.1. **The main features of cloud computing**:

Cloud computing technology has always been able to meet the IT needs of organizations with its outstanding features and expand rapidly in the world. From Mell and Grance’ point of view, the main features of cloud computing technology are as follows:

- Extensive Network Access: All the facilities are available throughout the network and are available through mechanisms that use narrow and thick heterogeneous platforms (such as cellphones, laptops and PDAs).
- Demand based service delivery: A user can unilaterally use computer capacities such as server time and network storage as needed and without human connection to service providers.
- A pool of resources: The computer resources provided by the service are collected to serve several users who use the multi-user model. This model has various physical and virtual resources that are used dynamically based on user demand. There is a sense of spatial independence in this model, because the user generally has no control or knowledge about the exact location of the resources available, but at higher resource levels this location may be determined (for example, at the country level or data centers). Examples include storage, analysis, memory, bandwidth and virtual machines.
- Fast Formatting: Capacities can change quickly and easily, and in some cases even automatically, to reduce and increase speed. For users, the capacity to make changes is often unlimited and can be defined at any time and in any amount.
- Measurement service: Cloud systems automatically control and optimize the use of resources. They do this by increasing the measurement power at certain levels and depending on the type of service (e.g. storage, processing, bandwidth and active user accounts). User's use can be controlled and reported to the user as well as to the provider if the service utilized is clear.

The following can also be mentioned as the main features of cloud computing: large-scale resource collection, repetitive patterns, more automation, trust, operational efficiency, resource formability, location independence and, access if needed (Marinescu, 2017).

Access to cloud computing services for users to the extent that technology is shortened through the communication service will bring IT transparency to users. It will also benefit the supplier's operations by reducing costs and allowing it to compete. To some extent, the speed of self-communication between employers and employees of the IT provider will keep them free to work to reduce the cost of SLA, and instead will move services as fast as users want and old IT communications will not exist. (Parfait, Satyarayana, 2020)

2.2.2. Cloud Service Models:

In general, there are three service models for cloud computing. Mell and Grance describe them as follows:

- Saas (Software as a Service): Skills available to users Use cloud computing service provider software. The software is available through various customer devices and using a small web browser interface. It does not manage and control the use of cloud infrastructure such as network, server, operating system, storage, or even personal use cooperatives, and there are exceptions to the limited software settings for users.
- Paas (Platform as a Service): Ability to allow the user to use software produced by users or software that works by using programming languages and tools supported by the service provider on the cloud infrastructure. The user does not control or manage cloud infrastructure such as networks, servers, operating systems, and storage centers, but controls the applications used and possibly the host environment settings.

- Iaas (Infrastructure as a Service): Ability to allow users to use processing resources, storage, network and other basic computer resources to run the user's desired software on the infrastructure, which includes operating systems and software. The consumer does not control and manage cloud infrastructure, but rather the operating system, storage resources, software used, and possibly limited network selection components (eg, host fire walls).

These three models are referred to as SPI models. What is described here are three broad classes of capacities located on the physical infrastructure of the cloud that can be layered or that can work individually.

2.2.3. **Cloud Types**:

Today, the use of cloud computing technology is possible in different ways according to the needs of countries and organizations (IBM/benefits-of-cloud computing). The most important models used in the operation of this technology are the following:

- Public clouds: The simplest description is that there is a public cloud outside the end user's domain, and it is often available to people with little restriction on who pays to use it. In fact, cloud infrastructure is available to the general public or to a large industrial group and is owned by organizations that sell cloud services. As a result, the most common public tools are those that are available over the Internet (Kirsch, Hurwitz, 2020). Public clouds can be created by providers who want to create high-capacity infrastructure and distribute its components among different customers. Therefore, information is stored on a shared storage device, which makes identity, access control, and encryption very important. There is significant trust from subscribers in relation to service providers. (Belbergui et al, 2017)
- Private Clouds: Unlike public cloud, private cloud has internal hosting. The sign of a private cloud is that it is often specific to an organization, although there is no mixing of information or sharing resources with external environments, and different departments in the organization can have strong rules for maintaining information isolation within the private cloud and participating in it. Private cloud organizations often do this using virtualization technology within their data center. (Kirsch, Hurwitz, 2020)
- Social Clouds: Social cloud features allow multiple users / independent organizations to take advantage of a shared non-public cloud and avoid security concerns and its functionality, which may be related to the use of a public cloud. It can also be managed by the organization or by a third party, and by default or without that it can exist. This model has great potential for companies that have the same legal restrictions (Kyle et al, 2010). Different types of social clouds in the United States and the European Union are used by governments at the national and local levels (Belbergui et al, 2017). This makes a lot of sense, because there are many benefits to both individuals and entities, for example, when several government agencies that do transactional business together gather their processes in one system can be both more economical and more secure. In terms of reducing the volume of traffic created, when multiple data centers are used to run such a community, the continuation of operations can also have lower final prices for all users.

- Hybrid Clouds: Hybrid clouds are exactly what they come from, they arise when an organization creates a private cloud and wants to use public or social clouds for a specific purpose in connection with its private cloud (Figure 2). (In fact, a hybrid cloud can be a combination of any of the three public, private, and social clouds) (Kirsch, Hurwitz, 2020). Many organizations use their sensitive infrastructure from internal private cloud, but there are certain needs for which building an internal cloud is not economical for them like when our goal is to ensure quality or experimentation. For example, an internal cloud may be used to set up a business infrastructure, but in that business it may be necessary to update or test a new system. It may be better to pay for the capacity of a public cloud for a few months to complete the testing phase, and when our private cloud is updated, we will no longer use the public cloud. (Belbergui et al, 2017)

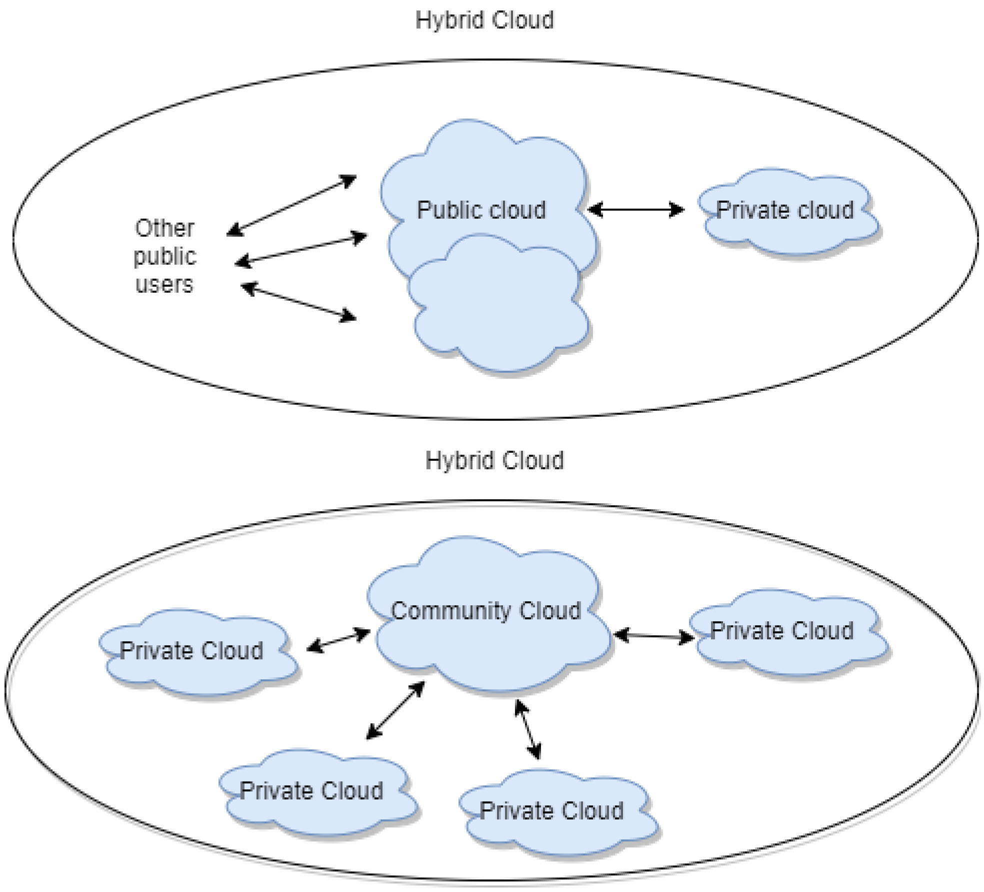


Figure 2:Hybrid Clouds

2.3. Fog computing:

Cloud computing technology provides cloud computing conditions near equipment that generates and operates on Internet of Things data. These devices are called Fog Node and can be used anywhere, such as factory levels, above power poles, along rail routes, in vehicles or on Fable oil rigs, by connecting to the network. Any device with a network connection, memory, and computing capabilities can be a Fog Node. Examples include controllers, switches, routers, servers, and CCTV cameras. (Bonomi et al, 2012)

According to estimates by international data corporation, the amount of data analyzed in equipment that is physically close to the Internet of Things is about 40 percent. So the argument is that analyzing IoT data near where it is presented reduces the latency. It is important to emphasize that the analysis of IoT data near the place of its collection reduces the latency. This technology transmits several gigabytes of traffic from the main network and keeps sensitive data within the network (Cisco, 2015).

Fog creates clouds near the data generator equipment.

2.3.1. **Features of Fog Computing**:

This technology places the cloud near equipment that generates data and performs activities on it. This technology will benefit the business in the following ways:

- More business agility: With the right tools, developers can quickly develop fog programs and use them when needed. Car manufacturers offer MaaS to their customers. Fog programs can adjust the device according to the needs of each customer. (Cisco, 2015)
- More security: The process of accessing fog nodes is done using similar control methods and policies and procedures used in other areas of information technology. In addition, it uses similar strategies to provide physical security and cyber security. (Atlam et al, 2018)
- More detailed information with privacy control: Instead of sending sensitive data to the cloud, it analyzes this data locally. Therefore, the IT team can control, monitor equipment that collects, analyzes, and stores data (Atlam et al, 2018).
- Reduces operating costs: Saves bandwidth by processing selected data locally instead of sending it to the cloud to perform the analysis process (Atlam et al, 2018).

3 Reference models:

3.1. Cloud Computing Reference Models:

In this section, different models of cloud computing reference are examined.

3.1.1. **NIST reference model**:

The National Institute of Standards and Technology (NIST) is a state-run scientific organization based in the United States under the auspices of the United States Department of Commerce, which aims to encourage innovation and industrial competition by advancing science and technology in the United States. In a way that enhances economic security and increases the quality of life. The institute has developed a standard for cloud computing, which is now considered a cloud computing architecture for most governments and organizations.

The NIST reference cloud computing architecture is shown in figure 3 below. Here are some of the key players in this architecture:

Cloud auditor, Cloud carrier, Cloud provider, Cloud consumer, Cloud broker. Each actor is an entity (individual or organization) involved in the transmission and processing or performance of cloud computing. (NIST, 2011)

- Cloud Consumer: The person or organization that controls the business relationship and uses the service forms.(National Institute of computers and technology (NIST,2011)
- Cloud provider: The person or organization or responsibility which is responsible for creating the service available to specific departments. (National Institute of computers and technology (NIST),2011)
- Cloud auditor: The part that performs independent evaluation of cloud services, information system, implementation and security in cloud implementation. (National Institute of computers and technology (NIST),2011)
- Cloud broker: An entity that manages the use, execution, and threat of cloud services and negotiates the relationship between the cloud provider and the user. (National Institute of computers and technology (NIST),2011)
- Cloud carrier: An interface that provides cloud services communications and transfers from provider to cloud user. (National Institute of computers and technology (NIST),2011)

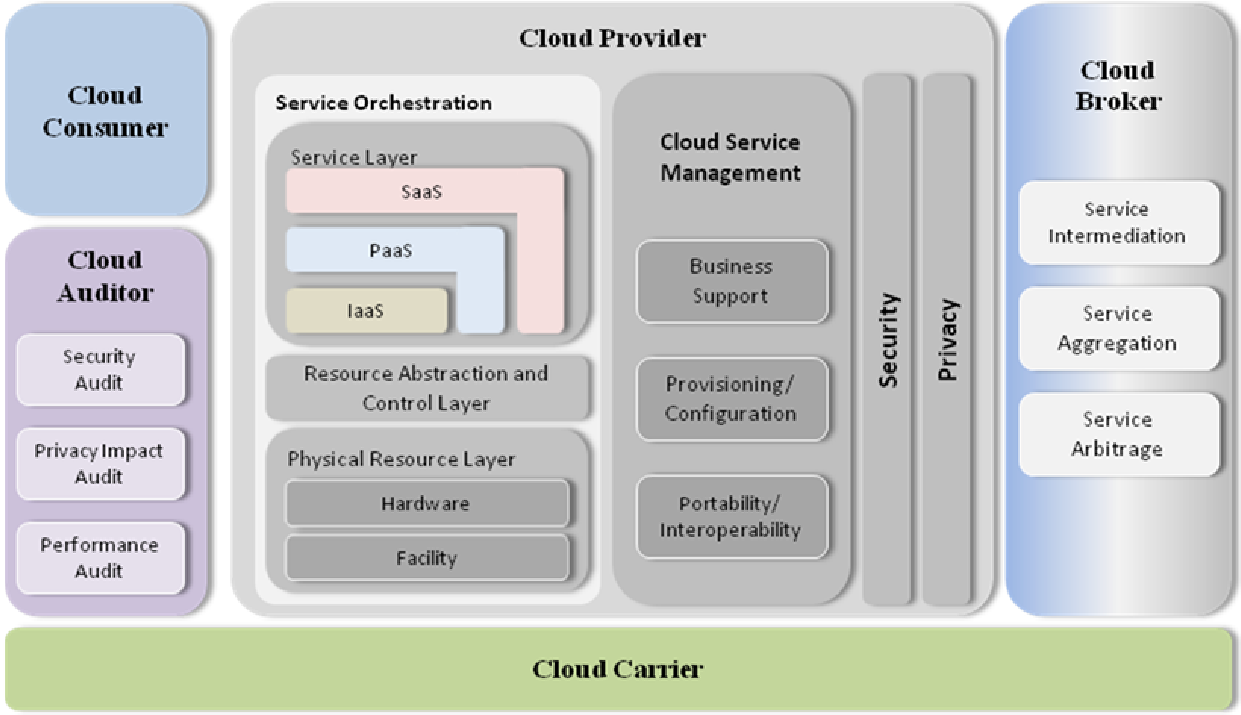


Figure 3:NIST Reference Model (National Institute of computers and technology (NIST, 2011))

3.1.2. IBM reference model:

The IBM reference model is shown in figure 4 below. This architecture defines three main roles: (Coyne et al, 2018)

1. Cloud Service Creator: This section designs, implements, and maintains the execution time and management of specific products for a service. The service development tool (Cloud Service Creator) is used to develop the concept of cloud service pack, including the effects of execution time and related dimensions management (monitoring, measurement, supply, etc.).
2. Cloud Service Provider: This section is responsible for providing cloud service to consumers. These services are delivered by a special cloud management platform or by running the management infrastructure and using one of the administrations as a service. Cloud service shows the ability to provide any kind of information by the cloud service provider to the cloud service consumer. This service is one of the main features of the cloud.
3. Cloud Service Consumer: An organization, individual, or information system that uses the services provided by a cloud service provider. In addition, the infotainment system can be used as a cloud service, and consumers may also be able to manage information at home in the traditional way. Ability to integrate cloud services requires combining the information system at home with the cloud service provider. Each role can be performed by one person or by a group of people with one or more organizations.

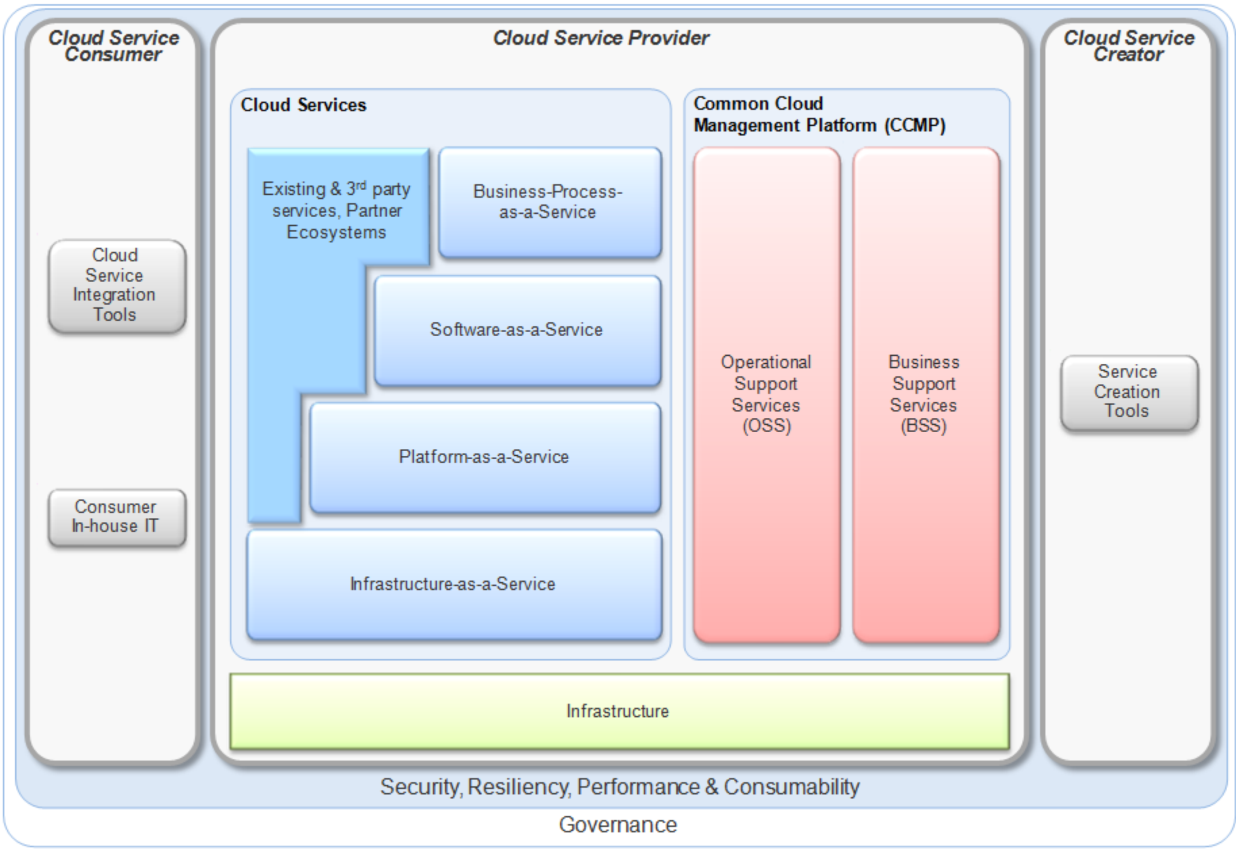


Figure 4:View of a cloud environment (IBM's Reference Architecture for Creating Cloud Environments)

3.1.3. Oracle reference model:

The concept of Oracle reference architecture, shown in the figure below (Figure 5), provides three key cloud perspectives: the provider, the consumer, and the interface in Oracle's reference resources. In this model, the role of the actors is similar to the NIST reference model.

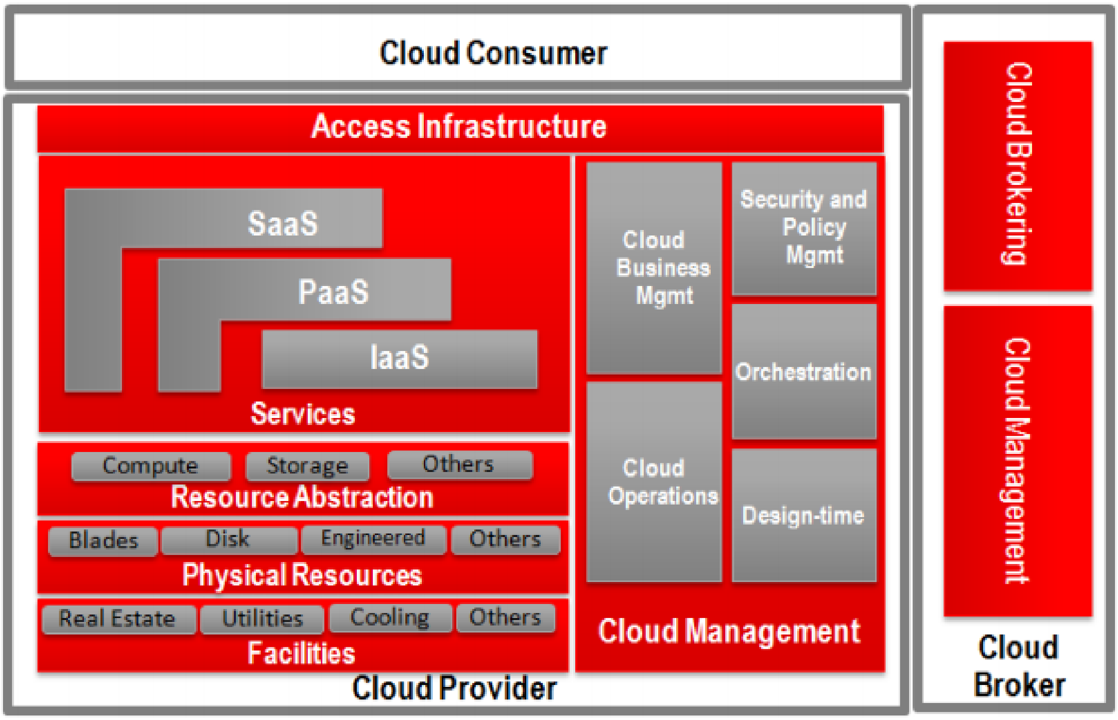


Figure 5: Oracle Cloud conceptual view

An Oracle White Paper November 2012, Oracle Enterprise Transformation Solutions Series Cloud Reference Architecture

3.1.4. HP reference Model:

The reference architecture of the HP cloud system, as shown below (Figure 6), is used. In this architecture: (Gebresenbet et al, 2013)

- The supply layer: provides all the infrastructure of the cloud service, which includes physical and virtual assets such as servers and databases.
- The delivery layer: provides infrastructure and applications as a service.
- The demand layer: includes the self-service portal, where services are used by end users or subscribers.

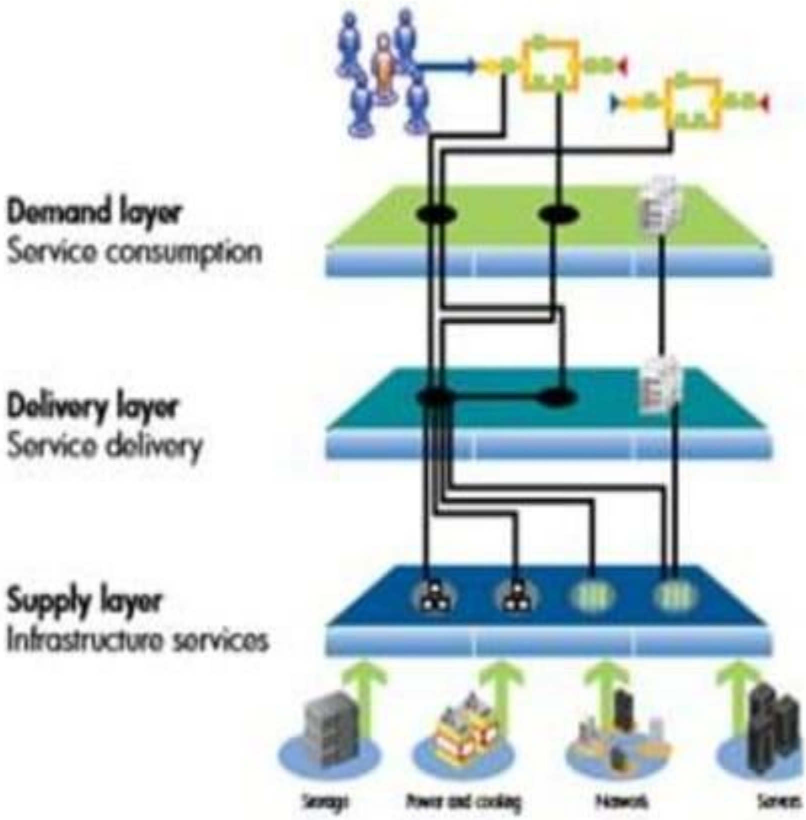


Figure 6: Three layers architecture of Cloud HP system (Gebresenbet, Demeke and Menchita F. Dumlao. 2013)

3.1.5. Cisco reference Model:

The figure 7 illustrates the architecture of the cisco cloud reference, which is the layers of architecture that are connected by application interfaces and reservoirs. This architecture consists of the following layers:

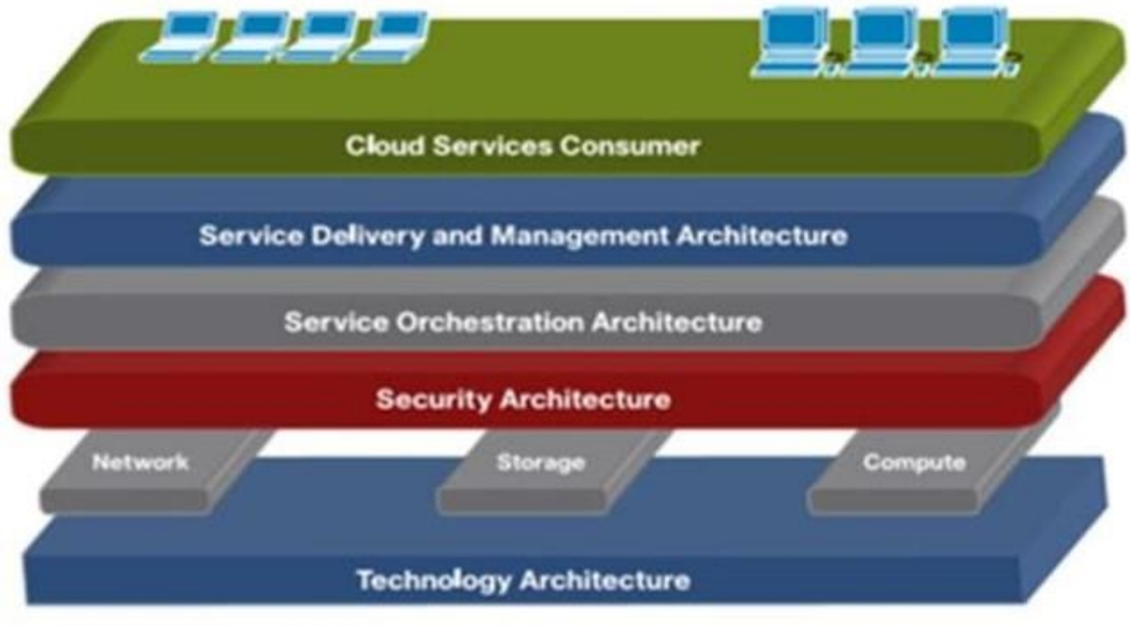


Figure 7:Cisco reference model (Lamtzidis, Odysseas. (2019))

- Technology Architecture Layer: The basis of the Technology Center's technology framework is the Technology Architecture Layer, which includes three prominent blocks with network titles, calculation, and storage. This layer hosts all services delivered to consumers and cloud subscribers.
- Security Layer: The key to this security layer is the end-to-end architecture in all landscapes. Security is considered one of the key challenges in the cloud framework.
- Service Orchestration Layer: This layer is implemented by enabling warehouse configuration.
- Service delivery and management layer: This is where the infrastructure and service management operations take place.
- Cloud Service Consumer Layer: This is where the service is defined, requested, and managed by the user.

3.2 Comparison of cloud computing reference architectures:

The nature of each architecture is based on the role of its actors in the table. The table of activities and abilities is assigned to different layers with the actors. These activities and abilities have been extracted from the reference architectures mentioned above.

Manufacturer	Cloud Consumer	Cloud Carrier	Cloud Provider	Cloud Manager	Cloud Auditor	Cloud Developer

NIST	An actor who uses a cloud is an organization, person or system that can request a cloud service from a service provider directly or through a cloud agent.	The cloud carrier is the intermediary that provides the connection and transfer of the cloud service from the cloud provider to the cloud consumer.	An actor is a cloud provider, an individual, an organization, or an entity that is responsible for making the service accessible to other parts.	The actor manages the service delivery superstructure and its infrastructure. The cloud agent also assigns the task of management.	A cloud auditor is the part that can guide the independent evaluation of cloud services, information system operations, performance, and cloud implementation security.	A specific actor is not defined as a developer but is considered as a cloud consumer.
IBM	An actor is a consumer of a cloud, a human being, an organization, or a system that can request a service.	The cloud carrier is responsible for providing connectivity and other infrastructure.	The service provider is the person who provides the service to the consumer.	The cloud service provider is responsible for managing the cloud.	The common cloud management platform is (CCMP) the part where the provider is responsible for auditing.	A Cloud Service Actor is someone who develops a service that can be run by a cloud service provider.
Oracle	An actor is a consumer of a cloud, a human being, an organization, or a system that can request a service.	The service provider is responsible for providing facilities to the consumer.	A cloud provider is someone who provides facilities and access to infrastructure for the consumer.	The cloud service provider is responsible for managing and managing security.	There are no cloud auditors, but the task is left to cloud management, which is part of the cloud service provider.	This section is considered as the creator of the cloud application and is defined as part of the actor providing the service.
HP	The demand layer is responsible for providing the portable service that consumers or business user's request.	This layer is responsible for providing physical and virtual assets.	The availability layer provides all services to the service consumer.	Delivery and demand layers are responsible for managing services.	Clearly, there is no description of which layer is responsible for auditing, but the delivery and demand layers are	This section is named as the application designer and the responsibility of this layer is on

					responsible for monitoring using cloud service automation software.	the delivery layer.
Cisco	The consumer layer of the cloud service, which is the layer facing the consumer.	The technology architecture layer is responsible for generating infrastructure.	The technology architecture layer is the person who hosts all the services that are delivered to the consumer or subscriber. The architectural layer of delivery and management is also responsible for providing the system.	The service delivery and management layer is responsible for managing the infrastructure service operation.	This is done using the Cisco Computing System Unit in the Technology Layer.	There are no cloud developer layers, cloud developer is considered as cloud consumer.

Table 1: Comparison of the main cloud computing reference architectures

Vendor Company	Architectural level	
	Layered based	Role based
NIST		✓
IBM	✓	
ORACLE		✓
HP	✓	
Cisco	✓	

Table 2: Comparison of the main cloud computing reference architectures based on their architectural level

3.3 IoT reference Model by Cisco:

The existing reference model of the Internet of Things is the Cisco model, which was designed in collaboration with companies such as Intel and IBM. In the following, this model is examined in detail.

3.3.1. Cisco reference model:

As it shows in figure 8 the proposed reference model of the Internet of Things has seven layers. Each level has terms that can be a world-class standard for defining a reference model. (Cisco, 2014)

At a conference of the World Association of the Internet of Things, Cisco, in collaboration with companies such as IBM and Intel, introduced the Internet of Things reference model, as shown in the figure below. In this model, the idea of data collection, management and analysis is divided into several smaller sections. In the reference model of different technologies, the relevant hardware and software components, how to communicate with each other, the scope of each layer along with the interfaces of different layers to identify the possibility of working with products of several manufacturers and the interaction between different layers are easily provided.

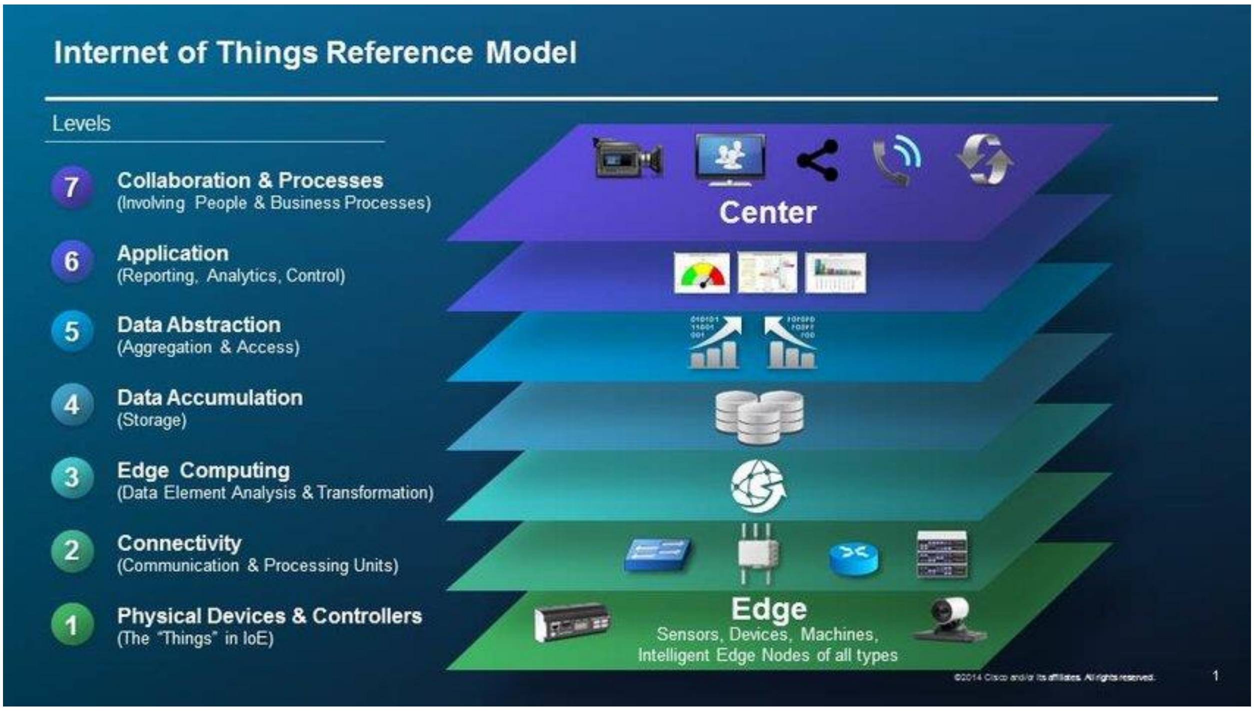


Figure 8: IoT reference model by Cisco (2014)

In the lowest layer (edge layer), the relationship between objects is described. Objects refer to any type of operating device or element. (Dos Santos et al, 2020)

The next layer allows you to connect all these sensors or edge devices using a gateway or a connection layer to connect local devices.

In the next layer, the concept of edge-computing is introduced. In this layer, users get special data from edge devices based on a set of rules. This layer has the ability to guide local analysis and produce results that can lead to local reactions without the need to send data to a higher layer for future analysis. This layer cannot be considered as an analysis layer. In fact, the above layer is a localized reaction layer that allows for fast and blurred reaction based on data in motion. If a process approaches a certain threshold for which it is defined, this layer provides an initial warning before the data is processed at a higher level (analytical layers). In the above time frame, this layer will send a suitable response to the lower layers in order to record additional data to improve the samples or detect trends with a high degree of accuracy and precision. (Dos Santos et al, 2020) (Cisco, 2014)

The figure 9 shows the reference Internet of Things model levels with the most important tasks.

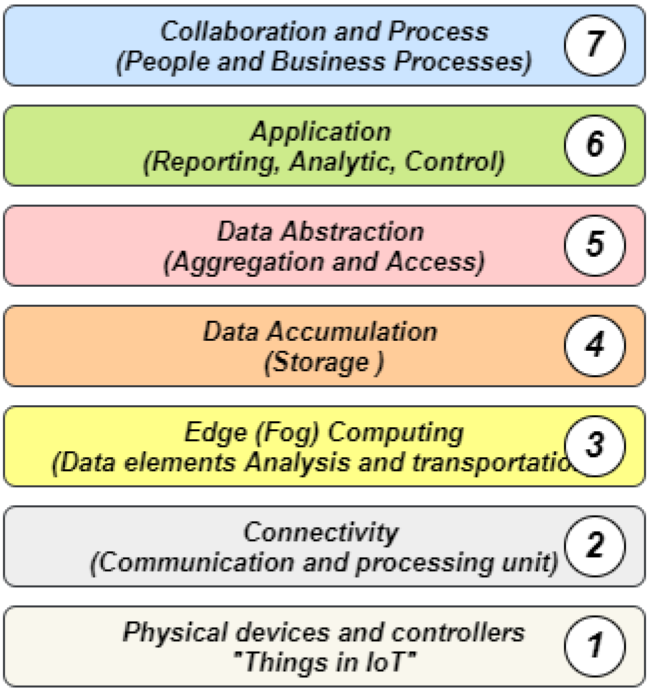


Figure 9:IoT reference model and the responsibilities (Cisco, 2014)

Level 1: Physical devices and controllers:

The Internet of Things reference model begins with level one, the level at which physical devices and controllers are placed, which may control several devices (figure 10). At the top level are Internet of Things objects, which include a very wide range of devices (Endpoint devices) that can send or receive information. (Cisco, 2014)

The number and variety of devices in this layer is very wide. Some devices are the size of a silicon chip and others are the size of a vehicle. The Internet of Things should support a wide variety of devices.

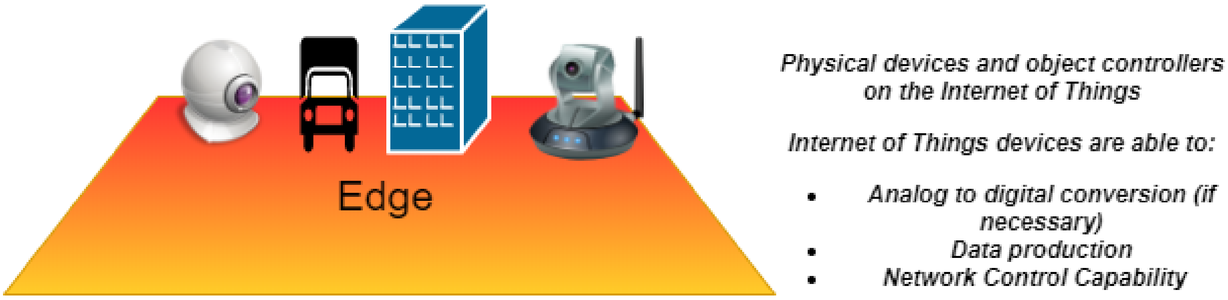


Figure 10: Physical devices and Controllers layer

Second level: connectivity

Communications and connections were focused on the second level (figure 11), the most important function of which is the timely and secure transfer of information between devices (level one), over networks and between networks (level two). Low-level information processing occurs at level three. Traditional data exchange networks have several functions. A complete IoT system includes multiple levels in addition to the communication network. One of the goals of the IoT reference model is to be able to communicate and perform the necessary processes alongside existing networks, and there is no need to introduce or create a different network. Some older devices are not IP-based and require a communication gateways to be introduced (Dos Santos et al, 2020),

In some devices, dedicated controllers are required to communicate in practice. In parallel with the diversity of devices at the level of a reference model, it is obvious that changing their interaction methods with the communication equipment available at the second level of the reference model. Regardless of the details of the work, devices at the level of a reference model communicate with an object Internet system through the communication equipment at the second level of the reference model. (Cisco, 2014)

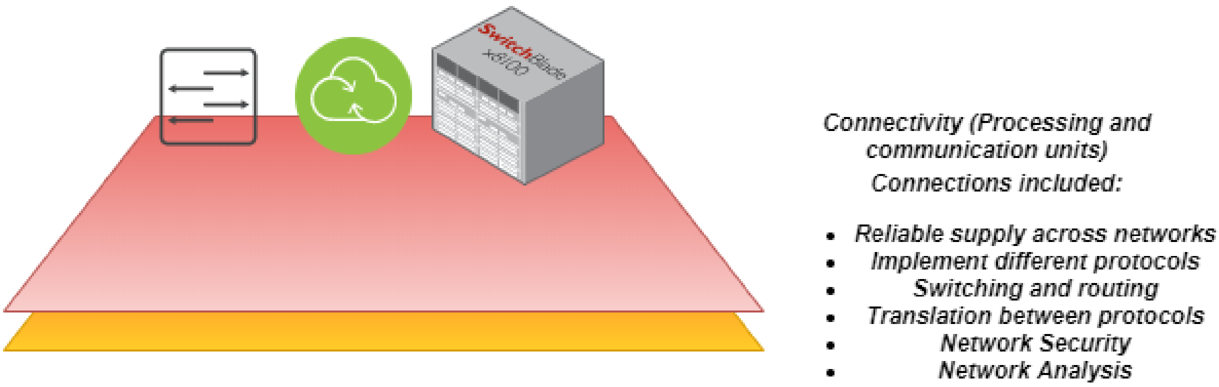


Figure 11:Connectivity layer

Third level: Edge Computing

The functions of the third level (figure 12), point to the important need that the data be converted into information so that it is suitable for storage and can also be used at a higher level like the fourth level. This means that third-level activities focus on analyzing large amounts of data and converting it into information (Cisco, 2014). One of the most important principles of the Internet of Things reference model is the ability to process in the first place and preferably in the edge network section by intelligent systems, the third level is where these actions are performed. Data is usually sent by network devices of the second level (connection level) in small units. At the third level, they are processed by packet-by-packet. The third level functionality of the IoT reference model is shown below (Dos Santos et al, 2020).

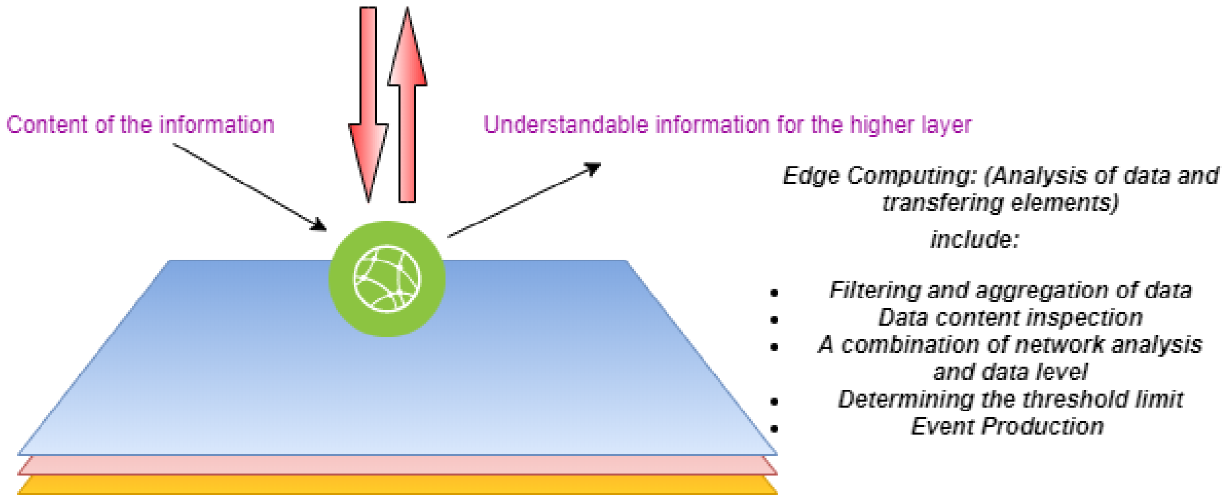


Figure 12: Edge Computing layer

Fourth level: data accumulation (storage)

Network systems are designed to securely transfer data. From this perspective, moving information can be considered, that it must be transferred from one point to another with a high degree of reliability, before the fourth level, data across the network is transmitted based on the size and structure determined by the production devices. The Internet of Things reference model is event-driven, meaning that data is transmitted simultaneously with data production. (Sethi, Sarangi 2017)

As mentioned earlier, devices on the first level do not have computational or processing capabilities.

This situation changes somewhat in the second level of the reference model, and it is possible to perform some computational activities such as compiling and setting network security rules in the form of some programs. Simultaneously with moving to higher levels, more processing is possible. (Dos Santos et al, 2020)

Most programs cannot or do not need to process data at cable network speeds. In the face of data, programs do not view them as moving data, but as data that are resting or immutable in memory or on disk. Unchangeability means that it is not possible to change them by the data source. With this approach, we can point to the general definition of the fourth level of the Internet of Things reference model, in which the moving data is converted into rest data (Dos Santos et al, 2020).

After the data is recorded and placed at rest by the fourth level, it is possible for the data to be accessed by the programs in a non-timed manner, and the programs can access the data when needed. The following figure shows the most important executive activities at level 4. (Cisco, 2014)

The data storage layer can be seen in figure 13.

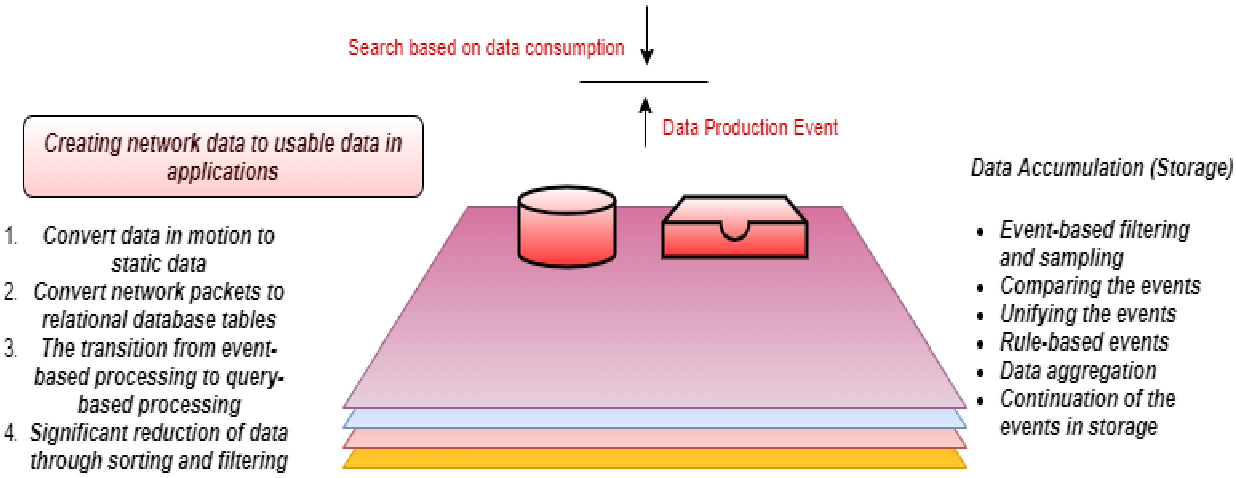


Figure 13: Data Storage layer

Fifth level: Data abstraction (aggregation and access)

Internet of Things systems must be able to be quantifiable in different dimensions. It is also necessary for such systems to support various storage systems so that data from Internet of Things devices and data from older systems can be stored. The tasks of the fifth level of the Internet of Things reference model are to focus on data interpretation and its storage space in order to facilitate the implementation and improvement of system performance (Cisco, 2014). Although several devices are involved in data production, for various reasons, the following data cannot be stored in the same storage space: (Sethi, Sarangi, 2017)

- The volume of data may be big enough that it cannot be stored in one place.
- Transferring data within a database may require a lot of processing power. Therefore, the data recovery process must be separated from the data generation process. This can be done today by using databases OLTP (Online Transaction Processing) and data warehousing.
- Devices may be geographically separate and processing may be optimized locally.
- Possibility of needing different types of data processing methods.

For the above reasons, the data drip level should be able to process different items:

- Combining multiple data formats from multiple sources
- Adjust the coherence of data meanings among all sources
- Verification of completeness of data for use by higher level applications
- Data protection with proper authentication and licenses
- Normalizing or denormalizing data indexing for fast data access

Figure 14 shows the functions of this level:

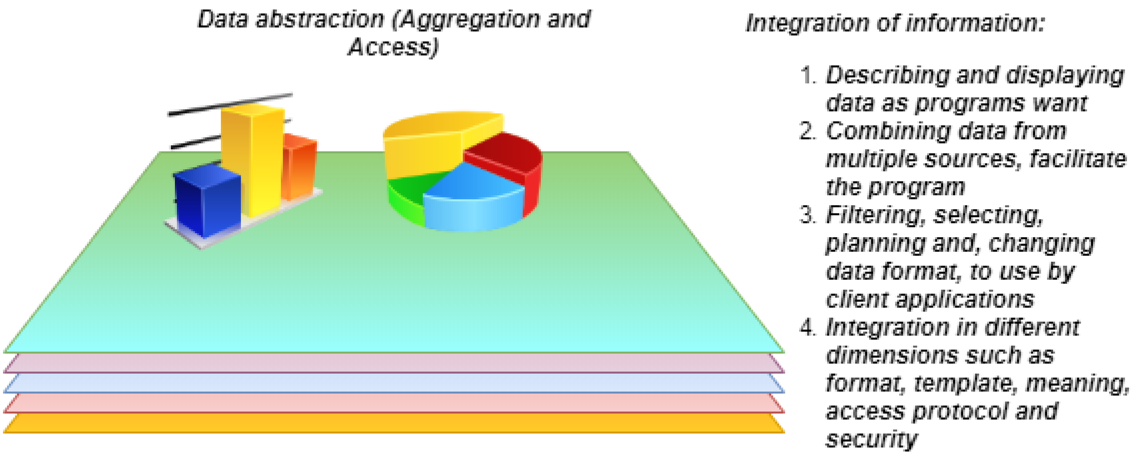


Figure 14:Data Abstraction

Level sixth: Programs and applications (Reporting, Analysis, Control)

The sixth level is the program level. In fact, it is a place where information is interpreted (figure 15). The software interacts at this level with the previous level and data at rest, so there will be no need for network speed. The Internet of Things reference model is silent on the nature of a program and does not involve itself, as programs can cover a wide range of factors, including market conditions, data nature, devices, and business needs (Jayavardhana et al, 2013). The work depends. For example, some programs will focus on device data monitoring, others will focus on device control, and others will combine device data and non-device data. Implementing control and monitoring programs requires the use of architecture and various programming patterns, which are beyond the scope of the Internet of Things reference model. The figure below shows the sixth level of the Internet of Things reference model. (Cisco, 2014)

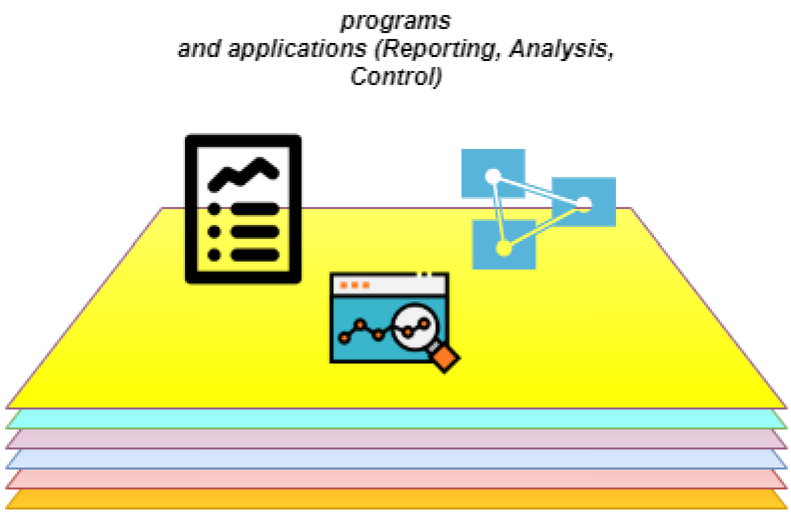


Figure 15: applications

Level seventh: Processes and Collaboration (including Individuals and Business Processes)

On the Internet of Things, people and processes are also involved. At level seven (figure 16), the manifestation of this conflict and interaction can be seen (Sethi et al, 2017). The information produced by the systems should lead to an appropriate action or response, otherwise they will have a little value. We need people and processes to fit and react appropriately. Individuals use related programs and data according to their own needs. Often, several people use the same program for a range of different purposes. Therefore, the goal of the program is not to strengthen and empower people to do their jobs. Sixth-level applications provide users with the right business data at the right time so they can take the right steps (Cisco, 2014). Most actions in a work area require the use of multiple people. Therefore, people should be able to communicate and interact with each other. Interaction and collaboration require different steps and usually goes beyond several programs. That's why the seventh level is shown at a higher level than the program (Sethi et al, 2017). The following figure shows the function of the seventh level of the object reference model. (Cisco, 2014)

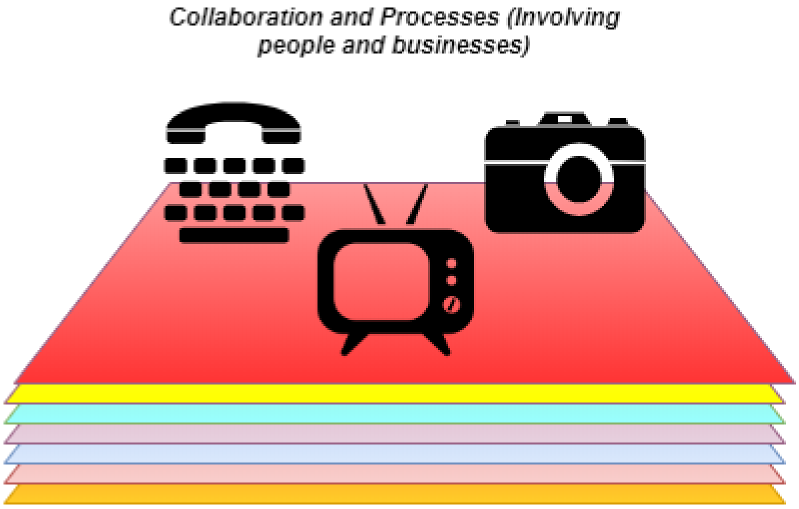


Figure 16: Application layer

Challenges and crisis of IoT reference model: (Mahmoud et al, 2015)

- Low arrangements of processing metadata
- Low arrangements of storing metadata
- Lack of process transparency and processing mechanisms
- Impossibility to control the sent information
- Lack of regular data transmission process

3.4. The conceptual model of the Internet of Things and cloud computing:

According to the study of processing components and reference models, the conceptual design of the combination of cloud computing and the Internet of Things has been presented in figure 17.

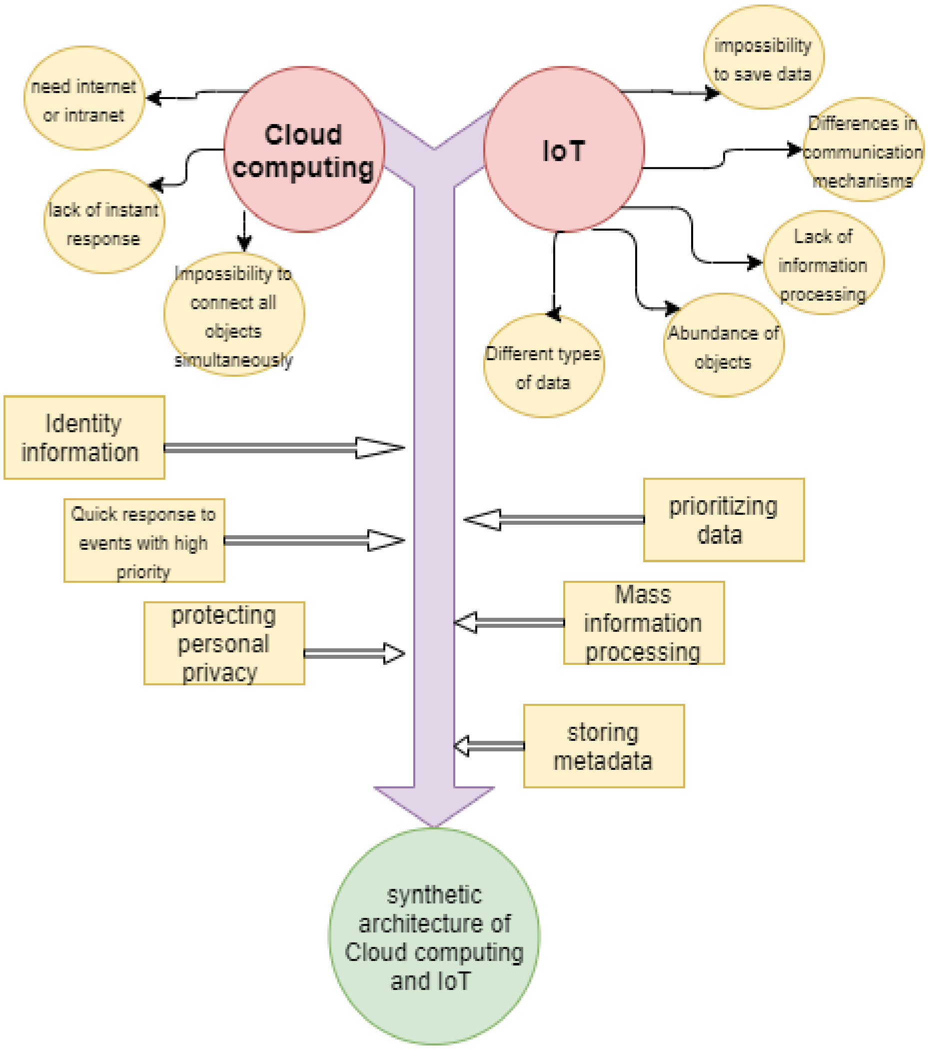


Figure 17: The conceptual model of the Internet of Things and cloud computing

4 Research methods and procedures:

4.1 Type of research

This research is an applied-developmental research. Applied research seeks to achieve a practical goal and emphasizes the provision of happiness and well-being of the masses and the desirability of activities. Information on this type of research will be useful in the planning, design, and practical practices of executive activities.

Why this research is useful?

- This research deals with the issue and has been presented in a systematic, accurate and logical manner based on the existing standards and models for solving and determining the research issue, which is in line with providing an optimal model for combining cloud computing and the Internet of Things.
- This research has provided appropriate processing strategies for IoT technology service providers and service providers, and strategy development is a feature of applied research.

Reasons for research development

Internet of Things technology has been introduced in various societies over the past few years. The developmental aspects of this research are:

- In this research, the researcher emphasizes the processing of information in Internet of Things technology and solutions in this regard.
- The combination of IoT technology and cloud computing to store and process cloud data will always further develop the use of IoT technology.

4.2 Research methodology

In this paper, since the nature of the questions is such that the research-analytical method is not suitable for answering each question, accordingly, the research method in answering these questions is descriptive because the researcher seeks to identify and determine the concept. And the objectives of Internet of Things technology and the purpose of expressing the concept of the Internet of Things is to determine the expected results of this model that will be done using research and development methods.

4.3 Research Questions

- What is the optimal model for combining cloud computing and the Internet of Things?
- What is the concept and structure of the combination of the Internet of Things and cloud computing?
- What are the Internet of Things processing Challenges?
- How the integration of cloud computing and the Internet of Things capabilities are emerging?

- What are the weaknesses and strengths of the existing models in the field of cloud computing technologies and the Internet of Things?

4.4 Data collection method

Documents and records:

In this method, the required information has been collected using the tools of filing documents of specialized and scientific books, archives of official organizations, online sites of university centers, scientific and research centers of strategic and specialized study and etc.

This research uses qualitative content analysis method to analyze the collected information.

What do we expect form this paper

The study seeks to describe Internet of Things and cloud computing technologies based on the optimal model for combining cloud computing and the Internet of Things so that policymakers and top executives can develop and implement the necessary policies and strategies for using IoT technology. Therefore, it is necessary to take the following measures:

- Understanding the nature and dimensions of IoT technology
- Explain the necessities of using the Internet of Things
- Understand the nature and dimensions of cloud computing technology
- Presenting the concept and structure of the Internet of Things and cloud computing
- Providing capabilities due to the integration of cloud computing and the Internet of Things
- Provide an optimal model for combining cloud computing and the Internet of Things

4.5 The research process

The process of executing the research has been shown in the presented diagram (figure 18).

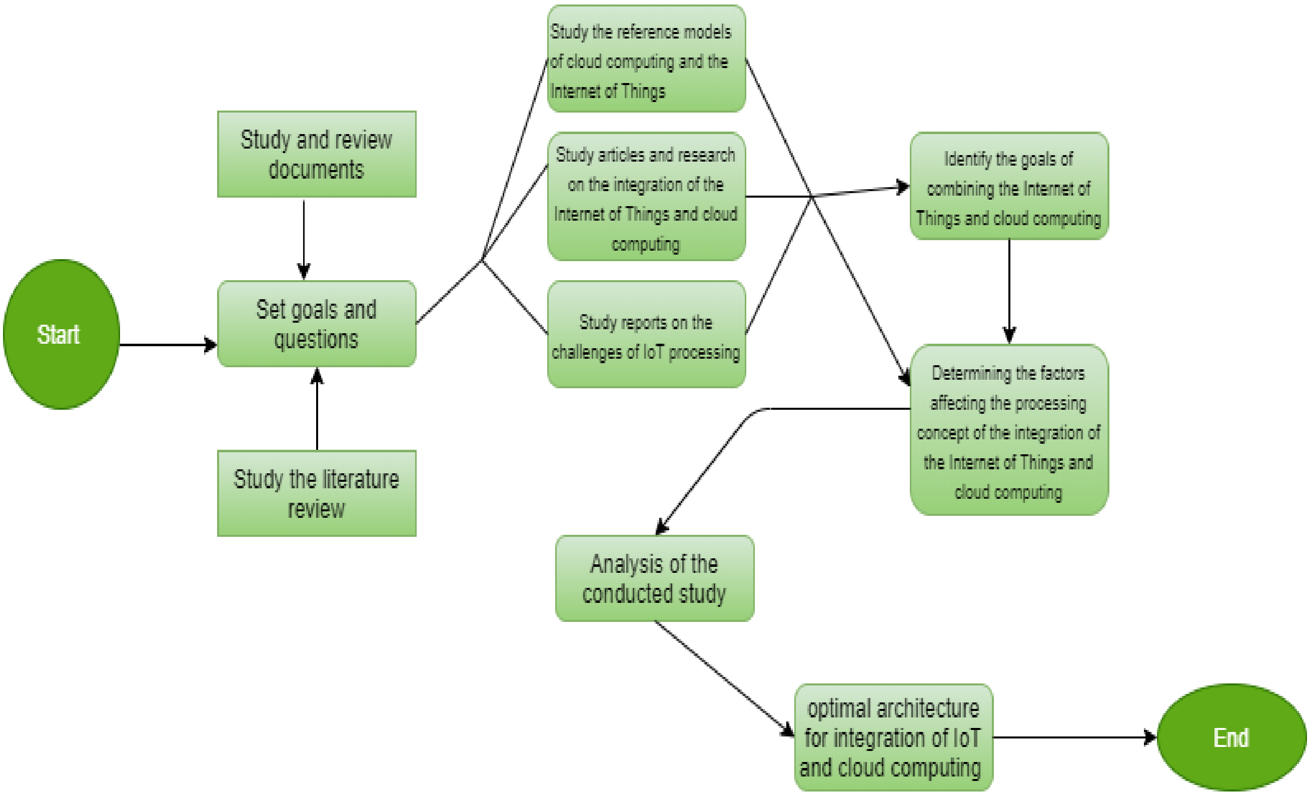


Figure 18:The research of process

5 Findings:

5.1 Main Findings

According to the mentioned components, the combined conceptual model of Internet of Things and cloud computing was designed and proposed with the aim of reducing processing challenges. The model described in the description section is fully described.

In the Internet of Things and Cloud Computing conceptual modeling, the architectural processing challenges of existing models have been eliminated and the processing layer in this model has been improved compared to other models.

Figure 19 shows a combined model of IoT technology and cloud computing.

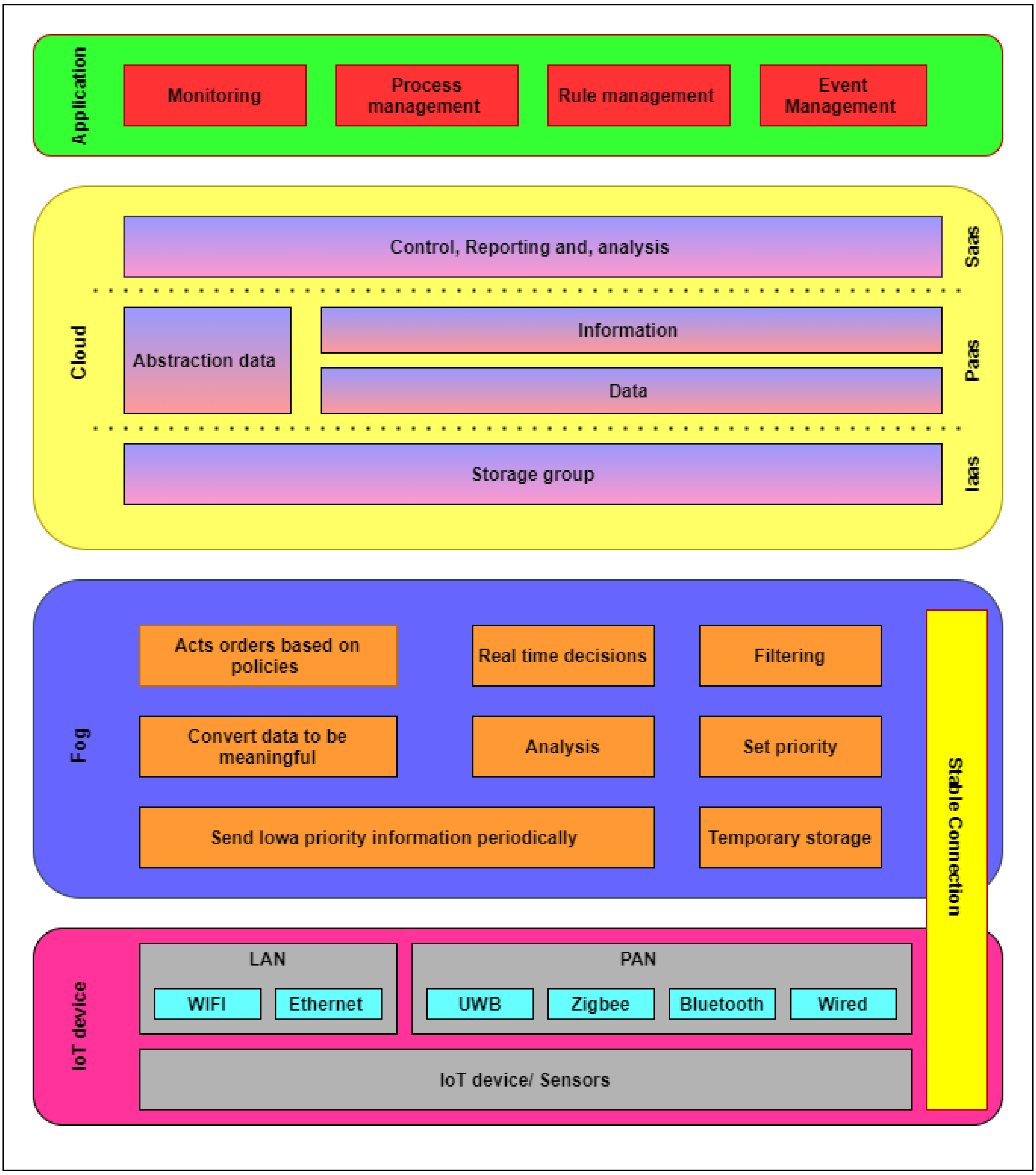


Figure 19:Suggested Architecture for integration of Cloud Computing and IoT

As shown above, the proposed architecture has four main layers, which each of them will be described as follows:

- IoT device
- Fog
- Cloud
- Application

IoT device layer

At the lowest level of the proposed model, equipment or sensors in various fields such as health, urban, industrial, military, etc. were placed with the ability to support IoT technology. For example, in the field of health, equipment information such as sphygmomanometer, thermometer, blood sugar, sports equipment reports such as treadmills, bicycles, etc. on a regular basis or based on approved policies and LAN communication methods including wireless or Ethernet or PAN communication methods such as Bluetooth, Zigbee, UWB are sent to the upper layers.

Fog layer

The use of fog computing technology as the intermediate layer between the Internet of Things and cloud computing based on the structure, and the tasks and policies specified in the proposed model has been able to play an important and key role.

This layer, like a cloud or fog, is closest to Internet of Things equipment and provides users with features such as controlling the information sent, sending time, defining policies, and controlling Internet of Things equipment.

The most important parts of this layer are the following:

Act order based on policies

Due to the necessity and timely response and the need to implement the necessary measures by the Internet of Things equipment in the defined events, this section will quickly make the necessary decisions based on defined policies or sends the necessary instructions if it needs Internet of Things equipment. For example, a fire alarm that is aware of the fire based on the urgent message that has been sent by smoke sensor to fog computing layer, will quickly sends a message to cut off power, gas, and water of the house, and dispatching a message to the user.

Convert data to be meaningful

Due to the high diversity of Internet of Things equipment in each location and the variety of types of data generated and the meanings of those data, this section is responsible for converting the generated data into meaningful data.

Real-time decisions

Quick decision making is one of the most important pillars of the proposed model. This section takes the necessary steps to respond and make timely decisions to high priority messages based on the pre-defined policies in the Act order based on policies section.

Analysis

Analysis of data produced from different Internet of Things equipment in this layer can play a significant role in other areas such as Real-time decisions, set priority, and etc.

Filtering

In this section, users are given the opportunity to define policies to control the submitted data to the upper layers and schedule the sending of low-priority data on a one-time basis.

This section, in addition to increasing the security of production data, reduces the use of bandwidth on a regular basis.

Set Priority

In this production data, objects are prioritized by the Internet of Things devices and sensors based on the importance and intervals defined for the data of each device. In general, in the presented model, the data are divided into two categories with low priority (low importance data) and high priority (high importance data).

Temporary Storage

The temporary storage source provided in this section allows you to store low-priority data for a short period of time (several days). The stored data is sent to the upper layers based on the policies defined in the periodic intervals (daily, hourly).

Send low priority information periodically

Due to network constraints in communicating and sending information to all high-end devices and sensors simultaneously to the upper layers, this section is responsible for sending low-priority information at predefined intervals on a one-time basis.

Cloud layer (Cloud Computing)

The high number of devices, the variety of data and the huge amount of information (super data) produced and Internet of Things technology have led to the use of cloud computing technology in the proposed model. Cloud computing technology can meet the challenges mentioned above, and combining this technology with IoT technology will increase the use and expansion of IoT technology.

Cloud computing technology at the three levels of Saas, Paas and Iaas can provide services to end users, and users can benefit from the features of these services based on the type of service requested. It should be noted that as we move from Saas services to Paas and Iaas, the amount of management and control on the client side increases. The proposed model also includes the type of cloud computing services. The following are some of the most important parts of a cloud computing layer.

- Storage group
- Abstraction data
- Application layer (Monitoring, Process management, Role management, Event management)

Let us thoroughly explain each one:

Storage group

Due to its nature, cloud computing technology has many storage resources for large data storage and management, on the other hand, IoT technology due to the variety of data and high number of equipment and sensors as a macro manufacturer. Data are considered.

In the proposed model, this section is responsible for storing and managing data received from the fog computing layer.

Abstraction data

Converting the received data to information is one of the most important features of the cloud computing layer. Cloud computing technology can do this with the ability to process big data.

The analysis of data and the conversion of raw data into information in the proposed model are as follows.

- Data: At this stage, the generated data or raw data from the Internet of Things equipment is specified in the required time and is transferred to high-speed memories for further processing in the upper layers of storage resources.

- Information: Data stored in high-speed memory is analyzed and the results are presented to the upper echelons as meaningful information.

Control, reporting and analytics

In this section, meaningful information is received from the lower layers and based on the needs of the end users, appropriate reports are generated in the form of chart, tables and etc.

Application layer

In this layer of applications, the following features will be provided to end users.

Monitoring

Monitoring and review of final outputs can be seen and used in the monitoring panel after analyzing the analyzes performed in the lower layers of all reports submitted by IoT equipment in the form of charts, tables, etc. For example, a patient's doctor can easily monitor the patient's symptoms in the past few months or during treatment and prescribe the required medication with more knowledge.

Process management

Process management is one of the features provided to end users in this area, and users can easily create new processes or modify or delete old ones.

Role management

In this section, users can create new policies, delete or edit old ones. For example, a patient's physician may need to report a patient's blood pressure every one hour, depending on the patient's condition.

Event management

One of the most important benefits of the Internet of Things is event management, which allows you to make the right decisions and implement them when a system event occurs correctly. Users in this section can specify if something happens in which layer what action should be taken. For example, if a smoke sensor in the Fog Computing layer is alerted, power, water, and gas equipment will be disconnected, and a high-priority message will be sent to the upper echelons and an alert text message will be sent to the building owner.

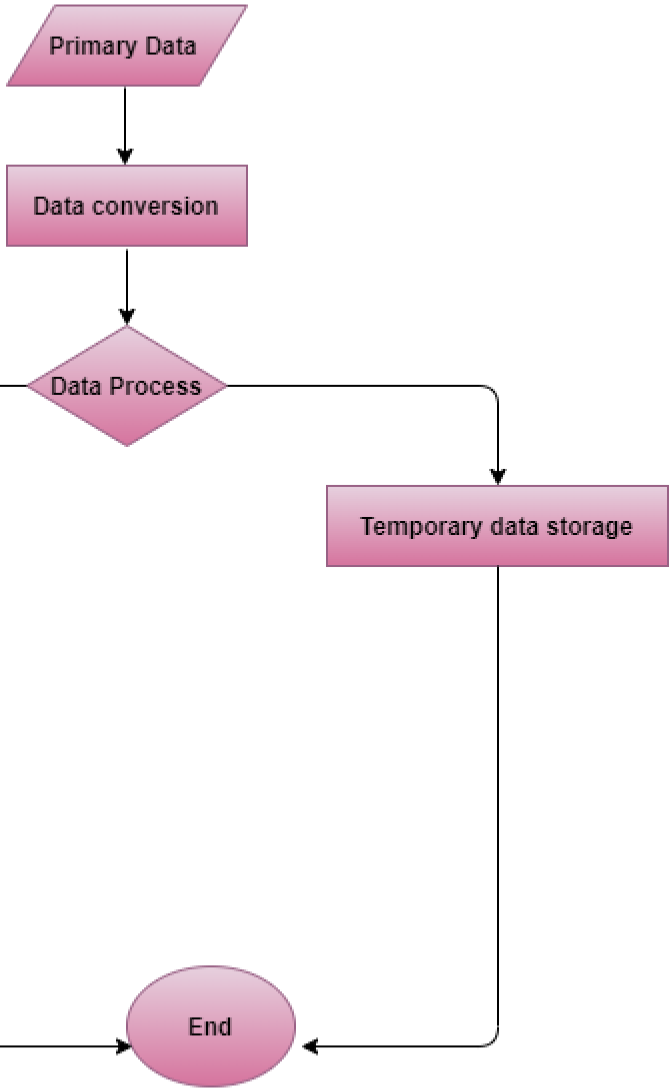
Scenario and event management process in the proposed model

According to the flowchart below, the initial data is generated in the lowest layer of the proposed model of Internet of Things equipment and sent to the Fog layer as input. With initial processing, the data are divided into the following two groups based on the degree of importance:

- Low priority data: This data is temporarily stored in the Fog area and sent to the Cloud layer based on the policies intended for storage and processing. It should be noted that the possibility of filtering data is also considered in this area.

- High priority data: Based on defined policies this data is sent to the Cloud layer as data with high priority. It should be noted that due to the high importance of this data, in addition to sending data to the Cloud layer, defined policies are implemented in the face of this event.

In the last step, the necessary information is provided based on the defined policies.



5.2. WSMT software

One of the common software for modeling architectures is Web Service Modeling Tools. In this paper, WSMT software has been used to display and simulate the proposed model, or in other words, for modeling of Internet of Things and cloud computing technologies, the relationships between them, defining examples of the main objectives, services and … we will use WSMT software.

The projects defined in WSMT software include the following three main sections:

- Goals
- Ontologies
- Services

Goals

In this section, the final goals of the service are specified, the specified goal includes one or more prerequisites, and if the prerequisites are observed or implemented, the post-conditional items will be performed.

Ontologies

The general outline of the model, including Ontology, the main components or concepts, the relationships between the different concepts, the type of data, and the acceptable range for each attribute are identified in this section. By viewing this section, users can easily view and understand the concepts and relationships between the various components of the model.

Services

In this section, the services are defined according to the need, each specified service includes one or more prerequisites, and if the prerequisites are observed or implemented, the post-conditional items will be performed. It should be noted that each final goal can include one or more services, and after the implementation of the goals, the services defined for that goal will be fully implemented. Figure 20 shows the general view of the software.

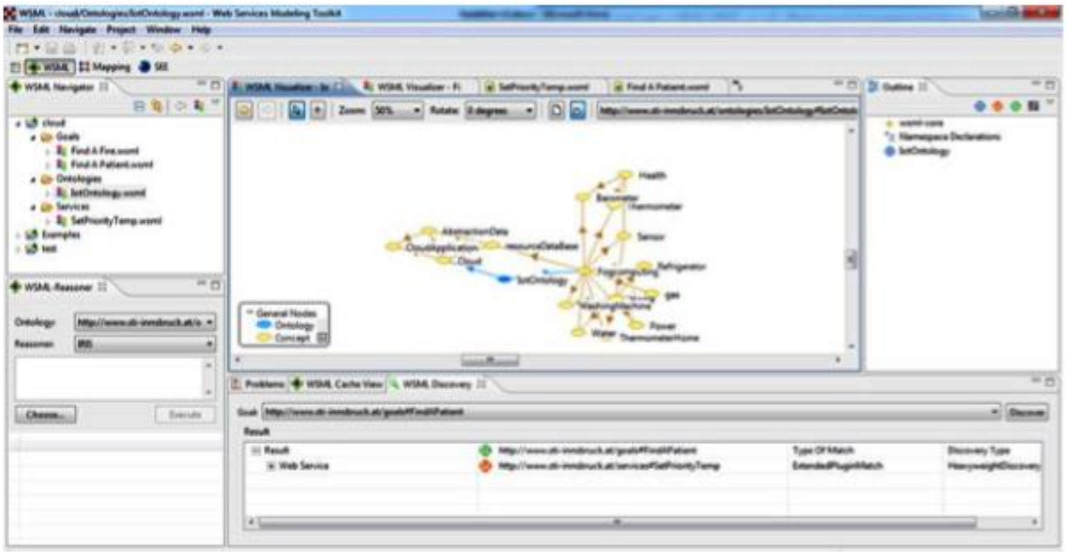


Figure 20: General view of the software

The software also includes different parts such as WSML Discovery, WSML Reasoner.

Each of the sections has been discussed:

WSML Discovery

This section is designed to check the correct connection between the service and the final goal. In fact, by selecting the relevant goals and Discover option, figure 21 is displayed, which shows the correct connection between the service and the relevant Goal. It should be noted that if the codes written in all three sections of Goals, Ontology and Services are correct, this section will be executed correctly.

Figure 21:WSML Discovery

WSML-Reasoner:

In this section, the possibility of query based on Ontology is provided. The following are examples of this section related to the proposed model.

The proposed architecture with WSML software

Using the Web Service Modeling Tools software, the various parts of the software, including Goals, Ontologies and Services, are designed based on the proposed architecture and are as follows.

It should be noted that in the presented example, two scenarios of fire detection and diagnosis of patient maladaptation are given.

5.3. Ontologies

As shown in the figure below, the main anthology is defined as IotOntology, which includes the two concepts of Cloud and Fogcomputing.

The following two concepts are comprehensively describes as Figure 22:

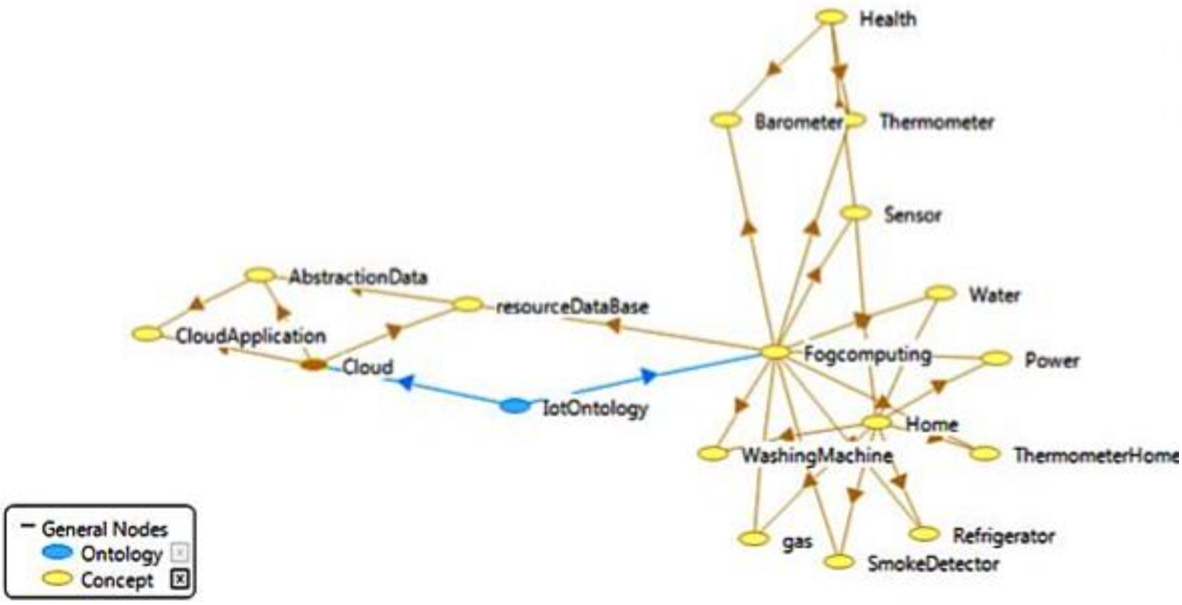


Figure 22: Ontology

Figure 23 shows the code for the Ontology, which identifies the main anthology, IoTOntology, and the two main concepts, Fogcomputing and Cloud, as well as the sub-concepts associated with each and the data type of each parameter.

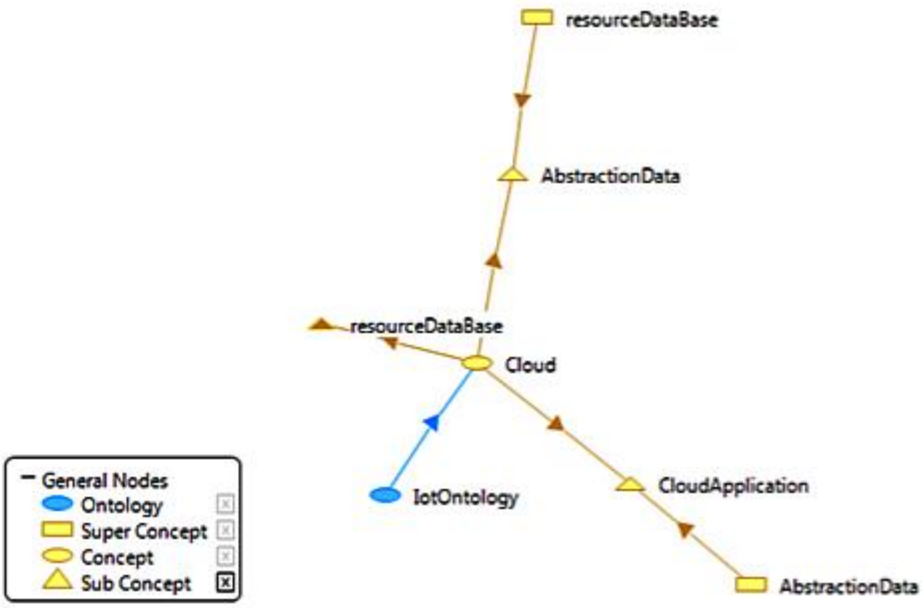
```
wsmlVariant _"http://www.wsmo.org/wsml/wsml-syntax/wsml-core"
namespace { _"http://www.sti-innsbruck.at/ontologies/IotOntology#"
 }
```

```
ontology IotOntology

concept Sensor subConceptOf { Fogcomputing, Fogcomputing}

concept Home subConceptOf Sensor
            StatusHome ofType _boolean
            PriorityHome ofType _boolean

concept Health subConceptOf Sensor
     Status ofType _boolean
       PriorityHealth ofType _boolean
concept Cloud

concept Fogcomputing

concept resourceDataBase subConceptOf { Cloud, Fogcomputing}

concept AbstractionData subConceptOf { Cloud, resourceDataBase}

concept CloudApplication subConceptOf { Cloud, AbstractionData}

concept Thermometer subConceptOf { Health, Fogcomputing}
     Temp ofType _integer

concept Barometer subConceptOf { Health, Fogcomputing}
     Pressure ofType _integer

concept ThermometerHome subConceptOf { Home, Fogcomputing}
            TempHome ofType _integer

concept SmokeDetector subConceptOf { Home, Fogcomputing}
     Smoke ofType _boolean

concept WashingMachine subConceptOf { Home, Fogcomputing}

concept Refrigerator subConceptOf { Home, Fogcomputing}

concept gas subConceptOf { Home, Fogcomputing}
      statusgas ofType _boolean
concept Power subConceptOf { Home, Fogcomputing}
      statusPower ofType _boolean
concept Water subConceptOf { Home, Fogcomputing}
      statusWater ofType _boolean
```

Figure 23: Ontology Code

Cloud

This concept is on the side of the Internet of Things service provider and finally the information required for storing, processing and submitting the report is sent to this section, for this purpose, cloud computing also includes the following three concepts:



Ontology 1:Cloud Structure

- ResourceDataBase
- AbstractionData
- CloudApplication

ResourceDataBase:

Due to the nature of cloud computing technology, there are many storage resources for storing and managing large data objects of Internet of Things technology, this section in the proposed model is responsible for storing and managing the received data.

AbstractionDataBase:

Converting the received data into information is one of the most important features of this model. Cloud computing technology can do this with the ability to process big data.

CloudApplication:

In this section, meaningful information is received from AbstractionData and based on the needs of end users, appropriate reports are produced in the form of tables, charts, etc. and provided to users.

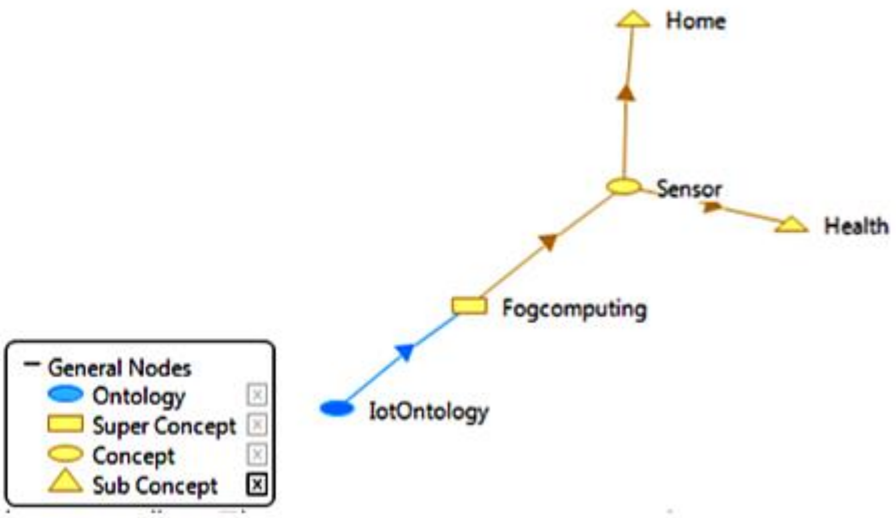
Fog computing:

This concept is on the side of the end user, or in other words, the closest place to Internet of Things equipment and sensors.

The important tasks of this pars are as follows:

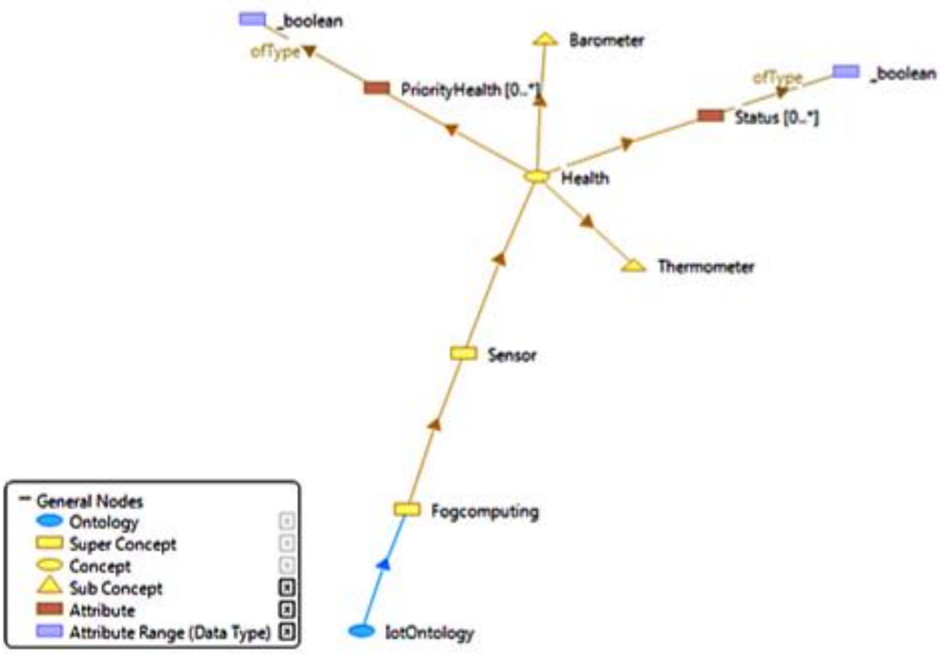
- Monitor the information generated or, in other words, identify the information sent to the cloud for storage and processing, which increases security and reduces the information sent to the cloud server.
- Categorize information and send it together according to defined schedules
- Implement orders based on defined policies

As shown in the figure below, the equipment connected to Fogcomputing includes two groups of sensors with health and home names. Each sensor collects and sends information to this section based on its application. In the following, each of the mentioned groups will be thoroughly described.



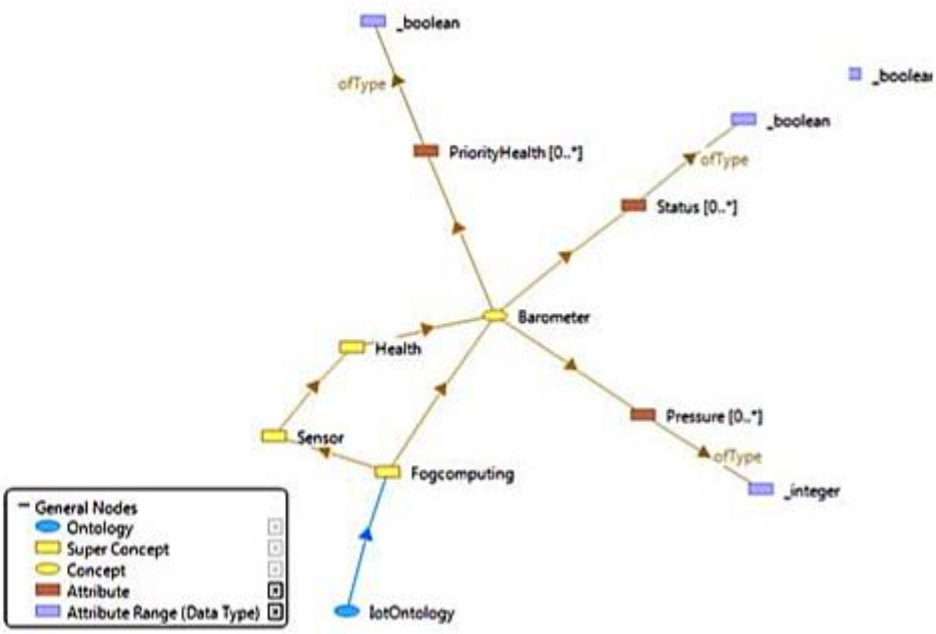
Ontology 2: Fog Computing infrastructure

In this figure, two concepts of blood pressure and temperature are specified and shown as an example to examine the patient's condition in the field of health.

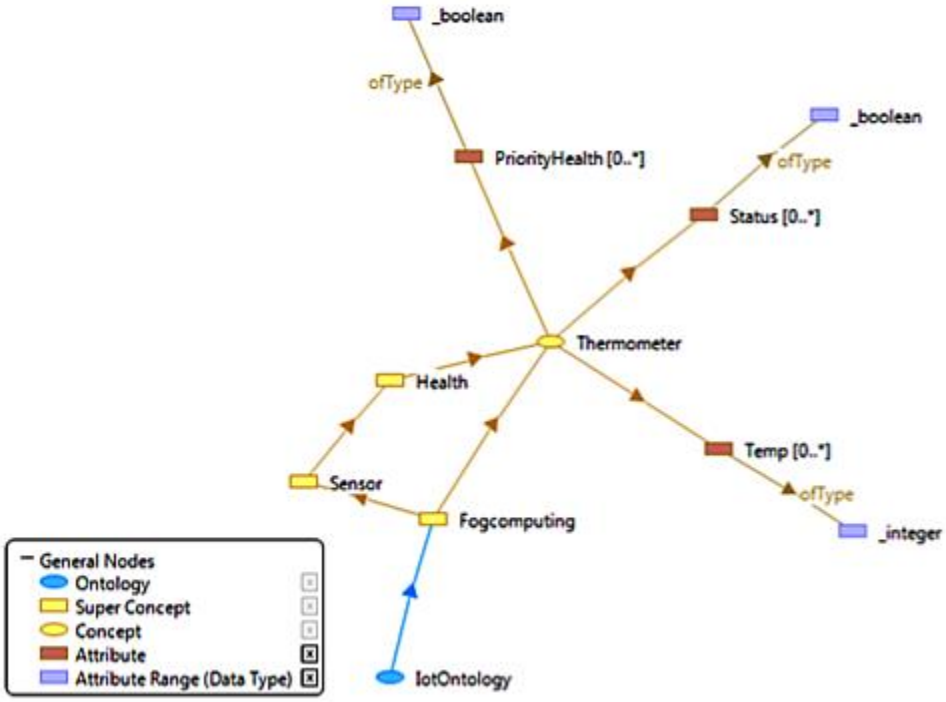


Ontology 3:Health Concepts

The following two figures show the data types and defined ranges for blood pressure, temperature, and common health parameters.

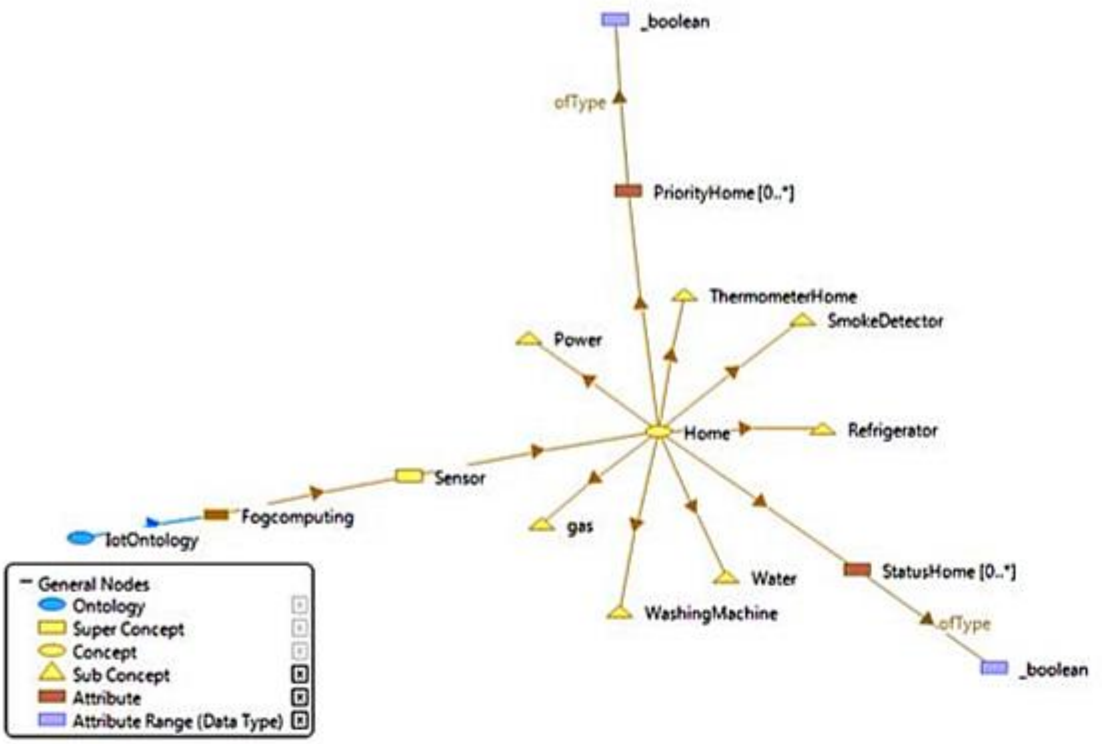


Ontology 4: Health and blood pressure parameters



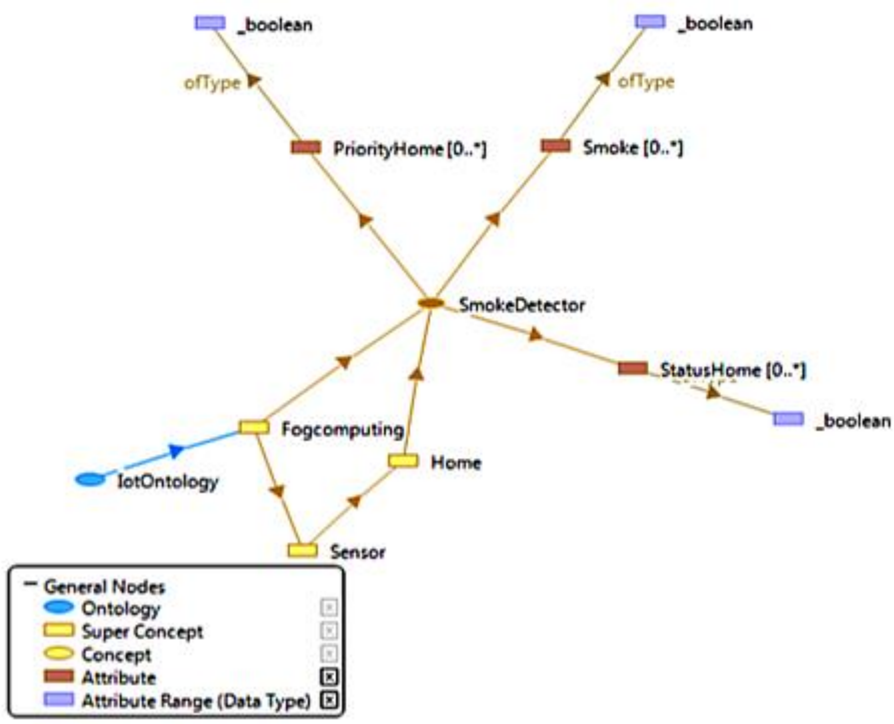
Ontology 5: Health and temperature parameters

In the following figure, the concepts related to the home domain, including temperature sensors and smoke detection sensors for fire alarms and equipment for controlling electricity, gas and water to send commands to deactivate the flow of these devices in case of fire, are specified and displayed.

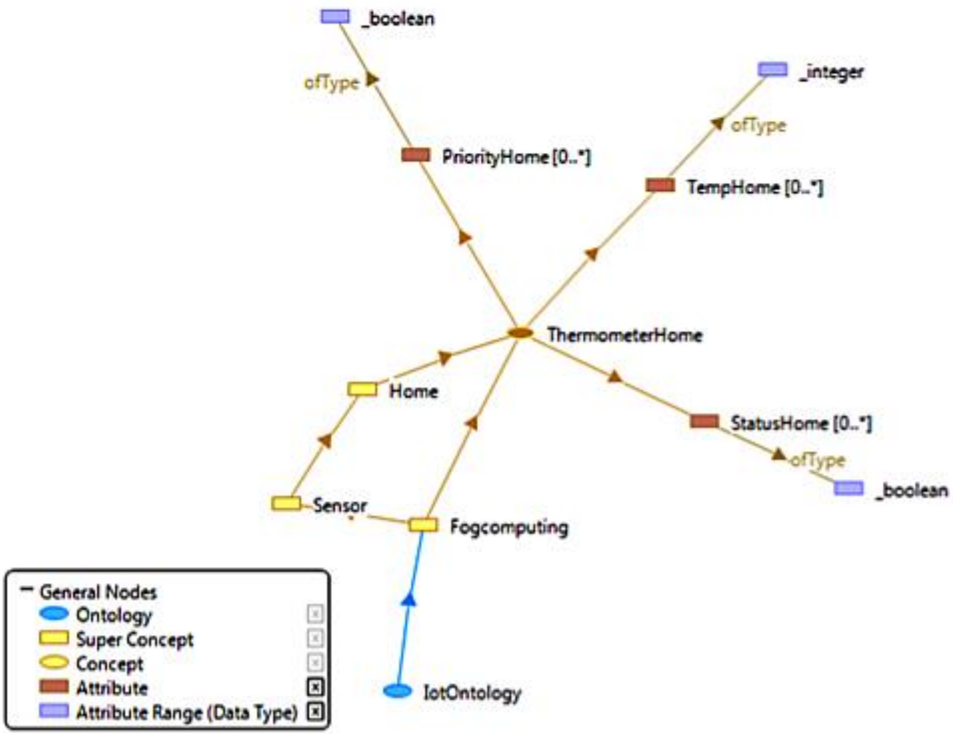


Ontology 6: Home Concepts

The following two figures show the data types and defined ranges related to the parameters of thermometer sensors and smoke detection and common parameters of the home domain.

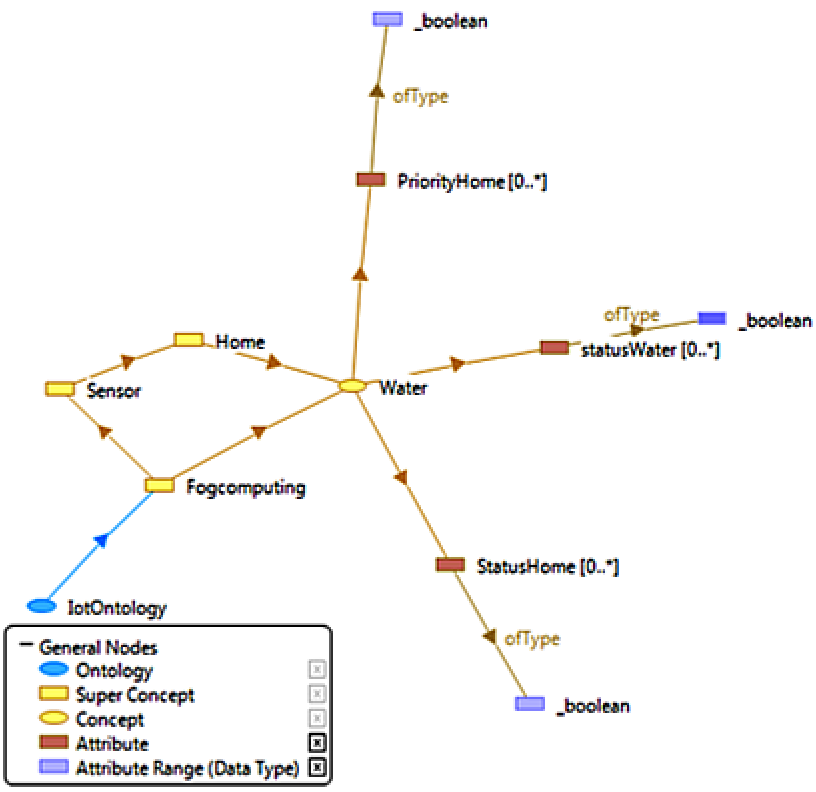


Ontology 7: Smoke detection sensor

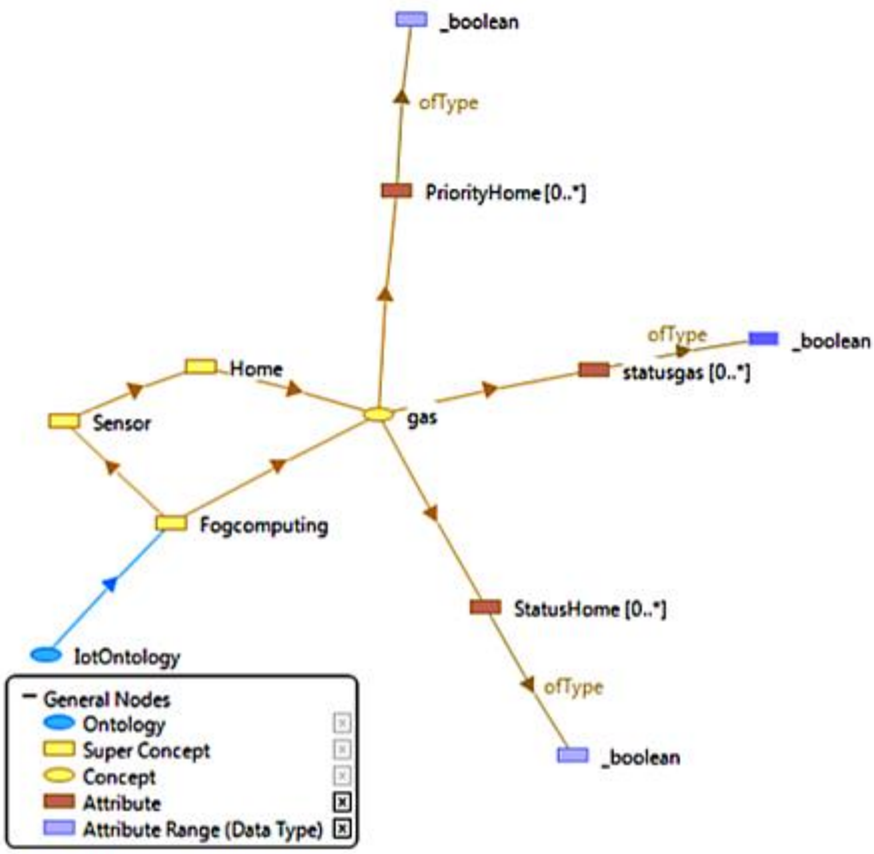


Ontology 8:Thermometer Sensor

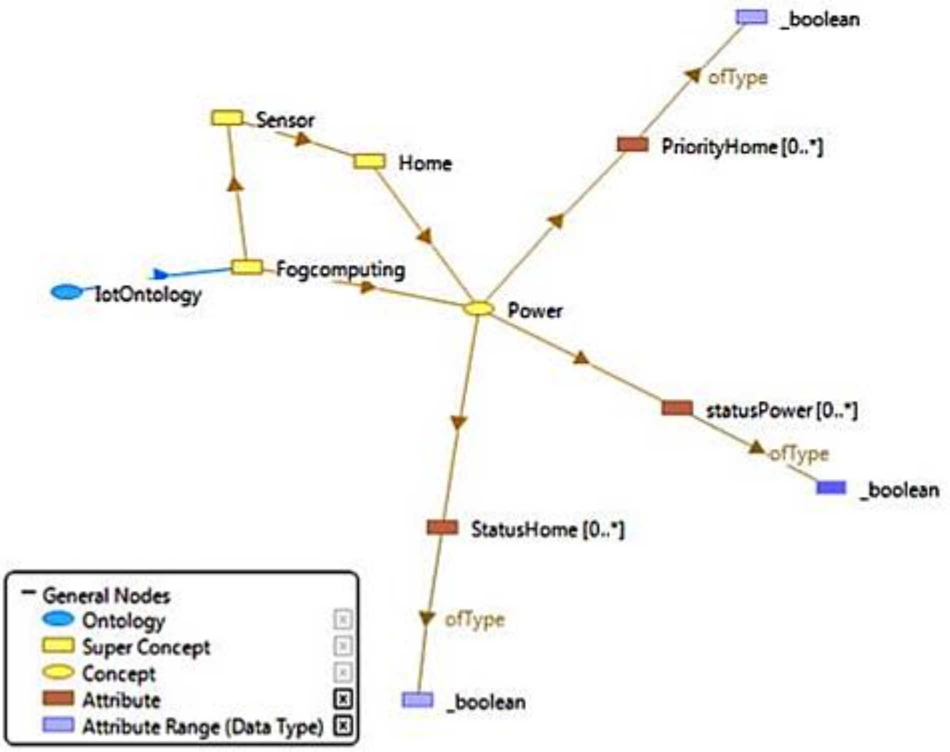
The following three figures show the types of data and defined ranges related to water, gas and electricity control equipment and common parameters of the home domain.



Ontology 9:Water control



Ontology 10: Gas Control

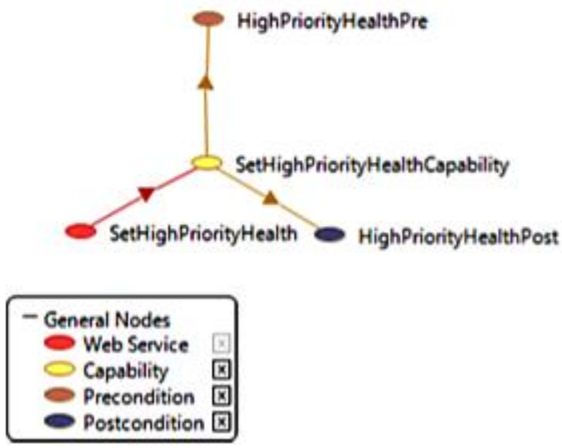


Ontology 11:Power Control

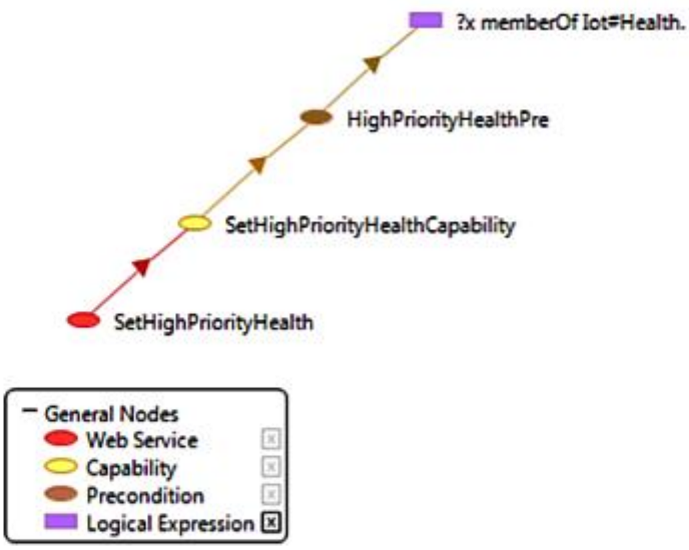
Services

According to the given explanations, each service includes one or more preconditions, and in case of observing or implementing the preconditions, the post-conditional cases will be performed. Examples of defined services are as follows.

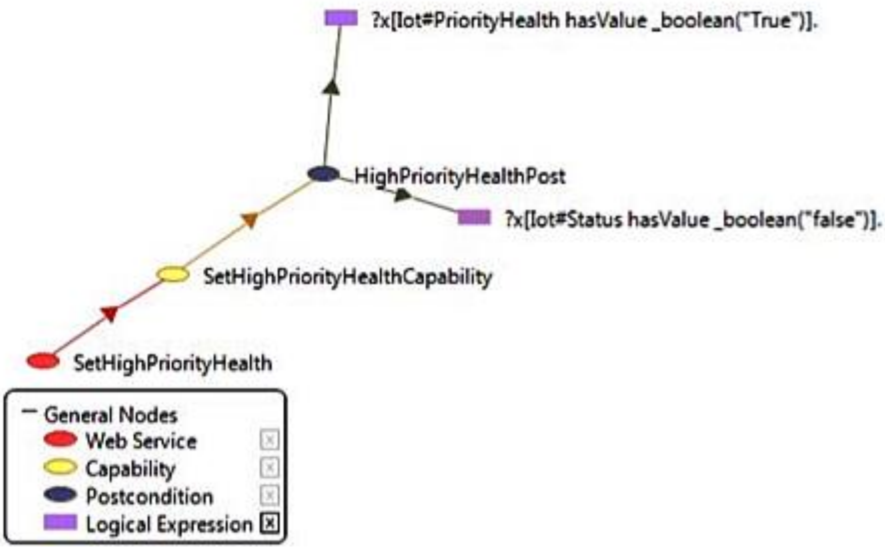
The SetHighPriorityHealth service shown in the figure, if the person's improper condition is detected by the target, is executed as FindAPatient, and specifies the patient's status data with high priority. The following is a prerequisite and a post condition for the desired service.



Ontology 12: SetPriorityHealth Service



Ontology 13: Pre condition of SetPriorit Health Service



Ontology 14:Post Condition SetPriorityHealth Service

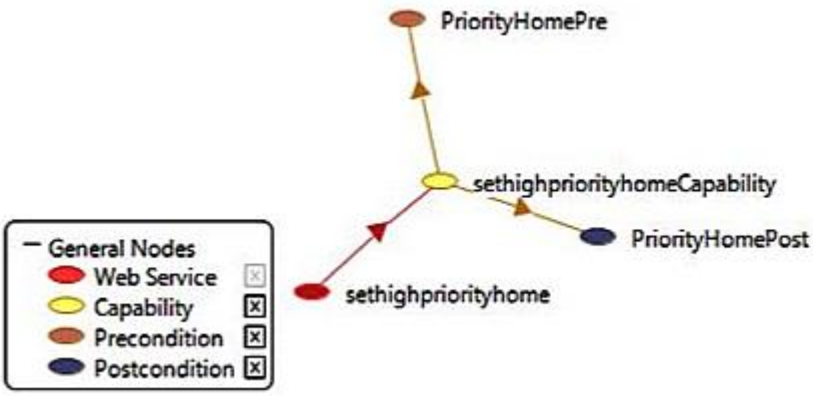
Figure 24 shows the service code SetHighPriorityHealth, which specifies the prerequisites and post conditions shown above.

```
wsmlVariant _"http://www.wsmo.org/wsml/wsml-syntax/wsml-rule"
namespace { _"http://www.sti-innsbruck.at/services#"
,
```

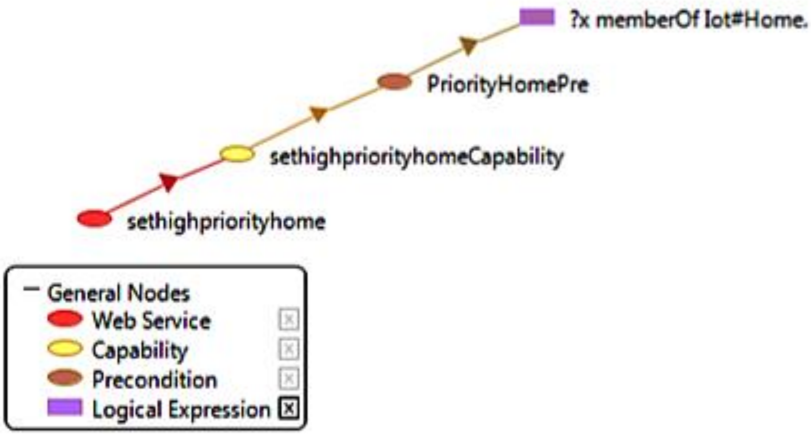
```
    Iot _"http://www.sti-innsbruck.at/ontologies/IotOntology#",
    discovery _"http://wiki.wsmx.org/index.php?title=DiscoveryOntology#" }


webService SetHighPriorityHealth
    nonFunctionalProperties
        discovery#preConditionMapping hasValue
_"http://wiki.wsmx.org/index.php?title=DiscoveryOntology#preConditionMapping
:?x=?x"
        discovery#typeOfMatch hasValue discovery#ExtendedPluginMatch
        discovery#discoveryStrategy hasValue
discovery#HeavyweightDiscovery
    endNonFunctionalProperties

    importsOntology
            _"http://www.sti-
innsbruck.at/ontologies/IotOntology#IotOntology"

capability SetHighPriorityHealthCapability
    nonFunctionalProperties
        discovery#discoveryStrategy hasValue {discovery#NoPreFilter,
discovery#HeavyweightDiscovery}
    endNonFunctionalProperties

sharedVariables {?x, ?z, ?y, ?m}

precondition HighPriorityHealthPre
    definedBy

            ?x memberOf Iot#Health.


postcondition HighPriorityHealthPost
    definedBy

            ?x[Iot#PriorityHealth hasValue _boolean("True")].
            ?x[Iot#Status hasValue _boolean("false")].
```

Figure 24: Service Code SetPriorityHealth Service

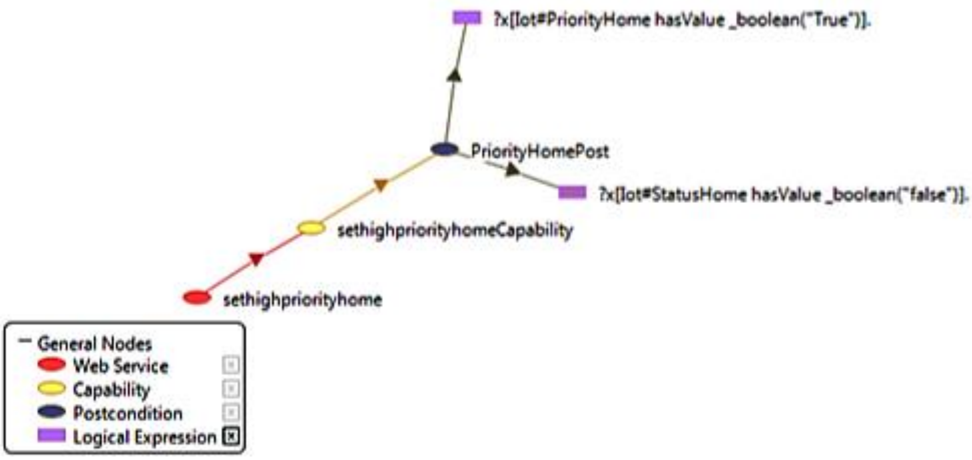
In this form, the SetHighPriorityHome service is displayed, and if the house is detected, it is likely to be set on fire by a target defined as FindAFireHome. The following is a precondition and a post condition for the desired service.



Ontology 15: SetPriorityHome Service



Ontology 16: Pre Condition SetPriorityHome Service



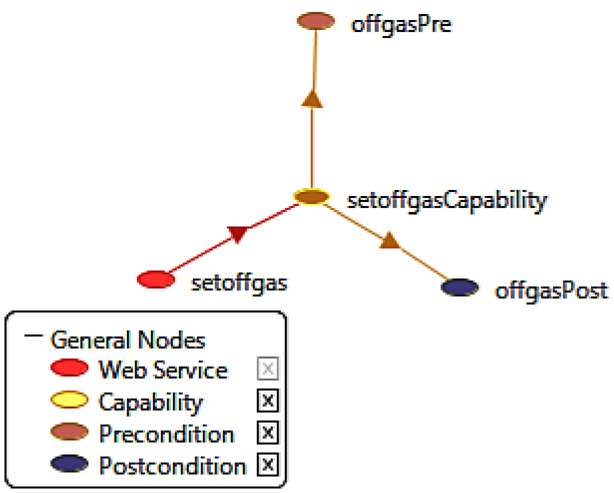
Ontology 17: Post Condition SetPriorityHome Service

Figure 25 shows the service code SetHighPriorityHome, which specifies the prerequisites and post conditions shown above.

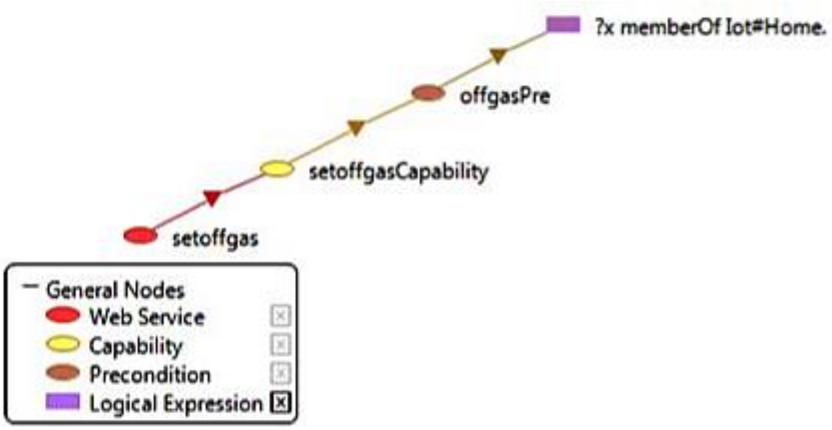
```
 wsmlVariant _"http://www.wsmo.org/wsml/wsml-syntax/wsml-rule"
namespace { _"http://www.sti-innsbruck.at/services#"
,
     discovery _"http://wiki.wsmx.org/index.php?title=DiscoveryOntology#",
     Iot _"http://www.sti-innsbruck.at/ontologies/IotOntology#" }


webService sethighpriorityhome

     importsOntology
            _"http://www.sti-
innsbruck.at/ontologies/IotOntology#IotOntology"

capability sethighpriorityhomeCapability
     nonFunctionalProperties
          discovery#discoveryStrategy hasValue
discovery#HeavyweightDiscovery
     endNonFunctionalProperties

sharedVariables {?x, ?y}

precondition PriorityHomePre
     definedBy
          ?x memberOf Iot#Home.

postcondition PriorityHomePost
     definedBy
          ?x[Iot#PriorityHome hasValue _boolean("True")].
          ?x[Iot#StatusHome hasValue _boolean("false")].
```

Figure 25: SetHighPriorityHome

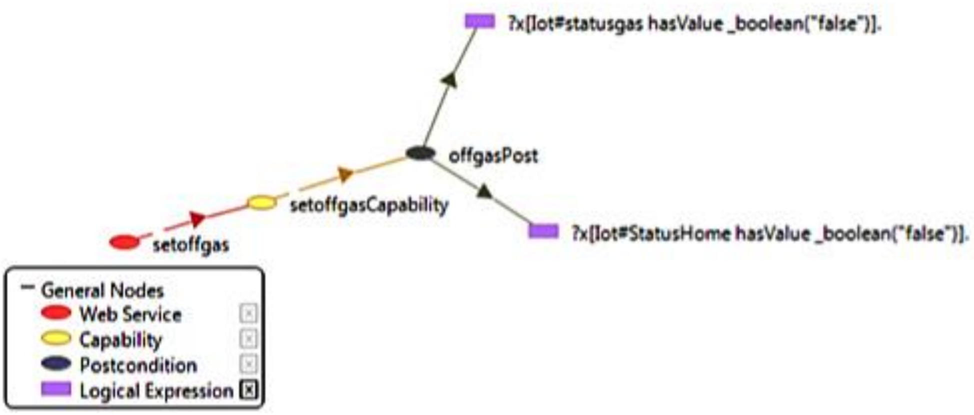
In this form, the SetoffGas service is displayed, and if the house is detected, it is likely to be set on fire by a target defined as FindAFireHome, which will cut off the gas flow to the home. The following is a prerequisite and a prerequisite for the desired service.



Ontology 18: Setoffgas Service



Ontology 19: Pre Condition Setoffgas Service



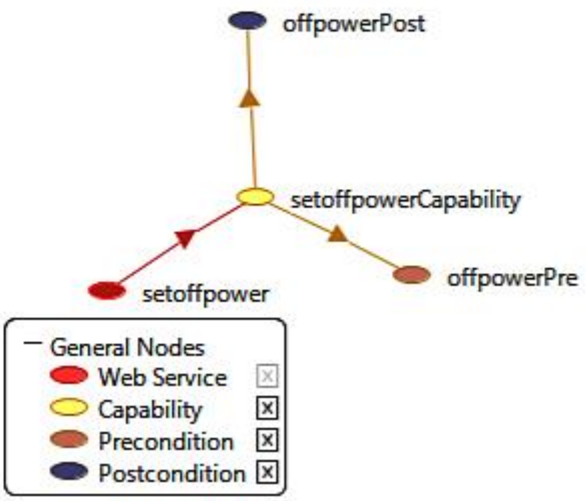
Ontology 20:Post Condition Setoffgas Service

Figure 26 shows the service code SetoffGas, which specifies the prerequisites and post conditions shown above.

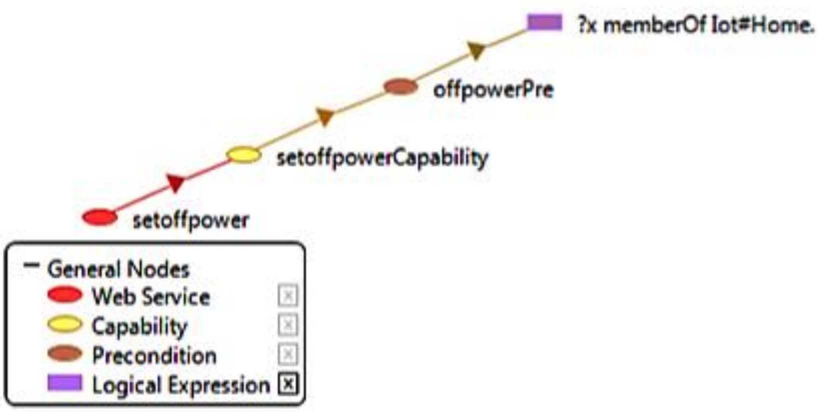
```
wsmlVariant _"http://www.wsmo.org/wsml/wsml-syntax/wsml-rule"
namespace { _"http://www.sti-innsbruck.at/services#"
,
     discovery _"http://wiki.wsmx.org/index.php?title=DiscoveryOntology#",
     Iot _"http://www.sti-innsbruck.at/ontologies/IotOntology#" }


webService setoffgas
     nonFunctionalProperties
          discovery#preConditionMapping hasValue
_"http://wiki.wsmx.org/index.php?title=DiscoveryOntology#preConditionMapping
:?x=?x"
          discovery#typeOfMatch hasValue discovery#ExtendedPluginMatch
          discovery#discoveryStrategy hasValue
discovery#HeavyweightDiscovery
     endNonFunctionalProperties

     importsOntology
            _"http://www.sti-
innsbruck.at/ontologies/IotOntology#IotOntology"

capability setoffgasCapability
     nonFunctionalProperties
          discovery#discoveryStrategy hasValue
discovery#HeavyweightDiscovery
     endNonFunctionalProperties

sharedVariables {?x, ?y}

precondition offgasPre
     definedBy
          ?x memberOf Iot#Home.

postcondition offgasPost
     definedBy
          ?x[Iot#statusgas hasValue _boolean("false")].
          ?x[Iot#StatusHome hasValue _boolean("false")].
```

Figure 26: Service Code Setoffgas Service

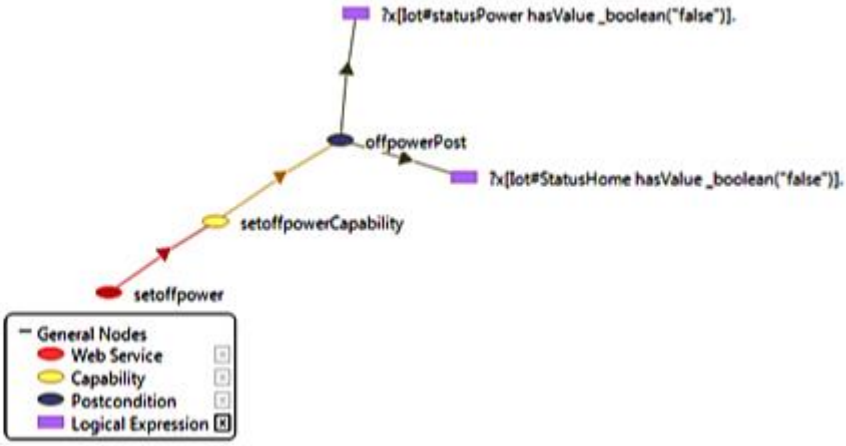
In this form, the SetoffPower service is displayed, and if the house is detected, it is likely to be set on fire by the target, called FindAFireHome, and the power supply is cut off. The following is a prerequisite and a prerequisite for the desired service.



Ontology 21: SetoffPower Service



Ontology 22: Pre Condition Setoffpower Service



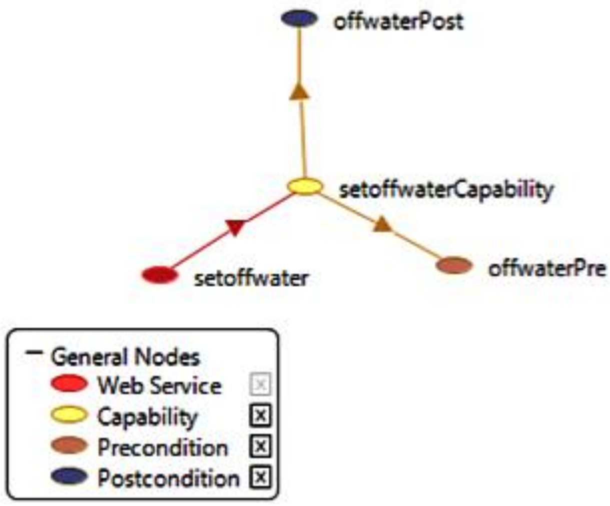
Ontology 23: Post Setoffgpower Service

Figure 27 shows the service code SetoffPower, which specifies the prerequisites and post conditions shown above.

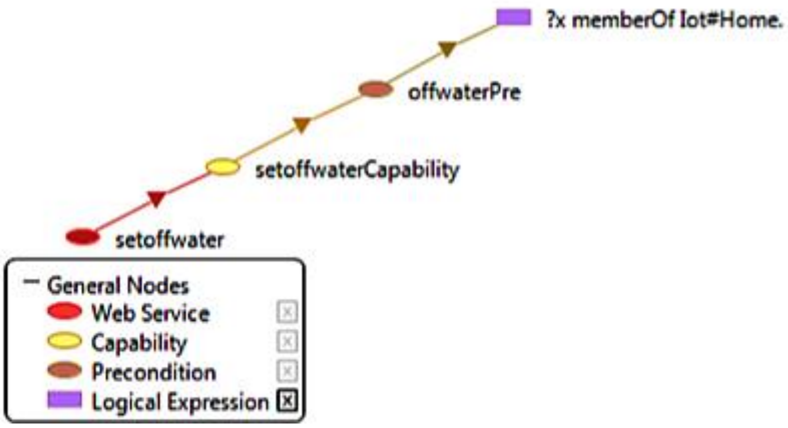
```
wsmlVariant _"http://www.wsmo.org/wsml/wsml-syntax/wsml-rule"
namespace { _"http://www.sti-innsbruck.at/services#"
,
     discovery _"http://wiki.wsmx.org/index.php?title=DiscoveryOntology#",
     Iot _"http://www.sti-innsbruck.at/ontologies/IotOntology#" }


webService setoffpower
     nonFunctionalProperties
          discovery#preConditionMapping hasValue
_"http://wiki.wsmx.org/index.php?title=DiscoveryOntology#preConditionMapping
:?x=?x"
          discovery#typeOfMatch hasValue discovery#ExtendedPluginMatch
          discovery#discoveryStrategy hasValue
discovery#HeavyweightDiscovery
     endNonFunctionalProperties

     importsOntology
               _"http://www.sti-
innsbruck.at/ontologies/IotOntology#IotOntology"

capability setoffpowerCapability
     nonFunctionalProperties
          discovery#discoveryStrategy hasValue
discovery#HeavyweightDiscovery
     endNonFunctionalProperties

sharedVariables ?x

precondition offpowerPre
     definedBy
          ?x memberOf Iot#Home.

postcondition offpowerPost
     definedBy
          ?x[Iot#StatusHome hasValue _boolean("false")].
          ?x[Iot#statusPower hasValue _boolean("false")].
```

Figure 27: Setoffpower Service Code

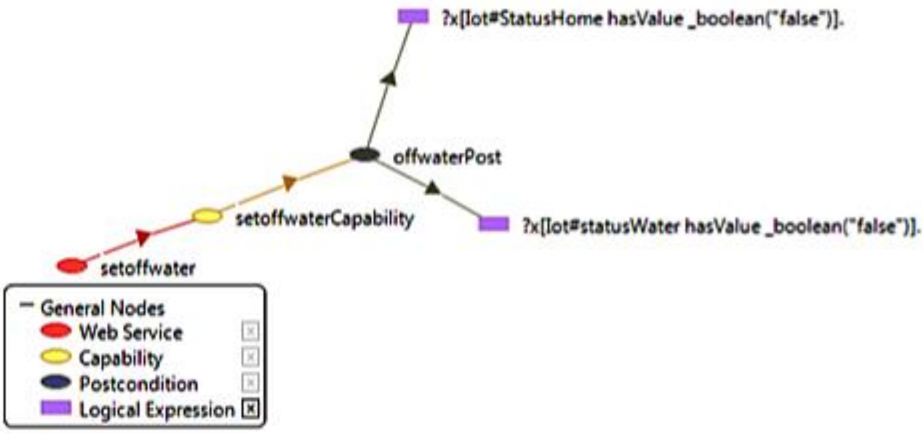
In this form, the SetoffWater service is displayed, and if the house is detected, it is likely to be set on fire by the target, called FindAFireHome, and the water flow in the house is cut off. The following is a prerequisite and a prerequisite for the desired service.



Ontology 24: Setoffwater Sevice



Ontology 25: Pre Condition SetoffWater Service



Ontology 26: Post Condition SetoffWater Service

Figure 28 shows the service code SetoffWater, which specifies the prerequisites and post conditions shown above.

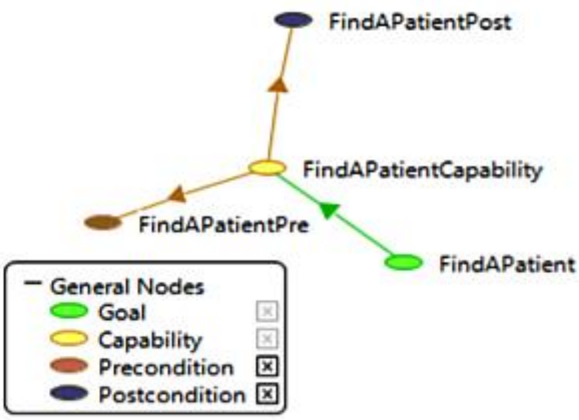
```
wsmlVariant _"http://www.wsmo.org/wsml/wsml-syntax/wsml-rule"
namespace { _"http://www.sti-innsbruck.at/services#"
,
     discovery _"http://wiki.wsmx.org/index.php?title=DiscoveryOntology#",
     Iot _"http://www.sti-innsbruck.at/ontologies/IotOntology#" }


webService setoffwater
     nonFunctionalProperties
          discovery#preConditionMapping hasValue
_"http://wiki.wsmx.org/index.php?title=DiscoveryOntology#preConditionMapping
:?x=?x"
          discovery#typeOfMatch hasValue discovery#ExtendedPluginMatch
          discovery#discoveryStrategy hasValue
discovery#HeavyweightDiscovery
     endNonFunctionalProperties

     importsOntology
              _"http://www.sti-
innsbruck.at/ontologies/IotOntology#IotOntology"

capability setoffwaterCapability
     nonFunctionalProperties
          discovery#discoveryStrategy hasValue
discovery#HeavyweightDiscovery
     endNonFunctionalProperties

sharedVariables {?x, ?y}

precondition offwaterPre
     definedBy
          ?x memberOf Iot#Home.

postcondition offwaterPost
     definedBy
          ?x[Iot#StatusHome hasValue _boolean("false")].
          ?x[Iot#statusWater hasValue _boolean("false")].
```

Figure 28:Setoffwater service Code

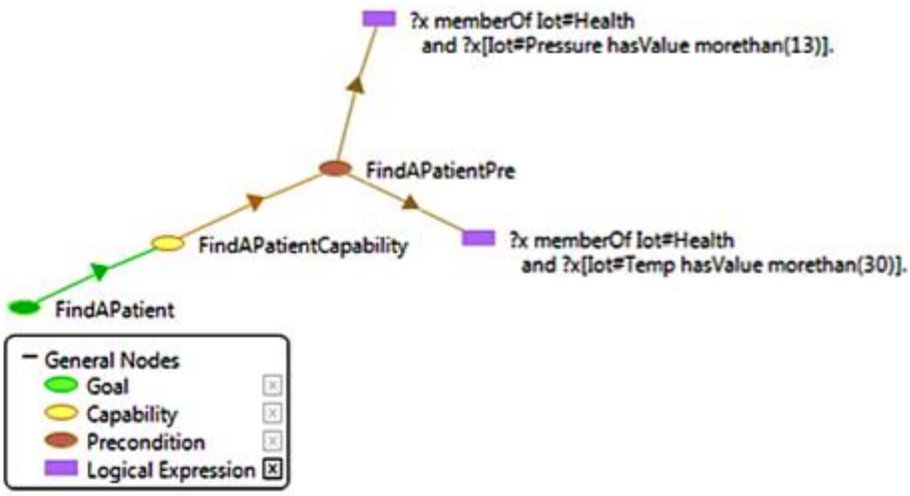
Goals

In this section, the final goals of the service are specified, each specified goal includes one or more preconditions, and in case of observing or implementing the preconditions, the post-conditions cases and the service or services related to that goal will be executed. It should be noted that the two main objectives of the examples described are fire detection and the detection of the inappropriate condition of the person described below.

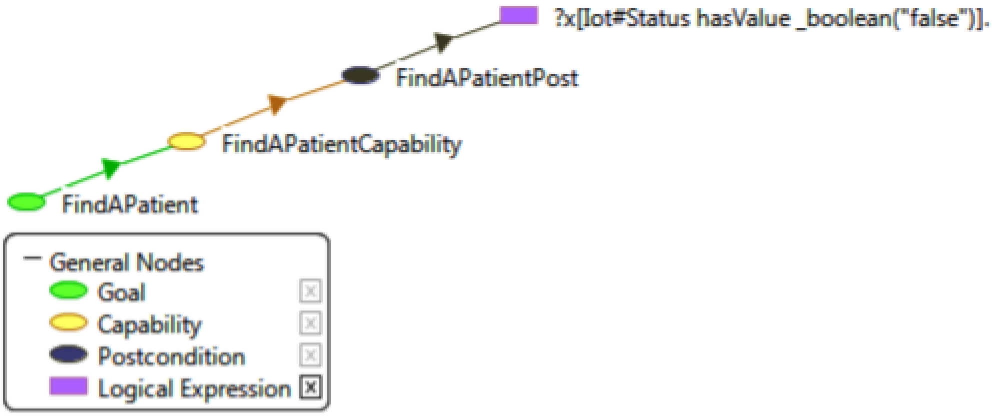
Find A Patient as a goal, it determines the status of the individual based on parameters such as temperature and pressure. It is necessary to explain that this goal changes the person's condition to the patient's condition if the person's temperature or pressure is high. The following is the prerequisite and then the condition of the target.



Ontology 27:Goal FindAPatient



Ontology 28: Pre Condition FindAPatient



Ontology 29:Post Condition FindAPatient

Figure 29 shows the service code FindAPatient, which specifies the prerequisites and post conditions shown above.

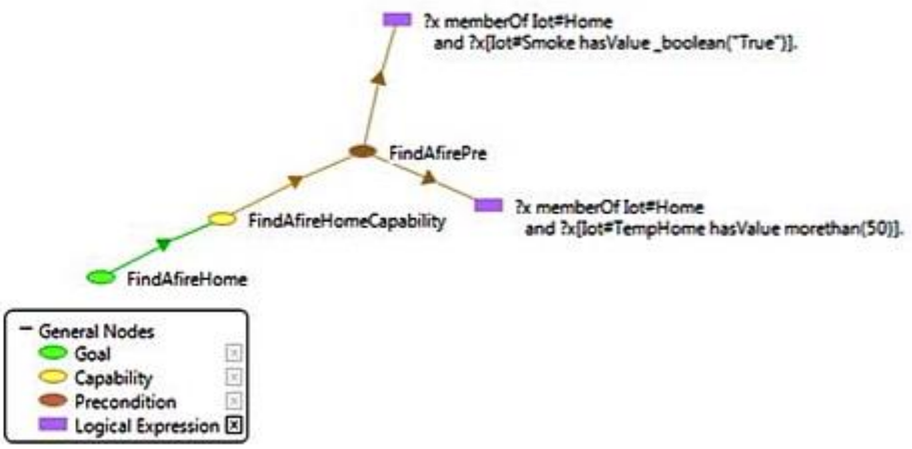
```
wsmlVariant _"http://www.wsmo.org/wsml/wsml-syntax/wsml-rule"
namespace { _"http://www.sti-innsbruck.at/goals#"
,
      Iot _"http://www.sti-innsbruck.at/ontologies/IotOntology#",
      discovery _"http://wiki.wsmx.org/index.php?title=DiscoveryOntology#"
}


goal FindAPatient

      importsOntology
             _"http://www.sti-
innsbruck.at/ontologies/IotOntology#IotOntology"

capability FindAPatientCapability
      nonFunctionalProperties
            discovery#discoveryStrategy hasValue {discovery#NoPreFilter,
discovery#HeavyweightDiscovery}
      endNonFunctionalProperties

sharedVariables {?x, ?z, ?y, ?m}

precondition FindAPatientPre
      definedBy
            ?x memberOf Iot#Health
  and ?x[Iot#Pressure hasValue morethan(14)].
            ?x memberOf Iot#Health
  and ?x[Iot#Temp hasValue morethan(39)].


postcondition FindAPatientPost
      definedBy
            ?x[Iot#Status hasValue _boolean("false")].
```

Figure 29: Service Code FindAPatient

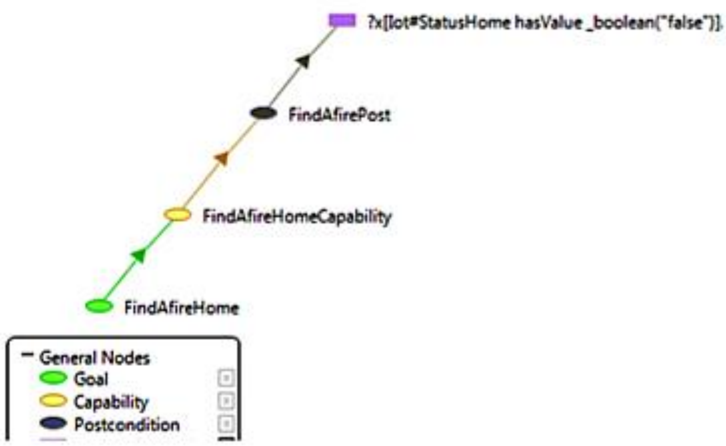
WSML discovery:

This section is designed to properly investigate the relationship between service and goal. In fact, by selecting the relevant goal with the name (FindAPatient) and by selecting the option Discover, it shows the correctness of the relationship between the service and the relevant goal. It should be noted that by identifying the inappropriate status of the individual in the goal (FindAPatient) of the service (SetHighPriorityHealth) is called and the priority of the data sent to the high priority changes the status.

FindAFire Home title is another goal that determines the condition of the house based on the study of the parameters sent by the temperature and smoke sensors. It should be noted that this goal changes the state of the house to a fire if the temperature is high or the smoke detection is shown below.



Ontology 30:Pre ConditionFindAfirehome



Ontology 31: Post ConditionFindAfirehome

Figure 30 shows the service code FindAFireHome, which specifies the prerequisites and post conditions shown above.

```
wsmlVariant _"http://www.wsmo.org/wsml/wsml-syntax/wsml-rule"
namespace { _"http://www.sti-innsbruck.at/goals#"
,
     discovery _"http://wiki.wsmx.org/index.php?title=DiscoveryOntology#",
     Iot _"http://www.sti-innsbruck.at/ontologies/IotOntology#" }


goal FindAfireHome

     importsOntology
            _"http://www.sti-
innsbruck.at/ontologies/IotOntology#IotOntology"

capability FindAfireHomeCapability
     nonFunctionalProperties
          discovery#discoveryStrategy hasValue
{discovery#HeavyweightDiscovery, discovery#NoPreFilter}
     endNonFunctionalProperties

sharedVariables {?x, ?y}

precondition FindAfirePre
     definedBy
        ?x memberOf Iot#Home and ?x[Iot#Smoke hasValue _boolean("True")].
          ?x memberOf Iot#Home and ?x[Iot#TempHome hasValue morethan(50)].


postcondition FindAfirePost
     definedBy
       ?x[Iot#StatusHome hasValue _boolean("false")].
```

Figure 30: Service code FindAfirehome

As previously explained, the section WSML Discovery examines the relationship between service and goals. In fact, by selecting the relevant goal with the name and by selecting the option, figure 31 is displayed, which shows the correctness of the relationship between the service and the relevant goal. It should be noted that the purpose (FindAFireHome) of fire detection is to turn off the water, electricity and gas flow of the house by calling the relevant services, and to change the priority of the submitted data to a high priority.

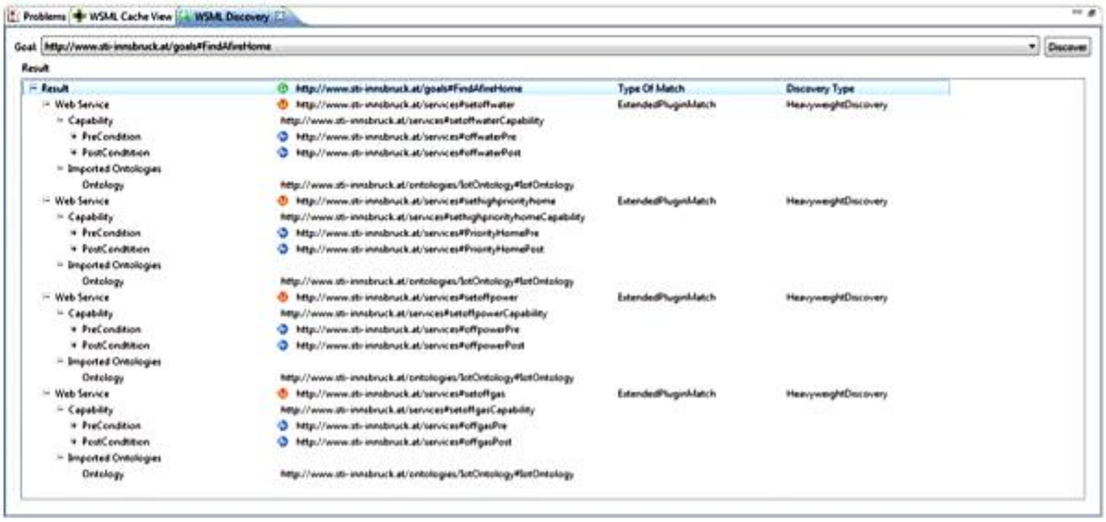


Figure 31: Final output

Two examples of the executed questions is shown in the WSML-Reasoner section below (Figure 32 and 33).

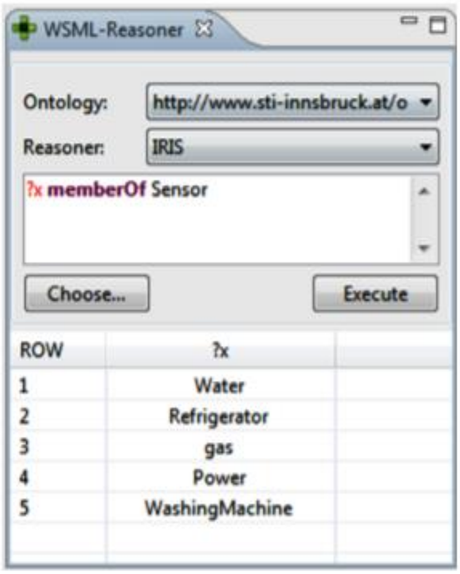


Figure 32:first Example

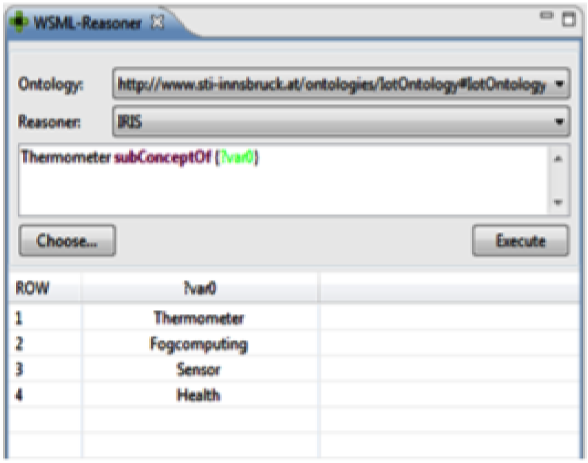


Figure 33: Second example

6 Discussion:

Due to the use of Internet of Things technology in sensitive areas such as healthcare, crisis management, etc., the need for quick decision-making and prompt response has become more important and has become a necessity. The proposed model addresses important issues such as reliability, processing time reduction, rapid decision making, and real-time response, which has always been a concern for users, to address processing challenges.

As mentioned in Chapter 3, the Internet of Things model does not pay enough attention to some processing issues due to the following reasons: (Mahmoud et al, 2015)

- Low cloud data processing
- Low cloud storage arrangements
- Lack of process transparency and processing mechanisms
- It is not possible to control the information sent
- Not a regular process of sending data

Examining the challenges and benefits of reference models in the field of Internet of Things and cloud computing, the most important components influencing the combined model of Internet of Things and cloud computing were as follows:

- Make arrangements to process cloud data in the cloud computing layer
- Create cloud data storage measures in the cloud computing layer
- Processing mechanism
- Send data based on defined policies
- Sustainable communication between IoT equipment and data transmission getaways
- Prioritize data based on defined policies
- Immediate response and execution of orders based on defined policies

Nowadays, with the use of pervasive environments, environments that provide human needs at any time and place, information technologies and artificial intelligence in the field of machine-to-machine interaction have evolved at an unprecedented rate of speed Dillon, (Tharam, et al, 2010). these technologies have evolved synergistically. However, data storage and data processing holes and challenges are on IoT (Khan, et al, 2017). On the other hand, cloud computing technology can play an important role in storage holes with the ability to store and process cloud data.

One of the important components that create the space for using this technology in sensitive areas such as medicine, health, industry, security, etc., is the response time, or in other words, the processing time and quick response. Therefore, timely processing is one of the main challenges in this technology, which was tried to solve this challenge.

Several challenges has been addressed in this paper.

The first of them is the one regarding low cloud data processing: Low cloud computing is considered a serious challenge in the use of IoT technology. On the other hand, cloud computing technology is inherently capable of processing super data, so in this model, considering cloud computing technology, this sector plays a significant role in solving the challenge of data processing.

Something similar happens with the low cloud storage arrangements: Due to the high volume of data produced in IoT technology, storing this data is considered as a major challenge in the implementation of IoT technology, so in this model, cloud computing technology has been used to solve this challenge.

Lack of process transparency and processing mechanisms has been another challenge adressed: In the presented case, by defining the tasks of each section, the processing processes and mechanisms are fully determined, which has made the transparency of the processing mechanisms clear.

Another challenge was the impossibility of controlling the information sent: In the model provided in the Fog computing section, by placing the possibility of filtering by users, it is possible to control the sent information.

Continuous data transmission by a wide variety of Internet of Things technology is considered a new challenge in this technology. Therefore, in this model, by placing the possibility of sending information of low importance, this challenge has been eliminated periodically.

Limitations:

Due to the wide range of areas for the implementation of IoT technology, this research is limited to reducing the response time to the field of health and firefighting. However there are countless fields to which this research could have been applied, but due to the nature of this paper I had to limit it to this two spheres, otherwise the scope of the paper would have been too wide in order to produce a comprehensive paper.

Problems and limitations of interaction with organizations. Due to the pandemic of Covid19 during the elaboration of this paper I was limited regarding to accessing scholars and institutions and getting information from them.

7 Conclusion

The integration of IoT and cloud computing technology has become indispensable and necessary. It is vital to mention that we are living in an era in which, technology can pledge human needs at any time and at any moment. Also the information technology and artificial intelligence are interacting at an unequalled speed rate so, here is when the problem of data storage and data processing evolves.

The research has been started by the in depth investigation of existed papers which has been identified that most of the materials are focusing on the state of these two technologies and how they can combine. Therefore, there is a failure in addressing the issue of processing layer and also the inaccessibility of a proper algorithm that can improve the processing time and the response time.

The proposed model is meant to address the limitations regarding reliability, processing time reduction, rapid decision making, and real-time response, which has always been a concern for users, to address processing challenges. By applying this architecture it would be possible to harmonize the existing unbalance between the data processing and data storage in the field of Internet of Things.

As success in this area would mean a major improvement in the development of this technology. The possible future applications can be a breakthrough in areas such as: healthcare, smart houses design, industries…

However, if we want to achieve the aforementioned advancement we should be able to provide a solid and reliable architecture that can support a system by reducing the crisis.

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