Agrosensor- A Smart Service Based Model for Crop Monitoring using Wireless Sensor Network And Vertical Farm Ontology

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Abstract

Application of the technology systems is growing in various fields and agriculture is not an exception. Agriculture is also reaping the benefits of technological innovation which helps in quantitative and qualitative food production. Vertical farm, one of the agricultural practices, is considered to be the future of agriculture with the rate of population migrating into urban areas. Ubiquitous computing in agriculture is emerging remarkably in this fast processing pervasive environment, owing to wireless sensor network (WSN). Building a context aware system for the vertical farm is complex without the semantic interoperability between the Internet of things (IOT). In this paper, we propose a vertical farm ontology (VFO), an OWL based ontology model which helps in more understanding of the relationship between the domain factors.
Keywords: Wireless Sensor NetworksPrecision agricultureCrop monitoring, Vertical Farm Ontology , OWL

I. Introduction

Agriculture is a fundamental human activity and also inseparable from human life. India being an agricultural country needs some becoming increasingly concentrated on monitoring and innovation in the field of agriculture. This can be achieved through modern technologies which assist computing, communication and control within devices. Wireless sensor networks (WSN) have become a backbone for modern precision agriculture monitoring. Recently, ubiquitous computing technology has been flourishing widely in agricultural field [1]. Some of the progresses in this area include automation process on the u-agriculture and smart services to control the activities. Such advancement in the ubiquitous computing encourages the agricultural researchers and even farmers to apply automation in the process.

Agriculture technique takes different form of advancement through centuries according to the lifestyle of the people. It is also estimated that 80% of the world population is expected to live in the urban areas by 2050. Also the rapid increase in population may be a threat to farmland

Vertical farming is a fully automated system without any human intervention, which is also considered as the new agricultural evolution. To serve as ubiquitous computing infrastructure, it needs to be aware of the context and provide appropriate data and services. Considering the situation of the large-scale farming system like vertical farming in real time, the system is independent of each other. Context-aware service is being realized between the system by using the set of common ontology that supports the communication and the relationship. In this paper, we propose an OWL based ontology model for the vertical farming environment. The suggested model concentrates more on the controlling and monitoring services of the environment. An upper-class ontology model is designed by identifying the important concepts in the vertical farm environment that focuses majorly on the services.

II. Background study

This section represents the background work of the proposed ontology. First, we have discussed about the vertical farming which has both technological and expert engineering that makes a perfect combination for the ubiquitous computing environment. Next, OWL based ontology model is briefly discussed which is considered to be well suited for the development of semantic interoperability and finally the related works that helped in the development of context model.

A. Ubiquitous in Vertical Farming Overview:

Vertical farming is considered as one of the modern agricultural technique in the future urban area, in where most of the people are expected to live. Agricultural farming took different forms over the millennium since the invention of agriculture in stone ages to which it finally reached the vertical farming. And it may take different dimensions in the future, as the technologies are evolving nonstop. Computer technology during the last decade has numerous changes in the many fields. But today, the popular devices as laptops, tablets and Smartphone are owned and accessed by all ages.

B. OWL:

OWL is the ontology representation language which helps in the process of context information instead of presenting the information. Basic OWL ontology concept include classes representing domain concepts, properties of classes, and individual instances specified from classes. Ontology is referred to as the shared understanding of some domains, which is often conceived as a set of entities, relations, functions, axioms, and instances. The reason for choosing OWL is to realize our context model and define our context model as follows. It is much expressive compared to other ontology languages. It has the capability of supporting semantic interoperability to exchange and share context knowledge between different systems. The context can be exchanged and understood between the systems in various domains.

III. VERTICAL FARM ONTOLOGY

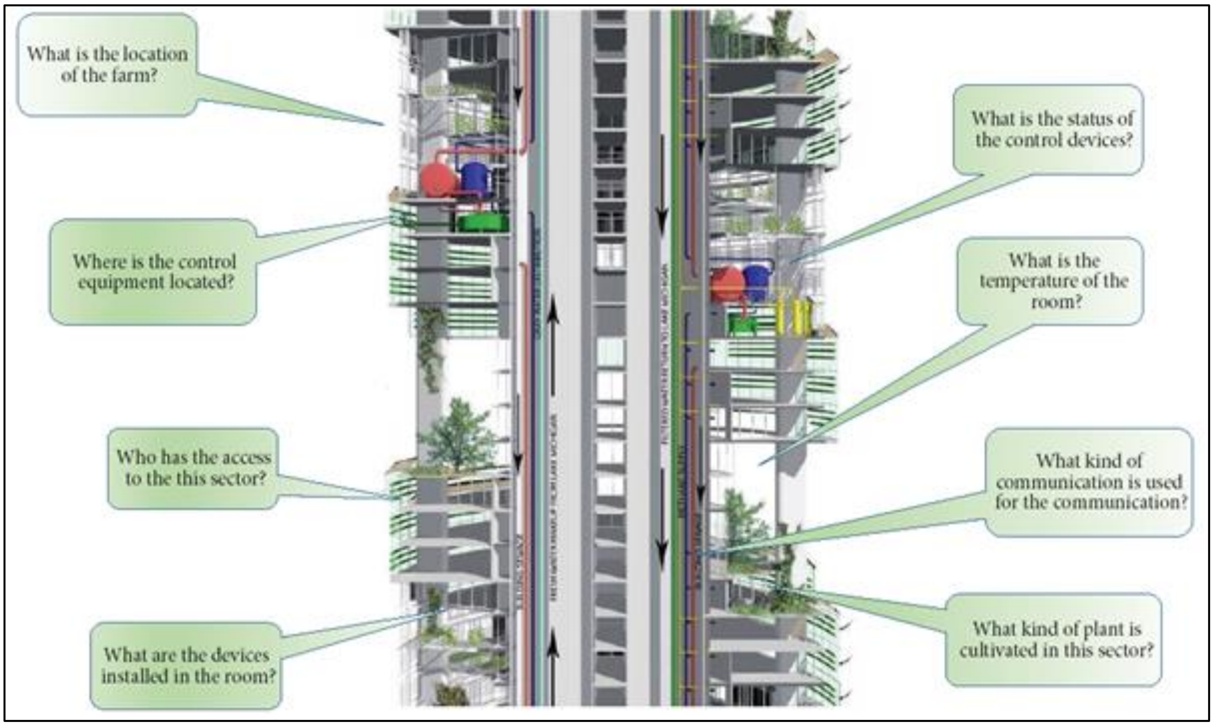


Fig. 1: Vertical Farm Environment

Vertical Farm Ontology Vertical farm ontology (VFO) is designed focusing on the service based vertical farm without any human intervention. The ontology model is designed using OWL based on RDF andimplementedinProt´eg´e4.2. In this fast evolving world of technologies, the model needs to be developed considering the future evolution. In our paper, we built a domain-specific model which is extensible. The first step handled in designing the model is by identifying the concepts of the environment. The concepts are physical or conceptual objects in the domain.

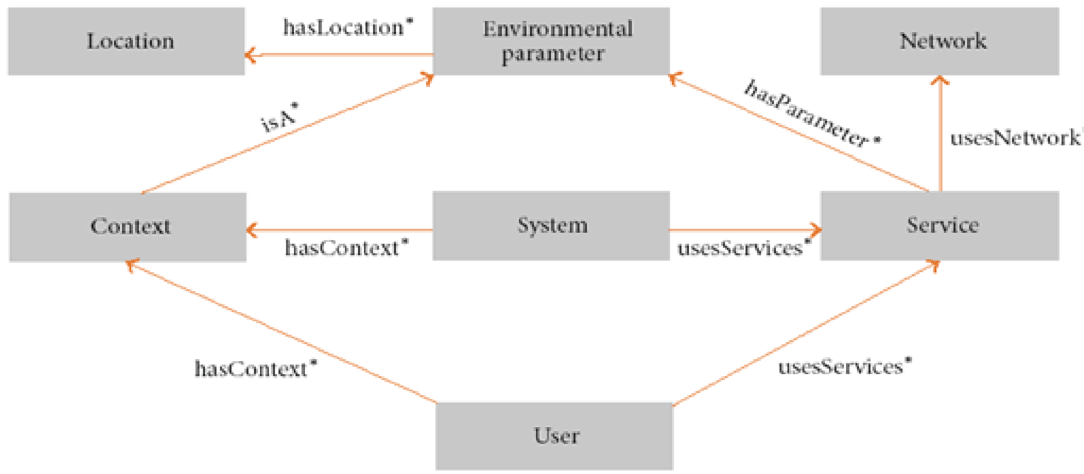


FIGURE 2: Upper-level model of VFO.

Fig. 2: Upper- Level Model of VFO

A. Context Concept:

Context is an often noted notion in the ubiquitous environment. Context awareness adds much to the dynamicity of the systems as their behavior varies depending on circumstances. Context aware systems are well known for their adaptability to the current context without any human intervention. The context information is mostly derived from sensors through a proper channel wireless sensor network. In VFO model, the context holds the set environmental parameter of a single location with a scheduled interval time. Also, an instance of the context class can be associated with a user in a time. The environmental parameter such as temperature, humidity, CO_2, and light as a context element, associated with appropriate control equipment, can range from specific sector, floor, or building. Thus, the location is interrelated with the context related concepts.

B. User Concept:

Vertical farm environment is entirely automated environment with intelligent services such as monitoring and controlling services. The user concept makes use of such smart services. The context information obtained from time to time are monitored by the User. Although the control services are automatic, in case of emergency or necessity, the user can manually access the control services. Figure3 depicts the user concept on VFO. In the vertical farm environment, the user can also be represented as person who has access to the services such as administrator, researcher, and system manager.

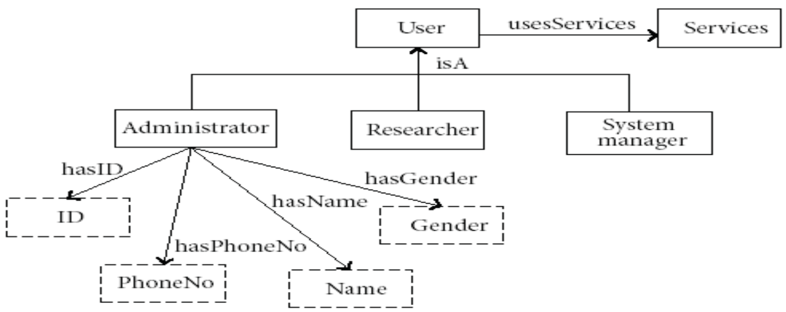


Fig. 3: User Concept

C. Environmental Parameter Concept:

For a healthy crop growth, an optimal environmental condition is needed. The environmental condition information is very important to control the most appropriate devices. The parameters are useful to express the functionality of both devices and services. Internet of things acts as the bridge between the physical objects such as place, person, or device which is known as "things". IOT consist of set of heterogeneous set of devices which are uniformly discoverable, closely integrated with the Internet infrastructure and service, regardless of the devices(RFID, sensor, or embedded devices).Presently, IOT is considered as the ideal emerging technology to influence the domain by providing new evolving data and the required computational resources for creating revolutionary apps.

In VFO, the autonomous services are achieved through the sensors and actuators. Sensors are directly related to the environmental parameter, from which the values are sent to the server via Wireless communication protocol (Zigbee). The actuators are in directly linked to the parameter. Actuator controls the control equipment such as air conditioner, heater, window, humidifier, and light. The result in the variation of environmental parameter affects the actuator to maintain the optimal condition through controlling the equipment. As we mention environmental parameter, it includes both the indoor and outdoor environmental conditions. Although the indoor factor plays major role, the outdoor factors are not to be omitted. According to the daily weather condition, the environment parameter needs to be manipulated and processed. Factors such as season, daily weather, and day night atmospheric differences are also taken into account for the more appropriate growth condition. As for the indoor parameter, the atmospheric condition and the soil condition (can also referred as soil nutrient) are given major concern. Figure4 represents the overview of the environmental parameter concept.

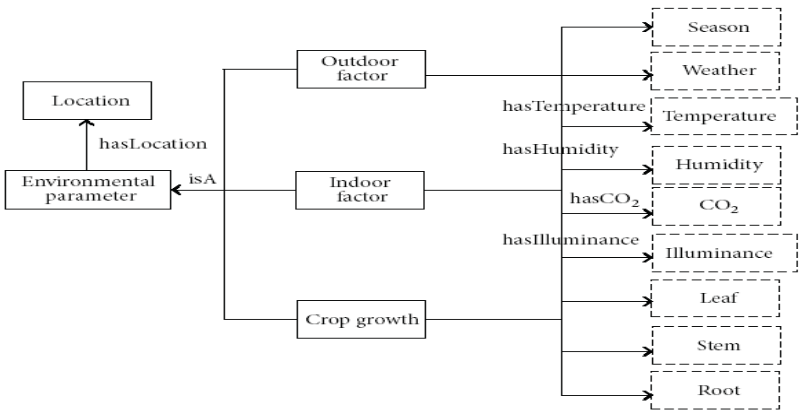


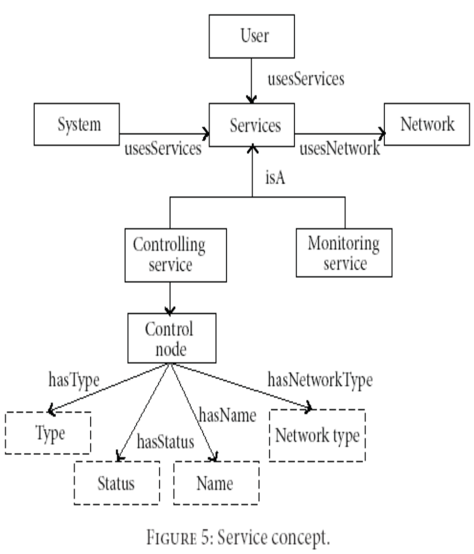
Fig. 4: Environment Parameter Concept

D. Service Concept:

VFO model is designed focusing on the service based environment. The two main services that revolve around the vertical farm automation monitoring and controlling services. The controlling service helps the control equipment to be controlled through the actuator node.Figure5showstheserviceconceptanditsrelationwith the other concepts.

E. Network Concept:

In this pervasive environment, the communication is most important factor that cannot be ignored. Not to mention, the WSN is overwhelming all over the world. The sensor uses the wireless communication protocol to deliver the parameter to the server. The wireless technology used in the vertical farm environment is Zigbee technique, which uses the frequency of 2.4GHz. The programmable logic controller(PLC) which is the wired communication protocol helps in controlling the control equipment.Figure6depictsthenetworkconceptusedinthe VFO model.



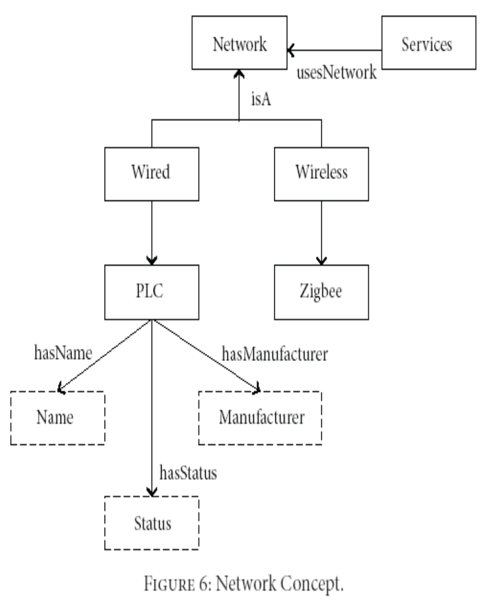


Fig. 5: Service Concept & Fig. 6: Network Concept

F. Location Concept:

The main concept of vertical farm is to produce maximum amount of crop production with optimal condition, even in the middle of the urban area. Hence the skyscrapers have much number of floors with variety of crops in it. As each crop is distinct, each needs a different environmental condition. Therefore, keeping track of the crop and its location is much more important. The environmental parameter of the corresponding sector should be maintained properly so as to control the equipment of the aboverequiredsector.Figure7showstheoverlookoflocation concept.

G. System Concept:

The system concept is commonly divided into devices and control Equipment. The concept is classified on the basis of their services. The devices that are categorized in the VFO model are computer and the so called smart devices which are sensors and actuators. As discussed in the environmental parameter concept, the sensor returns certain parameters and actuator performs the control actions. The sensed data from the each sensor are transferred to the sink node through the wireless sensor network. The control equipment are air conditioner, humidifier, CO2 generator, light, irrigator, and window. Figure8 shows the underlying relationship of the system concept.

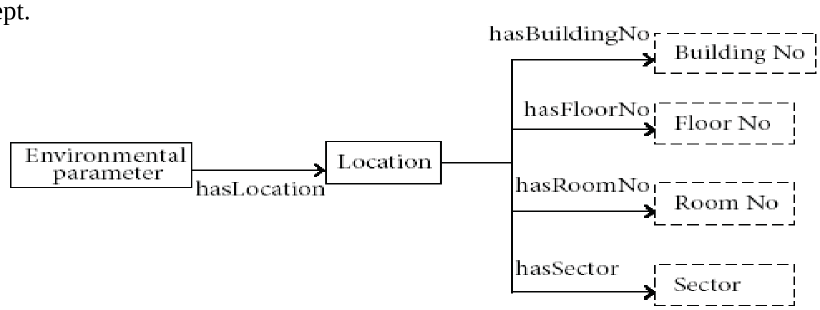


FIGURE 7: Location concept.

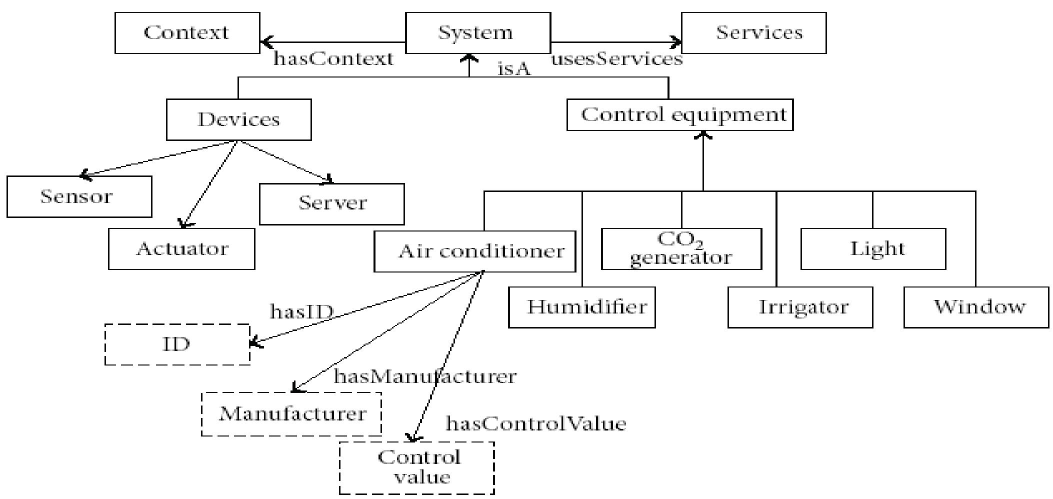


FIGURE 8: System Concept.

Fig. 7: Location Concept & Fig. 8: System Concept

IV. EXPERIMENT AND RESULTS

In this section, we present the implemented part of our VFO model. In our model, we have domain named class context where all the context information is gathered. In vertical farm environment, the set of environmental parameter and the location of the particular factor is considered to be more important. Figure9 shows the high level context information and the relationship of the particular scenario.

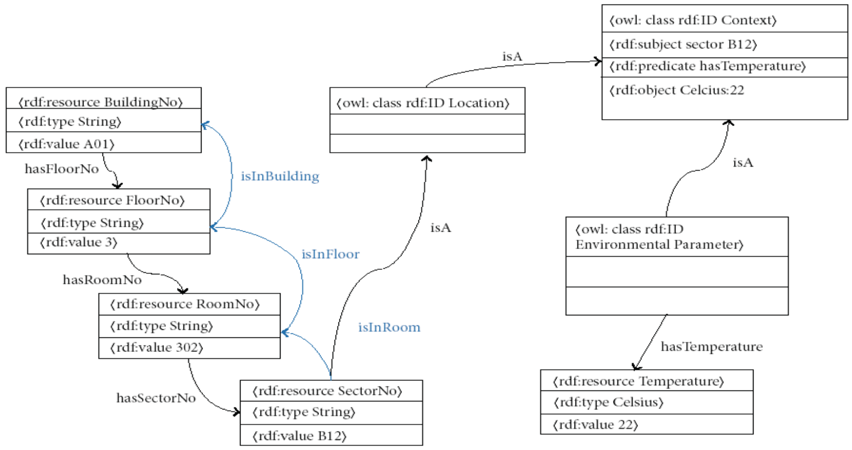


FIGURE 9: High level context information.

Fig. 9: High Level Context Information

It indicates that the temperature in the sector B12 is 22 degree Celsius. As we know the OWL basedontologyisinterrelated.ThelocationofthesectorB12 is in Building no. A01, Floor no. 3, and Room no. 302. The relationships between the type of crop, location of the crop, and the temperature of the environment are all well defined to form an appropriate context. Various devices such as sensor, actuator, and control equipment were installed in the vertical farming prototype to examinethemonitoringandcontrolservices.Figure10shows GUI application of the monitoring service where the context information is gathered and displayed. The sensed data are updated in the monitoring client on a regular time interval. Both the time-based and event-based readings are graphed for the comparison. The readings are taken from a single port ID, in other words, from a particular sector of the vertical farm. Each sector has different crop, which is mapped well to compare and monitor the crop's optimal growth environment.

A detailed middleware response of sensed data is presented in Figure11. As the wireless sensor network has number of sensors, each node of sensor with a unique node value sends the sensed value to the sink, where the mapped devices are found. The entire controlling service is performed automatically without any human intervention and the crops are monitored effectively. The process is based on the following steps.

1) The sensed data from the sensor such as temperature sensor, humidity sensor or light sensor are sent to the sink (wireless sensor node) through the wireless communication protocol.
2) The sensed values are stored in the server database.
3) The values are then sent to the actuator through the wired communication protocol.
4) PLC decides on the action after analyzing the values for the corresponding crop.
5) The control action is performed on the corresponding control equipment to maintain the optimal condition in the environment.

FIGURE 10: Vertical farm monitoring client.

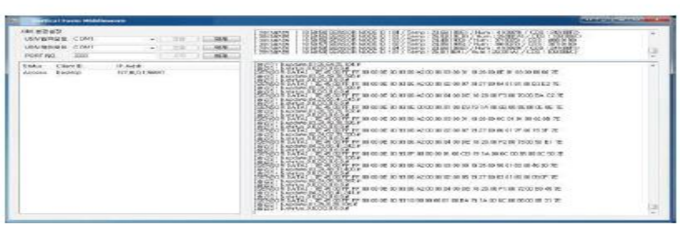


FIGURE 11: Vertical farm middleware.

Fig. 10: Vertical Farm Monitoring Client & Vertical Farm Middleware

V. CONCLUSION AND FUTURE WORKS

Recently, researchers are willing to make computing services smarter . In this paper, we presented vertical farm ontology(VFO) for the future agriculture evolutionary environment. The suggested context model uses OWL based ontology to define common understanding and relationship between the system and services. The upper level ontology is analyzed and derived with the set of concepts such as location, user, system, context, environmental parameter, user, and Network. The basic concepts proposed can be reused and extended for the agricultural based smart environments. With the gained experience from the prototype implementation, our VFO model and the concept will be more refined according to the domain-specific environment. By doing this, it may serve very helpful to develop agricultural service automation and smart service application in the agricultural environment.

We can improvise the vertical farm technology by deploying the sensor motes which have several external sensors namely leaf wetness, soil moisture, soil pH, atmospheric pressure sensors attached to it. Based on the value of soil moisture sensor the mote triggers the water sprinkler during the period of water scarcity. Once the field is sprinkled with adequate water, the water sprinkler is switched off. Hereby water can be conserved. Also the value of soil pH sensor is sent to the base station and in turn base station intimates the farmer about the soil pH via SMS using GSM modem. Obtaining the soil pH value in his mobile the farmer selects the necessary fertilizer and crop for his next season. Hereby the amount of fertilizer can be reduced.

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