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A Comparative Power Analysis for an Intelligent Greenhouse on a LORA System

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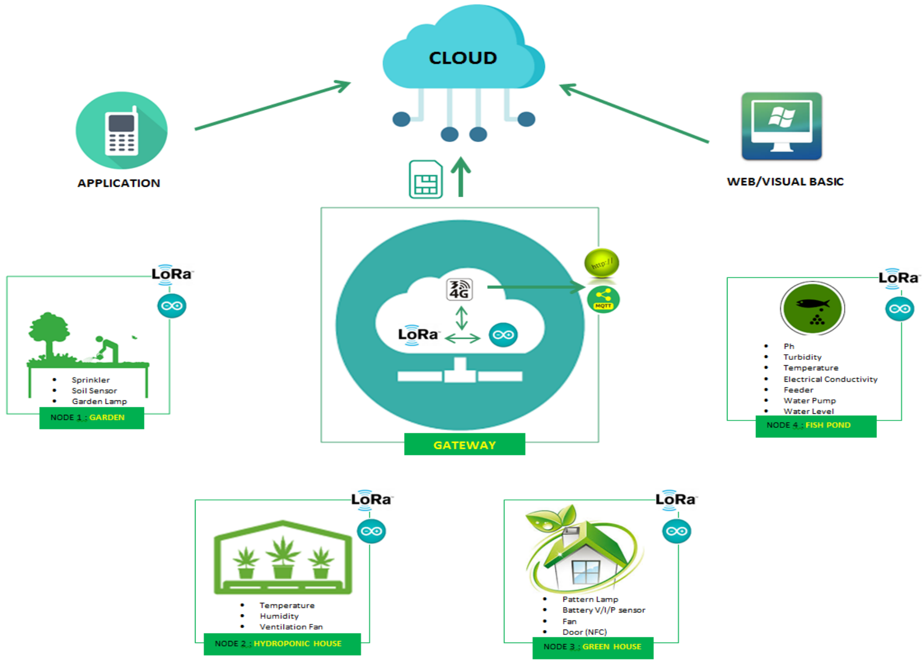
Smart gardens and aquaponics are sustainable systems in the world of agriculture. These systems can be highly successful if they have intensive monitoring. The water flow should be managed periodically to ensure that the plants get sufficient nutrients and the water quality can be monitored consistently. In this research, Smart Garden and Aquaponics systems were designed to control and monitor the water's pH level, turbidity, temperature, and humidity by integrating an Internet of Things (IoT) application. The systems were installed with sensors to retrieve data by using Long Range Radio (LoRa) to transmit in its cloud, and can be accessed in real time. Effective power consumption is important in this situation. Thus, power consumption during transmitting and receiving LoRa standalone and integration of LoRa with sensors was compared. These comparisons demonstrate LoRa's integration with sensors did not over-state the standalone LoRa.

Key words: *LoRa, IoT, power consumption, power analysis, intelligent green house.*

Introduction

Internet base monitoring and control systems have been introduced in recent years in numerous applications (Albert et al., 2017). This technology contributes many benefits for many areas not only in industry, but also in the field of agriculture. The objective of establishing the intelligent greenhouse is to enhance control systems, by adding the internet control known as the Internet of Things (IoT). The IoT is a new system that is increasing in popularity. It is defined as "an interconnection of uniquely identifiable embedded computing things within the existing internet infrastructure, offering advanced connectivity of things, and covers a variety of protocols, domains, and applications" (Daeun et al., 2018). With that, IoT systems will help to control the intelligent greenhouse more efficiently. The intelligent greenhouse consists of the smart garden and aquaponics shown in Figure 1. The system was implemented by LoRa (Long Range Radio) for monitoring each sensor. LoRa technologies are close to recent standards (Abdul-Salaam, 2015).

Figure1. Intelligent Green House System by Implement LoRa Sensor



The current LoRa research has concentrated on delay, range throughput and network capacity (Abdul-Salaam, 2015). LoRa is commonly used in sensor application. Several papers discuss LoRa with respect to energy consumption. Most current values were obtained from the data sheet (Abdul-Salaam, 2015). The result is without developing an energy model that can estimate the energy consumption of the wireless sensors. This paper describes a comparison energy consumption model based on LoRa standalone value and the value of LoRa implemented to our sensor in smart garden and aquaponics.

Related Word

IoT is also implemented in the manufacturing sector. In Albert et al., (2017) the web-based monitoring and data acquisition system (MCDAS) was designated to help the industrial sector to meet its responsibilities. Zig Bee is a wireless network. It was applied with Radio-frequency Identification (RFID) to monitor output. This automated control was enhanced in safety and quality, and reduced in cost. Zig Bee was stated by several previous companies in defining, low cost, low power and can support large nodes global network (Divas and Thomas, 2019). Besides that, IoT is also represented in building systems, to optimize energy consumption through energy management. LoRa Building and Energy Management System (LoBEMS) (Gope and Tzonelih, 2016) was proposed to improve overall energy efficiency. The system controls energy savings by operating the sensors coming with the LoRa as a system interface. Energy was saved by implementing a set of batteries. They operated sensors to control factors such as temperature, humidity, luminosity, air quality and also motion. Multiple systems are integrated, such as air conditioning, lighting and energy monitoring, to make sure the system will work properly. Of the reported energy savings, 20% are based on these actions (Gope and Tzonelih, 2016).

The healthcare environment is also implementing IoT technologies. They especially help by monitoring patients in real-time, and also in healthcare management generally. The body sensor network (BSN) (Zulkifli, 2015) technology is a development of IoT in healthcare. It can monitor a patient using a collection of tiny-powered and lightweighted wireless sensor nodes. The body-sensored network acts as the wireless sensor network, to collect patient data. Sensitive data are forwarded to the coordinator.

Additionally, many IoT use-cases (e.g. Smart Agriculture, Environmental Monitoring) (Dimitrioset al., 2018; Mahmoud and Mohamad, 2016; Tawfeeg et al., 2018) have been implemented. Traditional farming systems have been transformed into “smart farming” by sensing and networking technology. This system connects to the internet, and is also called Agricultural IoT (Andrew et al., 2016). IoT applications in agriculture should consider its characteristics, such as its vast field, outdoor area, less energy and power consistency. Remote sensors and wireless network devices often transport small data packets and require connecting in a wide area, using a convenient power supply (Andrew et al., 2016). One type of wireless telecommunication wide area network designed to allow long-range communications at a low bit rate among things (connected objects), is known as the Low Power Wide Area Network (LPWAN). Most outstanding technologies used in IoT are LPWAN while Bluetooth, Zigbee, and Wi-Fi are more adequate for consumer level IoT. LoRa is a type of LPWAN, and it works better in an outdoor and open area. In rural areas LoRa provides about 10-40km range of connectivity.

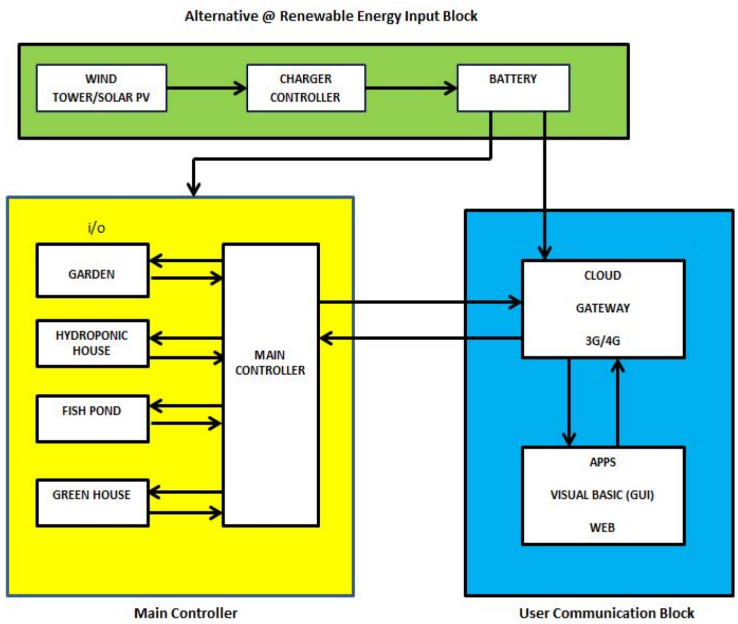
The previous study proves that IoT is mostly used in upgrading the system's control and monitoring in many areas. To apply the IoT system, crucial issues should be focused on, especially power consumption. Focusing on this issue will help the wireless sensor network efficiency. As mentioned (Abdul-Salaam, 2015; Divas and Thomas, 2019; Sunnyeo et al., 2018; Taoufiket et al., 2018), minimizing the power consumption of wireless sensor networks, will affect the life-time, cost and operation of the wireless sensor network itself.

In accordance with previous research, this paper is promoting the comparisons power analysis in standalone LoRa and LoRa integrated to the sensor that was implemented to our intelligent green house.

Methodology

Intelligent Greenhouse. The intelligent greenhouse consists of the aquaponics system (hydroponics combined with the fish pond) and smart garden. All the systems are monitored with the IoT system. Accordingly, all sensors were integrated with the LoRa wireless network. This IoT system will help us to manage plant nutrients, fish growth, and the pond surroundings. In this paper we are concerned about the sensors in terms of pH, turbidity and also the temperature in the aquaponics. Fig. 2 shows the intelligent greenhouse block diagram.

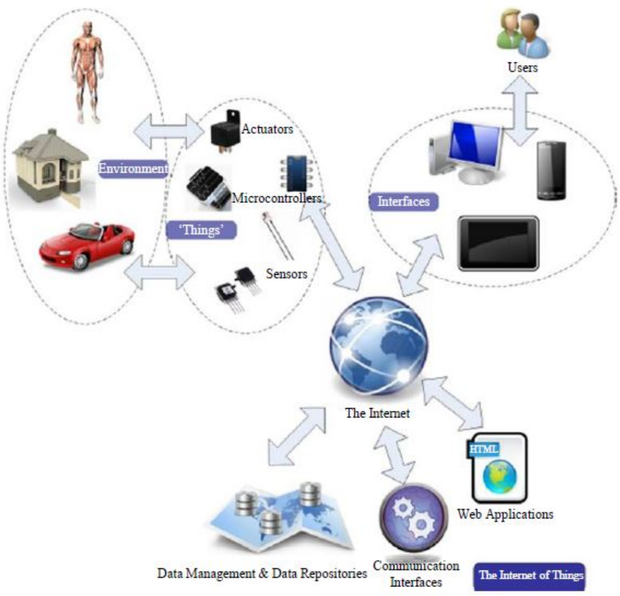
Figure 2. Intelligent green house block diagram



Internet of Things (IoT). The IoT refers to communication over the internet. Fig. 3 gives the IoT system view. Using the IoT not only allows people to communicate, but also enables communication from one machine to another machine (Mohammed, 2018). The IoT device has four main frames; the Main Control Unit (MCU-the brain of the devices), wireless sensor that collects information-signals from the environment, the communication modules and the power sources (Divas and Thomas, 2019). The wireless network refers to communication over the internet without any cable connection, between computers and other electronic devices. Wireless sensor networks are one of the most important technologies coming with the assembly of a number of low-powered, low-costed and multipurposed sensor nodes communication wirelessly over a short distance (Divas and Thomas, 2019).

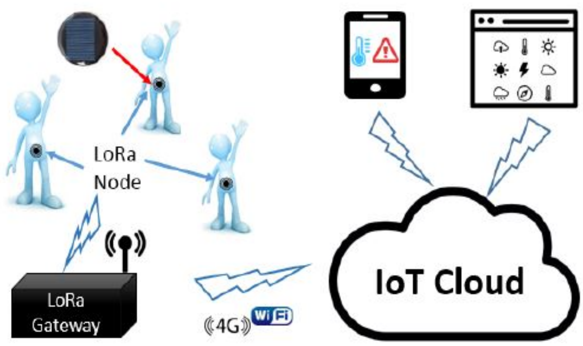
The networks perform an assortment certain number of deployed sensor nodes in a specific environment. Competent sensors are needed to detect information, process data and to perform a wireless communication (Taoufiket et al., 2018). Each sensor node is commonly powered with a built-in limited energy battery (Taoufiket et al., 2018; Abdul-Salaam, 2015; Antonio Cilfoneet et al., 2019). The sensor node has limited capacity to store data, limited processing capability, and limited communication bandwidth. The issue has always been sensor nodes which are always deployed in an unpractical or nasty environment. It is impossible or difficult to recharge or replace their batteries (Taoufiket al., 2018). In our research, wireless network is something that we studied for LoRa technologies. LoRa are one of the top wireless networks due their promotion of low energy consumption.

Figure 3. Internet of things view (Antonio Cilfoneet et al., 2019)



LoRaTechnologies. LoRa is a typical network of low powered wide area network (LPWAN) (Wu, 2018; Kaiset al., 2019). LoRa offers low power consumption that uses ISM band (the unlicensed radio spectrum in the industry scientific and medical radio band) (Abdul-Salaam, 2015; Oboko, 2018). This technology increases sensor battery lifetime and reduces cost. LoRa has scalability bandwidth and in addition LoRa can be used for narrowband and also wideband area (Zulkifli and Noor, 2017). The LoRa protocol has been designed especially for low power consumption and extending battery life up to 20 years (Zulkifli and Noor, 2017). LoRa is capable of reducing cost three ways; infrastructure investment, operating expenses and also end node sensors. All these requirements meet the standards of IoT needs especially for outdoor environments.

Figure 4. Network for LoRa Based System (Tahaet al., 2019)



Result and Discussion

Hardware setup. We used the LoRa shield based on Semtech SX1276 with 433 MHz due to Asian requirements. The sensor implementation to the aquaponics is based on pH level, turbidity and also the temperature.

Current Consumption Analysis. Theoretically, the value of the current consumption of the transmit mode must be higher than the value of the receive mode. In sleep mode, the power from a LoRa end device is automatically switched off. Thus, the data cannot be received and transmitted. The theoretical current consumption parameter values the main components used for the stand alone LoRa are listed in Table 1. The result is according to the datasheets of the modules used for the experimental test.

Table 1: Measured current standalone LoRa

Mode	Average current consumption LoRa (mA)
Transmit	64
Receive	11.4
Idle	1.6
Sleep	0.2

Table 2 refers to the result based on the performance of the LoRa end device integrated with the sensor. The measurement and analysis of the current consumption have been done with transmitting samples of data during operation. The experiment has been conducted in the real world environment.

Table 2: Measured average current LoRa integrated with sensor

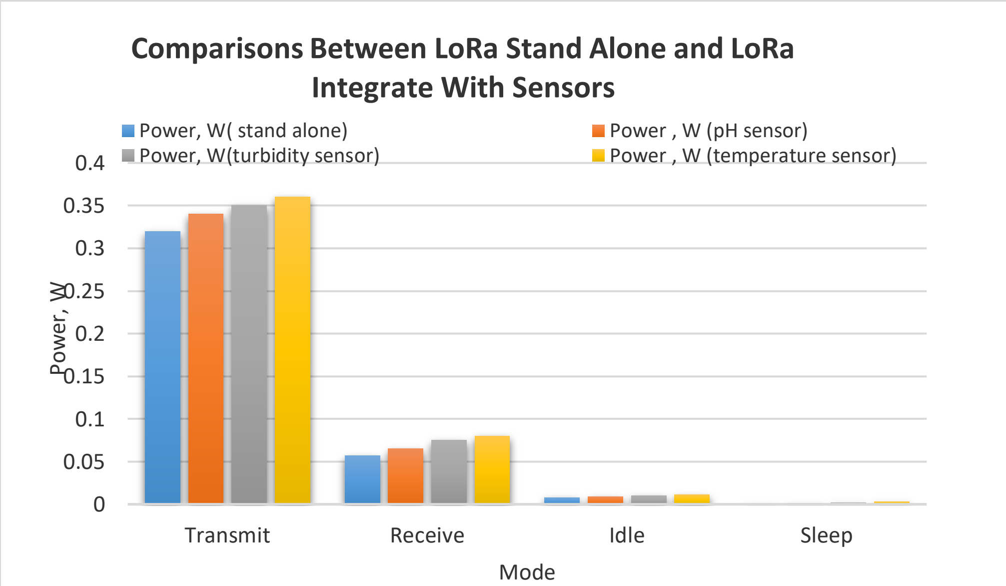
Mode	Average current consumption LoRa (mA) (pH sensor)	Average current consumption LoRa (mA) (turbidity sensor)	Average current consumption LoRa (mA) (temperature sensor)
Transmit	68	70	71
Receive	13	16	15
Idle	1.8	2.1	2.0
Sleep	0.3	0.4	0.6

The analysis of power consumption of LoRa stand alone and LoRa integrated with sensor. The power value is P = IV, where I is the measuring of the current from Table 2, for both system (LoRa stand alone and LoRa integrated with sensor), whilst V is the DC supply voltage is 5 V. Table 3 compares them.

Table 3: Comparisons of power consumption between LoRa stand alone and LoRa integrated with sensor

Mode	Power, W (Standalone)	Power , W (pH sensor)	Power, W (turbidity sensor)	Power , W (temperature sensor)
Transmit	0.32	0.34m	0.35	0.36
Receive	57m	65m	75m	80m
Idle	8m	9m	10m	11m
Sleep	1m	1.5m	2m	3m

Figure 5. Comparison between LoRa standalone and LoRa integrated with sensor



Wireless IoT systems are reducing and are often powered by small energy harvesters. Due to the current flow from sleep mode/power down to full operation of the wireless transceiver, it is not an easy task to verify the actual power consumption conventionally (Umber et al., 2017). In this result, we have computed the power consumption for three sensors in the intelligent greenhouse system (aquaponics). The sensors are measured for pH, turbidity and temperature. The power consumption for standalone LoRa is computed by referring to the element in the datasheet. The other sensors are measured in a real environment network. Normally the power consumption will increase due to the transmit and receive data process (Taoufiket al., 2018).

This paper shows that power consumption in the LoRa integrated with the sensor meets the requirements of LoRa stand alone. The power consumption of LoRa integrated with the sensor has not much difference compared to the stand-alone result. This result meets the requirement mentioned in (Gray et al., 2015). Therefore LoRa is suitable in terms of battery life-time, capacity, range and cost. This result is proof that our intelligent green house is stable and our wireless sensor network is working properly.

Conclusion and Recommendation

Power consumption during transmitting and receiving for standalone LoRa and LoRa integrated with sensors is not exaggerated. It also proves that our system is stable. In the near future many more sensors recommendations can be calculated to verify the stabilization of the system.

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