Smart lighting system based on IoT with Alexa and LIFX

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Abstract:

Internet of Things (IoT) involves discovering and communicating with tremendous peripherals including mobile devices, cameras, actuators, other computer devices with internet facilities. With IoT enabled technology, the advantages such as automation in home appliances, monitoring and controlling data, networking, and so on. In these days, the human machine-based user interface is dramatically increased. The growth is processed by adopting the devices such as a mouse, touch device, keyboard, and voice devices. The novel technology has developed with the emergence of Alexa Voice Service. This new user interface can be accomplished with the Alexa Voice service. The smart light system includes information on the light state (ON/OFF) that can be operated over the Internet using the Alexa Echo Voice Assistant feature. The proposed methodology has been adopted with IoT devices via voice facilities. The IOT-based smart lighting system helps connect devices quickly, resulting in effortless and easy connecting configurations.

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1.Introduction

Smart lighting is an illumination methodology that is engineered to be energy efficient and centrally controlled from anywhere. Lighting is the deliberate application of light to create some sort of visual or functional effect. With smart lighting, conventional lamps are reinstalled with smart LED light bulbs mounted in the accessible sockets [1]. Internet- connected smart hubs link the smart bulbs, providing power from every remote locationsmart bulbs connected to a WI-FI networking atmosphere for lighting that has extremely advanced regular systems. A smart light bulb looks "intelligent" since a smart device tracks its day-to-day operation [2]. A smart lighting system is a vastly sophisticated routine system for tracking and managing smart lighting and many other features.

Almost any light point can be linked to the wireless network via the IoT Platform [3]. IoT Smart device allows any of these linked physical objects to be managed and tracked from any location. The value of the Internet of Things is much greater in many other aspects, including:

- IoT has made it possible to transport bigdata for devices which is characterized by exceptional volume and time and deliver technology that must be linked to the development of new

smart technologies and goods that support companies, companies, and society.

- Similarly, the IoT ecosystem consists of IoT products, cloud storage, and data processing services, mostly owned, managed, and run by individual providers. As a consequence, IoT is essentially a combined environment where IoT objects and data, cloud services, and applications (e.g., data processing, simulation, and actuation) are components that are mostly supplied by individual vendors and provide a range of interfaces, market, and cost [4].

Better illustrate the federated essence of IoT, the lighting utility is designed to dynamically change lighting patterns to conserve electricity while increasing the number of lights in the building. The IoT service would need to communicate with the unique light mounted to read data from the system and activate the on and off illumination.

This paper's remaining part is structured as follows: Section 2 summarizes relevant work on the IoT network. The methodology for smart lighting with Alexa Echo dot in Section 3 and its complete explanation is given. The simulation outputs are offered with their discussion in Section 4. Although Section 5 accomplishes the paper and discusses future work.

2 Literature Review

This section presents the current research presented here about IoT-based Lighting Systems and challenges and compared various existing systems as per Tab. 1. IoT product may have to execute all the below given steps if any IoT devices which are using IoT applications and the data of that IoT application is providing an IoT support or service, which include the IoT enabled device application lifecycle:

- Find out the IoT enabled devices which can able to get their required data,
- Consolidate these IoT devices and their data, and
- Analyze the consolidated data as required by the goal IoT product/service.

Earlier researchers suggested few responses to the same issues studied as follows. Rajput et al. [5] proposed a solution using GSM for an intelligent street lighting scheme that aims energy-saving and self-sustaining on economical street-friendly activity.

Chetna Badgaiyan et al. [6] proposed a smart street lighting device using a wireless sensor network, a pyroelectric infrared sensor (PIR) and a Zigbee sensor. Parkash et al. [7] have introduced a smart built-in system that regulates street lights on the basis of vehicle detection or some other road barriers. Whenever an object is found on the route, the light is immediately turned on/off via the Internet. The LDR and PIR sensors detect the individual and the light intensity of a specific location and relay the wireless data mode to the Zigbee portion of the EB. Deepak Kumar Rath [8] suggested an LDR-based smart street lighting system to automatically turn on/off and change the light intensity.

The IoT home lighting and control system of the appliance is developed by [9]. Speech regulation for smart home automation is explained in the assessment of methods and potential architectures [10]. The following issues are captured when managing smart bulbs using the current system, such as low latency, voice classification, and security. As suggested earlier, this paper focuses primarily on the IoT framework for human voice regulation of smart bulbs and involves cloud computing for this purpose [11].

Table 1: Comparison of Various Systems

Existing system	Advantages	Limitations
GSM Based System	Different commands are used for controlling the Devices.	The users had to remember the commands for controlling the devices.Hence, not convenient and user friendly

Bluetooth Based System	All devices are easily monitored within the communication range. It is a robust method.	The range is limited (100m), and the devices are controlled within a range.
SOAP based System	The devices are controlled remotely and easily.	It is a complex method and lays overhead for client- server systems. It has a slower operation and requires more bandwidth.

The literature review suggested a few gaps in the earlier system, like only motion detection or day/night light conditions, to solve the problem alone. Only movement detection does not work because movement's detection is possible in daylight also. The street lights must be ON only when there is Dark (night) and when the movements are detected on the road. Hence a new solution is proposed here to make the system more capable. "To design a self-regulatory and energy-efficient intelligent lighting system, which is self-capable of identifying the natural light conditions and moving objects also can communicate about light health status to the operator."

3 Methodology

In this section, the proposed methodology on the Alexa Echo voice assistant for smart lighting with low latency in the IoT platform is presented. Adopting LED lighting to the ambient environment and switching on/off or dimming lights depends on user requires. These can be done by smart lighting which is used for power saving. This will reduce the unnecessary usage of power. For cost reducing part, this power saving is play a main role. Smart lighting gives the user more flexibility to turn on or off the lights using a voice or mobile phone and reduces power consumption. Alexa for Smart Lighting System utilizes information about the lights. Alexa Controls the lights through Wireless Communication. It reduces the workforce to operate the lights. Users can switch ON/OFF of the lights from anywhere over voice or web. Wi-Fi network is used to define and determine the IoT devices and their data by the suggested IoT Platform. By providing a data, standard, and machine-readable interpretation of its description, the Wi-Fi network enables interoperability for IoT devices.

Artificial Intelligence (AI) technology that relies on two main components: the hardware (a way to communicate commands) and the software (a way to observe requests and process a response) is used. When the verbal command is given to a device such as the Alexa Echo, it picks up on the voice and the associated background noises during the vocal capture. The Alexa device is activated with a wake-word, voice identification service that resides locally on the main circuit board to recognize a user voice command instantly. Once the analog recording receives the user's oral command, it is processed for converting analog-to-digital. The original voice is sent to the AI device for Natural Language Processing (NLP) to understand the intent and produce a response. Computing the voice in the cloud with natural language processing (NLP) generates a suitable response for user requests, and Alexa is always-on for voice recognition. It can be seen from Fig. 1 that computing the voice in the cloud with Natural Language Processing (NLP) generates a suitable response for user requests, and Alexa is always-on for voice recognition.

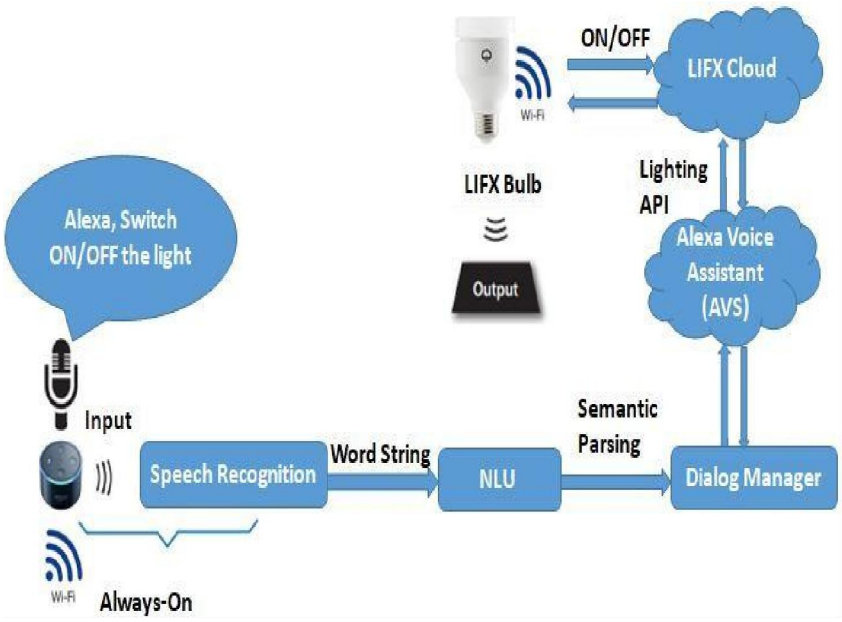


Figure 1: Architecture for voice-based smart lighting system

3.1 Infrastructure for Smart Lighting

The block diagram for the intelligent lighting system is shown in Fig. 2. With the beginning of the digital era, lighting systems have developed into more intellectual and automated. This lighting system includes Alexa for voice Assistant and controlling the lights over the human voice. IoT-based lighting systems are designed to save power consumption, low latency, high security, and control lights on/off over human voice from anywhere and anytime. The following IoT devices are utilized to collect data: the Alexa Echo Dot AI device and LIFX LED Bulb (A19 LHA19E26UC10).

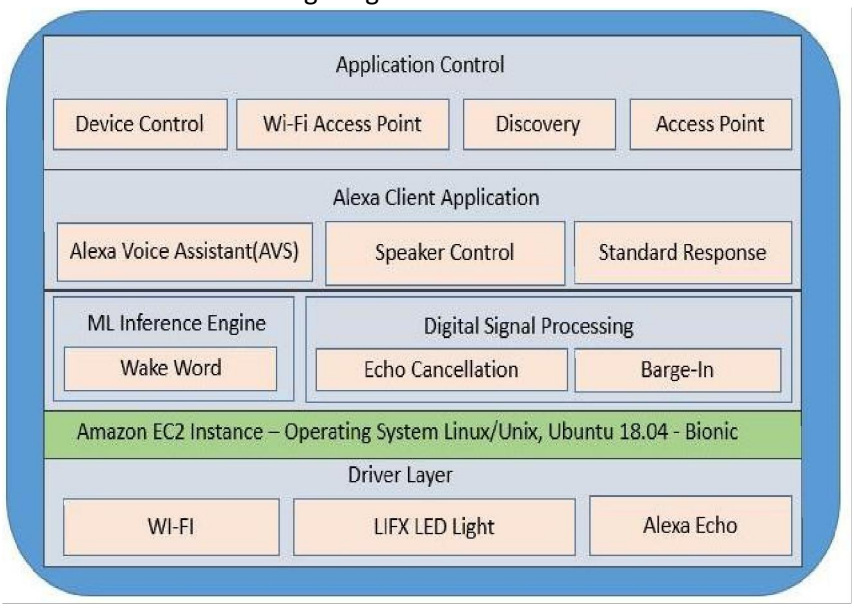


Figure 2: Block diagram for smart lighting system.

3.2 Alexa Voice Service (AVS)

Alexa Echo devices are powered by the intelligent voice control service, called Alexa Voice Service (AVS). To map the user requests and provide their requests and responses, Alexa always uses Natural Language Processing (NLP)

approaches qualified by the user community and the developers of Amazon. The Alexa AI device can be activated by the keyword "Alexa." Only the necessary information is sent to the Alexa by AVS Service, and a response is sent to the user.

3.3 Alexa Echo AI Device

Alexa Echo is an AI device with a voice-enabled wireless smart speaker developed by Amazon. The device is capable of voice interaction, getting the real-time information of the smart bulbs. Alexa Echo AI Device allows the user to voice command on/off at home or street lights. It also allows the user to manage the intensity of the smart light. With Alexa, the users need not use remote controls and manually switch on/off. Users can say, "Alexa, turn on the light," and Alexa will control the lights to be switched on. Alexa Echo connects to 802.11a / b / g /n standard utilized Wi-Fi (2.4 GHz / 5 GHz) networks.

3.4 LIFX Smart Bulb

LIFX LED Bulb comes with Cloud API (LIFX Community Forum, 2020) to communicate over the HTTP protocol and is enabled with High Availability (HA) Wi-Fi network. These innovative LED bulbs are more efficient and brighter. It is also called second-gen smart bulbs. The proposed research has utilized an A19 LED Bulb to collect the lighting data and connected it with the Amazon Alexa voice control device. LIFX A19 is the Wi-Fi Smart LED Light Bulb that gives the Adjustable and Dimmable of the light.

3.5 Voice Command Structure

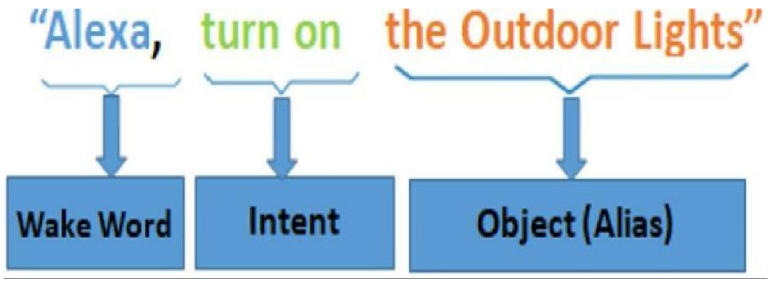


Figure 3: Alexa voice command structure

Alexa Voice command provides a suitable layer of control for the end-user, offering hands-free support for physical devices. Voice control provides a way to control space from anywhere within the distance without going to a specific physical location. The integrator must understand its capabilities and design with the end-user in mind.

As shown in Fig. 3, every voice command is composed of three core components: Wake Word, Intent, and Object.

3.5.1 Wake word

It is a word which can triggers the Amazon device to wake up, listen and drive to the direction on what to do.

- Default is "Alexa"
- The wake word is altered by going to the Amazon device's settings within the Alexa app.

3.5.2 Intent

These words are command words that can drive the Alexa device on what action to take. For lighting control, common intents are:

- Turn on
- Turn off
- Set
- Dim

3.5.3 Object

The device being controlled by the Alexa device; the object's name is known as the Alias.

- Each Alias must be unique.
- Examples of Aliases used in lighting control: Outdoor, Indoor, Kitchen, etc.,

3.6 Artificial Intelligence

Artificial intelligence Technology that replicates human cognitive process:

- Observe
- Interpret
- Evaluate

Artificial intelligence Examples in Practice

- ***Automotive***: assisted driving, traffic optimization
- ***Manufacturing***:faster processes, machine learning technology
- ***Services***: search, commerce, music, and movies
- ***Speech recognition***: analyzing and understanding speech

Artificial intelligence helps to solve the below challenges for Smart Lighting.

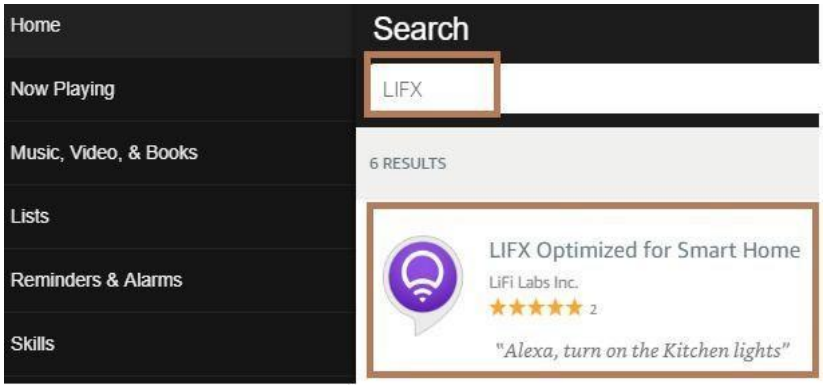
- ***Auto-commissioning***: removes human error, reduces the cost of installation.
- ***Reliability***: data enables predictive maintenance of light fixtures
- ***Value***: adds value through data processing and analysis.
- ***Learning***: constantly monitors and improves environment AI-enabled lighting systems provide the best user experience and maintenance enables easier upgrade from "dumb" to intelligent lighting.

4 Results and Discussion

In this modern world the technologies are growing and the usage of internet services are increased. According to that, the utilization of this technology has much higher possibilities and it will be soon in practice of everyday life [12, 13]. Every normal bulb will be reinstating by smart LED bulbs, and it might be used as a HA Wi-Fi network system for the communication of data [14]. These devices are the most efficient smart devices which are available today in the market [15]. The module used for testing home lights using Amazon Echo in real-time obtained promising results as per Tab. 2 and Tab. 3.

4.1 Simulation Environment

For the smart lighting system, the Alexa Echo dot and LIFX A19 LED Bulb are used to execute simulations.



4.1.1 System Specification

The system's specifications for network simulations are Intel Core i5-8500 @ 3.00GHz, 8GB RAM, operating system Ubuntu Linux 18.04 LTS, Alexa Echo Dot LIFX LED Bulb.

4.1.2 Connecting Alexa Echo to the LIFX Smart Bulb

- Open the Alexa app on the mobile device, Search for LIFX and Select the LIFX Optimized for Smart Home option as shown in Fig. 4.
- After Sign in to the LIFX Cloud account, and user needs to authorize the Echo device as shown in Fig. 5.
- After authorized, the user will get the successfully linked message from LIFX and return to the Skill page in Alexa App.

Figure 4: Search alexa skills

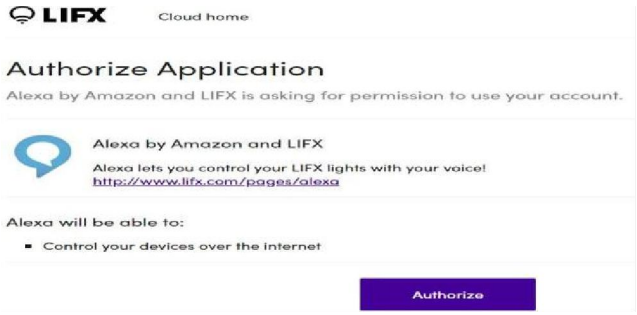
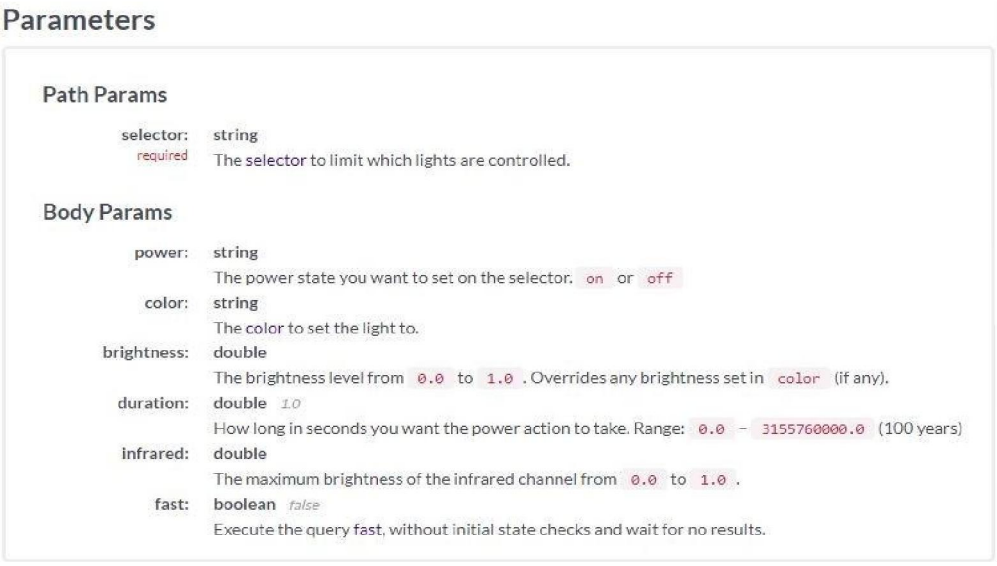


Figure 5: Authorize the device

4.1.3 LIFX Cloud API for Device Control

The API is designed to ensure seamless transitions for devices from one state to the next. For many situations, the system involves having an accurate view of the device current state before taking any device action [16]. Fig. 6 explains the device parameters required for switching the light on/off and brightness. Power attribute is used to control the light ON or OFF.

Figure 6: LIFX bulb parameters



Smart home devices will appear in the Alexa app and can be controlled from there with a tap or via Alexa voice commands if an Amazon Echo speaker is in range [17]. For smart lights, for example, user could say, "turn the outdoor light on" or "set the outdoor light to 50 percent".

4.1.4 Grouping Discovered LIFX Smart Bulbs

Use the Alexa app to delegate groups of LIFX lighting devices. LIFX bulb groups allow for the controlling of multiple smart bulbs using a single Alexa voice command.

For example, the LIFX device group named "Outdoor" can have multiple IoT devices located in the Outdoor assigned to a group of devices for control at one time.

"Alexa, turn on the [Outdoor] lights."

"Alexa set the [Outdoor] lights to a red."

4.1.5 Alexa Voice Commands

The following voice commands are used to control the lights on or Off, Dim and Brightness. Alexa commands to turn the device ON or OFF.

"Alexa, turn [my/the] [device name] [on/off]"

"Alexa, turn [on/off] [my/the] [device name]"

Table 2:RESTful APIs for smart lighting system

API Management	URI	Verb	Action
Device Management	/api/device/enroll	POST	Register a device
	/api/device/{deviceId}	DELETE	Unregisteringa Device
	/api/devices	GET	Getting Details of Registered Devices
	/api/devices/{deviceId}/changestatus	PUT	Changing the Status of a Device(ON/OFF)
	/api/devices/{deviceId}/location	GET	Getting Location Details of a Device
User/Owner Management	/api/users	GET	Getting Details of Users
	/api/users	POST	Adding a User
	/api/users/{username}	DELETE	Deleting a User
	/api/users/{username}	PUT	Getting Details of a User
	/api/users/{username}	GET	Updating Details of a User
System Management	/api/system/ping	GET	Test the Connection to the IoT Devices
	/api/system/identities	GET	Get All Identities
	/api/system/identity	POST	Issue an Identity to the Specific IoT device

Tab. 2 describes a part of Smart Lighting System REST APIs created for communication between the application web client, IoT device, and Ethereum based blockchain network. HTTP-based RESTful APIs contain an application-based URI, a content media type that defines state change for data elements (e.g., Application/JSON), and HTTP verbs (e.g., GET API, POST API, PUT API, DELETE API). The base URI typically describes the path of the data entity, and the HTTP verb indicates the preferred action to be performed in the recognized resource along with the request.

Table 3: Testing methods with various factors

Testing Methods	Testing Factors	Device Response	Output Accuracy
Distance from Alexa Device	Lesser distance 5 inches	Accurate response 8 out of 10 times	80%
	Greater distance 2 Feet	Accurate response 4 out of 10 times	40%
	Small Room (10 * 10)	Accurate response 6 out of 10 times	60%

Room Size	Large Room (15 * 30)	Accurate response 2 out of 10 times	20%
Speaker	Multiple Speaker (4 Bluetooth speaker)	The device responds accurately 2 out of 10 times	20%
	Single Speaker	The device responds accurately 8 out of 10 times	80%

4.1.7 Low latency

Response time for voice technologies, in particular, is critical. The voice command request was accepted by Alexa Echo and executed command in LED Toggle, the output accuracy captured with various testing factors as shown in Tab. 3. The latency between a consumer's question and the device's answer has the power to make or break the customer experience and should be kept to a minimum. Optimal response times of voice assistants will be those that imitate a natural, human-like interaction. Integrating voice technology with results that support central needs such as low latency and low power consumption will drive voice in the smart home or city forward (Parkash, Prabu V, et al., 2016).

The commands are covered over data transfer's single layer. So that, the latency rate of response between the devices are reduces. User gets the desired output with a change in the state of the LED. The latency rate between Alexa Echo commands which are accepted and execution of the command in the form of the LED toggle is denoted in the graph as shown in Fig. 7.

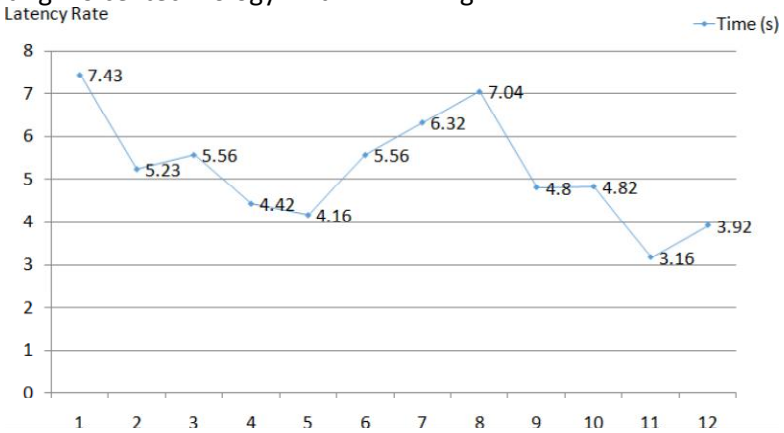


Figure 7: Graph for latency rate

This shows an average latency of 5 seconds— the data represented in the graph that we captured during the turn on or off. The data is stored in the queue even if the device is overloaded and the data which are stored is never lost. Alexa Echo is enhancing its efficiency to receive new commands by providing a timeout value for each command.

5 Conclusions and Future work

This paper suggested an IoT platform with Alexa Echo dot capable of controlling the LIFX smart bulb through human voice and devices connected through a Wi-Fi network. We also prepared to store IoT data in the cloud and execute real-time IoT analysis using elastically computing data-driven model based innovative approach. Various research challenges have been recognized and examined. These researches are expected to become foremost research trends in upcoming years. Through this paper, we have provided a complete understanding of artificial lighting to help the readers realize how significant artificial intelligence is in any IoT system and how to achieve it. In the future opportunity, the cognitive method of the IoT network based the systems are can be created with Blockchain Technologies and IPFS. This approach will improve the performance, security, safety, and energy savings and give user-friendly results to the user.

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Conflicts of Interest

Authors do not have any conflicts.

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