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ITDS: An Intelligent Tissue Dispenser System

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Abstract*: The Internet of Things (IoT) technology is the main contributor in numerous smart applications. The reason is because it offers for 24/7 hours of control and maintenance geographically apart, thus reduces labor or manpower cost significantly. The 3 main components for any IoT applications are the source of power (energy), the microcontroller and the sensor (s) involved. Previous issues mainly related to how long the source of power could last for the applications to continue its operation. This paper presents IoT technology for hygiene application to address the utilization of toilet tissue named as Intelligent Tissue Dispenser System (iTDS). The iTDS device relies on the microcontroller and sensor in order to operate the intended task. The microcontroller used is an IoT based device called ESP8266 which is a WiFi-embedded microcontroller that utilized standard everyday WiFi band frequency which is at 2.4 GHz. For the sensor, an ultrasonic distance measurement device is used. The ultrasonic sensor transmit an ultrasonic wave that hit the object to be measured. Upon hitting the surface of the object to be measured, the wave is then reflected to the receiver of the sensor and the time difference between transmitted wave and received wave is calculated to get the actual distance of the object from the sensor. The main contribution of iTDS is to monitor and track for the toilet tissue to be refilled. The implementation shows the iTDS ables to update for the status of each tissue which reducing the cost of manually human checking for tissue refill.

***Index Terms*: Tissue Dispenser system, Cloud Server, Internet of Thing (IOT), microcontroller**

I. INTRODUCTION

The era of people doing things has emerged drastically from static and batch processing into dynamic and real time processing. The Internet of Things (IoT) technology drives the need of attaching to many types of devices especially communication devices. The proliferation of these devices in a communicating–actuating network creates the Internet of Things (IoT), wherein sensors and actuators are inevitably blended with the environment around us, and the information is shared across platforms [1].

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As the emerging technology has changed from www (static pages web) to web2 (social networking web) to web3 (ubiquitous computing web), the need for real time data (data-on-demand) increases drastically. Undoubtedly, these IoT enabling technologies offer for (1) Better decision making via real case studies, (2) Real time tracking and monitoring of appliances, (3) Lighten the workload with automation, (4) Increases efficiency by saving money and resources. The ultimate goal is to achieve true quality of life. In this paper, we develop an IoT application for toilet usage focusing on toilet tissue dispenser system called as intelligent tissue dispenser system (iTDS). The aims is to efficiently manage the toilet tissue dispenser varying from reducing the labor cost to change or refill the tissue as well as increasing customer's satisfaction while using public hygiene infrastructure. The rest of the paper is organized as follows. Section 2 reveals the literature reviews being done related to IoT enabled applications, Section 3 defines the methodology that the research follows, Section 4 describes the system design of iTDS, Section 5 explains the experimentation being conducted, Section 5 shows on results and discussion and the last Section 6 recapitulate the conclusion and future recommendations.

II. RELATED WORKS

An automatic toilet paper dispenser is a toilet roll holder that can be either button or sensor-activated to fold and cut the toilet paper automatically. Tissue dispensers enhance image, improve hygiene, increase operational efficiency and help preserve the environment by reducing wastage. Towel dispensers are well known and are shown in U.S. Pat. Nos. 3,647,159, 4,131,044 and 4,165,138 [2]. For example, Bump, U.S. Pat. No. 3,647,159 shows a towel dispenser having an automatic towel length controlling means and roll support tensioning means. The towel dispenser disclosed generally comprises a shell, means within the shell for rotatably supporting a roll of paper toweling, a frictional power roller engaging a paper web from the roll, and means for limiting the length of individual paper towels withdrawn from the dispenser [3]. The latter means includes a first gearlike member rotatable with the power roll, a second gearlike member rotatable in response to rotation of the first gearlike member, a finger carried by the second gearlike member, a strap mounted for linear movement on the dispenser between a first position and a second position, an abutment surface carried by the strap in a position intersecting the excursion path of the finger when the strap is in a first position, a limit abutment carried by the strap in a position intersecting the excursion path of the finger when the strap is in the second position, means temporarily holding the strap in the second position and means urging the strap toward the first position. The strap is moved toward the second position by contact of the finger with the abutment surface in response to rotation of the second gearlike member [3-4]. Refer to Fig. 1 for a sample of automated tissue dispenser.

Figure 1. Sample of mounted Automated Tissue Dispenser

Regarding IoT enabling infrastructure, numerous researches, developments have been envisioned, proposed, designed and developed the prototypes of ubiquitous applications that can transform from static physical into smart environments [5-7]. An IDEA (**I**ntegrated ADL **d**etection **e**stimation of functional redundancy and **a**lerting for maintenance visit) system [5] wherein a novel sensor management system for IoT-enabled smart environments is proposed. The IDEA tolerates a number of sensor failures by leveraging the functional redundancy among heterogeneous sensors, and minimizes the degradation of ADL (Activity Daily Living) detection performance in the presence of smart home sensor failures. From the experimental conducts with eight (8) ADL datasets when variety of sensors i.e. contact, temperature and motion sensors are triggered once user undertakes various ADL activity such as sleeping, eating, preparing meals, taking medicines and personal hygiene, and the results show that the IDEA leads to 3 to 40 times fewer maintenance personnel than usual scheme (failed sensors are fixed without considering their impact). A new system architecture suitable for human monitoring based on Wi-Fi connectivity is introduced [6]. The authors propose a plug and play IoT Wi-Fi smart home system to lower the cost and implementation burden using standard home modem routers. It considers the low power design to provide each battery-powered sensor with a lifetime suitable for a consumer application. The whole system that consists of Armchair sensor, a Magnetic contact sensor, a Toilet sensor and a Passive Infra-red (PIR) sensor are tested in a real environment to evaluate the feasibility studies in real situation. To consider the higher power consumption when Wi-Fi connection loss, the proposed solution seems to save energy up to 91%. The research concludes that exploiting Wi-Fi as an infrastructure for smart home systems is a possible alternative to other protocol based such as ZigBee due to low cost and ease of use and installation.

Performance evaluation of Smart Home Control System (SHCS) using four types of sensors including PIR, temperature, ultrasonic and smoke gas sensor is done in [7]. All sensors and data communication modules are connected to Arduino as the IoT platform. The results from real environment show an effective performance evaluation deems important towards achieving successful smart home system.

Very few number of researches being done focusing on toilet or bathroom appliances. Undoubtedly, statistics have shown that many of injuries among elderly are first discovered from toilet and bathroom incidents. Thus, the authors [8] have presented a holistic conceptual approach of an IoT system development and implementation for bathroom safety enhancement. A typical sensor module consists of four (4) main components including power supply, sensor, actuator and communication port is designed. The study demonstrates tremendous potential of IoT and big data applications for improving user sustainability.

The project on Smart Toilet (Swachh Shithouse) is developed in [9-10] to achieve the objective of Clean India. The purpose is to use a clean, safe and hygienic toilets in Indian resident. Project implementation is absed on IoT using different sensors i.e. smell sensor, IR (infrared) sensor, sonic sensor and RFID reader. IR sensor uses for dirt detection, Figaro sensor is used for smell detection, RFID reader to monitor sweeping activity and sonic sensor is used to detect the depth of septic tank.

III. METHODOLOGY

The iTDS methodology comprises of four (4) main phases as shown in Fig. 2. Phase 1 is dedicated for development of communication infrastructure such as the most suitable microcontroller, battery and sensor that aims to give the best solution methods for the development of intelligent tissue dispenser system. Phase 2 is intended for the development of an appropriate middleware to enable interaction between two different applications based on JSON (JavaScript Object Notation) approach. The aims to develop a data integration model for iTDS with the development of a new algorithm. Phase 3 is meant for development of iTDS data visualization on dashboard. The aims to track and visualize on the level status of tissue dispenser in real time. Those level that approaching ‘low’ level status requires attention for refill pack so that it would not be at the ‘empty’ status and continue its operation and function. Finally Phase 4 is for development of iTDS commercialization model through registered IP or patent. This phase aims for finding the best design and packaging solution of iTDS for future innovation and commercialization.

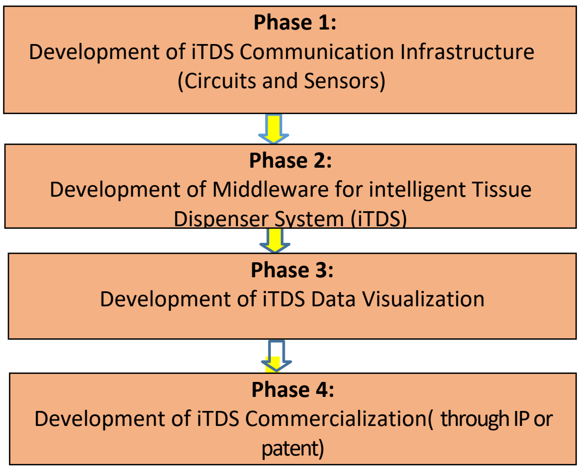

Figure 2. iTDS Methodology

IV. SYSTEM DESIGN

A. iTDS Architecture

The underlying architecture of iTDS is based on three (3) tier architecture [11] that makes of Client Application (Presentation tier), Business layer (Application tier) and Data Layer (Data tier) as shown in Fig. 3. The tier 1 (presentation) consists of User Interface part which makes the input and gives the output to the user. The tier 2 (business logic) is the interface between client and data layers. The operation such as validation, calculation, the data related operations exist at business logic layer that allows for instant communication between client and data layers. Tier 3 (data/resource) consists of actual database. It contains methods to connect with database include all operations such as insert, delete, update and get data.

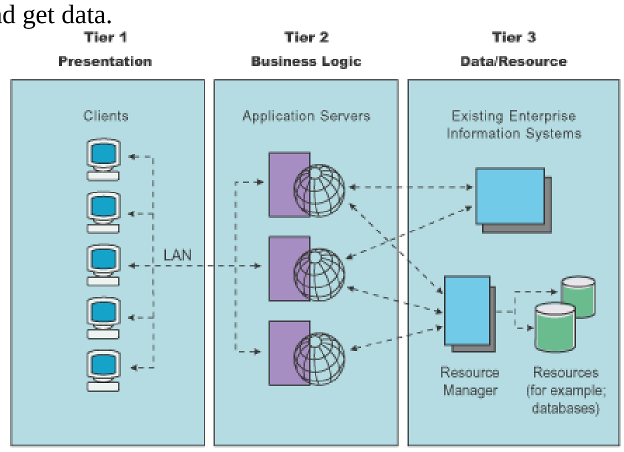

Figure 3. iTDS Layer Architecture

B. Hardware Component

The iTDS device is hugely dependent on the microcontroller and sensor in order to perform the intended task. The microcontroller used is an IoT based device called ESP8266 [12-13] which is a WiFi-embedded microcontroller that utilized standard everyday WiFi band frequency at 2.4 GHz. For the sensor, an ultrasonic distance measurement device is used. The ultrasonic sensor transmit an ultrasonic wave that hit the object to be measured. Upon hitting the surface of the object to be measured, the wave is then reflected to the receiver of the sensor and the time difference between transmitted wave and received wave is calculated to get the actual distance of the object from the sensor.

Every aspect for hardware required is critical. Ultrasonic sensor [14] come in variety specification, in this case US-015 is being used because the ability to operate in low voltage which is at 3 volts compared to commonly use ultrasonic sensor which is HC-SR04 that mainly use 5 volts to operate decently. Hardware specification for specific device to measure distance and transmitting data to cloud is shown in Table 1. Referring to our Phase 1, each required hardware for an intelligent Tissue Dispenser System are assembled in a circuit board connection as shown in Fig. 4 while Fig. 5 illustrates the actual design of our iTDS in different views i.e. (1) iTDS casing, (2) iTDS with circuit board from top view and (3) iTDS with circuit board from side view.

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. It has 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.
US-015 Ultrasonic sensor 	For distance measurement. The US-015 can provide distance measurement with accuracy up to 0.3mm with ±15% tolerance. Can be operated with wide voltage range from 3.3V up to 5V.
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.

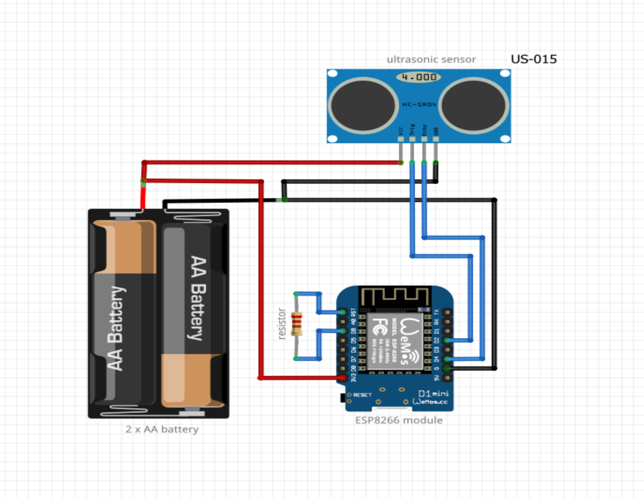

Figure 4. A schematic diagram of iTDS Circuit Board connection

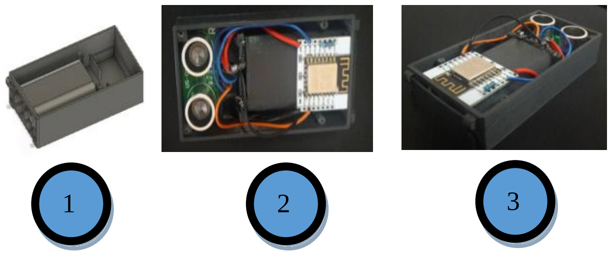

Figure 5. Actual implementation of iTDS

C. Software Component

iTDS 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 iTDS Database Management System (DBMS) and PHP 7 for page scripting. Refer to Table 2 for detail software specification.

TABLE 2. SOFTWARE COMPONENTS

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)

V. EXPERIMENTATION

A. Setup and Data Source

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. We test with four (4) devices where each is provided with the device id, the level of tissue, date of data retrieval, the location of the tissue in latitude and longitude as well as the category of tissue (Jumbo roll black, hand towel, blank) as tabulated in Table 3.

TABLE 3. iTDS DATA SOURCE

Device ID	Level	Date	Latitude	Longitude	Type tissue
dev_001	high	13/1/2019	5.397454	103.094569	Jumbo Roll Black
dev_002	low	13/1/2019	5.397678	103.094569	Hand Towel
dev_003	low	13/1/2019	5.390517	103.099623	Blank
dev_004	high	13/1/2019	5.390517	103.099623	Blank

B. Database

For our MySQL database, we have developed four (4) tables i.e. user_info for all users information, device_info for device information such as date, location, user id and tissue id, Tissue_info for tissue id and tissue category and post_info for information on the posted id, posted category, posted body, posted date and posted issuer. Detail information is illustrated in Table 4 to Table 7 respectively. The relationship between all tables is given in Fig. 6.

TABLE 4. iTDS USER_INFO

userEmail	userPassword	userName	userAddress	category	userid
irfan@gmail.com	Irfan345	Irfan Hakim bin Razak	Taman perwira	Supervisor	001
Aisyah@gmail.com	Ais234	Aisyah bt Hafiz	Taman maidam	Supervisor	002
hazrul@gmail.com	Azrul12	Hazrul bin Hisyam	Kg gong badak	admin	003

TABLE 5. iTDS DEVICE_INFO

Device ID	Level	Date	Latitude	Longitude	User ID	Tissue_id
dev_001	high	13/1/2019	5.397454	103.094569	001	T001
dev_002	low	13/1/2019	5.397678	103.094569	002	T002
dev_003	low	13/1/2019	5.390517	103.099623	003	T003
dev_004	high	13/1/2019	5.390517	103.099623	003	T003

TABLE 6. iTDS TISSUE_INFO

Tissue_id	Tissue_category
T001	Jumbo Roll Black
T002	Hand Towel
T003	Blank

TABLE 7. iTDS POST_INFO

post ID	category	body	status	Post date	postby
9	Announcement	Product lines in the AFH market include...	closed	2019-04-01	001
10	News	wipers & cleaning cloths includes	closed	2019-04-01	002
11	Article	Our principal mills are internationally	publish	2019-04-01	003

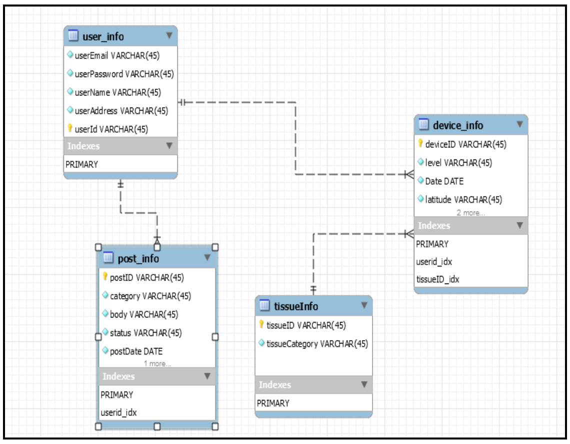

Figure 6. An iTDS relationships between tables

C. GUI Development

In our Phase 2, we develop the suitable graphical user interface for iTDS. A sample of main interface is depicted in Fig. 7. In Phase 3 of Data Visualization development, the four-steps of device setup configuration is done as in Fig. 8 and Fig. 9. Then the status of tissue level is plotted in vertical bar graph and pie chart as shown in Fig. 10. The device application configuration is set by clicking from *Device management* menu and the location of longitude and latitude is displayed as depicted in Fig. 11 wherein details of each longitude and latitude location is viewed through Google Maps. Then, Fig. 12 shows five-steps of user management setting from *User management* menu. Any news update or issues pertaining to tissue dispenser may be posted by system admin from *Post* menu as given is Fig. 13.

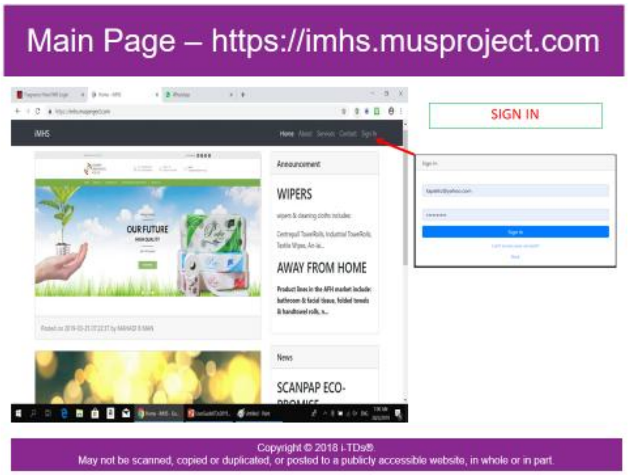

Figure 7. Main Interface

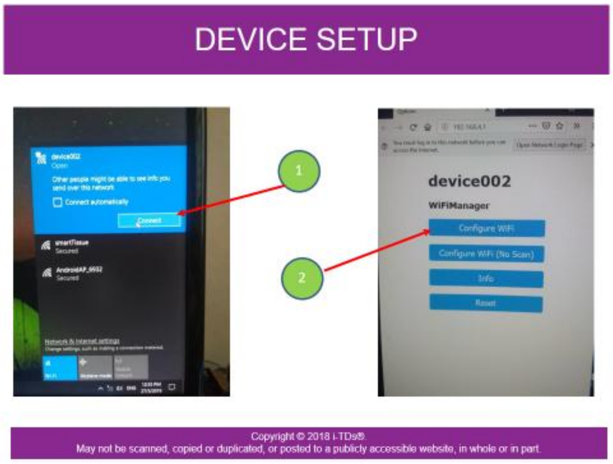

Figure 8. First and second steps to setup device

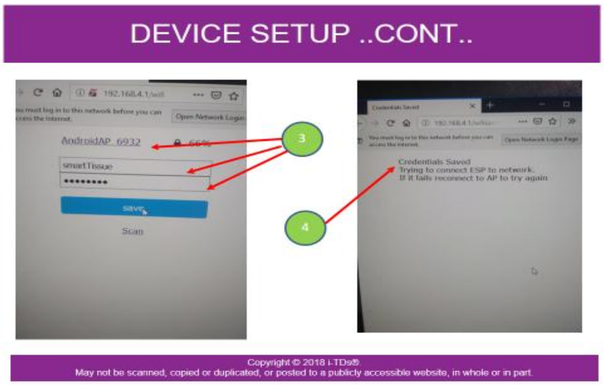

Figure 9. Third and fourth steps to setup device

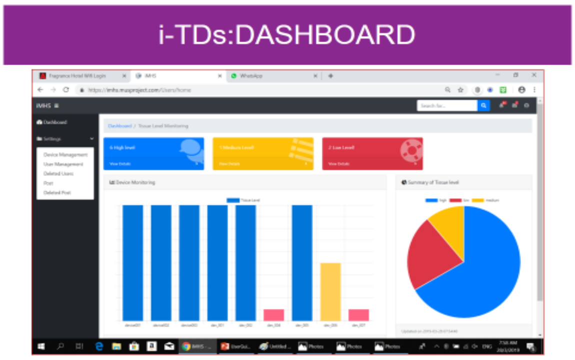

Figure 10. iTDS Dashboard showing Tissue Level Status

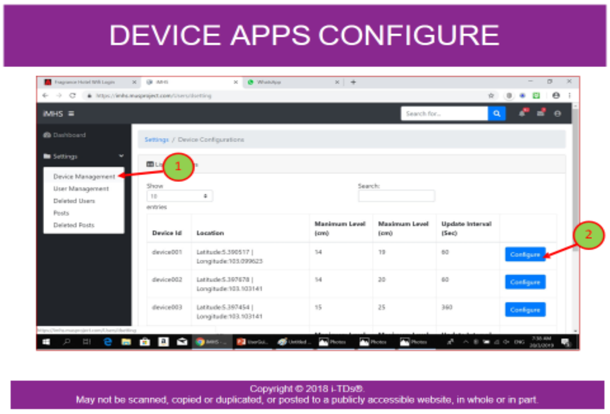

Figure 11. Device Configuration

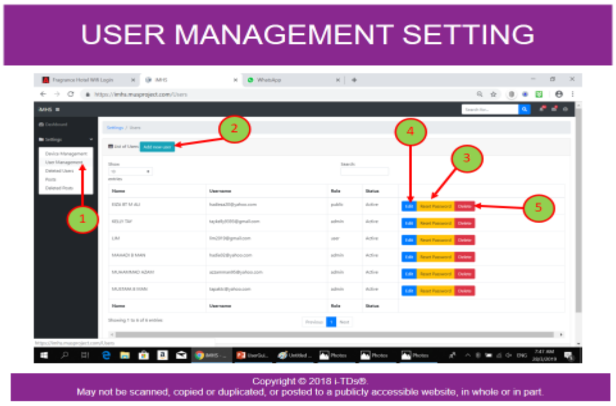

Figure 12. User Management Settings

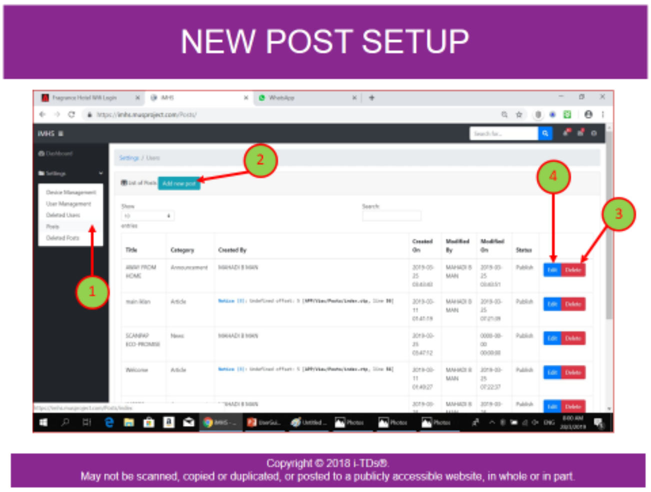

Figure 13. To setup new POST

VI. RESULT AND DISCUSSION

We elaborate how iTDS components works in determining the tissue level status in Fig. 14. The setting of Arduino ultrasonic sensor in iTDS 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.

```
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 tissue
4 Writing
   4.1  Set int val = analogRead(sensorPin)
   4.2  If val < Maxlow, then Tissue is empty
   4.3  Else
   4.4  If val<Low, then Tissue level is Medium
   4.5  Else
   4.6  Tissue level is high
   4.7  Record data
5 Close connection
6 Sleep function for ESP8266.
End
```

Figure 14. Pseudocode for device in iTDS

VII. CONCLUSION AND FUTURE WORKS

The development of iTDS fulfils for Malaysian Industry Revolution 4.0 (IR4) to enable IOT technology in our daily live activities especially for public hygiene system. With iTDS, the manpower cost to manually check and track for the emptied tissue in a tissue dispenser may reduce and increase efficiency in time management. Our ultimate goal is fulfilling customer's satisfaction for public hygiene infrastructure. The concept of auto-detection device can be apply for other industry domain that might as well create new business opportunities in the near future. The proof of concept of for tissue level sensor is successfully accomplished. For our future work, we would proceed for our Phase 4 development (Commercialization, Patent and IP). The outstanding issues would be first, on fabricating the iTDS device (ultrasonic sensor) to be attached at the mounted automatic tissue dispenser. Second issue on finding solution for long lasting battery power to accommodate the daily functioning of this Intelligent Tissue Dispenser System (iTDS). We are looking for collaboration of IoT design industry in achieving this target.

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AUTHORS PROFILE

Mustafa Man is an Associate Professor in School of Informatics and Applied Mathematics and also as a Deputy Director at Research Management Innovation Centre (RMIC), UMT. He started his PhD studies in July 2009 and finished his studies in Computer Science from UTM in 2012. He has received Computer Science Diploma, Computer Science Degree, Masters Degree from UPM. In 2012, he has been awarded a "MIMOS Prestigious Awards" for his PhD by MIMOS Berhad. His research is focused on the development of multiple types of databases integration model and also in Augmented Reality (AR), android based, and IT related into across domain platform. He is the leader of UMT matching grant collaborator.

Wan Aezwani Bt Wan Abu Bakar received PhD in Computer Science at Universiti Malaysia Terengganu (UMT) Terengganu in Nov, 2016. Her focus area is in association rule in frequent itemset mining. She received her master's degree in Master of Science (Computer Science) from Universiti Teknologi Malaysia (UTM) Skudai, Johor in 2000 prior to finishing her study in Bachelor's degree also in the same stream from Universiti Putra Malaysia (UPM) Serdang, Selangor in 1998. Her master's research was formerly on Fingerprint Image Segmentation in the stream of Image Processing. Currently joins UniSZA under Faculty of Informatics & Computing, Besut Campus, Terengganu since 01 January 2018. She led 2 grants with total of 40K. Her research involvement is mostly on setting the water based sensor in Aedes Mosquito Home System named as Intelligent Mosquito Home Systems (i-MHS) for UniSZA matching grant (3+1) University-Industry collaboration and embedding CRS measure in i-Eclat model for frequent itemset mining for UniSZA internal grant.

Mohd. Irfan Hakim Mohd. Noor currently study at University Malaysia Terengganu, Bachelor of Computer Science Software Engineering. He learns Java programming language using NetBeans, HTML, database using MySQL and phpMyAdmin and also Arduino. He has volunteered for Young Innovation Challenge (YIC) in his first year in university and in second year, he becomes a tutor and teach secondary school student about basic Arduino programming. Thus, he has gained experiences to work in his final year project.