Green Smart Home by Fog Computing

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Abstract — IoT devices are incomplete without a cloud server. Without cloud services, we cannot collect and process the data that is sent from each IoT sensor, then execute and send back the result. Implementation of a fog node near an IoT device results in storing and processing data at the fog node rather than sending it to the cloud. This study proposed multiple sensors for a smart home that is connected to a cloud server with a fog node and without a fog node. A smart home consists of 10 sensors like motion, gas, light, vibration, location, water leak, air, video, and humidity. The evaluation is done by comparing the energy consumption and network usage of sensors that are connected to the cloud with a fog node and without a fog node. The energy consumption and network usage of sensors with fog computing are lower than without fog computing, so these will lead to a green smart home. If more sensors are added, then also energy consumption and network usage of fog computing will be lower.

Keywords: Green Smart Home, Fog Computing

I. INTRODUCTION

All IoT devices, such as vehicles, traffic lights, smart watches, smart medical sensors, smartphones, smart alarms, and IoT sensors, use cloud servers to complete tasks. A smart home makes people's lives comfortable by automatically controlling devices from anywhere with an internet connection using a mobile device. Nowadays, every device is becoming an IoT device. Excessive use of the IoT will increase energy consumption. So our main goal is to reduce energy consumption and network usage and make the IoT green. In cloud architectures, the data is processed, analyzed, and stored in the cloud. This leads to high delays and network bandwidth overloads because the cloud is far from IoT devices. It's not applicable for real-time IoT applications because it needs low-delay constraints. Using a cloud server with a smart home will lead to heavy energy consumption and network usage that will cause several unpredictable problems in the future. To overcome this problem, thanks to the fog computing paradigm[2], It's a decentralized infrastructure where data is stored process. The fog layer is the intermediate layer between the IoT devices and the cloud server, which extends the traditional cloud computing architecture. The fog layer works near the IoT devices; instead of sending all the data to the cloud, it processes and stores it for some time. Fog computing works with many latency-sensitive applications, such as healthcare.

If we implement smart homes with fog computing, It provides security, low latency, low cost, and energy efficiency. The smart home devices are connected to the fog nodes at the network edge. In a smart home, many sensors and devices send data, status, and measurements to fog nodes. Fog nodes process and send data to the cloud for storage. It immediately responds to services. Energy consumption is low with fog computing, which leads to greening the IoT, so we see how energy optimization is low with fog computing. Smart home devices produce data continuously and need to be analyzed faster; transferring data to the cloud and analyzing it may cause a problem. Implementing a cloud with a fog node will reduce the burden on the cloud. Fog computing is used in several areas like healthcare, big data analytics, and vehicles.

These experiments were done on the iFogSim Toolkit with 10 sensors and the experiment result was evaluated on network usage and Energy consumption. The rest of this paper is structured as follows: Section II proposes a literature review; Section III proposes a Methodology; Section IV proposes an Experiment result; Section V proposes a conclusion and future work.

II. RELATED WORK

The interest of users towards a smart home is increasing day by day. Home appliances are getting connected to the cloud via the internet and controlled remotely by smartphones from anywhere. Issues arise with SHAS[3]. Sensors of the smart home are controlled, analyzed, and executed by Wi-Fi, Internet, and Bluetooth. simple technologies are used for connecting smart home devices to the cloud [5]. This paper provides a method to reduce energy consumption and create a green environment by using HEMS (Home Energy Management System) techniques and balancing energy consumption between devices[6]. A machine learning method will have an intelligent energy management system in a smart home that gives ideas about how to consume energy [4][1]. Now consuming less energy in smart homes by implementing fog nodes and making smart homes green smart home.

III. METHODOLOGY

The scenario is created by connecting with and without fog computing. The proposed scenario consists of 10 sensors, a fog node, a cloud, and an actuator or phone. The first layer consists of 10 sensors like motion, gas, light, sound, vibration, location, water leak, air, video, and humidity. The second layer consists of a fog node, which is connected to sensors for fetching data. The third layer contains a cloud that is connected to a fog node responsible for storing, managing, and analyzing data. The user will control all home appliances through the smartphone. The sensor is used for fetching data from home appliances. After a specific time interval, sensor data will go to the fog node. Fog nodes react immediately, and after some time, fog nodes send data to the cloud for storage and analysis. A fog node can be deployed in a home environment. Cloud computing can process and manage data for a long time, but it increases energy usage and consumes high network bandwidth for transmitting data to the cloud. This will cause some issues. It is not suitable for real-time appliances because of the latency delay, and it consumes high

energy too, so we use the fog node as an intermediate layer between sensors and the cloud. Fog nodes reduce latency delays by working with near-edge devices like home appliances, and they also work with real-time applications present at home.

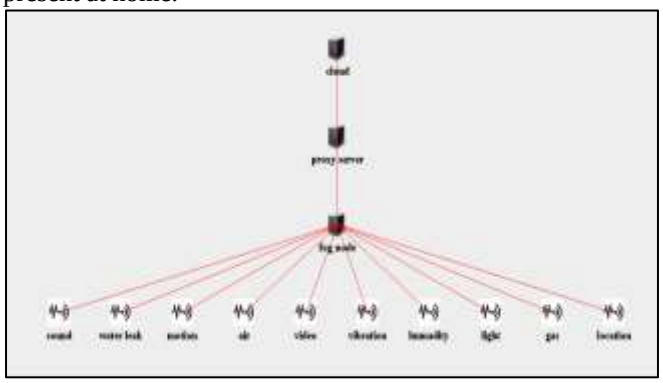

Fig. 1: Topology of fog-based smart home

The prototype is created for smart homes by taking 10 sensors, like motion sensors, which capture motion in smart homes. A gas sensor is used for capturing gas. Light sensors are used to turn on lights when someone walks by. A vibration sensor is used for capturing any type of vibration that is happening in the house, similar to location, humidity, and air, and video sensors are used to continuously capture all the data of the smart home. Here, two prototypes are created based on energy consumption and network usage.

A. Fog-Based Smart Home

In fog-based smart homes, integrating a fog layer as an intermediate layer between the cloud and sensors Fog layers work near edge devices. Fig. 1 shows the topology of the fog-based smart home. Here, all the smart sensors are connected to the fog node, and the fog node is connected to a proxy server. A proxy server helps provide a connection between the fog and the cloud. After every specific time interval, all sensors capture data and send it to the fog node. The Fog node works as a detector, looking at all the data sent from a sensor to see if some abnormal situation is happening or if gas is leaking. According to the data, it will respond. If the fog node finds that something abnormal is happening in the home, it will immediately inform the owner of the house via smartphone. Further, all the data is sent to the cloud for storage. There are two models: the first is for capturing all the data from sensors, and the second is created on the fog node for analyzing all the data.

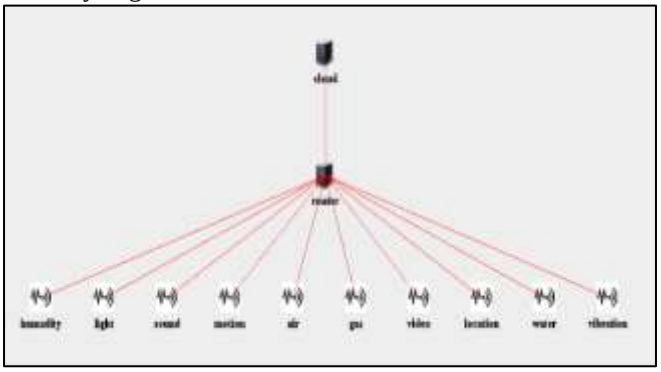

Fig. 2: Topology of cloud-based smart homes

B. Cloud-based smart home

In a cloud-based smart home, all sensors are connected to the cloud via a router. Here, all sensors capture data and send it to the cloud for analysis. A router provides internet connectivity between sensors and the cloud. After capturing all the data from the sensor's cloud, we analyzed it and sent it to the user's smartphone, but the problem was that it would take time for these processes to apply In real-time applications. Fig. 2 shows a cloud-based smart home. Here, all the sensors are connected to the cloud, and two models are created. The first model is used to capture data from all sensors. The second model is cloud-based for detecting all the captured data, analyzing it, and sending it to an actuator or smartphone.

IV. EXPERIMENT RESULT

Section III, you have seen the experiment setup by comparing the fog-based and cloud-based smart home results in terms of energy consumption and network usage. Experimental results show that fog-based smart homes consume less energy and use less network bandwidth than cloud-based smart homes.

No of Smart home	Energy consumption	Network usage
1	1.1938633	1194.53
2	1.193836	2389.06

Table 1: Fog-based smart home value

No of Smart home	Energy consumption	Network usage
1	1.39693599	28069.04
2	1.39693599	28377.08

Table 2: Cloud-based smart home value

The result of the experiment is shown in Table 1 and Table 2. The network usage and energy consumption of a fog-based smart home are lower than those of a cloud-based smart home. As our devices increase, our smart home's energy consumption also increases. As our devices increase energy consumption network usage of fog computing will be lower than cloud computing smart home.

Table 1 shows the value of a fog-based smart home in two columns energy consumption and network usage with two smart homes. Table 2 show the cloud-based smart home in two columns energy consumption and network usage of two smart home. let's see by graph how energy consumption and network usage are lower

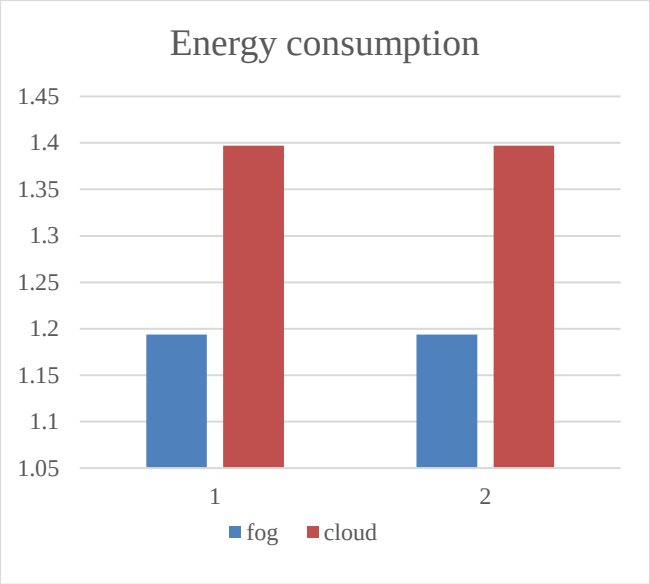

Fig. 3: Energy consumption

A. *Energy consumption*

Fig. 3 shows the total energy consumption of clouds with fog and without fog. I observed that the energy consumption of fog-based smart homes is lower than that of the cloud as more devices are added, or if we deploy fog computing in smart buildings or smart cities, this will lead to a reduction in energy consumption on a large scale.

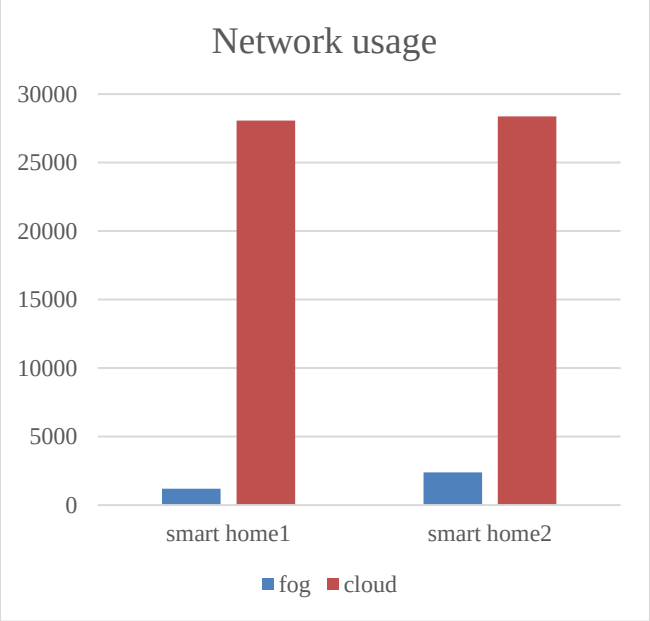

Fig. 4: Network usage

B. *Network usage*

Fig. 4 shows the network usage of all the smart devices that are connected to the cloud with and without fog computing. I observed that the network usage of a fog-based smart home is lower than that of a cloud-based smart home. An increase in smart sensors and devices leads to an increase in network usage. As more and smarter homes increase network usage of fog-based smart homes is lower

V. Conclusion and Future Work

Based on the results, the fog-based smart home helps in reducing energy consumption and network usage and helps in creating a green smart home. creating a green smart home leads to the creation of green smart cities. By deploying fog in a small chip and using optimal energy management methods using solar panels and renewable resources, we will lead to a green smart home.

Future work should focus on security in smart homes. Using fog computing in healthcare, Farm applications, and smart city applications Artificial intelligence and machine learning methods should be used in smart homes for predicting Energy consumption.

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