# Prototype System For Vertical Farming : A Review on utilization of IoT in Vertical Farming

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## I. Abstract

This article critiques recent researches on IoT applications that are applying in Vertical farming. The underlying review was developed following a few articles published between 2015 and 2018 and all of them are discussing a prototype system designed for vertical farming with the adoption of IoT to achieve the challenges arising in indoor farming. Selected papers were discussed under four main layers respectively Sensor Layer, Controller Layer, Actuator Layer, and Communication Layer. Discussion of this review can be useful to improve the use of IoT in intelligent farming.

## II. Introduction

The pressure in the field of agriculture is increasing as a result of the decrease in cultivable spaces due to urbanization and ineffective crop plantation. Human take away space from farmland in order to provide space for housing and construction. However, farmlands play a major role in supplying sustainable food all around the world. As a result, the farmer started moving into vertical farming [1], [2] .

Vertical farming is the practice of planting plants in vertically stacked layers providing controlled environment factors inside a high-tech house that normally reside in the city center [3] . Not like in traditional farming inside vertical farm crops are grown under controlled circumstances. Therefore, crops get rid of facing extreme weather conditions like droughts and floods [4].

In order to provide controlled surrounding farmers need a way of monitoring the farming conditions by grabbing environment data and analyzing them, But limited knowledge of data management has become the main threat for farmers in investigating the plant conditions [1] . Therefore, Vertical farming monitoring system with the utilization of the Internet of Things (IoT) has introduced to collect and manage data in a convenient way. With the help of technologies using in IoT, farmers are able to form a reliable environment in farming activities. The objective of this article is to review the utilization of IoT in vertical farming in terms of four main layers respectively sensor layer, Controller layer, actuator layer, and communication layer.

## III. Background

During this review, A prototype system for vertical farming using technologies in the Internet of Things will be discussed by following few articles which have mentioned in the bellow reference section. Fundamentally this paper reviews this system by considering room temperature, soil condition, watering system, and illumination. For the simplicity information taken by research papers reviews in a layered architectural way. Layer one involves the sensors placed in the structure of vertical farming which used to collect desired environment data. In this layer sensors like temperature, soil moisture, light intensity, water level measuring sensors have used. All the data gathered by sensors will be sent to the second layer called the Controller layer. In this layer, appropriate actions will be taken once the sensor data received. In most research papers Arduino UNO has used to do the task of the controller layer. However, work by Yap Shein et al have used a BeagleBone Black (BBB) to coordinate with sensors. Next layer is the actuator layer which is going to manipulate the physical environment according to the input received from the controller layer. Communication layer is the last layer. In this layer, All the collected sensor data will be uploaded to the cloud with the network access supported by a wireless module. In the cloud platform, all the sensor data will be stored, analyzed and give the summarization about the current state of the system. The user will allow monitoring, analyzing and changing of data in the system through a web service.

## IV. Descussion

In this section selected research papers are reviewed under four layers respectively Sensor layer, Controller Layer, actuator Layer, and Communication Layer.

### *A. 4.1 Sensor Layer*

Utilizing various sensors farmers are able to monitor the indices of the indoor environment and collect desired data realtimely [3].

*4.1.a Soil Moisture Sensor*

From the reviewing papers they have used soil moisture sensors in their prototype system. This type of sensors are useful to measure the volumetric water level in the soil. It is consists of two probes, from one it will pass current to the soil while taking the reading of the moisture level from the other probe. Another advantage is that it contains both digital and analog pins, therefore users have multiple choices about the type of the output signals and able to tune the sensitivity using the variable resistor [3], [2], [1], [4] .

*4.1.b Water Level Sensor*

Muhammad Ikhwan et al have used a water level sensor to measure the water level in the tank. This sensor has placed at the bottom of the tank so that it can detect when the water in the tank reached the lowest level [3] .

*4.1.c Temperature Sensor*

With the aid of this sensor, we can measure the surrounding temperature. Yap Shein chin et al have used LM35 temperature sensor which has a tolerance of ±0.25 degree Celsius in room temperature. Using this sensor we are able to measure temperature from -55 to 150-degree Celsius [4] . However, Sanket Salvi et al used DHT11 [2] and DHT22 have used by Wanda Vernandhes et al [5] to measure the surrounding temperature. Not only Temperature but also Humidity could be measured by using the DHT sensor.

*4.1.d Light Intensity Sensor*

From the resistance of LDR-photoresistor light intensity will be detected and can adjust the sensitivity by adjusting the variable resistor. This sensor comes with digital and analog pins, therefore users have multiple choices of the type of output signal. Sanket Salvi et al [2] and Wanda Vernandhes et al [5] have used this sensor to detect the Light intensity.

### *B. 4.2 Controller Layer*

Manipulating all the data received from the sensor layer and sending Appropriate signals to actuators while communicating with the communication layer are the tasks occurring in this layer. In most of the research papers, they have used ArduinoMicrocontroller as the controller. The relevant program logic has written in the Arduino IDE and uploaded into the Arduino platform in order to control the system [3] . For each sensor, a specific threshold value has defined and if the particular sensor reached the relevant threshold value controller will trigger the relevant actuator [2] .

Comparatively Cheaper, Cross platform(Can run on Linux, Macintosh, OSX, Windows ), Easy and flexible for beginners, extensible and open source software, extensible and open source hardware are some advantages which we can list under Arduino Microcontroller [2] . However, Jun Yang et al have used a processing chip (STM32-ARM) as the controller [1] . Moreover, Yap Shein Chin et al have used BeagleBone-Black microcontroller which is more powerful than Arduino and the STM32-ARM processing chip.

### *C. 4.3 Actuator Layer*

Actuator is a mechanism for turning energy into motion. Once an actuator receives a control signal from the controller layer it will trigger and convert the signal's energy into mechanical motion. Selected research papers have used UV LED light, water pump and water valve as actuators in developing their Prototype system.

*4.3.a UV LED light*

Almost every research paper except for the research conducted by Muhammad Ikhwan et al have used UV LED light as an actuator. In vertical farming, UV LED light promotes the process of photosynthesis of plants, hence it is utilized as a substitution for the sun. Once the LDR sensor detects the lower or higher values than the initially defined threshold values it will trigger the UV LED light through the controller layer [2], [1], [4], [5] . Furthermore, the Research conducted by Wanda Vernandhes et al has used both red and blue LED lights. According to them blue light is more effective in fast flowering and quicker fruit development [5] .

*4.3.b Water Pump and Water Valve*

The research conducted by Muhammad Ikhwan et al has used a water pump and water valve as actuators in their prototype system. Once the water level sensor detects the lower water level it will trigger the water pump to release water towards the tank until the water level reached the relevant threshold value. Same as that, once the soil moisture sensor detects the low amount of volumetric water in the soil it will trigger the water valve to channel to the designated plants [3]

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### *D. 4.4 Communication Layer*

This layer considers the communication between the prototype system and the user has taken into consideration. In the research conducted by Muhammad Ikhwan et al, User controls the system through the web browser on a mobile phone or computer. They have used an ethernet Shield to connect the hardware setup with the web browser by adopting the network connection through a router. All the data received from the system kept by the database of the web server. One of the drawbacks in this system is the user has to control the system manually by pressing the on or off the water valve control button through the web browser [3] . Moreover, In the research conducted by Wanda Vernandhes, the Ethernet Arduino connects with a server through a router and the user would be able to operate the system remotely via the web server [5] . However, the research conducted by Jun Yang et al has used a better methodology in the communication layer. In their system using TCP Socket Protocol all the sensed data gathered by sensor layer uploads to the cloud platform and stores them in MySQL database real-timely and have used HTTP protocol and standard JSON for data transmission between the user terminal and the cloud [1] . Yap Shein Chin et al has used a Sierra wireless module to provide a LTE 4G network in order to upload data in the thingspeak cloud platform. A Global Position System (GPS) has placed inside this wireless module to locate equipment in a proper way. All the received data have stored and taken into a statistic analytical process and have displayed using graphs, charts, and tables for the simplicity of the user [4] . HC-05 short-range wireless communication Bluetooth module has used by Sanket Salvi et al to connect the sensor layer and controller layer instead of directly connect those two layers by using wires. In order to upload data to the cloud platform, an Ethernet shield and a wifi shield have used by them to get the connection to the internet. Same as Yap Shein Chin et al thingspeak cloud platform has used by them [4] .

## V. RESULT

This survey systematically reviewed the use of IoT technologies in vertical farming under four main layers with respect to a prototype system. The discussed IoT based prototype system in the majority of reviewed papers have automated and able to monitor and control the vertical farm even without the presence of farmers. But the work by Muhammad Ikhwan et al let the farmer manually control the system which is a drawback when comparing to the other prototype systems [3] . However, the analysis process provided on raw data taken from wireless sensors let the farmers become more educated about growing crops by managing the limited resources and take appropriate decisions at the right time to reach for a rich harvest. Ensuring the increase of quality and productivity, faster reactions for unpredictable events, more transparency to the customer, real-time decision making without depending on predictions are some benefits which made farmers motivate on moving into vertical farming integrated with IoT technologies from traditional farming in order to improve best practice in the farming industry.

## REFERENCES

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