Hybrid Mechanisms on IoT Smart Lamps' Model for Time Efficiency

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Abstract:
This study performs lamps activation process based on the Internet of Things (IoT) using hybrid mechanisms: site and far-off system. The site mechanism is using Bluetooth. Nevertheless, the far-off mechanisms are using internet and Network time protocol (NTP) activations. These mechanisms are presented in a model named I-Smart Lamps, which is designed and constructed conveniently to activate the lamps over the internet. The process of the three mechanisms: Bluetooth, NTP, and IoT are discussed in effective time activation. The Bluetooth mechanism gives an average time process of 13 seconds, the duration of the Bluetooth mechanism is better for residents in the building. The far-off system using IoT gives a better time process of activation. These mechanisms are convenient for residential buildings to serve the residents' activities with a rapid duration of lamps activation time.

Keywords:
Smart lamps · Network time protocol · Internet of things (IoT) · Bluetooth · Time process

1. Introduction

Lighting systems in buildings are known, approximately 40% of total energy consumption [1]. However, the implementation of smart lighting techniques offers promising opportunities for energy conservation. One effective strategy involves the integration of light sensors into the lighting system, enabling automatic dimming when the available natural light is deemed sufficient to meet the desired lighting requirements. This approach enhances overall energy efficiency, thereby contributing to sustainable and environmentally conscious building practices.

Smart lamps or lightning are often implemented for smart traffic lights or cities [1]–[8]. Smart lamps for smart homes are limited and mostly focus on energy consumption. The comparative analysis of simulated data pertaining to the utilization of three lamps sources: Compact Fluorescent Lamps (CFLs), Light-Emitting Diodes (LEDs), and Smart LEDs are discussed in [9]. These lamps are in conjunction with the implementation of sensor technologies, specifically occupancy sensors with varying time delays and daylight harvesting capabilities. The objective of this investigation was to evaluate the performance and energy efficiency of these lighting systems under different scenarios, thereby providing valuable insights for optimizing lighting strategies in diverse indoor environments. However, for each simulation of smart lamp type, it only uses two lamps. An examination of energy consumption in smart homes through the implementation of machine learning models reveals valuable insights that are discussed in [10].

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Employing prominent machine learning techniques enables predictions of power consumption across various datasets. Nevertheless, these methods do not discuss the time process to turn on the lamps. The study in [11] endeavors to integrate three distinct communication channels, namely Bluetooth, Web/Internet, and SMS, within a unified system to offer users enhanced versatility and flexibility. The primary objective of this research is to merge the aforementioned communication channels and introduce an additional feature for timer-based automatic control of lighting, enabling scheduled activation and deactivation of lights based on user-defined time intervals. This mechanism discusses the duration of the time process to activate the lamps, however, the results give a relative delay in processing time. A study in [8] presents the design of a Bluetooth-based smart lighting control system integrated with the Android platform. In the automatic mode, the system of an infrared sensor detects human presence and subsequently controls the LED light, enabling its activation or deactivation accordingly. In the manual mode, the Android application facilitates Bluetooth communication to provide users with direct control over the LED light. The proposed system gives 10 meters of distance from the lamps, but still does not discuss the processing time to activate the lamps.

There is an opportunity to discuss smart lamps regarding the duration of the activation process. Nevertheless, most lamps in the residence are activated manually, and this condition makes a complicated activation process. When the residents are not locally in the building, problems to activate the lamps can occur. The fast response process to activate the lamp in the I-smart lamps can be a solution for an effective way. The I-smart lamps' model for residential buildings needs manually or remotely activation. The residence with some lamps: in the bedroom, kitchen, garden, living room, and so on, the residents' activities are crowded and an effective mechanism to activate the lamps is needed.

This paper discusses the activation mechanism for the I-smart lamps model in residential buildings. The mechanisms to turn on the lamps are classified into three scenarios: using Bluetooth, NTP, and IoT. The model is tested in time process activation, accordingly the duration time, the effective mechanism can be chosen manually or remotely.

1.1 Network Time Protocol

The Network Time Protocol (NTP) serves as a fundamental protocol for achieving time synchronization with nanosecond-level precision while ensuring unambiguous date preservation, particularly within the current century. It encompasses provisions for defining the precision and estimated error of local clocks, as well as the characteristics of the reference clocks for synchronization. However, the protocol itself solely specifies data representation and message formats, omitting the details of the synchronization algorithms or filtering mechanisms.

The Internet protocol suite encompasses additional mechanisms to record and transmit event timestamps, such as the Daytime protocol and IP Timestamp option. It is important to note that NTP does not aim to replace these existing mechanisms; rather, it complements them by providing specialized functionality for accurate time synchronization.

1.2 Research Contributions

This paper proposes the model of the I-smart lamps to effectively activate the lamps. The contributions are: suitable model for a residential building with four lamps inside; activation lamps locally or remotely; three mechanisms to activate the lamps: using Bluetooth, NTP, and IoT; the best selection mechanism for local or remote residents; in case the residents do not activate the lamps, however, the NTP mechanism will turn on the lamps. The four lamps in the residential building can be LED or fluorescent lamps. In case the residents do not activate the lamps, however, the NTP mechanism will turn on the lamps.

2. Materials and Methods

2.1 Material

The I-smart lamps' model is designed for a residential with four lamps: the bedroom, kitchen, garden, living room, or family room. These lamps are activated using three mechanisms: IoT, Bluetooth, and NTP. Each internet, Bluetooth, and NTP works independently. The NTP server is set to displace the Real-time clock (RTC module). The lamps are controlled with the internet using devices and the X-Node module. In case the internet is disrupted, the I-smart lamps can be activated using Bluetooth. The I-smart lamps block diagram model can be shown in Figure 1.

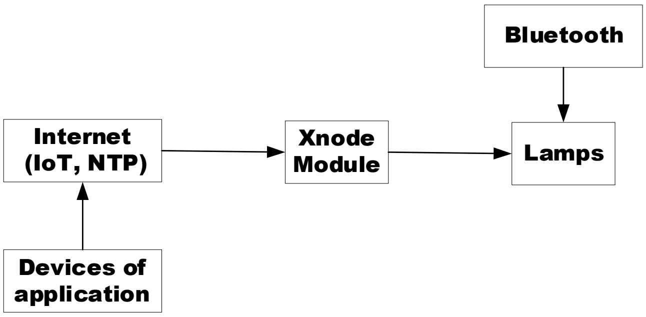

Figure 1: I-Smart lamps model

2.2 Smart Lamps Model

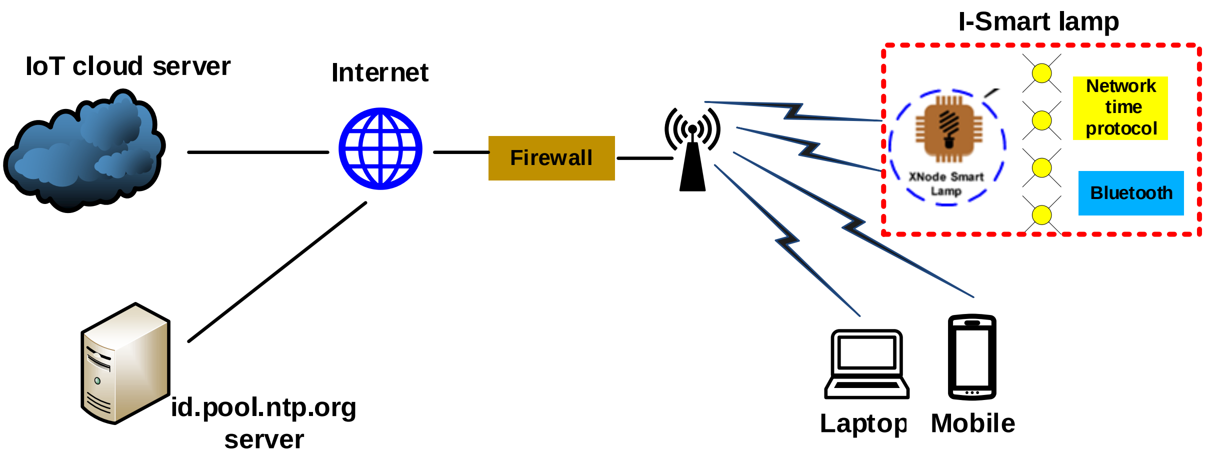

Figure 2: I-Smart Lamps configuration system

The I-smart lamps model has a configuration system, as shown in Figure 2. The system is controlled with a device (Xnode), connected to the WLAN (Wireless Local Area Network), monitored, and controlled using an application on a computer or Mobile device. Computers and mobile devices are also connected to the same WLAN. Nevertheless, the time configuration synchronization system utilizes the "id.pool.ntp.org" server. The time from the NTP server will be compared with the time entered on the IoT cloud server. The I-Smart Lamp system is connected to the IoT platform in the Internet Cloud.

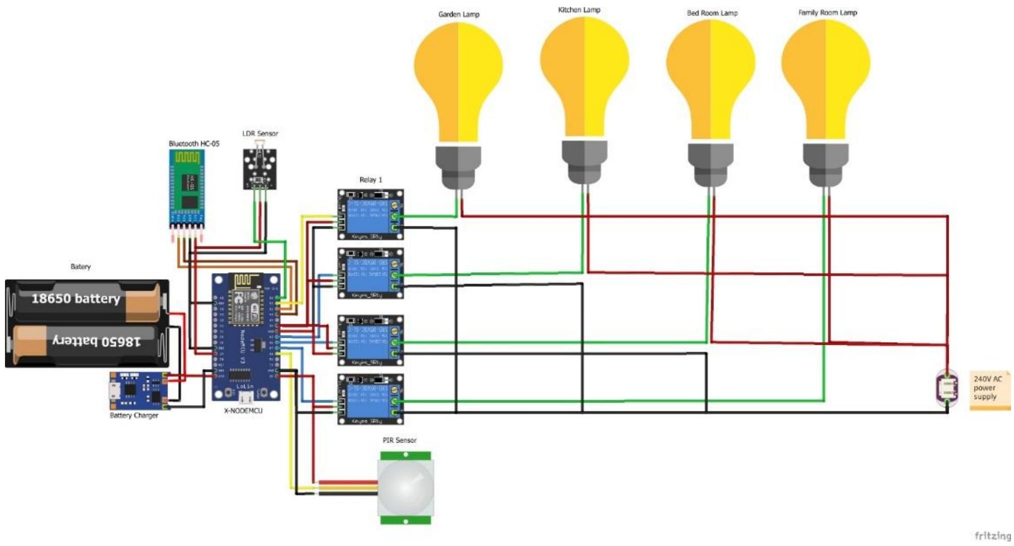

Figure 3: Detail I-Smart lamps model

Figure 3 presents the detailed I-smart lamps model. The components consist of XNode, LDR (Light Dependent Resistor) sensor, PIR (Passive InfraRed) sensor, relay, Bluetooth module, power supply, battery, and four lamps. The LDR has a function to detect the light, and it will turn the lamps on automatically. Furthermore, in the morning, the LDR will turn on the lamps when the sun has arisen and turn off the lamps in the afternoon. Meanwhile, the XNode will control the LDR, PIR, and relays. The XNode output is only 3.3 dc volts, while each lamp needs 220 ac volts, therefore the relay is used for connecting or disconnecting the lamps with a power supply of 220 ac volts.

2.3 Methods

The smart lamps system procedures are shown in Figure 4. The process starts when the lamps are turned on at site or far-off. The far-off condition is a remote mechanism to activate the I-smart lamps. The system is activated by login using SSID and password in the I-smart lamps application on the internet. When the network of the cloud IoT server is connected with the system, it will read the data and activate the lamps. Nevertheless, the site mechanism is activated using NTP. Due to some humans' hectic activities, there might be a possibility that the far-off mechanism is forgotten to process. In this case, the I-smart lamps will turn on automatically by NTP at some set time. Smart lamps can also be controlled manually using Bluetooth from a smartphone with a Bluetooth terminal application. By sending data 1,2,3,4 from Bluetooth to turn on garden lights, kitchen lights, living room lights, and bedroom lights alternately. And by sending data 5 from Bluetooth to turn on all the lights, and sending data 6 from Bluetooth to turn off all the lights.

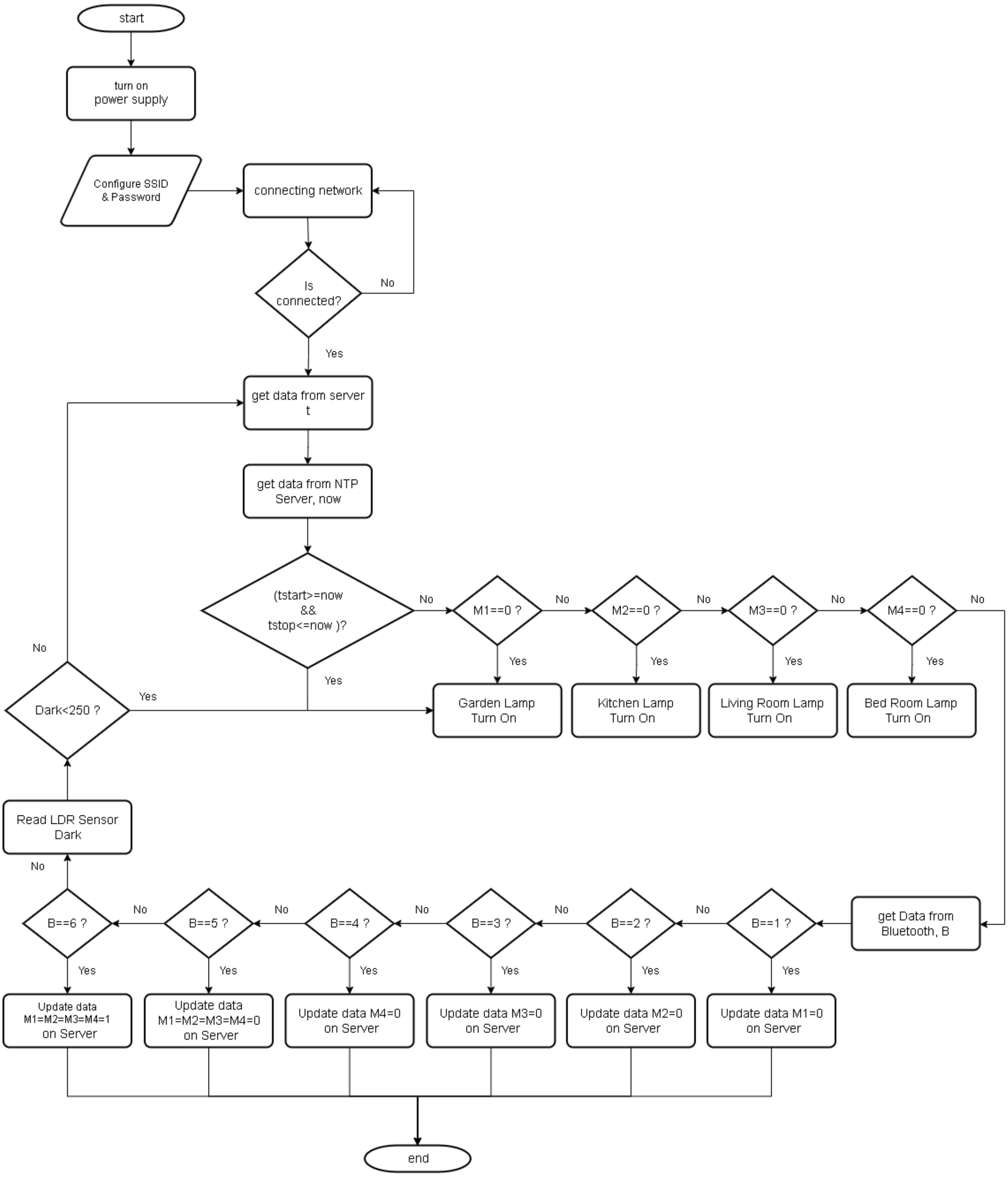

Figure 4: The I-smart lamps flowchart

The I-smart lamps system requires a Bluetooth module to monitor and control smart lamps locally, and remotely using ICS= IoT Cloud Server. The system also needs to ensure real-time light monitoring and remotely controlling. Meanwhile, the IoT for smart lamps system has algorithms as:

Algorithm 1: An algorithm for Smart Lamp

```
Data: SSID = 'SmartHomeWiFi', pass = 'PasswordWiFi'
Data: BL ≥ 0, D ≥ 0, DTh = 250, M1 = 1, M2 = 1, M3 = 1, M4 = 1
Result: Lamp = ONorLamp = OFF
WIFI ← begin(SSID, pass);
if WIFI = true then
 | isconnected ← true;
end
while true do
 | if isconnected is true then
 |  | D ← lightsensor;                          /* Read LDR sensor */
 |  | if D ≤ DTh then
 |  |  | M1 ← 0, Lamp1 ← turnon;
 |  | end
 |  | TStart ← DatafromServer, TStop ← DatafromServer,
 |  |  Tnow ← DatafromNTPServer;
 |  | if Tnow ≥ TStart&Tnow< TStop then
 |  |  | M4 ← 0, Lamp4 ← turnon;
 |  | end
 |  | M1 ← DatafromServer, M2 ← DatafromServer,
 |  |  M3 ← DatafromServer, M4 ← DatafromServer;     /* from
 |  |  DB Iot Cloud Server */
 |  | if M1 == 0 then
 |  |  | Lamp1 ← turnon;
 |  | end
 |  | if M2 == 0 then
 |  |  | Lamp2 ← turnon;
 |  | end
 |  | if M3 == 0 then
 |  |  | Lamp3 ← turnon;
 |  | end
 |  | if M4 == 0 then
 |  |  | Lamp4 ← turnon;
 |  | end
 |  | BL ← BluetoothSensor;
 |  | if BL == 1 then
 |  |  | M1 ← 0;
 |  | end
 |  | if BL == 2 then
 |  |  | M2 ← 0;
 |  | end
 |  | if BL == 3 then
 |  |  | M3 ← 0;
 |  | end
 |  | if BL == 4 then
 |  |  | M4 ← 0;
 |  | end
 |  | if BL == 5 then
 |  |  | M1 = M2 = M3 = M4 ← 0;     /* Update Data DB ICS */
 |  | end
 |  | if BL == 6 then
 |  |  | M1 = M2 = M3 = M4 ← 1;     /* Update Data DB ICS */
 |  | end
 | else
 |  | isconnected ← false;
 | end
end
```

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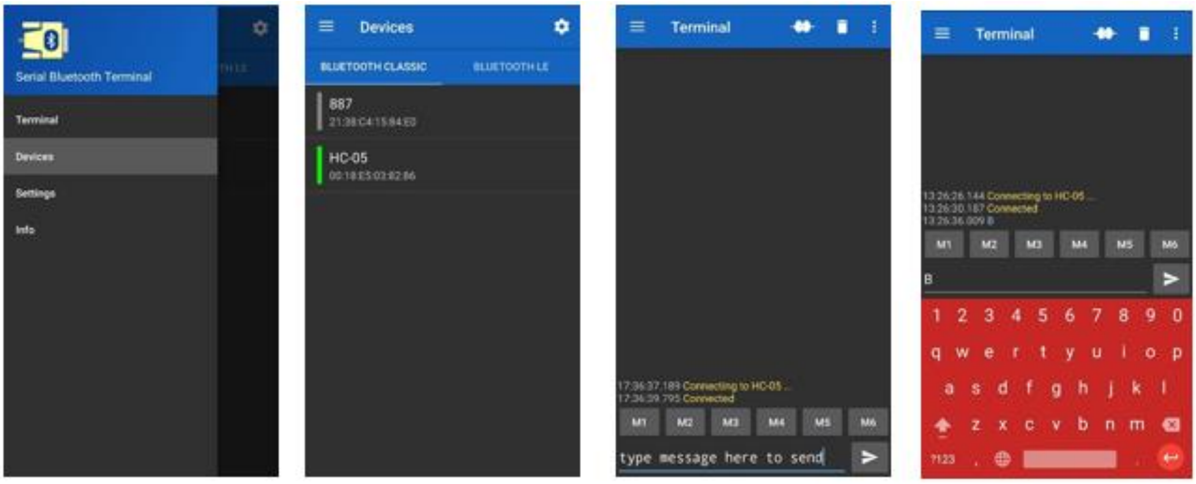
3. Results and Discussion

The I-smart lamps system has been examined and the results are discussed in this section. The I-smart system consists of the I-smart lamps model and an application on the devices: laptop and mobile equipment. The process of connecting the application and the lamps is also discussed. Detailed process results are presented in this part.

3.1 Bluetooth

The I-smart lamps' model has been connected to the Bluetooth module. Detailed processes are shown in Figure 5. The lamps are activated locally using Bluetooth, which is proofed in Figure 5d.



(a) (b) (c) (d)

Figure 5: The Bluetooth connected, (a): Bluetooth dashboard application, (b): The second appearance on-screen display of mobile equipment, (c): The process of Bluetooth connected with lamps, (d): The connecting process is succussed

3.2 The I-Smart Lamps

The I-smart lamps' model has been connected to the Bluetooth module. Detailed processes are shown in Figure 5. The lamps are activated locally using Bluetooth, which is proofed in Figure 5d.

(a) (b) (c)

(d) (e)

Figure 6: The smart lamps model activations, (a): All the lamps switch off, (b): The first lamp switches on, (c): Two lamps switch on, (d): The three lamps switch on, (e): The four lamps switch on

The four lamps of the I-smart model are shown in Figure 6, the lamps are turned on one by one in order. The first, second, third, and four lamps are turned on. The turn-on processes are tested using the internet, NTP, and Bluetooth.

3.3 Discussions

This section discusses the results of the I-smart lamps' model in the system. The results give three lamps activation mechanisms: Bluetooth, NTP, and IoT.

3.3.1 Bluetooth Results

The I-smart lamps use a Bluetooth mechanism to activate the four lamps. Each lamp activation is tested five times using Bluetooth. The model gives a duration average time process of 13 seconds. The results are stunning for a fast activation process using Bluetooth.

Table 1: The I-smart lamps using Bluetooth

Lamp	Time On Click	Time Execution	Duration (Delay)
Kitchen Lamp	14:11:29	14:11:37	0:00:08
	14:18:43	14:18:57	0:00:14
	14:33:13	14:33:25	0:00:12
	14:34:45	14:34:51	0:00:06
	14:35:59	14:36:10	0:00:11
Garden Lamp	14:38:04	14:38:17	0:00:13
	14:40:06	14:40:27	0:00:21
	13:29:28	13:29:37	0:00:09
	13:34:56	13:35:11	0:00:15
	13:36:11	13:36:23	0:00:12
Living Room Lamp	13:37:48	13:37:58	0:00:10
	13:39:24	13:39:31	0:00:07
	13:40:43	13:40:57	0:00:14
	13:42:03	13:42:09	0:00:06
	13:43:19	13:43:35	0:00:16
Bed Room Lamp	13:44:32	13:44:49	0:00:17

13:45:44	13:46:01	0:00:17
13:47:07	13:47:28	0:00:21
13:48:49	13:49:09	0:00:20
13:49:48	13:50:09	0:00:21
Average		**0:00:13**

3.3.2 NTP Results

The NTP in the I-smart lamps is tested and the results are shown in Table 2. The NTP mechanism is an automatic process to turn on or off the lamps in the building. The tests are performed in two conditions: the turn-on and turn-off processes. The processes need a time of seconds, and the average duration of turning on or off the I-smart lamps is 1.75 minutes.

Table 2: The I-smart lamps using NTP

Lamp	Schedule On	NTP Time	Time Turn on	Duration of Turn-on Process (seconds)
Kitchen Lamp	07:45:00 AM	07:45:05 AM	07:45:07 AM	2
Garden Lamp	07:46:00 AM	07:46:02 AM	07:46:04 AM	2
Living Room Lamp	07:47:00 AM	07:47:06 AM	07:47:07 AM	1
Bed Room Lamp	07:48:00 AM	07:48:03 AM	07:48:05 AM	2
Average duration				1.75

Lamp	Schedule Off	NTP Time	Time Turn off	Duration of Turn-off Process (seconds)
Kitchen Lamp	08:12:00 AM	08:12:02 AM	08:12:04 AM	2
Garden Lamp	08:13:00 AM	08:13:05 AM	08:13:07 AM	2
Living Room Lamp	08:14:00 AM	08:14:02 AM	08:14:03 AM	1
Bed Room Lamp	08:15:00 AM	08:15:05 AM	08:15:07 AM	2
Average duration				**1.75**

3.3.3 IoT Results

The four lamps of the I-smart model are classified as kitchen, garden, living room, and bedroom lamps. Each lamp is tested five times, and the average duration time of the process is one minute and nine seconds. The average time of the IoT duration process gives better time than the NTP process.

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Table 3: The I-Smart Lamps using IoT

Lamps	Time On Click	Time Execution	Duration (seconds)
Kitchen Lamp	12:52:24	12:52:37	0:00:13
	12:52:24	13:00:05	0:07:41
	13:09:22	13:14:21	0:04:59
	13:16:24	13:16:27	0:00:03
	13:16:24	13:23:13	0:06:49
Garden Lamp	13:27:17	13:27:25	0:00:08
	13:28:27	13:28:37	0:00:10
	13:29:28	13:29:37	0:00:09

	13:34:56	13:35:11	0:00:15
	13:36:11	13:36:23	0:00:12
Living Room Lamp	13:37:48	13:37:58	0:00:10
	13:39:24	13:39:31	0:00:07
	13:40:43	13:40:57	0:00:14
	13:42:03	13:42:09	0:00:06
	13:43:19	13:43:35	0:00:16
Bed Room Lamp	13:44:32	13:44:49	0:00:17
	13:45:44	13:46:01	0:00:17
	13:47:07	13:47:28	0:00:21
	13:48:49	13:49:09	0:00:20
	13:49:48	13:50:09	0:00:21
	Average		**0:01:09**

3.3.4 Control System of I-smart Lamps

The applications in the system are tested and the results are presented in Table 3. The control functions of Bluetooth, NTP, Web, and mobile applications are all successfully tested.

Table 3: Control Component Testing

Control	Information
Bluetooth	Successful
Timer NTP	Successful
Web	Successful
Mobile Apps	Successful

3.4 Feasibility of Other Smart Lamps

The I-smart lamps' model successfully works for activating the lamps locally and remotely. The best process is using the IoT mechanism due to the duration time process being faster than the Bluetooth and NTP mechanisms. The model is also compared with other methods in Table 4. The I-smart lamps model has a better in-time process activation.

Table 4: Smart Lamps Comparisons

	Reference [11]	Reference [9]	I-smart lamps this paper
Duration of time process	16.625 minutes	15 minutes	1.42 seconds (NTP) 1.09 seconds (IoT)
Method	IoT, RTC, Bluetooth	virtual sensor and the behavior of inhabitants	IoT, NTP, Bluetooth
Implementation purposes	Residential buildings	Residential buildings	Residential buildings
Number of lamps	4 - fluorescent lamp	2 -each CFL, LED, and Smart-LED	4 – LED or fluorescent lamps

4. Conclusion

The I-smart lamps' model is an effective mechanism to turn on the lamps, site, and far-off. It is proven: the three mechanisms of lamps activation have their function independently. The duration time process of lamps activation is better than other references. Nevertheless, the Bluetooth mechanism gives a fast duration of time process for residents in the building. While the IoT mechanism is convenient for far-off residents to activate the lamps in the building. And when the oblivious resident does not activate the lamps in the evening, the NTP will turn on the lamps automatically.

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