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ONTOLOGY-DRIVEN SMART FRAMEWORK EMPOWERED AGRICULTURE SYSTEM

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Abstract

Technology performs an essential position in our everyday life. There has been a heavy demand for the Internet of Things (IoT) in many sectors, which has drawn important research attention from academia and the industry. Smart agriculture is used to denote the application of IoT solutions in the area of agriculture. Precision Agriculture attaches smart devices to farmers like machines, soils, animals, climate, sensors, etc. There are numerous smart agriculture services including moisture sensing, spraying pesticides, livestock monitoring, irrigation control, water monitoring, illumination control, pest control, etc. These applications are working as individual services and the need of the hour is to provide a management platform where all these services work as a single unit providing all these facilities to the users.

Index Terms: Internet of things, smart agriculture, precision farming, smart irrigation, smart harvesting, ploughing and seeding through IoT

1. INTRODUCTION

The IoT is an essential communication advancement that joins the internet with everyday working devices and sensors with an IP-based architecture. These electronic devices interconnect through wireless or wired channels to exchange and gather data. The numerous interdisciplinary applications of IoT include smart cities, smart healthcare, and automation in agriculture, industries, and transportation where decision-making is very

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difficult. Sensing objects and devices in the internet of things sense and gather related information which later on can be analyzed, processes for healthier decision making [1]. The Internet of things allows physical objects in the real world to attach to deliver computation-based performance.

The IoT in the last decade carried uncountable paybacks to organizations and citizens all around Globe. Maybe the most significant benefits were the ability to produce and consume data and facilities in an actual period. IoT packages convey the same benefits to regular objects, giving a manner to unfold recognition and potential to alternate environments around us [2]. Environmental fields and agriculture are ideal for the implementation of the Internet of things answer because they happen in wide-ranged regions that want to be continuously controlled and monitored. IoT can be used at exceptional factors within the farming production chain. It can assist to assess field variables consisting of soil kingdom, atmospheric conditions, and biomass of flowers or animals. It could additionally be used to assess and control variables inclusive of temperature, vibration, humidity, and shock during the delivery of merchandise [3].

The IoT smeared to agriculture can donate a connected, informed, adaptable, and developed rural area. Under the umbrella of the Internet of things, cheap electronic devices can better human relations all around the world. Software and computing power are to be had on the Internet and can offer valued analytics [4]. IoT is an essential tool in the current years to come for humans interrelating inside an agriculture gadget: farmers, vendors, suppliers, businesses, technicians, customers, and government officials. IoT can be mixed with environmental packages to provide impenetrable and actual-time maps of water and air pollutants, temperature, dangerous radiation, and noise degree amongst others. The digitalization of agriculture can be a technique to feed a massive developing population in the future. The software program of massive records is a key device to digitalizing the agriculture region. Despite the reality that there may be an extended debate on its applicability to agriculture, this seems to cope with how the massive records era contributes to virtual agriculture in phrases of sustainable farm manipulation [5].

Virtual agriculture is now a holistic approach that uses the know-how of information technological information, environmental generation, computer, and software program engineering, tool technological knowledge, Geographical Information systems (GIS), Global Positing systems (GPS), far-off sensing generation, and digital satellite tv for pc television for computer television for laptop imaging for better integration with soil, climate, environment with agriculture. It is needed to incorporate different smart agriculture services in one solution. There is no such existing management architecture that can handle different smart agriculture services as a single architecture in the literature.

Although the utility of big statistics in agriculture relies upon a couple of elements like user attractiveness of the new generation, the willingness of stakeholders, data possession, privacy, and control it works at the sphere level [6]. The decision of farmers the adoption of the latest technology is encouraged by numerous social and monetary factors. Virtual

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agriculture, its miles extra complex due to the new state-of-the-art era like clever devices, network infrastructure, technical know-how, and expertise in analytics. As the arena's population grows, agriculture is dealing with a growing call for productivity, efficiency, and sustainability to make sure meals security. Agricultural equipment and specific 'hardware' play a vital position in the implementation of virtual agriculture and new technological trends in this vicinity [7]. The electronics used in farm equipment, in particular tractors, started in the 1980s. While you recollect that then, the software of digital structures to enhance functionalities in mechanized agricultural operations has grown to be superb. The motives for this style include agricultural entry savings, operations timeliness, increased yields, safety, and environmental safety [8].

IoT is turning into a more and more developing topic of communication both inside the workplace and outside of it. IoT is a gadget of interrelated computing devices, mechanical and digital machines, items, animals, or humans which are furnished with unique identifiers and the capacity to transfer records over a network without requiring human-to-human or human-to-computer interplay. The agriculture quarter is the backbone of an agricultural united states. The traditional methodologies may be integrated with modern-day-day technologies like the IoT and Wi-fi Sensor Networks (WSNs) to permit diverse packages inside the virtual agriculture place [9]. The advanced improvement in Information Communication Technologies (ICT) and its adoption in the agricultural place open the field to the advent of virtual agriculture; which created new techniques for making farming greater effective, green, and controllable at the same time as respecting the environment [10]. DA can control crop vitamins by way of locating the premiere fertilization program for each discipline, and its choicest irrigation application, and can help farmers to react otherwise for every part of the field. The DA involves the improvement, adoption, and new release of all the above-cited technology in the agricultural area in unique spatial contexts [11].

IoT and a huge range of agriculture sensors play an important feature to support farmers in improving their agricultural production irrespective of the unpredictable behavior of natural parameters. Global weather alternates, increasing international populace, and degradation in meals nice are forcing humanity to search for modern techniques and technologies which might be able to address agriculture-associated issues [12].

2. PROBLEM STATEMENT

Agriculture, today, is refining with new smart solutions provided by the IoT and cloud-based Artificial intelligence (AI). The emergence of new agriculture procedures also brings unfamiliar operational challenges. The study identified that the majority of smart agriculture services are focused on specific objectives or service domains like disease control services, Crop management, or resource management service. These services are invented, introduced and installed mostly in a disjoint fashion. Though these smart services are intended to work independently, there are many resources and dimensions shared that can affect other service operations. This paper aims to address these

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interoperability issues that occurred due to these heterogeneous and disjoint services operating concurrently over the shared agricultural fields and crops. The research uses an ontology-driven solution using a standard formal representation of the smart services through ontologies and semantic framework. The standard ontology engineering process is adopted to create a merged ontology for integrated smart agriculture services.

Numerous research organizations present viewpoints and movements for the forthcoming Internet of things. International Data Corporation (IDC) guesses that IoT will reach about a US$ 1.7 trillion market by way of 2020. Gartner expects 25 billion associated gadgets by way of 2020. Cisco remarks around approximately 50 billion. Harvard enterprise review thinks 28 billion gadgets are interconnected to the internet [13]. The growing adoption of IoT-linked devices has penetrated each aspect of life like fitness and health, automotive, logistics and home automation, smart cities, and the industrial internet of things. Thus, it is logical that the IoT, connected devices, and automation will find application in agriculture and vastly improve many facets of the agriculture practice. Nowadays how does someone rely on plows and horses when virtual reality and self-driving cars are no longer a science fantasy but an everyday incident?

On the other hand, smart agriculture is typically used to provide the application of Internet of things solutions in farming. This is a trend to use information technology for the development of modern agriculture. According to Food and Agriculture Organization (FAO), to feed the ecosphere's growing populace, the world will necessity to produce extra than 70% of the food in 2050. For the fullness of demand agricultural companies and farmers are moving towards the IoT for analytics and large production capabilities [14]. The rapidly growing network of IoT-linked items is meant to collect and exchange data using embedded sensors. IoT is usually to change the upcoming of agriculture to the advanced level. IoT technology mixes a variety of technologies such as automation, sensor, computer, telecommunications, Radio Frequency Identification (RFID) with agricultural machinery, bio systems engineering, agricultural products supply chain management, animal, food science plants, and soil science [15].

The market is still very dynamic, though smart cultivation, as well as smart manufacturing, is not as famous as customer-connected gadgets [16]. The adoption of Internet of things solutions for farming is continuously growing. BI Intelligence predicts about the number of smart agricultural IoT device installations in 2020 will be 75 million. The growth rate is 20% per year. The global agriculture IoT market is probable to three times in 2025 at the same time, getting to $15.3 billion related to being little over $5 billion rear in 2016 [17].

Because the market is still developing, there are still plenty of opportunities for businesses ready to join. In the coming years, building IoT products for agriculture can be separated as early adoption and thus will help you to succeed.

2.1 Objectives

The aim is to provide all IoT-based Smart Agriculture Services in the smart environment

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under a single management flow. Management of agriculture services will increase the cultivation quality and decrease the farming cost.

The objectives of this research are as follows:

1) Exploring the commonalities and differences among smart agriculture service architecture
2) Exploring the commonalities and differences among smart agriculture service process model
3) The common standardization of smart agriculture carrier structure and technique model
4) Integration of different Smart agriculture service
5) Making sure the interoperability and standardization of the proposed integrated solution.

3. LITERATURE REVIEW

The term IoT was first devised by Kevin Ashton in 1999. The term 'Internet of Things is defined as electronic gadgets of various scopes and abilities which are connected to the Internet. The role of connection capacity is only extended from Device-to-Device (D2D) communication. IoT devices deploy a wide array of network domains, applications, and networking protocols the rising majority of internet of things technology numerous types of short-term wireless technologies are provided by internet-related physical objects like RFID, Zig-Bee, networks, sensor, and location-based technology [18]. The Internet of things makes the effect of the Internet smooth more common, in daily and personal life. According to Cisco Business Solutions (CBS), the appearance of the internet of things as a unique entity was attained, when many inorganic gadgets were linked to the Internet compared to human clients. In keeping with this definition, this is an accelerating persevering with a machine with the rollout of Cisco Planetary pores and skin, smart cars, and smart grid [13].

Internet of things objects is not presently powerfully consistent in how they're related to the internet one after the other from their protocols of networking. Internet of things operating with extra safety and control topographies to join, for example, domestic surroundings management structures, vehicle electronics, telephonic networks, and domestic utility offerings. The massive scope of the internet of things and the way it may be used to link different dissimilar networks [19]. Probable applications of the Internet of things are several and different, soaking into basically all areas of everyday life of enterprises, society, and individuals.

IoT is used in remotely handling different electronic appliances to save energy. Refrigerators have display screens showing what’s inside and the expiry of food. Alarms are generated on smartphones to buy the vegetables and fruits that are going to be

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finished soon. Smart washing machines allow monitoring the laundry from anywhere anytime, and. Kitchen ranges like microwave ovens can be handled using a smartphone app as well. Outside weather conditions such as humidity, temperature, wind speed, pressure, and rain levels can be seen using IoT [20].

The Internet of things is also used in the arena of transportation. Using smart roads can be built that warns the smart vehicles moving on the roads to avoid travel during unwanted conditions like heavy snowfall or thunderstorms and it can also help people to avoid going to those roads where there is heavy traffic blockage. Smart Parking can also be enabled using IoT in which the availability of parking spaces in the city can be monitored and make populaces able to find and reserve nearby obtainable spaces.

IoT in the industry additionally performs a critical role. Explosive and Hazardous Gases may be detected using IoT-enabled sensors. Gas levels and leakages can be monitored in the industry [21]. Monitoring toxic gas and oxygen levels can help in securing the health and safety of the workers in the industries. Maintenance and repair of the equipment can be made easy using IoT due to early forecasts of equipment breakdowns and maintenance by services can be spontaneously planned ahead of a real part failure by planting sensors in the equipment to be monitored.

The Internet of Things also influences the field of agriculture. Greenhouses are maintained using IoT to control climate conditions to increase the production of vegetables and fruits and it's also used for the betterment of the quality. Temperature and humidity levels are monitored in different crops like hay, alfalfa, straw, etc. To avoid fungus and bacterial pollutants. Farming-related animals are also one of the subcategories of smart agriculture in which the location and identification of animals eating in an open area in big strings are observed [22]. Smart control of rising conditions in animal farms is carried out to safeguard their health and survival, IoT also enables us to maintain a smart environment around us. Air pollution monitoring can be done using IoT in which Carbon dioxide emissions of factories can be controlled. Pollution released by vehicles and toxic gases produced on farms can be detected. Jungle fire detection can be smartly handled using IoT such as monitoring burning gases and anticipatory fire conditions to generate alarming messages. Weather monitoring can also be done in which weather conditions such as temperature, humidity, wind speed, pressure, and rain are monitored. Any natural disaster can be anticipated using IoT techniques for example Earthquake Pre-detection is also possible by implanting sensors in the crust of the Earth [23].

3.1 Digital Agriculture

Making digital agriculture can be a strategy to food a huge increasing populace in destiny. The request for huge statistics is an energetic device to digitize the agriculture region. Even though there is extended debate on its pertinence to agriculture, this seems to goal to address how large records generation makes contributions to virtual agriculture in phrases of maintainable farmhouse management. This study reveals numerous to be had

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large data technology and applies them in cultivation for the resolution of the current problems and destiny tests at the sphere stage. We have a look at exhibits that the utility of huge facts technologies in agronomy is rising but still at a low stage. It additionally discovers that there are some techniques used for yield production, livestock production, plant protection, fisheries, market development, and put-up-harvest management [24].

We have a look at find out a few challenges along with the privateness of information, statistics availability, excellent and openness, financial funding, lack of awareness and context of a particular generation. This article clearly articulates that a huge-scale adoption of agricultural massive records technologies requires authority projects, a public-personal corporation, the directness of records, monetary speculation, and local basis explore work [25].

3.2 Smart Agriculture

In 2050 the world population is around 9.6 billion. For feeding this much of the population the enhancement of the Internet of things is very important. Against the challenges of excessive climate situations inclusive of change in the climate. More food is required to feed that much of the population. For this purpose, precision farming or smart agriculture is most important.

Sensible farming primarily based on IoT technologies will assist farmers. Farmers grow and promote the productivity generated by fertilizer; farms are made for that purpose [26]. The main question is what is sensible farming? Clever farming is a capital-in-depth and hello-tech gadget for growing food cleanly and sustainably for the masses. It is the utility of modern-day ICT in agriculture. In IoT-based clever farming, a device is constructed for monitoring the crop field with the assistance of sensors for light, humidity, temperature, soil moisture, and so on. And automating the irrigation device. The farmers can screen the sector situations from everywhere [27]. IoT-based system agriculture is used for tracking the field of vegetation with the assistance of sensor light, humidity, temperature, soil moisture, and many others. Smart farming automatically monitors irrigation fields. Farmers may display the sector from anywhere. When agriculture smart is extremely well-organized compared to the traditional viewpoint. The supplication of an IoT based cannot only target traditional way but also a modern way of farming. Smart farming may provide many advantages which include irrigation of water, disease detection, and pesticides for crops.

3.3 Detection of Diseases in Grapes

Grape cultivation has an economically and socially very important source of food. Grapes' quality downed and the production of grapes is also decreased due to disease and less knowledge information farmer has. In this system, the disease is early identified and according to that prediction, we enhance the production of grapes. WSN is deployed in the vineyard these wireless sensors take the reading of temperature, humidity, and leaf wetness. Using the Zig-Bee module, these wireless sensors take data input of vineyard

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temperature, humidity, etc., and transfer these data to the server [28].

Zig-Bee collects data from the sensor and transmits these data to the server. The wireless sensor is interconnected to the Arduino board that converts the analog system into digital. The data from the sensor is stored in the MySQL database. After the data transmission system starts data analysis for this Hidden Markov Model is used. In this system, the Baum-Welch algorithm is used. This model is based on three hidden states each state has some condition like leaf wetness or state changes from like state 2 to 1. By using the Markov Model system classify the disease. The System is used for disease early detection by using the internet of things. This system help farmer improve the quality and production of Grapes [29].

3.4 IoT-Based Smart Agricultural Monitoring System

Due to potential health hazards after the usage of insecticide, the charge of new wasting has increased rapidly in recent centuries. Government procedures have become further stringent, reducing the growth percentage, and consequently the price of innovative products increases. The biggest benefit of insecticides is that they are easily available and are very calm to use in contrast to alternative methods and other comparable methods that can be taken a long for plan and often but it does not matter. The system has a WSN to acquire data on water level, temperature, and humidity [30]. The data collected through sensors provided detailed information about the different environmental factors.

Consequently, the system is beneficial to square the constraints for agriculture corresponding to temperature, humidity, moisture, spraying the water, leaf growth, and pesticides via the motor pump through the IoT module. The system diminishes the manual paintings and guy strength. This setup changed into accepting the use of Arduino UNO, soil moisture sensor, Temperature and Moistness sensor, IoT module, and ultrasonic sensor. The issue speaks page can be evolved to govern the system via the cellular. Damage as a result of predators is decreased and additionally is used to grow productivity. The system is included an ultrasonic instrument to reveal the health of the vegetation to take a look at their plants each time, anywhere on the internet [31].

4. ONTOLOGY & SEMANTIC FRAMEWORK

Ontology is a clean clarification of a not-unusual conceptual hobby. Complex actual-global standards may be formally described using ontologies. Ontologies can be logically reasoned and they can also be shared within a domain. The use of ontologies is to provide machine-process able semantics so that they can be shared among numerous software programs and gear. The term “shared” denotes back to the idea to seize consensual expertise. So, it's miles ordinary use of the community or a group and also not restricted to an individual. Therefore, formal representation of the concepts to the particular domain using ontologies can also allow automated reasoning among those concepts [11].

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Ontologies are shared concepts and provide a standardized solution. Therefore, research is also focused on building technology for the reuse of these ontologies worldwide. Ontological engineering is a combination of medicinal development works for special domains. These are used for defining terms in the domain and relationships among them. Defining concepts in the domain are named as classes then these concepts are arranged in a hierarchy in the form of sub-classes. Further, the object properties and data properties are assigned to these classes. Smart healthcare systems are hard to define formally because most of them lack standardization of architecture. Ontology in IoT shows an important function in supporting functioning and strategic preference-making scenarios that may boom the productiveness of IoT gadgets. Those IoT policies have partial memory and facts assets due to which ontology may assist those gadgets in the concept of the fact. This distracting information is then offered in a green way to control the intricacy through a way of selecting the most effective exact article out of all [22].

4.1 Methodology

Many systems are studied in the literature review of IoT-based agriculture applications. These systems are operating on requirement precise tasks. These systems offer unique offerings primarily based on the necessities which might be fulfilled through acting different activities within these services.

This section of the thesis describes the plan of studies and solution exploration for the integration of various smart agriculture architectures. The ontological modeling is used for clever agriculture systems in penetration definition. This ontological prototype goes to symbolize smart farming expertise with all semantic members of the family and the constraints furnished by using them. This ontology modeling is finished for unique clever agriculture software which leads to searching the unities and variances of many of the IoT-primarily based agriculture machines. Discovering the unities and dissimilarities helps to join the displayed ontologies of various structures into one ontology of a unified smart farming system.

In our state of affairs, we have considered one of the typical smart farming applications operating autonomously primarily based mostly on precise facilities and activities. The offerings and their corresponding sports are necessary to be accomplished at the same time to shape an IoT-based consistent farming solution and for this reason, we are using ontology engineering.

4.2 Research Questions

Q1: What are the commonalities and differences among smart agriculture service architecture?

Q2: What are the commonalities and differences among the smart agriculture service process models?

Q3 How can the standardization of not unusual smart agriculture carrier structure and manner model be carried out?

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Q4: How the Integration of different Smart agriculture services will be possible?

- H0: We cannot develop a cohesive smart agriculture services management architecture.
- H1: Develop a cohesive smart agriculture services management architecture

4.3 System Analysis

We have studied several systems in the domain of smart agriculture. These systems are working independently on their architecture and standards. Several smart agriculture systems are being studied and out of which 21 systems are selected for analysis. The details of these 21 systems in the form of a table are provided in Appendix-I for consideration. These systems are classified based on targeted requirements specified in the literature. These systems are classified into two categories namely disease-based systems and service-based systems.

Service-based systems provide different types of services i.e., Monitoring services, Irrigation services, harvesting services, Disease-based Services Robotics services, etc. Monitoring systems provide different services like automated agriculture monitoring, rice crop monitoring, potato crop monitoring, etc. Irrigation System provides irrigation management service during this service time and the schedule of watering is decided. There is another type of irrigation service in which live monitoring of irrigation is performed. These kinds of services help the farmer to save time and for better production of food by providing bi-directional communication over the cloud.

Service-based systems may be further categorized into two types of systems i.e., disease-based systems and robotics Systems. Disease-based systems are disease-specific and work on specific requirement-driven services. For example, the Disease detection of the Cotton Crop system is used to detect different types of diseases in cotton crops. Grape's disease detection system is used to detect all kinds of infections that occur due to moisture. The robotic system is used to perform different kinds of functions like seeding and plowing. Automatic Ploughing system in which robots perform the activity of plowing with the help of farmer commands. These Systems are being performed by different services which are comprised of different activities. These activities within different services perform specific functionality depending on the type of system we are utilizing. The detailed study of these systems shows that these systems have many common activities within similar services like data acquisition, data analysis, processing, and data transmission. These common activities perform a similar type of operation. The devices like sensors for such common activities may be different but the observation involving them are quite the same. For example, processes to detect and diagnose a disease may be different but the observation values will remain the same. The frequency of observation will be similar but the analysis algorithm may vary for processing purposes.

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4.4 Competency Questions

CQ1: How may smart agriculture be officially defined?

CQ2: How may the standardization of not unusual smart agriculture carrier structure and manner imitation is carried out?

CQ3: How may smart agriculture services be combined over the unities and variances among irregular architectures?

CQ4: What is the meaning of relatives and restrictions within and throughout one-of-a-kind clever agriculture Designs?

These competency questions define what we need from our solution of ontology. We will have to prove that software necessities may be described (specified) within the shape of ontologies and be proven as proper. For this purpose, we've followed the ontology engineering method.

4.5 Requirement Analysis

Ontologies are beneficial for representing and interconnecting numerous expertise. Thinking about the reality that Requirement Engineering includes know-how in taking pictures and analysis, there can be easy synergy between the various ontological modeling of a domain and the modeling that a Requirements Engineer will perform during the obligation process. Due to intersection, many works dating back have communicated the use of ontologies in Requirement Engineering. The necessity is considered essential to be exhibited in prospective use cases. Those are exclusive since software use instances are used in area modeling of the software program requirements. It explains for what goal it is to be developed, who will develop that, and for what purpose it will be developed.

4.6 Use Cases

We have developed 3 use instances for 3 different consistent systems using 21 systems we are considering for prospective engineering shown in Tab. 1. These use instances show unique offerings of different structures working together to obtain one intention. The offerings are coined collectively to make an integrated smart agriculture device.

Table 1: Use cases

UC_1: Agriculture System:	UC_2: Sowing Crop:	UC_3: Crop Irrigation:
Image Capturing Humidity Sensing Moisture Sensing Temperature Sensing Data Upload on the cloud Image Remove Distortion Prediction of Forecast Prediction of Pest Cluster Analysis K- Mean Clustering Hierarchical Clustering Live Monitoring Average Moisture report Pest attacking report Pesticide for the crop report	Moisture Sensing Temperature Sensing Humidity Sensing Wireless Data Transmission Analyzing Data Command to robot Field Display Ploughing obstacle detection Break Obstacles Distributed Seed User Receive Output from Robot	Moisture Sensing Temperature Sensing Humidity Sensing Light Sensing Weather data Transfer Data to Cloud using Zig-Bee Combining data for analysis and computation K-mean clustering Accurate Generate Alarming Message Pump on Off

4.7 Taxonomy Building

Taxonomies had been validated success in resolving numerous problems in automated systems use in one-of-a-kind sciences. It has also been used in software requirements analysis to understand several concepts and to resolve particular problems. Several other taxonomies have been proposed by others for requirements engineering in general. They also offer the idea for the application of ontology. Taxonomy is a community of groups, individuals, and sub-classes. Afterward, all the phrases to be used in our classification are chosen, the following step is to become aware of the proper placements of these phrases in our taxonomy. We have implemented the bottom-up (Generalization) technique. A bottom-up improvement system begins with the definition of the maximum unique education, the greeneries of the grading, with the consequent grouping of those training into more preferred requirements.

In our method, we have clarified approximately supergroups like Actors, Services, Machines, Activities, fields, Observation, and Smart Agriculture Systems. The actor category has specific bodily participants in it. It has a sub-group of Machine and Person. A person has a farmer, user, and director in it. The machine has subclasses like communication systems, motors, robots, sensors, software applications, water taps, etc. Same like observation has different data values like moisture, humidity, acidity, temperature, etc. actor and observation classes are involved in frequently Systems of Smart agriculture. We have 21 different smart agriculture services recognized to u's for reviewing different IoT systems of agriculture. To associate them underneath one magnificence we've used services magnificence. This offerings magnificence is organized into important subclasses like monitoring services, disease-based services, robotic services, harvesting services and irrigation systems, etc. These subclasses in the offerings superclass incorporate all forms of offerings used in the distinctive systems below study.

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Different forms of facilities are provided in the class of services. These services are further containing many sub-services shown in Fig.1.

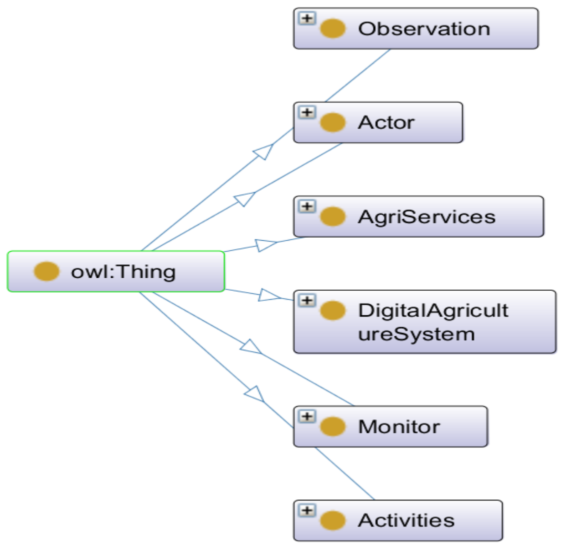

Fig. 1: Taxonomy and semantic relation of service class

Different services have different activities we have an activities class which has many subclasses shown in Fig. 2 Activities class has different classes like Data Acquisition, Action Performed, Data Transmission, Data Visualization, Data Processing, Dedicated App and Services. These activities are performed accordingly to related services. After taking data from Observation activities are performed on that data like data acquisition, Data processing, Data transmission, etc.

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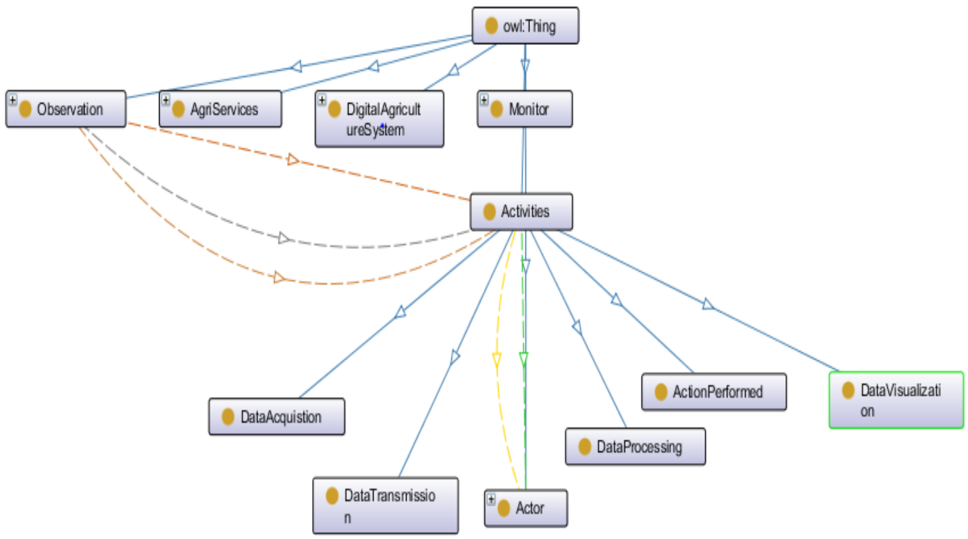

Fig. 2: Taxonomy & semantic relation of activities

Fig. 3 shows Observation class is a superb class that contains distinct subclasses like Moisture, Time, Temperature, Water Salt, Weather, Soil Temperature, Tomato Crop Image, Dew, Wind Velocity, Solenoid Value, Potassium, etc. On these observations, different activities are performed.

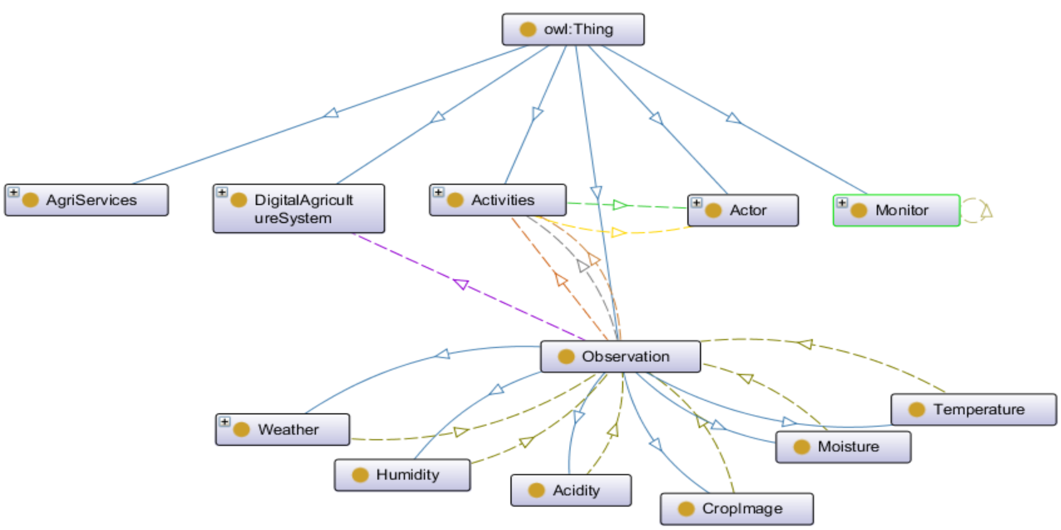

Fig. 3: Taxonomy & semantic relation of observation class

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4.8 Semantic Relations

The theoretical structures that truly outline ontology provide the important thing to system-process able data on the Semantic Web. Ontologies assist as meta-data schemas, serving a measured vocabulary of thoughts, each with unambiguously defined and machine-process able semantic relationships. By outlining common and shared concepts, ontologies help machines and people to interconnect concisely supporting meaning exchange, not only just structure. The semantic relations are represented through the predicates defined in two different concepts like services, systems, actors, or diseases.

Service is provided by Smart Agriculture Systems:

Service has Activities:

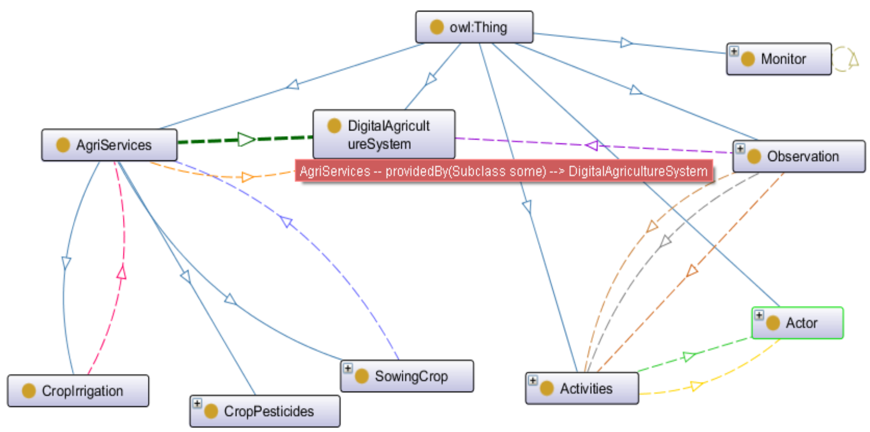

Fig. 4: Semantic relation of service and system

Activities performed by Actors:

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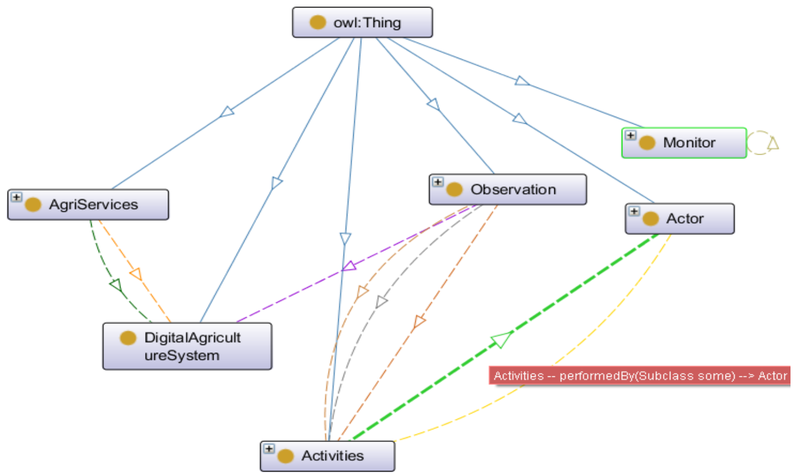

Fig. 5: Semantic relation between service and activities

Observations acquired by activities:

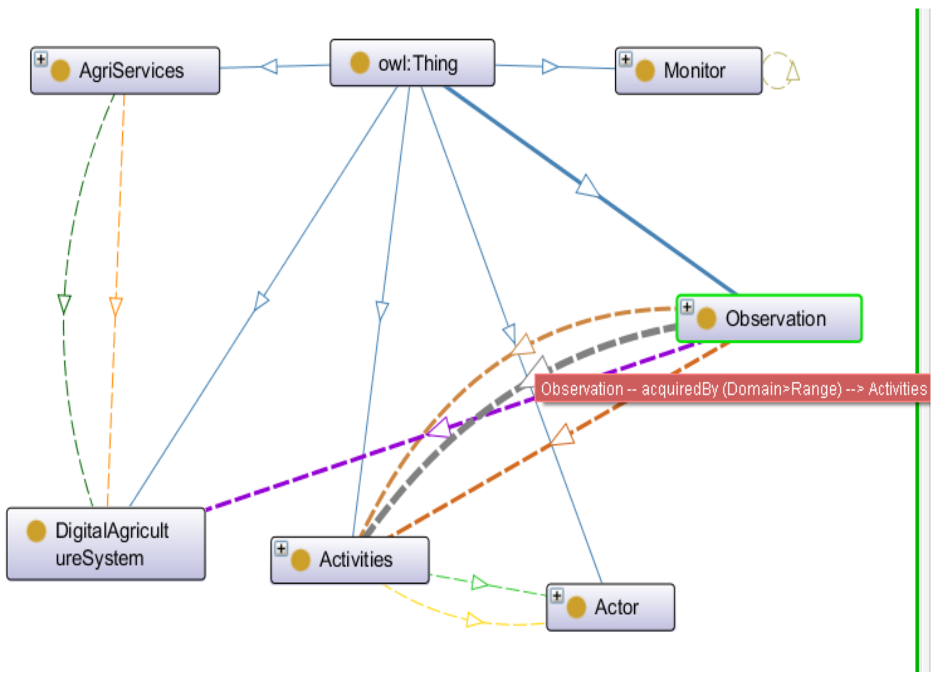

Fig. 6: Semantic relation of activities and actors

Observation transmitted by activities:

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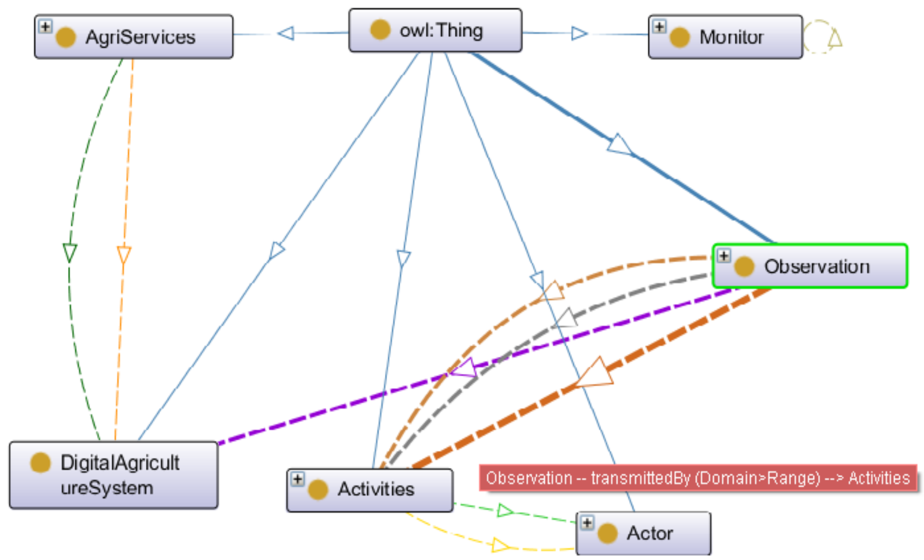

Fig. 7: Semantic relation of observation and activities

Observations processed by Activities:

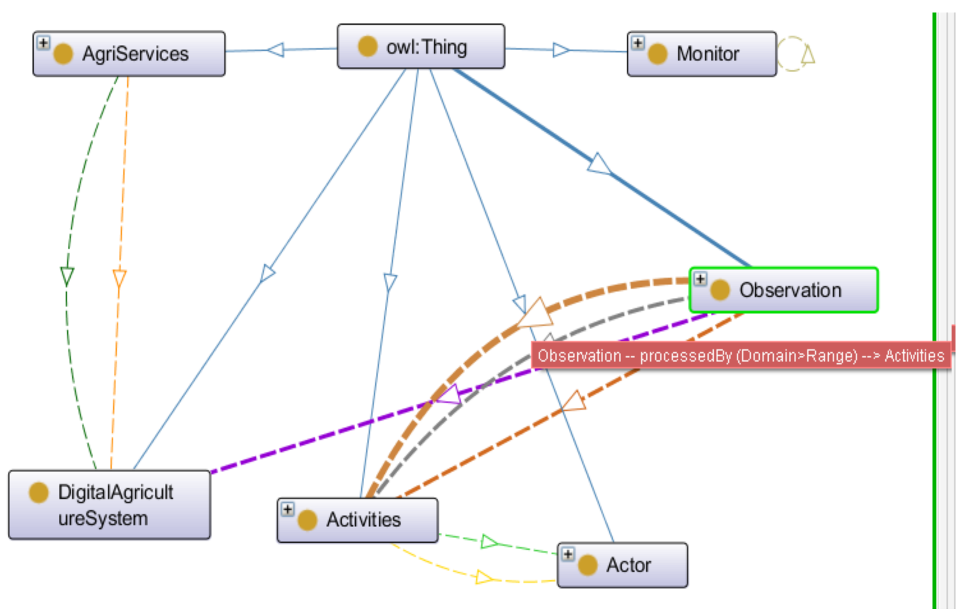

Fig. 8: Semantic relation of observation and activities

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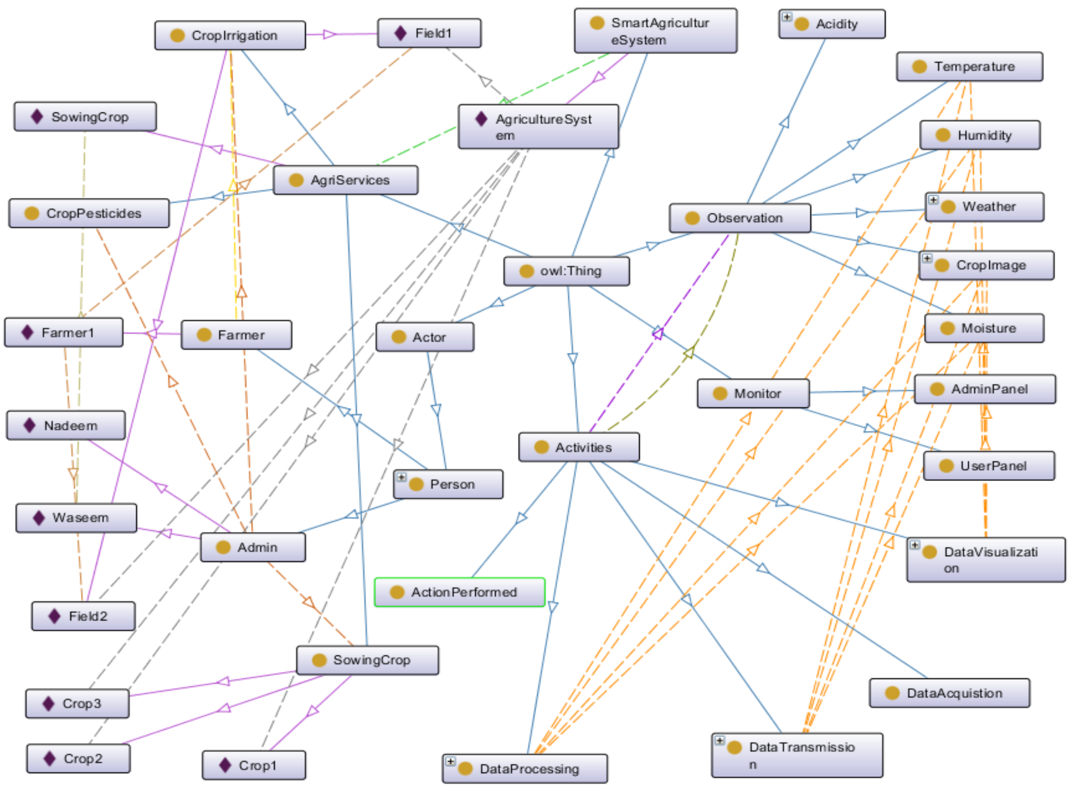

Fig. 9: Semantic relation of Smart Agriculture System

4.9 Constraints

Similar to the semantic own family individuals and viable connections of information, tool constraints also are defined. Those constraints characterize the necessity of some ideas being disjointed with now not allowed individuals of the circle of relatives. The one's constraints encompass the following restrictions of the system:

1) Temperature can-not be sensed by Moisture Sensor
2) Moisture cannot be sensed by Temperature Sensor
3) The farmer does not have Disease
4) Pest control spay is never finished.
5) Fields are not watered manually.

4.10 Experimentation & Results

In this section, we will show how we can evaluate an individual to view all of its interrelated object properties in better considerate different magnitudes of entities in process of

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software development. We will display all of the item residences in our ontology used and mentioned in this segment. Item property assertions can be represented by using special arc sorts in the complete record due to the selection of arc sorts with the aid of Protégé for a selected wide variety of individuals in a search. However, the legend in the parent will correspond to best the item residences described in this section consequently, the maximum of the item residences shown elsewhere won't be consistent with this myth due to the fact for them, and their legend is furnished someplace else with them or cited in their discussion. After we've finished the advent of ontology and represented its handiest then we may be interested in viewing all characters of man or woman object residences. In this, we can first show all of the item homes of smart cohesive agriculture devices people. Then we can flow immediately to showing all item homes of surrender person type people. For the reason that every derived man or woman within the location ontology represents the particular requirement of the meant software program software. Thinking about the truth that we're involved with taking photographs of the necessities specification in ontology, among other blessings of this approach is that we're capable of having a study of all viable individuals of the own family associated with an unmarried requirement or man or woman through that every man or woman. Such methods of item homes and information houses and linking with the main instructions offer insights into the inner, deeper, and the smallest possible info of each software program software requirement that might not be precise completely in paper-primarily based SRS. In a similar manner to creating object homes, records of residences also are created and maintained for instance, Moisture, Temperature analysis and humidity of the soil and lot others. Consequently, complete requirements ontology is crafted from precise software programs.

Now we can glide on to the validation of our capability query in our subsequent section and therefore the method we carried out for software program application requirements specification the use of ontology. Validation is of two sorts. One is reasoned-based which orders for inconsistencies. And the SPARQL queries will display us if we're without a doubt capable of outlining the software requirements.

4.11 SPARQL Based Validation

SPARQL is an SQL-like query language. For our validation, we use SPARQL for the answer to our questions. Queries answer our questions and prove the logic we built. The queries are written in the DL Query portion in Protégé.

Our first use case is verified from the query shown in Fig. 10 which is UC1_AgricultureSystem. This service belongs to the Smart Agriculture System class and this service is provided by UC1_AgricultureSystem. The result of the query shows that this service has different activities from a different system. UC1_AgricultureSystem has many activities like UC1_AgricultureSystem has Activity of Sowing Crop Provide Services to Crop1, Crop2 and Crop3: These services are used to acquire some Observations from different sensors like moisture, temperature, and humidity data of Soil.

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UC1_AgricultureSystem has one more Activity of Services Provided to Field1 and Field2. UC1_AgricultureSystem has Activity Crop Name in this activity data gathered from the above activities is uploaded to the cloud. The Next Activity is Crop Sowing Date in this activity we analyze data.

Fig. 10: SPARQL query of use case 1

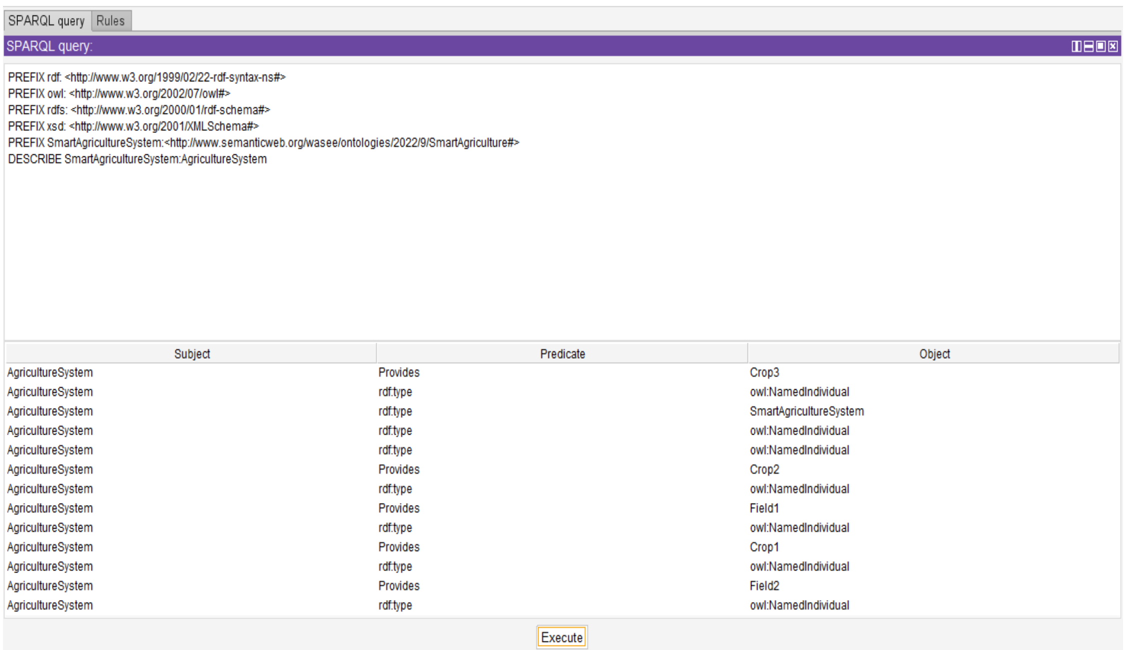

Fig. 11, and 12 shows the query in which we describe the 2nd Use case name as UC2_SowingCropService provided by UC2_AgriServicesSystem. This service has a list of activities like UC_ Sowing Crop Service has an activity of Crop Name: this activity acquires data on Moisture, Temperature, and Humidity. UC_ Sowing Crop Services has the activity of Crop Sowing Date: acquired from the above activities is transmitted to the cloud. UC_ Sowing Crop Services has activities for Crop Age: the age of the crop can be measured by the above activities like Crop Name and Crop Sowing Date. UC2_SowingCropSystem has activities of manage of crops and Prediction of Forecast. UC_ Sowing Crop System has activities of Admin that can control Smart Agriculture System.

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Fig. 11: SPARQL query of Admin

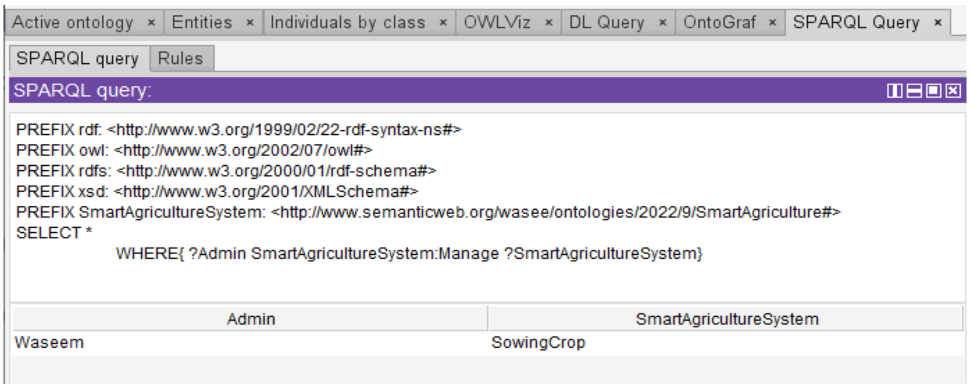

Fig. 12: SPARQL query of use case 2

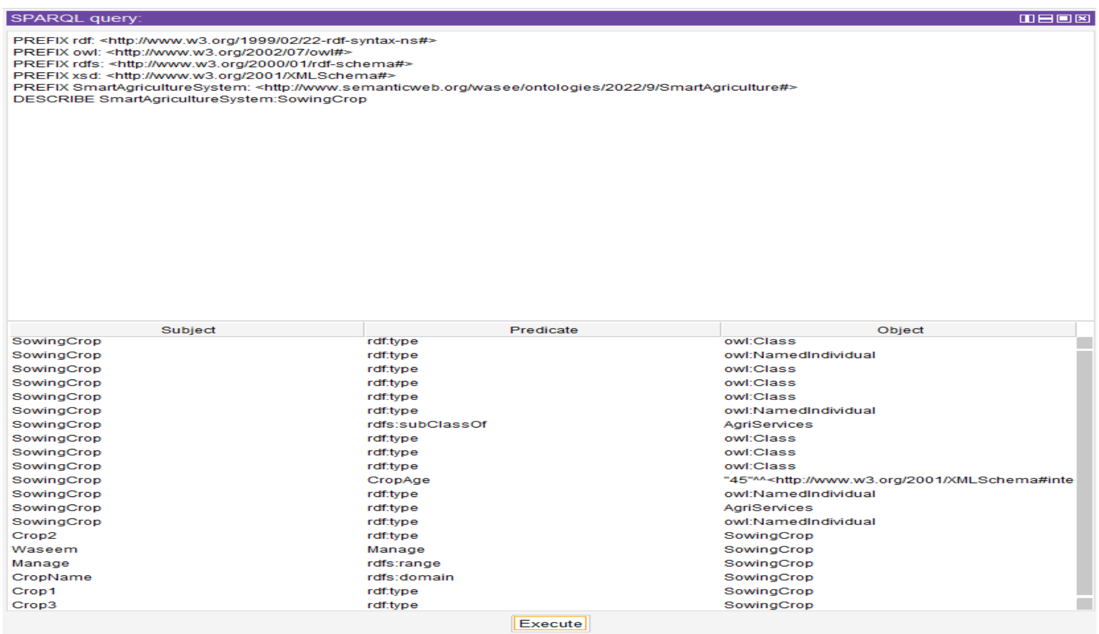

Fig. 13 the query showing UC_ Crop Irrigation provided by UC3_AgriServices. UC_Crop Irrigation Service has an activity for data acquisition like Moisture sensing, humidity sensing, and temperature sensing. UC_Crop Irrigation Service has activities wireless data transmission, the command to the robot, Robotic service, Breaking Obstacle, Distributed Seed, Field display and User receives output from the robot via the cloud, for better management of the system.

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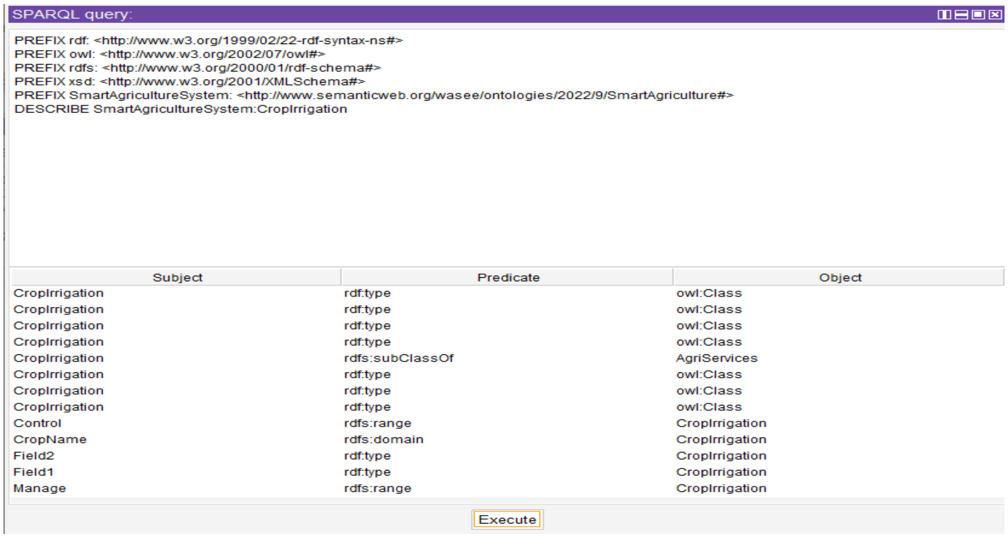
Fig. 13: SPARQL query of use case 3



SPARQL query:

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX SmartAgricultureSystem: <http://www.semanticweb.org/wasee/ontologies/2022/9/SmartAgriculture#>
DESCRIBE SmartAgricultureSystem:CropIrrigation
```

Subject	Predicate	Object
CropIrrigation	rdf:type	owl:Class
CropIrrigation	rdf:type	owl:Class
CropIrrigation	rdf:type	owl:Class
CropIrrigation	rdf:type	owl:Class
CropIrrigation	rdfs:subClassOf	AgriServices
CropIrrigation	rdf:type	owl:Class
CropIrrigation	rdf:type	owl:Class
CropIrrigation	rdf:type	owl:Class
Control	rdfs:range	CropIrrigation
CropName	rdfs:domain	CropIrrigation
Field2	rdf:type	CropIrrigation
Field1	rdf:type	CropIrrigation
Manage	rdfs:range	CropIrrigation

Execute

4.12 Reasoner Based Validation

Protégé oneself isn't a professional system however its miles a device that supports researchers to build ontologies to help expert structures. And for the reason of validating the ontologies, it presents the 1/3-birthday party reasoners like FaCT++, Hermit, and others. Reasoners offer a justification of the ontologies via information discovery and by locating and detecting contradictions or inconsistencies. These reasoners are based on mathematical models. They provide reasonable deductions based on implications and rules well-defined that are defined in description common sense. They either use backward chaining or forward chaining to carry out inference. We've got used Hermit Reasoner 1.3.8.413 in our studies. It's far based upon hyper tableau calculus and affords the reason for OWL-based ontology documents. Two forms of validation exist for our technique. One is the Reasoner-based justification that exams for the information discovery and reliability of the classes, sub-instructions, and of the times. The second one parallels the SPARQL validation as a good way to show that the necessities are defined and may be recovered consequently using those queries. For the primary one, i.e., reasoner-primarily based validation, we can take a few examples from our ontology to inject a few inconsistencies within the definition to test whether or not or now not Reasoner identifies that or now not.

5. CONCLUSION

Distinct smart agriculture systems are considered which are giving a numeral of smart services of agriculture. Those services are collected from different activities. Those activities perform precise tasks under the precise service. As an example, the automated irrigation system is provided by the automated irrigation system. Automated irrigation has the activity of moisture sensing for acquiring data, an activity of moisture analysis then has activity of water flow for field and soil.

Those systems of distinct agriculture applications are characterized by 5 types

1) Disease based on IoT applications in agriculture
2) Monitoring based on IoT applications in agriculture
3) Irrigation IoT agriculture application
4) Harvesting IoT agriculture application
5) Robotics IoT agriculture application.

A number of those services paintings in an isolated manner to entertain purchasers in specific problems. Consistent agriculture programs are lacking. Each of those packages works on its float and structure. This painting includes locating positive commonalities and differences in the ones stand my applications of IoT agriculture. Responsible for those differences and commonalities an integrated shape of different applications of IoT agriculture can be evolved. This cohesive shape will offer a selection of agriculture programs to the clients underneath one umbrella.

To reap this purpose theoretically, we've got implemented the ontology engineering method. We have properly described 21 structures on the ontology presenting the offerings and sports of each provider for my part. As quickly as the ontology for every system is well-defined, an incorporated ontology for a consistent smart fitness machine is intended based on principles of ontology engineering. This consistent ontology is then tested with the aid of defining one-of-a-type use cases. One-of-a-kind offerings of different smart agriculture gadgets are applied to make certain the cohesiveness of this machine. We've no longer worked at the physical infrastructure of all of the structures and it is going to be a vital destiny path to paintings the physical infrastructure of various agriculture systems in a mixture with the formal definition of the structures shown by using manner of the ontology engineering.

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CONFLICTS OF INTEREST

All authors show no conflict regarding results, theme, discussion and conclusion.

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