PROTOTYPE OF SMART HYDROPONIC SYSTEM AS PRACTICAL ACTIVITY SUPPORT BASED ON INTERNET OF THINGS (A CASE STUDY AT SMK PERTANIAN PEMBANGUNAN NEGERI LEMBANG)

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ABSTRACT

Smart Hydroponic is a design prototype of hydroponics system that are equipped with computing systems data and information technology which can respond to meet the requirement of practical teacher and students in conducting practice hydroponcs. The construction of this system targeted to monitor the condition of the nutrition of plant in each group practical hydroponics; can give efficiency to the teacher and the students to perform the maintenance remotely against the elements of the plant; as well as logging activity report becomes easier. Development of smart systems hydroponic uses Raspberry Pi as mini PC and Arduino microcontroller as well as DFR0300 as measuring the value of Electro Conductivity (EC), the sensor is SEN0161 as a measure of the value of the Potential of Hydrogen (pH), and sensors As the DS18B20 temperature measuring. as well as applications-based websites using Angular framework 5 as interface for teachers teaching and students. Stage work began by building a Web Service Developed API with JSON-based data exchange. The function of this web service as a liaison with the database that serves the request and response of each insert or activities as needed. Software development and models using model prototype. The results of the research showed that by implementing a concept of Internet Of things as practical activities supporting hydroponics can help and satisfy the needs of constrained problems on practical hydroponics in SMK Pertanian Pembangunan Negeri Lembang.

Keyword: Internet of Things, hydroponics, Raspberry Pi, Arduino, RESTful API

1. INTRODUCTION

SMK Pertanian Pembangunan Negeri Lembang located in JL. Tangkuban Perahu Km 3 Cilumber Lembang, Bandung Regency, where CMS has a course of agribusiness food crop Horticulture expertise (ATPH). In the commodity program studied namely planting crops horticulture crops like vegetables, ornamental plants, medicinal plants, and fruits. One of the standards of competence of graduates that the majors controlled mandatory is able to care for and maintain horticultural plants with a hydroponics system. standard of competence cultivating hydroponic plants are basic competence by making use of the method of culturing water as a medium for planting. the hydroponics are generally stored on land as greenhouse processing, aiming to keep it from any environmental conditions. in the process of learning practical hydroponic cultivation begins since the class XI in which the lab course learn about basic hydroponics and resumed class XII for the practical entirety of knowledge, especially in the hydroponics plant maintenance Indicator process of basic competence in the maintenance of hydroponic class XII students required i.e. capable of maintaining the plant and manage the harvest. According to his Mother Matrieka, SP. as the teacher of practical teaching activities to explain that farm in hydroponic methods students are required to take care of and nurture their plants for planting, in the process of hydroponics require maintenance attention a fairly regularly in this method needs required intake of plant elements depending on what we give, because each plant can only grow at the levels of certain nutrients or pH of the element, as for some elements that should continue to be observed continue to periodically i.e. nutrition, pH and water temperature.In fact, students often do not pay attention to such matters and was declared failed in his Providence in addition to a teacher teaching cannot continue to monitor the condition of each student-run plants, because of the lack of attention quite against the required elements of the plant resulted in plant nutritional deficiencies even to die, with the cause of the problem, namely the process of learning lab course to be not in accordance with the provisions of the basic competencies, because it cannot do a lab course next harvest and manage the harvest.The learning process of cultivating plants in hydroponics at this time in the 1st-grade teacher teaching dividing groups into 5 groups that each group is composed of 8 members of the students. In learning practical-each group has a responsibility towards their planting plants, each group is required to perform the money and perform record keeping elements of the condition of the plant regularly three times a day in at 07.00am, 13.00pm and

17.00pm during planting, time limited too practical lessons allow students not solid member of a group to be able to constantly take care of the plants each day by coming to the green house right time, and the most difficult is when the school holidays and assigned him to the maintenance of the garden officials are required to take care of the plants each group teaching.From the problem statement above, conducted research "Prototype Of Smart Hydroponic Application Horticulture Plants As Supporting Practical Activty Based Internet Of Things (a case study at SMK Pertanian Pembangunan Negeri Lembang)" Smart hydroponics aplication that will be created is a smart tool that is able to undertake monitoring and remote control against the element of water, nutrients, pH and water temperature. that can be accessed by practical teachers and students through a Personal Computer (PC) or Smartphone.

1.1 Goals

Based on existing problems, then the meaning of the construction of this system is to build a prototype application Smart Hydroponics as practical support by using the concept of the Internet of Things (IoT), in order to provide convenience for students and teachers in conducting monitoring and maintenance of the plant. As for the goal that will be achieved from the construction of this system are as follows:

1. Monitoring of the elements of the plant do Practical teachers in each group becomes easier.
2. Can give efficiency to the teacher and students to do keeping remotely against elements of nutrients or pH of the water the plant on required element of hydroponics plants can continue to be fulfilled.
3. The recording of reports is made easier and the response in real-time

1.2 Software Development Model

The model used in the development of this software is to use the prototype model (model prototype) started collecting users ' needs which are then implemented in against software that will be made. Then make the prototype user program more stated at the desired needs. Here is a picture of the method prototype that corresponds with Roger. s. Pressman [1] can be seen in picture 1



Figure 1 Illustration Model Prototype

1. **Communication**
   At this stage carried out an analysis of the problems occurred from the results of communication to potential users the user then after that perform analysis to identify all the needs and specifications need to be made.
2. **Quick plan**
   At this stage the redesign prototypes quickly by creating a temporary design-centered presentation to prospective users
3. **Modeling Design**
   At this stage done Modeling Process create design prototype model to assist in the pembutan system
4. **Construction Of Prototype**
   At this stage the prototyping model, evaluated in accordance with the needs of the users based on the design that has been modeled before.
5. **Deployment, Delivery And Feedback**
   At this stage the system tested by the user, if the user is not satisfied with the current prototype, then it will be perfected in accordance with the needs of the user. The process is repeated until all the refinement of prototype user requirements are met.

2. THE CONTENT OF RESEARCH

2.1 The Cornerstone of The Theory

The cornerstone of the theory of the construction of this system contains a description of the theory – theory as the basis of the analysis process system as supporters in the process of construction of a prototype system Smart Hydroponic by using a concept of Internet Of Things (IoT) and the computer network that serves as the system that connects your computer to be able to share resources [2] so that it can be used as supporting practical activity at SMK Pertanian Pembangunan Negeri Lembang.

2.1.1 Hydroponics

Hydroponics is a method of farming by making use of the media to plant water where the concept basically works by reverse engineer artificial nature by creating environmental conditions which are almost similar with actual natural condition [3]

The basic concept of a hydroponic plant which itself depends heavily on what human beings give mainly from process maintenance grant of the required elements of the plant, where the process of awarding the item was given by way of dissolving the same element contained in the soil into the water with a certain measure of size, so that the process of with the required elements of the plant can continue to be fulfilled and can grow well. The basic concept of hydroponics itself can be seen in Figure 2:

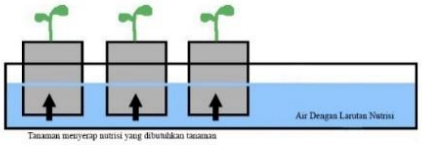


Figure 2 Basic Concept Hydroponics

2.1.2 Water

In a hydroponic system that need observe is water as we know planting from hydroponic media this is water in which plants absorb elements dissolved in water, hence its usage in water often contains substances or elements that can influence good or poor plant growth. Water quality can be one of the main causes of hydroponic cultivation in doing her with lots of organic matter or inorganic dissolved in the water.[3]

2.1.3 Electro Conductivity

Electrical Conductivity (EC) is an indicator of the level of density of the electrical conductivity that is dissolved in water which is composed of positively charged ions (*kation*) and negatively charged ion (*anion*) ion existence the two elements allow the occurrence of electrical conductivity that occurred a nutrient solution containing dissolved in water by measuring the level of electricity transfer between *kation* and *anion*. [3]

The *electrical conductivity* in hydroponics is the benchmark levels of soluble nutrients, where every plant has different nutritional needs are different so that needs to be taken into account his density, nutrient density can be measured with using a TDS meter select unit of measurement (EC).

2.1.4 Potential of Hydrogen

Potential of Hydrogen or is usualy called with pH unit of measure of the value of acidity or alkalinalitas of substances dissolved in water. The term pH refers itself based on the content of hydrogen ions or solution in which the *hydroxyl hydrogen ions* (*positive*) more than the aqueous hydroxyl ion (*negative*) then the solution is acidic (*acid*) as well as vice-versa in a solution of ions Select a solution of hydroxyl (*negative*) higher than hydrogen ions (*positive*) then the solution can be said to be alkaline (*alkali*) [3]

In hydroponic plant pH has a very big role because each plant can grow at different pH condition is different, therefore the exact pH will help the process of absorption of nutrients by plant

2.1.5 Raspberry Pi

Raspberry Pi, is a mini PC that measuring of credit cards that can run a computer program like computers, in general, are provided with components that are small but fairly complete features of input or output is provided. Raspberry Pi using Linux kernel based operating systems. Raspbian is Open Source so that it can continue to be developed in his use of optimization. [4]

Very small size is very helpful in the implementation of his high level of mobility and comprehensive features make Raspberry Pi is suitable in the creation of a research project in the field of technology without having to use a computer in General. Specification of Raspberry pi can be seen on table 1

Table 1 Raspberry Specification Pi 3 Model B

Processor	1.2GHz 64-bit quad-core CPU ARMv8
Wireless	802.11n Wireless LAN
Bluetooth	Bluetooth 4.1
RAM	1GB RAM
Port USB	4 *port* USB
*Pin O*ut	40 *pin* GPIO
HDMI	1 *Port* HDMI
Ethernet	1 Ethernet *port*
Jack Sound/ Video	Combine with *jack* 3.5mm *audio* dan *video* komposit
Port Camera	camera interface (CSI)
Port Display	Display interface (DSI)
Storage	MicroSD
VGA	VideoCore IV 3D

2.1.6 Arduino

Arduino is an electronic circuit board that is the Open source in its main companion chip microcontroller from Atmel company. With the kind of Advanced RISC Versatile (AVR). You can program by using an idea from the Arduino. Electronic circuits with Arduino can read the input and generate output in accordance with the program made by users via the Arduino IDES

If we want to create an electronic device can interact and do what we want. Arduino is the right choice. In addition to its Open source, we can change according to the necessity that we want to use. Arduino uno specification can be seen on table 2

Table 2 Board Arduino Uno Specification

Microcontroller	ATMEGA328
Operating Voltage	5V

Input Voltage	7-12V
Maximum Voltage Input	6-20V
Digital Pin I/O	14 (6 pin PWM)
Analog input pin	6
DC current I/O Pin	40 mA
DC current pin 3.3V	50 mA
Flash memory	32KB(ATmega328) 0,5 KB boot loader
SRAM	2KB (ATmega328)
EEPROM	1KB(ATmega328)
Clock	16MHz

In the use of the Arduino can be powered via USB connection or power Supply from External or from AC to DC adapter input voltage required for the Arduino range of 12V 5V – When the input is less than 5V Arduino boards then < active and However, it is possible for the operation may become unstable. And when the input power is greater than 12V > then the Council will be hot and at risk of damage.[5]

2.1.7 Electrical Conductivity Sensor DFR0300

Electrical Conductivity sensors DFR0300 sensor is a physical analog in the form of either an electrode. Associated with type BNC connectors. In the process the use of his or her sensor works with dipped water and check the level of electrolyte from the concentrate is dissolved in the water, with the ability to be able to measure the value range 0–15 (EC unit).

To get the value of the value corresponding with the units we use of Electro Conductivity of this we need to do unit conversion at the time of programming on ideas used in the use of Electrical Conductivity sensor is to be aware of is the power of the sensor which uses a voltage of + 5V stabilized power make this sensor can read accurately value with response time ≤ 1dengan accuracy < ± 10%.[6]

2.1.8 PH Meter Kit Sensor SEN0161

SEN0161 is a sensor for measuring the Potential of Hydrogen (*pH*) that is a physical analog in the form of either an electrode. The sensor is connected to the cable with BNC connector type which was used in the use to check the quality of water from acidic (*Acid*) levels up to the level of the base (*Alkaline*) with the ability to check the quality of water from the range 0 – 14 level accuracy These sensors need to be supported by environmental factors i.e. in temperatures (25 ℃*Celcius*) [7]

2.1.9 Temperature Water Sensor DS18B20

DS18B20 temperature sensor is functioning sensors measure the temperature of the water, with the type of sensor output is digital so there is no need to worry against degradation of data when using in a State long distance. with the ability of small shapes and materials are water resistant (*Waterproof*). This sensor can be used in a difficult place.In the use of his or her sensor is very suitable to use in measuring the water temperature with an accuracy of ± 0.5 ° C and the sensor range from-10 ° C to + 85 ° c. with the response time ≤ 750ms.[8]

2.1.10 Relay

The relay is a switch or a switch that is operated with the help of electricity because the main component used shaped Electromechanical (*Term*) using the principle of the electromagnet (*Coil*) capable of moving a contact switch or (*switch*) connected with a large voltage to 220V 2A.[9]

2.2 Analysis of System

System analysis can be defined as the unravelling of an intact system into parts of its components with a view to identifying and evaluating problems, obstacles that occur and the expected needs.

2.2.1 Analisis Masalah

Based on the results of the research that has been done, there are problems or constraints that occur so that the building of Smart Systems Hydroponics is as follows:

1. The difficulty of monitoring conducted a teacher teaching against elements of nutrition of plants grown to each group.
2. Time limitations lead to the maintenance process done students and teachers against the elements of plant nutrition constrained especially when school holidays.
3. Does not match the time of the recording of the elements of plant with time maintenance.

2.2.2 Analysis of System Architecture

Analysis of system architecture is the system to be built, Smart applications that Hydroponics based internet it will communicate with Raspberry who bridged by the web service using JSON draft language Exchange system that will built can be seen in Figure 3

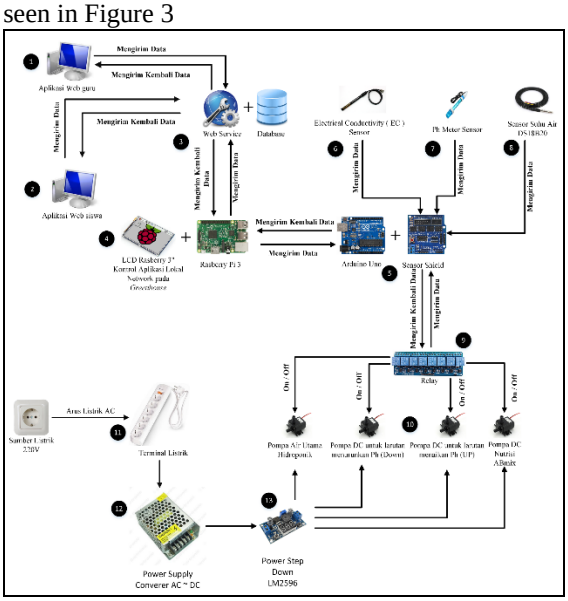


Figure 3 Architecture System

The following description of the architectural image of the prototype Application Systems Smart Hydroponic As Practical Activity support based on Internet of Things Practical case study at SMK Pertanian Pembangunan Lembang

1. Application on teacher Websites used to do practical work group registration, wich will be used to login to the student application
2. Addition the application on students can be used for the control and monitoring of conditions of temperature, ph, and nutrition of plant.
3. *Web Service* is used as the data exchange between web applications web application teacher and student on Raspberry Pi with a database on the server.
4. Raspberry Pi installed on each (*gully*) hydroponic every group of students as the interface for the user application either by teachers or students (gully) mounted LCD touchscreen besides Raspberries Pi is also useful for bridging data obtained from the Arduino to proceed to to web service
5. Arduino is used to read the value of both digital and analog sensors by installing additional modules Arduino sensor shield, shield sensor module serves as an extra Extension pin Arduino Uno.
6. DFR0300 Sensor serves as a sensors that checks the content of *Electrical Conductivity (EC).* Or nutrients on the tub unit with shelter millisiemens *(ms/cm)* or *Parts Per Million (PPM)*
7. SEN0161 Sensor serves as a sensor that checks the content of acid-base in the water tub of shelters or better known as a Potential Hydrogen (Ph). By Displaying information in the form of numbers 1-14 in accordance with the international standards of measurement of potential hydrogen (Ph).
8. DS18B20 Sensor serves as a sensor that checks the condition of the temperature of the water in the tub of the shelter with the units *Celcius* (°C)
9. The automatic switch is used as a relay for electronic devices, in accordance with the input data on the Arduino, this relay will turn on the pump nutrients, ph-up, and ph-down.
10. DC submersible pumps used as nutrient pumps or AB-mix. Acid-alkaline ph or the liquid into the tub shelter.
11. Power terminal as a divider of the main source of power source
12. Power supply function as a converter AC-DC as the source of the voltage of the pump.
13. Power step down LM2596 serves as a voltage loss or as a control against the discharge of water to the pump

2.2.3 Analysis of Web Service

In the construction of this web service web service based Developed which are used with JSON-based data exchange. This Web service will connect to a database. Here is a picture from the Groove web service data in Figure 4.

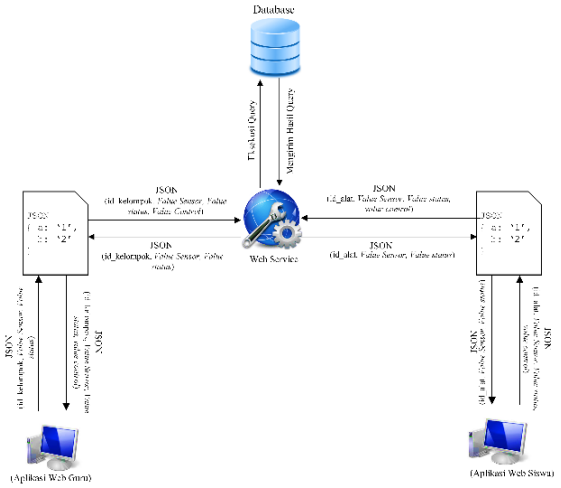


Figure 4 Web Service Data Flow

2.2.4 Analysis of Data Communication

Data communication is a detail or details of communications data, an application that was built by showing data exchange. Communication of the data used in the application of Smart hydroponic uses JSON data. The following is the flow of data communication device in Figure 5.

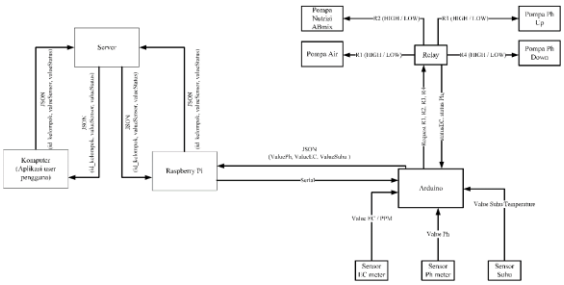


Figure 5 The Flow of Data Communication

The following is a description of the analysis of data communication on the application of smart hydroponics:

1. The Sensor that is mounted on the Arduino will send the value value in the form of JSON to raspberry pi
2. Then raspberry pi will forward the data to the server in the form of JSON through a web service.
3. After that, the server will forward the received data back to the user application as output either a view of the data that has been processed.
4. The user will control the elements then the application will send the data input to the server.

5. Then raspberry pi will forward the input to the Arduino with the value the input entered by the user.
6. The Arduino will perform the action that the user wanted by turning on the pump corresponds to the action that was performed.

2.2.5 Analysis of System Working Smart Hydroponic

System working Raspberry Pi serves as a tool for students to use as a display interface or the user to run the application in the Hydroponics greenhouse, Smart Arduino is used to control the pump and transmit data of several sensors that will be processed by a web application. While the web service is used to bridge the data exchange between web applications web applications teacher and student on Raspberry Pi with a database on the server. Here is a picture of the analysis system of working Smart Hydroponic on images 6.

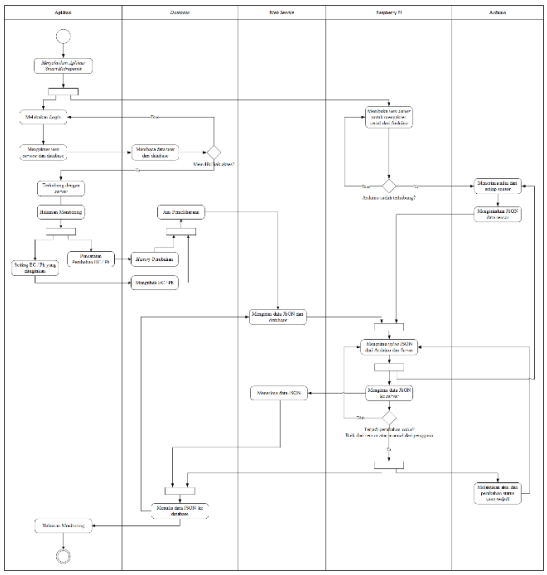


Figure 6 Work Flow System Smart Hydroponic

2.2.6 Analysis of Non-Functional Requirements

Non functional requirements analysis is an analysis that is used as the specification of system requirements. Non-functional requirements that are needed to build this system consists of three things, including hardware requirements, software requirements, and the needs of users.

2.2.6.1 Analysis of Hardware Requirements

The hardware will be used based on the minimum requirements that must be met, namely:

1. Practical teachers Computer
2. Practical students Computer
3. Raspberry Pi 3 Type B for inside
4. Server *Hosting*
5. Arduino Uno
6. *Electro Conductivity* sensor DFR0300
7. *Potential of Hydrogen* Sensor SEN0161
8. Temperature Sensor DS18B20
9. Power Step Down LM2596
10. Relay

2.2.6.2 Analysis of Software Requirements

Software needs analysis is an analysis process more emphasis on the aspects of the utilization of the software. The minimum requirements of the software on the computer that will be using this application can be seen in Table 3.

Table 3 The Minimum Specification of Computer Software

Software	Minimum Requirements
Operating System	Microsoft Windows 7
Web Browser	Google Chrome

As for the minimum specifications of the software on a Pi Raspberry will use this application can be seen in Table 4.

Table 4 The Minimum Software Specifications Raspberry Pi

Software	Minimum Requirements
Operating System	Raspbian Jessie with PIXEL 2017.04.10
Web Browser	Chromium
Node JS *Version*	7.9.0

As well as minimum requirements for the specification of software on the server hosting the web application you want to install Smart hydroponics and web service can be seen in Table 5.

Table 5 The Minimum Specification Of The Hosting Server Software

Software	Minimum Requirements
cPanel *Version*	64.0 (build 19)
Apache *Version*	2.4.25
PHP *Version*	7.0
MySQL *Version*	10.1.30-MariaDB
Architecture	x86 / x64
Operating System	Linux
Perl *Version*	5.10.1

2.2.6.3 Analysis of User Requirement

The user needs analysis intended to find out the details of the prospective users and to know the skill level of the user in using the computer. The analysis of the needs of the user can be seen in Table 6.

Table 6 Analysis Of User Needs

No.	Users	Spesification
1	Students	Can use Windows operating system Can use web-based application sCan use browser android smartphone

2	Teachers	Can use Windows operating system Can use web-based applications Can use browser android smartphone
3	Electronic Data Carriers	Can use windows operating system noCan use web-based applications

2.2.7 Analysis of Functional Requirements

functional needs analysis conducted to know the description of the process activities which will be implemented in the software applications that will be built. On this analysis using UML (*Unified Modeling Language*).

2.2.7.1 Use Case Diagram

Use Case Diagram is a model that shows the look of the system from the perspective of the user so that it can describe what the system will do without explaining how the system does it. [10]

Use Case Diagrams can be seen in Figure 7

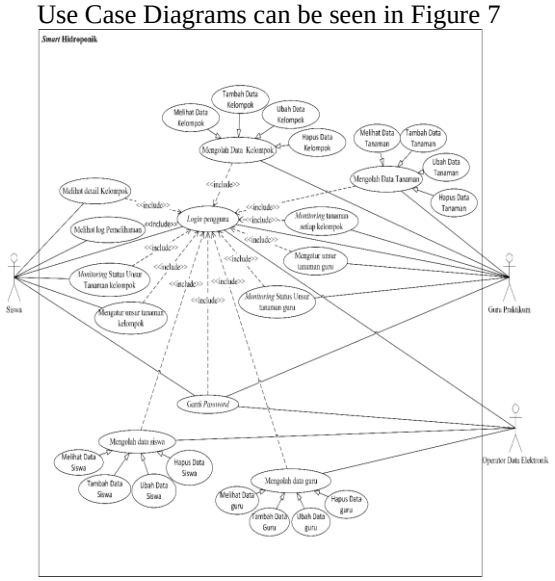


Figure 7 Use Case Diagram

2.2.7.2 Class Diagram

Class Diagram serves to show the static features of the system and does not represent a specific process. Now here is a class diagram of the Smart Systems Hydroponics can be seen in Figure 8

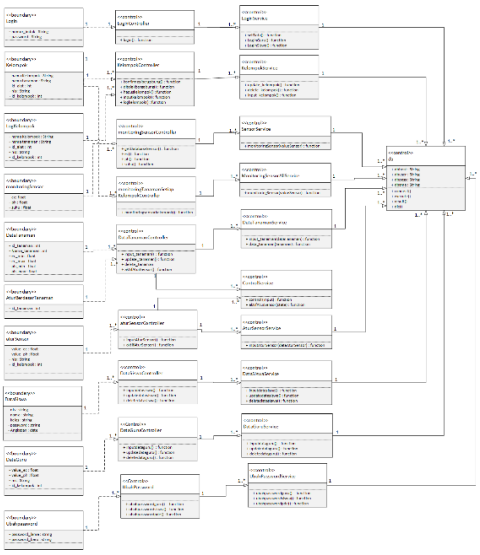


Figure 8 Class Diagram

2.3 Testing The System

System testing done to find out if the application has been built can be run well or not. As for in testing system using three techniques testing i.e. functional testing, performance testing, and beta testing.

2.3.2 Functional Testing

Functional testing is done to see if the functionality has been designed already running or not, but here is a scenario testing

functional testing.Based on testing against any functionality of the three subsystems that consist of a system of students, teachers, and the system subsystems of electronic data-processing staff using black box has done, then it can be inferred that the system was built already working in accordance with the expectations.

2.3.3 Performance Testing

Performance testing scenarios on this smart Hydroponic system will test the speed of load and page size found on the system. Following are the results from the testing page size from smart Hydroponics can be seen in the table 7

Table 7 Page Load Testing

Speed Response	Target	Speed Result
Cable (5/1 Mbps, 30ms)	Less than 5 Seconds	6 seconds
DSL (1.5 Mbps/385 Kbps, 50ms)	Less than 5 Seconds	10 seconds
4G Mobile (1.6 Mbps/768 Kbps, 200ms)	Less than 5 Seconds	7 seconds

testing page load where the speed is not acceptable because the speed is expected over the next 5 seconds. However, the speed of the generated test is greater than 5 seconds.

2.3.4 Hardware Testing

Hardware testing aims to guarantee that the hardware can work and have a good quality and a good accuracy so as to comply with the requirements which will be used.

2.3.4.1 Analog Sensor Electrical Conductivity Testing DFR0300

Testing Electrical Conductivity sensor DFR0300 aims to find out the level of precision of the sensor used, testing is done at this stage using a measuring instrument-EC Meter TDS 3 as a comparison with the sensor DFR0300. By using the standard buffer liquid EC Solution 1413 us/cm as the calibration standard solution testing. Here is the DFR0300 sensor testing can be seen in Figure 9



Figure 9 *EC solution 1413 us/ms*

Following the results of testing performed on the sensor can be viewed at DFR0300 Table 8.

Table 8 Testing Sensor DFR0300

No	The Result Sensor (DFR0300)	The Result *(TDS-EC Meter 3)*	*EC Solution 1413 us/cm*	Comparison Error (%) (DFR0300)	Comparison Error (%) (TDS-EC Meter 3)
1	1.66	1.64	1.41	0.17%	0.16%
2	1.63	1.69	1.41	0.15%	0.19%
3	1.66	1.69	1.41	0.17%	0.19%
4	1.69	1.50	1.41	0.19%	0.06%
5	1.76	1.65	1.41	0.24%	0.17%
Average Error againts *EC Solution*				0.18%	0.15%
Difference Sensor DFR0300 dan TDS-EC meter				0.03%	

Error = ((value sensor – value EC solution) / (value EC solution) * 100%
Difference = (Error DFR0300 – Error TDS-EC meter)

The conclusion of the testing results of DFR0300 accuracy sensors read the value of the sensor by using a liquid buffer can be concluded that the Sensor DFR0300 the median value – error of average 0.18%. And for EC meter TDS-3 has the value error of 0.15%. with so it can be concluded that the EC-TDS meters 3 has a 0.03% more accurately value the accuracy of reading value of Electro Conductivity.

2.3.4.2 Analog Sensor Testing pH Meter Kit SEN0161

Testing of potential Hydrogen sensor SEN0161 aims to find out the level of precision of the sensor used, testing is done at this stage using a measuring instrument Vivosun Ph Meter-02 as a comparison with the sensor SEN0161. That is where both the tool is tested by using a liquid buffer solution of weak acid test as 4.00 and fluid buffer Solution 7.00 As Neutral fluid Test, both the buffer fluid serves as a calibration standard solution of pH value testing Here is a picture of the testing that is done from the Vivosun Ph Meter-02 can be seen in Figure 10



Figure 10 Testing Vivosun Ph Meter-02 Ph buffers

And the following image testing is done with the SEN0161 sensor can be seen in Figure 11



Figure 11 Testing SEN0161 pH *buffer solution*

Following the results of testing conducted in the process of testing the sensor SEN0161 Ph Meter using the buffer fluid solution 4.01 can be seen Table 9.

Table 9 SEN0161 Sensor testing With pH 4.01 Buffer Solution

No	Result Sensor (SEN0161)	Result *(Vivosun Ph Meter-02)*	*Ph buffer solution 4.01*	Comparison Error (%) (SEN0161)	Comparison Error (%) *(Vivosun Ph Meter-02)*
1	3.98	3.90	4.01	0.00%	0.02%
2	4.04	3.90	4.01	0.00%	0.02%
3	4.01	4.00	4.01	0.00%	0.00%
4	4.00	4.00	4.01	0.00%	0.00%
5	4.04	4.00	4.01	0.00%	0.00%
Average Error Sensor againts *Buffer Solution 4.01*				0.00%	0.00%
Difference Sensor *SEN0161* dan *Vivosun Ph Meter-02*				0.00%	

Error = ((value sensor – value *ph buffer 4.01*) / (value *ph buffer 4.01*) * 100%
Difference = (Error SEN0161 – Error *Vivosun Ph Meter-02*)

The data of the test results of both of these tools by using the testing accuracy by using liquid Ph buffer solution 7.00 the following is a table of results of testing by using a liquid buffer solution 7.00 can be seen in table 10.

Table 10 Testing SEN0161 Sensor With pH *Buffer Solution 7.00*

No	Result Sensor (SEN0161)	Result *(Vivosun Ph Meter-02)*	*Ph buffer solution 4.00*	Comparison Error (%) (SEN0161)	Comparison Error (%) *(Vivosun Ph Meter-02)*
1	6.98	6.70	7.00	0.00%	0.04%
2	6.99	6.70	7.00	0.00%	0.04%
3	7.00	6.70	7.00	0.00%	0.04%
4	7.01	6.99	7.00	0.00%	0.00%
5	7.00	6.99	7.00	0.00%	0.00%
Average Error Sensor Against *Buffer Solution 7.00*				0.00%	0.02%
Difference Sensor *SEN0161* dan *Vivosun Ph Meter-02*				0.02%	

Error = ((value sensor – value *ph buffer 7.00*) / (value *ph buffer 7.00*)) * 100%
Difference = (Error SEN0161 – Error *Vivosun Ph Meter-02*)

The conclusion of the testing results of SEN0161 accuracy sensors read the value of the sensor by using a liquid two ph buffer solution ph 4.01 buffer i.e. ph 7.00 buffer & can be concluded that the Sensor SEN0161 for testing using a Ph buffer the median value is 4.01 – median error of 0%. and as for the Ph 7.00 buffer testing using have a median value – average error of 0%. and to test result tool Vivosun Ph Meter-02 for ph 4.01 has averaged – averaged error amounting to 0% while for test result tool Vivosun Ph Meter-02 with a Ph of 7.00 has an average error of – 0.02%. with so it can be concluded that the Sensor SEN0161 0.02% more accurate in testing when compared with Vivosun Ph Meter.

2.3.4.3 Testing System Of Controlling Smart Hydroponic

Testing at this stage starts from the reading of the data value of the sensor in the send the user to the web server. In his testing was done in two stages the first DC pump testing against the values (pH) and phase two testing against your test DC pump of (EC). Results from the testing of two of these factors with the controlling systems through smart hydroponics and test results can be seen in table 11

Table 11 Controlling pH Testing

No	Initial pH	Ph value expected	pH Value after *control*	Difference *Error* from value expected
1	6.89	3.00	3.89	0.89
2	3.54	7.57	8.25	0.68
3	7.89	7.00	6.56	0.44
4	6.56	4.00	3.56	0.44
5	3.56	7.50	8.54	1.04
Average Error				0.69

Error = (value pH expected – pH after *Control*)

Following are the results of the testing that is done against a controlling (EC) conducted from smart systems hydroponics. Can be seen in table 12

Table 12 Controlling EC Testing

No	Initial EC	EC value expected	EC Value afterc *control*	Difference *Error* from value expected
1	1.24	2.00	2.80	0.80
2	2.35	4.00	.4.32	0.32
3	.4.32	5.00	6.55	1.55
4	6.55	8.00	8.66	0.66
5	8.66	9.00	9.54	0.54
Rata – Rata Error				0.77

Error = (EC value Expected – value EC after *Control*)

2.3.5 Beta Testing

Based on the results of beta testing through interviews with teachers teaching teachers, particularly practical hydroponics stated that prototype application smart hydroponic plant horticulture as supporting the activities of the internet of things-based teaching study the case in vocational agriculture development lembang is already in compliance with the expected purpose i.e. can perform monitoring of plants against each group becomes easier; can give ease to the teachers and students to conduct monitoring and maintenance against the plant mainly on school holidays;While the results of beta testing through the questionnaire to respondents to the student who has tried the application follows the students very much agree that this application can help students to monitor elements of hydroponic crops that

students planting; students strongly agree that this application can help students do the keeping elements of hydroponic plants remotely; students strongly agree that this application can help the teaching activities; students could not agree when this application implementaskan to support the activities of practical hydroponics and students agree to display the interface of the application is easy to understand and the students agreed on the error message from the application is quite helpful in understanding Error Please insert.

3. CLOSING

3.1 Conclusion

Based on the discussion of the results of the analysis, design, implementation and testing phase there are some conclusions from the construction of the Prototype Application Smart Hydroponic as practical activities support at SMK Pertanian Pembangunan Negeri Lembang. As for the conclusion of the results of this research are as follows:

1. This rototype can help practical teachers in performing monitoring elements of plant in each group practical hydroponics.
2. This Prototype already can help and provide convenience to the teachers and students to conduct remote maintenance against the elements especially when plants are not able to come to the greenhouse.
3. This prototype already can perform monitoring activities of the maintenance and recording of reports easily and real-time.

3.2 Advice

This hydroponic system prototype smart still needs further development, including:

1. The prototype needs to be developed in a visually monitoring so that monitoring is more evident in the changes to the physical form of the plant.
2. This Prototype still need to test the precision of the flow of nutrients in doing long distance controlling.
3. The prototype needs to be fixed in security and appearance of each subsystem app smart hydroponic.

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