iMHS: An IOT Embedded for Aedes Mosquito Home System

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ABSTRACT

The proposed of Intelligent Mosquito Home System (iMHS) encompasses of a complete Internet of Things (IoT) based solution. This IoT solution shall leverage the complete eco-system consisting of the devices (i.e. Sensors), the network connectivity, the cloud computing platform, the data analytics and a comprehensive web base system. The fundamental component of IoT embedded solution is the optimization of the device from the low-power wide-area network which is designed to enable battery-powered devices to operate with a long of read range. This research is to enable a suitable method to detect to status level of fluid (Attractors), or also called as Insecticide Growth Regulator (IGR) that is equipped together in the Mosquito Home System (MH). The IGR status is plotted in three (3) different status i.e. low, medium or high by using the appropriate sensors components. Here, the battery capacity is crucial to allow for a well-received and consistent communication between sensors and signal receivers. Data sent or received is processed and inserted into a database on a public server (Cloud Server). In this research, we deployed an Arduino water level sensor that is controlled by NodeMCU (ESP8266) module as the microcontroller that is powered by AA Battery pack. Prior to implementation, the result of the battery sustainability in iMHS shows that it could last for 10 days under setting with 15 interval time, assuming under normal working condition.

Keywords: *Water Base Sensors, Mosquitoes Home Systems (MHS), Insect Growth Regulator, Aedes, Cloud Server, Internet of Thing (IOT).*

I. INTRODUCTION

Human health is increasingly threatened by pathogens transmitted by vectors, especially those transmitted by mosquitoes. *Aedes aegypti* mosquito species are species vectors that are very difficult to control. Dengue fever has become synonymous in the rapidly urbanized area of development and *Aedes* breeding sites [1], where densely populated populations will be exposed to this mosquito. Now, it is considered to be one of the main vectors of the recent Zika's epidemic [1-4] which is more dreadful than dengue fever as Zika is able to infect babies in the womb. Since it is known that the dengue and Zika virus spreads via mosquito-bites, several measures have been taken to control the growth of the *Aedes* population and thus, hindering the spread of these viruses. Preventing or reducing the virus transmission depends entirely on controlling the mosquito vectors [1]. Transmission control activities should target *Aedes* in its immature stages (egg, larva and pupa) and adult stages in the household and immediate vicinity as referred to Fig. 1. In light of this, many mosquito control systems have been developed [4-5]. The purpose of mosquito control system is to control mosquito populations from the aquatic level at the stage larvae and also adult female mosquitoes laying eggs.

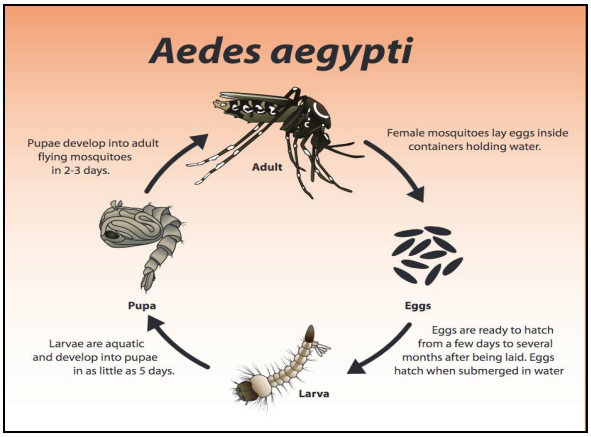

Figure 1. Aedes aegypti life cycle

Despite the various efforts to control Aedes, dengue fever statistics continue to increase every rainy season that will be followed by hot weather. Thermal spray (smoke) and ULV (without smoke) and larvaciding (larvacide control) seem to be less successful in preventing Aedes from continuing to be the most dangerous insect in Malaysia. Failure to control Aedes may be due to various factors such as the population ignores the cleanliness of the home, the increase in housing area, the drainage system is not designed properly, the use of the same insect pesticide for the same period, until Aedes becomes immune to the poison and lastly, control techniques that do not follow specifications.

II. PROJECT DESCRIPTION

The Mosquito Home System (MHS) [6] is designed prior to examining the entomology [7], especially Aedes mosquito and their relationship to humans, the environment, and other organisms. It is a winner of Dengue Tech Challenge 2016 [8]. The AedesTech Mosquito Home System uses natural ingredients to lure Aedes Mosquitoes into the Mosquito Home to lay eggs. The secret formulation will block the growth of micro-organism, thereby limiting food supply for larvae - suppresses their survival rate. It also destroys the composition of adult mosquitoes' hormones, thus retarding their breeding abilities.

A. Mosquito Home & Insecticide Growth Regulator (Attractants)

The Mosquito Home System (MHS) as illustrated in Fig. 2(a), has a pheromone-like liquid formulation (also called as Insecticide Growth Regulator – IGR as in Fig. 2(b)) that is a liquid chemical that contains hydroprene and methoprene, which disrupt and impede the life cycle of insects in the egg and larvae stage of development. The idea with an IGR is that if an insect cannot reach adulthood, it cannot reproduce. The IGR serves as a stimulator for sexually attract between male and female mosquitoes. Then it attracts adult female mosquitoes to lay eggs in them, and the adult mosquitoes will soon die after laying eggs in five (5) different breeding sites. The mosquito eggs will not hatch or die at an expected 99% rate, or go beyond the pulp level. The unhatched eggs would serve as research data for the Ministry of Health Malaysia (MOH) or pest control industry in finding cure to dengue disease. This liquid formulation will prevent the food for the larvae into the water and in turn will kill the larvae. The female mosquitoes who once lay eggs in the Mosquito Home System will have the impression of the contaminated formulation that will kill the larvae and pulp in the new breeding ground.

The IGR formulation is non-toxic and environmental friendly. Such controls can act all the time, 24 hours a day and 365 days a year as compared to the use of poisons and mosquito repellents. This MHS will last until the last drop before the refill or "refill" for the pheromones is needed. A system that will last a long time and is very economical. Not harmful to humans such as fogging and ULV. This product has been accredited by Universiti Sains Malaysia (USM) and Institute of Medical Research (IMR).

Figure 2(a). Mosquito Home System (MHS) or Aedes Trap

Figure 2(b). IGR or attractant

The MHS offers for auto-dissemination approach where it uses female mosquitoes as vehicles for the insecticide formulation. Following contact with the formulation, contaminated adult mosquitoes will subsequently deliver the Insect Growth Regulator (IGR) or insecticide, spreading it to others breeding sites. Creation of an attractive "breeding site" enables the mosquitoes to bring the formulations back to hidden breeding sites, and effortlessly retard all those eggs. Refer to Fig. 3 for MHS defense mechanism against Aedes mosquito.

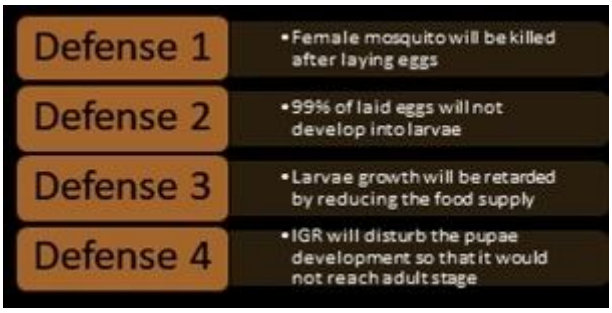

Figure 3. iMHS Defense Mechanism

B. Issues in MHS

There are four (4) issues pertain to MHS functionality. First is to ensure the IGR is not dry, second is to detect which IGR is currently empty that needs for refill in each particular MHS. Thirdly, whom going to take charge of

the refill process and finally where is the location of the MHS with that emptied IGR? Under normal Standard Operating Procedures (SOPs), the rate of evaporation or dehydration of the liquid is expected to take up to 6 weeks, but may be less than 6 weeks due to high vaporization and moisture content will cause the liquid to undergo a rapid reduction (drying) process before the 6-week period. In addition, weather, humidity and air droughts may also be the source of deficiency and loss of fluid caused by vandalism from animals such as cats that violate these MHS and cause them to reverse and this pheromone fluid will spill.

A standard SOP cannot be made because all of these MHSs need to be manually checked from time to time for each liquid content. If this matter cannot be monitored on a regular basis and focus, MHS does not have a significant effect on controlling Aedes mosquito population.

III. METHODOLOGY

The methodology of iMHS (refer to Fig. 4) consists of four (4) main phases. Phase 1 for Development of communication infrastructure between MHS and users using the Internet of Things (IOT) approach that aims to identify best solution methods for the development of smart mosquito traps (i-MHS) using IoT technology. Phase 2 for Development of data integration middleware to enable interaction between two different application bases using the JSON (JavaScript Object Notation) approach. The aims to develop a data integration model for iMHS with the development of a new algorithm. Phase 3 for Development of Mathematical Model Forecasting based on data mining method and data visualization on map layers (Map). The aims to develop a mathematical model forecasting based on data mining approach and data visualization. Finally Phase 4 for Development of iMHS commercialization model through registered IP that aims for product's innovation and commercialization.

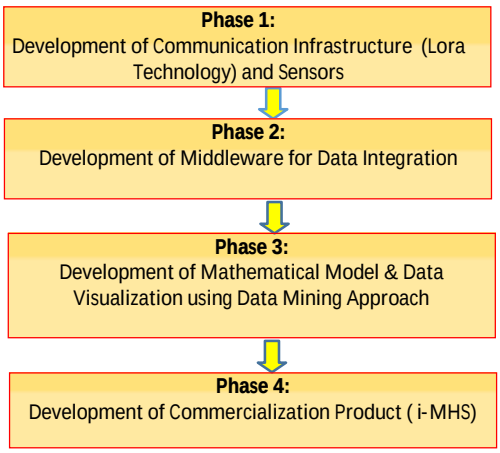

Figure 4. iMHS Methodology

IV. HARDWARE AND SYSTEM DESIGN

A. iMHS Design Framework

The design framework of iMHS is based upon three (3) tier architecture that comprises of three (3) layers i.e. Client Application (Presentation tier), Business layer (Application tier) and Data Layer (Data tier) as shown in Fig. 5. Presentation tier includes User Interface part which is makes input and gives output to the user. Application tier is the interface between client and data layers. All the logic such as validation, calculation, the data related operations exist at business layer. It helps communication fast between client and data layers. Data tier consists of actual database. It contains methods to connect with database. The operations such as insert, delete, update and get data lies here.

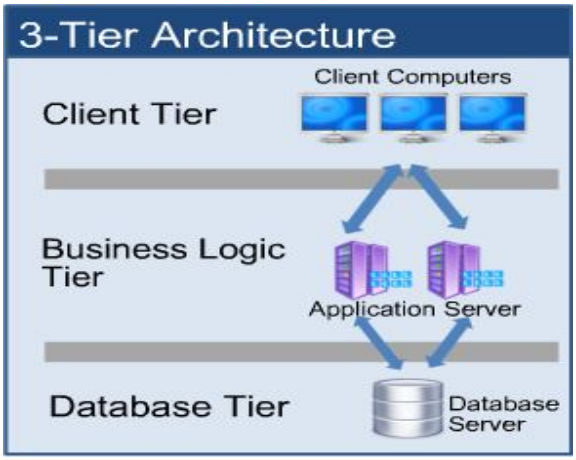

Figure 5. iMHS 3-tier Architecture

B. Hardware Component

The iMHS device is hugely dependent on three (3) components i.e. the microcontroller, a water level sensor in order operate to perform the intended task and an AA battery. The first component, microcontroller used is an IoT based device called ESP8266 [9-10] which is a WiFi-embedded microcontroller that utilized standard everyday WiFi band frequency which is at 2.4 GHz. For the second component, i.e. sensor for iMHS is an Arduino water level sensor [11-12]. The water level sensor is easy to use for an effective water level / drop detection type of sensor. This is an easy completion of the water conversion to analog signals, and the simulated value of the output can be read directly by the Arduino development board, to achieve the water level alarm. Lastly, the third component that is an AA battery

[13-14] or also called a double A or Mignon (French for "cute" or "adorable") battery, is a standard size single cell cylindrical dry battery. The AA batteries are common in portable electronic devices, compose of a single electrochemical cell which may be either a primary battery (disposable) or a rechargeable battery. Detailed hardware components are tabulated in Table 1 along with the connection of the circuit is illustrated in Fig. 6.

Table 1. Hardware Components

Hardware Components	Functions & Specifications
NodeMCU (ESP8266) module 	• As a microcontroller to gather sensor data and provide connectivity to the gateway for transmitting data. • Have micro-USB for flashing or reprogramming via Arduino IDE and can be operated from voltage as low as 3.3V. • Module also included 3.3V and 5V power regulator to stabilize output voltage and provide more flexibility of type of sensor to be used.
Arduino Water Level Sensor 	• For water level measurement. • Working voltage DC 3-5 v • Working current: • Sensor type: analog • Width of detection: 40X16mm • Technology: FR4 double spray Tin • Working temperature: 10-30 □ • Humidity Working: 10% -90% non-condensing • Weight: 4G (individual) • Size: 65X20X8mm
AA Battery pack 	• To provide power for the microcontroller and the sensor. • By using two AA battery in parallel can provide up to 3V of power.

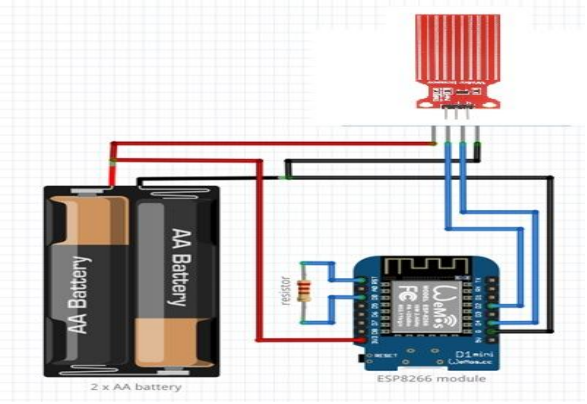

Figure 6. iMHS Circuit Board

V. EXPERIMENTATION

A. Setup

All experimentations are conducted in the platform of Intel Core i5 Processor, 4GB RAM, NVIDIA GeForce 940M with 2GB Dedicated VRAM and 120 GB SSD with 1TB HDD storage. Within Microsoft Windows 10 pro, the IBees system is accessible through Google Chrome, Internet Explorer, and Mozilla Firefox browsers. Using NetBeans 8.2 platform to develop software while Apache Tomcat is a web server that supports for the functionality of the modules. The programming languages used in iMHS are MySQL to manage database of the system, Hypertext Markup Language (HTML5), JavaScript, Cascading Style Sheets (CSS), Java for page scripting.

B. Sensor Installation

Water based sensor is used and installed in the MHS as depicted in Fig. 7, the internal architecture and the actual implementation.

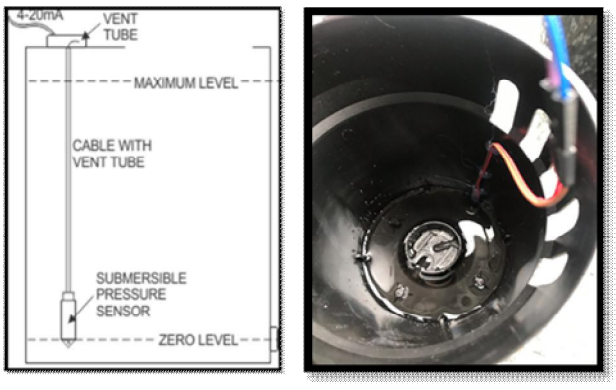

Figure 7. Installation of water level sensor in MHS

VI. RESULT AND DISCUSSION

iMHS is accessible through Google Chrome, Internet Explorer, and Mozilla Firefox browsers. Using Arduino 1.6.4 platform to develop software for ESP8266 microcontroller while Apache Tomcat is a web server that supports for the functionality of the modules. The MySQL is used for iMHS Database Management System (DBMS) and PHP 7 for page scripting. Refer to Table 2 for detail software specification and the pseudocode for iMHS circuit board is depicted in Fig. 8.

TABLE 2. SOFTWARE SPECIFICATION

Microsoft Windows 8 and above	Operating system (OS)
Google Chrome, Internet Explorer and Mozilla Firefox	Web browser
Arduino IDE 1.8.9	Coding for device platform
PHP 7	Page scripting
Apache Tomcat	Web server
MySQL	Database Management System
Microsoft Windows 8 and above	Operating system (OS)

Start
1. Include header file for
1.1. Client – MySQL, ESP8266 and Wifi
1.2. Server – DNS, ESP8266 and Wifi
2. MySQL configuration
2.1. Userid
2.2. Password
2.3. sensorPin = 0 //for analogue
3. Reading
3.1 Retrieve configuration query for MySQL and Wifi
3.2 Setup function for pinMode (Input and Output)
3.3 Wifi configuration
3.4 Establish MySQL connection
3.5 Loop
3.5.1 Retrieve configuration
3.5.2 Execute query
3.5.3 Fetch column and print them
3.5.4 Fetch row and print them
3.5.5 Set high and low level of water
4 Writing
4.1 Set int val = analogRead(sensorPin)
4.2 If val < Maxlow, then Bottle is empty
4.3 Else
4.4 If val<Low, then Water level is Medium
4.5 Else
4.6 Water level is high
4.7 Record data
5 Close connection
6 Sleep function for ESP8266.
End

Figure 8. Pseudocode for device in iMHS

Based on Fig. 8, the setting of Arduino water level sensor in iMHS project is set to read in three (3) different level status i.e. low, medium and high. The difference distance in centimeter (cm) is particularly set for each status. The main interface of iMHS is illustrated in Fig. 9. Each location of iMHS devices is viewed by its longitude and latitude as if Fig. 10 while the detailed of each longitude and latitude location can be viewed through Google Maps as shown in Fig. 11.

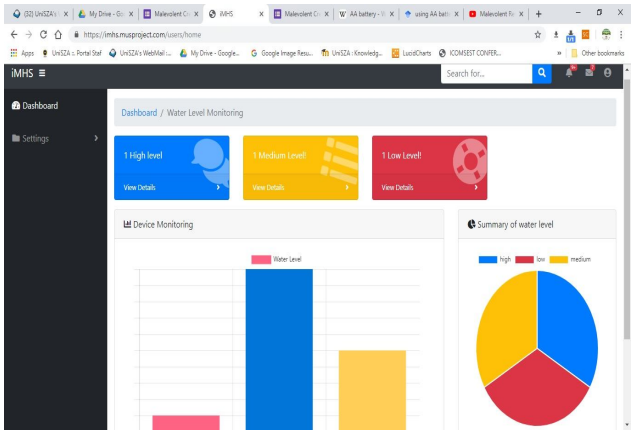

Figure 9. Main interface of iMHS

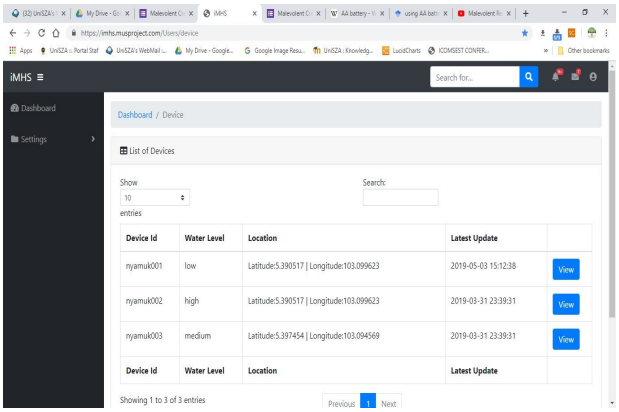

Figure 10. iMHS location in longitude and latitude

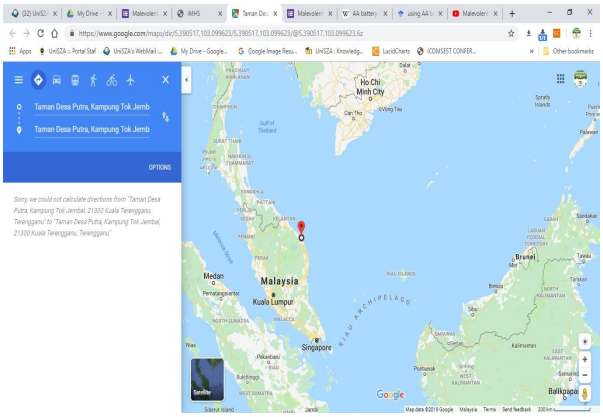

Figure 11. Location Interface of iMHS Viewed Through Google Maps

VII. CONCLUSION AND FUTURE WORKS

The development of iMHS is considered to successfully embed the Internet of Things (IOT) technology for our dengue innovation project. This research collaboration has transferred the knowledge and technology between Universities as well as its industry partner. With iMHS, the cost for labor to manually check and track for the emptied IGR is totally reduced and cut-off. The main objective of reducing manpower usage in controlling the dengue disease at the national as well as international level. The concept of auto-detection device can be applied for other industry domain that might as well create new business opportunities in the near future.

The proof of concept of embedding water level sensor is successfully achieved. The remaining issues would be first, on fabricating the iMHS device (water level sensor) to be attached at the top cover of our Mosquito Home System (MHS) and secondly, finding solution for long lasting battery power to accommodate the daily functioning of this Intelligent Mosquito Home System (iMHS). We are looking for collaboration of IOT design industry in achieving this target.

With datasets of the pheromone lasting level gained, as well as dataset from project in [15], we hope to further our studies in mining between frequent [16] – [17] and infrequent [18] of Aedes dataset as to complement the whole Aedes Dengue Innovation project.

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