HEES -HOME ENERGY EFFICIENY SYSTEM: A FOG APPLICATION

[1]Devender Chandra, [2]Soni Chaurasia
[1]Student, [2]Assistant Professor
[1,2] Department of Computer Science & Engineering
Noida Institute of Engineering and Technology, Greater Noida

Abstract: Internet of things is a major advancement which has emerged with the growing need of inter-communication of devices. Internet of things or IoT's has many applications and it creates a wide field of research and development. The traditional cloud computing is unable to provide support to the internet of things due to many issues like latency , lack of mobility support and security.In this paper shows how fog computing can be used to support internet of things and provide a wide range of application one of which is proposed here as home energy efficiency system that can help to reduce the overall power consumption at homes.

Keywords: IoT's, fog computing, li-fi

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1. INTRODUCTION

Advancement in the field of inter-communication of devices has lead to the rise of internet of things or IoT's with the help of internet of things the idea of development of smart metering, smart city, connected vehicles and large-scale wireless sensor network can be achieved.According to a research paper [1] consumers awaits for such technology and will welcome IoT's services .

1.1 INTERNET OF THINGS

The idea to interconnect devices in order to make them smart and invoke machine to machine communication is called internet of things. we can connect electronic devices by means of internet, sensors, actuators etc thereby implementing and allowing them to communicate with each other. Internet of things thus has two main objectives communicate and compute, thus internet of things communicate and performs according to the need.

A wide range of applications , there has been many research work and ideas on working of internet of things. Now on most of the cases cloud computing paradigm is being used in order to establish communication between the devices and internet. Cloud computing will provide great support to Internet of Things , but when it comes to wide range of devices with high mobility need cloud computing is unable to fulfill the demand , the number of connected IoT (Internet of Things) devices, sensors and actuators by 2021 is expected to be 46 billion therefore cloud computing has IoT's of limitations in the near future.

Now the major drawbacks that cloud has are latency issue, security threats and lack of mobility support. Cisco came with the solution by introducing the idea of fog computing, which will overcome the drawbacks of cloud computing and provide communication paradigm to internet of things.

1.2 FOG COMPUTING

Fog computing is the network paradigm introduced by Cisco with the purpose of extending the cloud computing model rather than replacing it.

Fog computing allows service mobility across platforms and provides technologies that preserve both end-user and cloud data security and privacy across domains. Fog devices are geographically distributed ,unlike traditional centralized data centers. The model comprise of geographically distributed nodes called fog server. Fog server has three main characteristics compute, communicate and storage. Now a Fog server can be distinguished from a Cloud server by its vicinity to end-users. Fog servers interacts with each other for data exchange and communicate with cloud only when it has to upgrade its existing system or require to search information which is not available in any of the nearby fog server. Fog computing provides following functionality:

Efficient network:

Fog computing reduces traffic created between the mobile users and cloud server. It also reduces the energy consumption of core networks and saves the backbone bandwidth.Thus invokes the idea to sustainable energy consumption.

Better mobility support:

Fog computing provide better service quality,faster data rate, reduces response time and service latency due to geographically distributed fog servers. Therefore due to the presence of local fog server devices has better mobility support than cloud server.

Reduces security threats:

Fog computing has single hop connection this means that the number of devices and gateways are reduced this in turn reduces security threats. Fog Computing system even tries to work against the attacker by provide it with a decoy or dummy data once it gets suspicious [2].

1.2. Fog Computing Architecture

The Fog computing architecture is established by extension of traditional cloud computing. This is done by introduction of Fog layer between mobile devices and cloud server. Thereby establishing a three-layer Mobile-Fog-Cloud structure. The Fog layer comprises of fog servers which are geographically distributed. A Fog server is a device which has the capability of data storage, computing and communication. These fog servers communicate with themselves and the cloud, they are deployed near the local premises of end user thereby invoking single hop connection using wireless connection like WiFi, LiFi, Zigbee or bluetooth.

Thus instead of centralized cloud server, geo-distributed fog servers are being used with its capability to present at the proximity of user, these devices are connected both with the cloud and with the user, they provide services to the user and in the same way updates themselves by connecting with the cloud.

COMMUNICATION:

Now the devices within the fog architecture can use different technologies to communicate like wifi, zigbee, bluetooth and WiMAX. But these technologies lack when high speed support for IoT's is needed, this is probably because all these technology uses radio waves for communication which has limited bandwidth in the em-wave spectrum, thus these must be replaced by a new technology known as lifi or light fidelity.

1.3 LIFI

Introduced at TED Global Talk by professor Harold Hass co-founder of purelify, by providing the idea of using LED bulbs for data exchange thereby establishing communication between devices.LED bulbs has very high flickering rate and each flicker means sending of one bit of data therefore establishing a connection .

Traditional technologies like WIFI and bluetooth have issues like low speed, high cost and security threats thus LIFI is a better option, this is so because it uses light waves for signal transmission, light-waves has higher bandwidth than radio waves thereby provide higher speed than wifi. LIFI technology uses LED bulbs which are comparatively cheaper and provides connectivity and illumination at the same time therefore it is cost efficient. Now the major limitation is its range since LIFI uses visible light and as light cannot penetrate opaque objects thus LiFi has a limited range but this also comes as an advantage as limited area means less prone to being hacked from outside hacker. Therefore LiFi being cheaper, faster and safer than WiFi can be used for communication of devices in fog architecture.

In short we can aim to create a system which provide the purpose of machine to machine communication that is IoT's device by using fog computing architecture where LIFI is used as a mean of communication between devices.

2. RELATED WORK

As machine to machine communication advances internet of things and its applications grows due to which various research and scientific work are constantly going on some of which are discussed.

In the paper by **t. balakrishna 1, r. naga swetha 2** [3] which involves monitoring parameters such as CO2, temperature, humidity and light around a pipeline structure using ARM7 processor, which is a RISC processor which can perform millions of instructions per second, it uses Zigbee module that has a range of 10-20 meters for communication.

In this paper **Two Paradigms in Cellular IoT Access for Energy-Harvesting M2M Devices: Push-Based Versus Pull-Based**[4] in which devices harvest energy from an ambient source like sun using machine to machine communication where a hybrid system of push-based and pull-based mechanism are being used for energy distribution.

Now there has been different theories and research going on the development of fog computing as well . For instance in the paper **"Fog Computing: Focusing on Mobile Users at the Edge"** [5] author discuss how fog computing can be used in near future with 5G Technologies, Network Function Virtualization (NFV) and Software-defined Networking (SDN) .

In this paper,"**Fog Computing: Helping the Internet of Things Realize its Potential "** [6] the author discuss how Fog computing is designed to overcome the limitations of cloud computing in its inability to support internet of things. The paper also puts a glance at how fog computing can present various challenges like enabling real-time analytics, programming models and power consumption.

Now one of the most relative work is smart meters which consists of 3 components namely electricity smart meter and gas smart meter, communication hub and smart energy display or SED, the data which includes electricity or gas usage is needed to be uploaded by the user to the website, the website compare the usage among other months and year, the graphical data will be displayed on the website and bill is generated accordingly. Now with the help of this actual bill will be generated based on actual usage. Therefore the consumer will pay only for what he uses, hence reducing overall cost of the user.

Though smart meters contribute in reducing overall consumer cost but it fail to contribute in reducing the overall energy consumption, this is where the idea comes which has the primary objective to reduce overall energy consumption by the user.

3. PROPOSED WORK:

The idea is to develop and modify the traditional electronic systems which are currently being used in homes without any overhead cost and effort into a smart, efficient and user friendly technology. This can be achieved by creating certain modification in the existing traditional electronic system at homes, which can be done with establishing the following three components :

1. MI's (mobile iots): These are the internet of things devices which can be mobile and deployed over any area. These devices basically acts as Electrical Portable Outlet Devices (EPODs) which can be mounted on switch boards where any kind of electrical appliance can be connected. The MI'S has the capability to communicate and perform accordingly. MI'S will perform following tasks:

- **a.** Identify the appliance (type, brand via its model no.)
- **b.** Analyses the basic electricity usage
- **c.** Will be on 3 different modes: 1.ON 2. OFF 3 .LOW USAGE
- **d.** Communicate with the CFS (centralized fog server) and adjust the modes accordingly.

Thus the MI's will work in cooperation with the CFS in such a fashion that a low cost energy efficient smart home automated environment can be established.

1. Connection of device to the mobile IoT's.
2. Detection of device id or model number
3. Sending data to the centralized fog server
4. Receive data from the server
5. Automatically adjust the limiter according to the data from the CFS
6. Mi will switch to either ON, OFF or LOW USAGE mode as per the command from the CFS.

The low usage mode is the limiter which is the lowest amount of energy required by the electronic device to work.

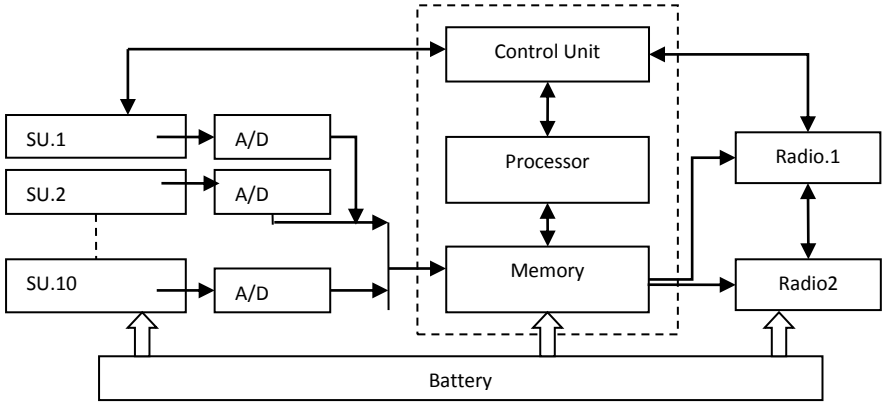

Figure.2. Sensor Node Architecture (Mobile IoT)

2. CFS (centralized fog server): This is basically a fog server which can be geo distributed over any area and has capability of compute, store and connect. Introduce a fog server by connecting it to the electrical wiring central panel. Now by doing this the CFS will have direct access to the electrical wiring and in-build appliances like fans, bulbs, tube lights etc.
The CFS has following task:

- **a.** To control all the MI's
- **b.** To control all the wires and in-build appliances
- **c.** Constant software update through cloud
- **d.** Store and analyses data

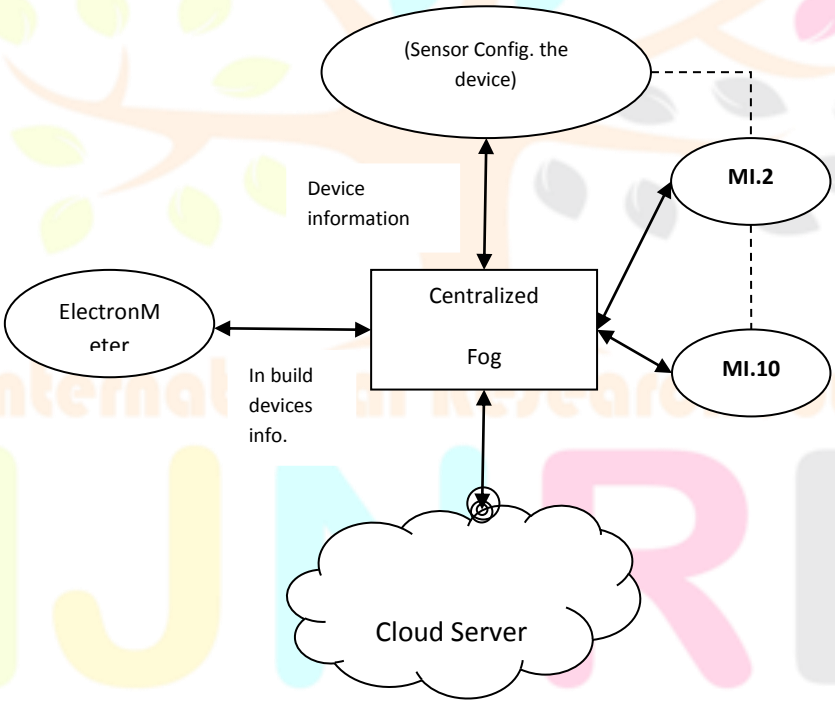

Figure.3. Three-way communication

Thus CFS will have 3 kinds of connections:

- **a.** Electrical connection with wires and in-build appliance
- **b.** Low range connection with mi's
- **c.** High range connection with cloud

In figure 3 the fog server has 3 primary functionalities and these are:

- **a.** Store
- **b.** Compute
- **c.** communicate

Now including these functionality the fog server also perform many other and the above bock diagram shows that , following is the list of all those components and there functionality :

1. Storage : it consists of 2 storage sections secondary and primary storage respectively-

a. Primary storage: it is the storage section which consists of data related to processing and computation of fog server and mobile IOT's.
b. Secondary storage: it is the storage section which consists of dynamic data coming from the cloud regarding all the electronic devices and appliances.

2. Display: it is a LED screen which displays following data:
a. Electricity voltage being used
b. Electricity voltage limit
c. Mobile IOT's being connected
d. Battery stored

3. Processor: the processor block consist a standard processing element which handles the computational part of fog server.

4. Communication source: the fog server contains 3 sources for communication these are:
a. Electrical connections : for in build appliances
b. Wi-Fi : for medium range connections(fog-fog)
c. Zigbee/LiFi : for low range connections(mi-mi and fog-mi)

5.Working components:
a. Energy regulator: Regulates main energy from the power supply
b. Energy analyzer : To analyses and compute amount of electricity being used
c. MI connector : To connect and handle all the MI'S
d. Energy source : There are two types of energy source which power the fog server and these are :
I. Traditional energy source from the power supply
II. Ii. Renewable energy source from solar or wind source.

ALGORITHM:

1. A limited value of electricity usage is asked by the user.
2. Else contains a default value
3. It makes sure the value doesn't exceeds
4. Receive data from MI's (device id or model number)
5. Sending data to the nearby fog devices or the cloud and receive data accordingly.
6. Store the received data and send a limited number to the mobile IoT's.
7. Contains a processing component which commands the MI's to work in a specific priority.
8. The CFS makes sure that the set limit of max usage doesn't exceed.
9. If it does so CFS starts turning off all the connected devices.
10. The devices with lowest priority are automatically switched to OFF mode first.
11. In-build devices are temporarily switched off if the limit exceeds.

3. COMMUNICATION:

Now the next question arise here is: HOW WILL THE DEVICES COMMUNICATE?
This can be done by using FOG COMPUTING'S 3 TIER ARCHITECTURE.
The diagram given below shows the 3 tier architecture, where there are 3 levels:
LEVEL 1(cloud): this is the level where our centralized cloud server is present
LEVEL 2(fog servers): this level belongs to the fog servers, which are geo - distributed over any area.
LEVEL 3(IoT's): this is the bottom level, where the IoT's are present which are mobile and constantly communicating with the fog servers.

4. CONCLUSION

Internet of things invokes the idea of machine to machine communication and is expected to withstand an industry worth trillions. But with the existing cloud computing paradigm it faces a lot of challenges. Cisco came with the idea of fog computing. Fog computing is the extension to cloud computing rather than its replacement which can be used to support internet of things.

In short a system can be created which provide the purpose of machine to machine communication that is IoT's device by using fog computing architecture where LIFI is used as a mean of communication between devices.

Thus an idea which focuses on the primary objective to reduce overall energy consumption in a home by using an application of fog computing is shown in this paper.

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