Fog Computing based Smart Home Controller

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Abstract

The Internet of things (IoT) will be the Internet of future, as we have seen a large raise in smart home/city, smart connected vehicles, wearable technology, and smart grid. Cloud computing cannot solve all troubles due to its own disadvantages. Applications, for instance real, augmented reality, real time streaming and time gaming, are high in latency sensitive to install on cloud. The newest fashion of computing paradigm is to push elastic resources such as computation and storage to the border of networks, which inspires the promising computing paradigm of fog computing as a result of occurrence of all over the place connected smart devices relying on cloud services. Fog computing remains information and computation close to end users at the edge of network, and thus offers a new services and breed of applications and to end users with low latency, high bandwidth, and location-awareness, what's more, hence gets the name as fog is comparably a cloud near the ground. Home automation systems are group of smart devices that permit different functions within a house or building, such as light and heating, energy monitoring, air conditioning, plug control and temperature metering, etc. Typically, these devices are smart sensors that are applied with low power communication protocol like ZigBee only can be controlled from an Internet gateway. These days, there are number of home automation products on the market for customers. Client can utilize application on smart phone to control the items they purchased. The control command can go through a cloud-based server and be directed to the corresponding gateway, and internally reach to the sensor devices, which is referred to as "Cloud-based mode" system.

Keywords

Fog Computing, Zigbee protocol, IoT, Power consumption, smart home management

I. Introduction

Fog computing stretches out the Cloud Computing worldview to the edge of the system, accordingly empowering another type of utilizations and administrations. Characterizing qualities of the Fog are:

- Low latency and location awareness,
- Heterogeneity,
- Predominant role of wireless access,
- Wide-spread geographical distribution,
- Very large number of nodes,
- Mobility,
- Strong presence of streaming and real time applications.

In this paper we contend that the above qualities make the Fog the fitting stage for various basic Internet of Things (IoT) administrations and applications, specifically, smart Grid, Smart Cities, and Connected Vehicle and as a rule, Wireless Sensors and Actuators Networks (WSANs).

The "pay-as-you-go" Cloud Computing model is an effective contrasting option to owning and overseeing private data centers (DCs) for clients confronting Web applications and clump preparing. A few variables add to the economy of size of uber DCs: higher consistency of enormous conglomeration, which permits higher usage without corrupting execution; helpful area that exploits reasonable power; and minor OPEX accomplished through the arrangement of homogeneous process, storage, and systems management segments.

Cloud computing frees the enterprise and also the user from the specification of the many details. This rapture turns into an issue for inertness delicate applications, which require hubs in the region to meet their postpone necessities. A developing flood of Internet arrangements, most strikingly the Internet of Things (IoTs), requires versatility bolster and geo-circulation notwithstanding area mindfulness and low latency. We contend that another stage is expected to meet these necessities; a stage we call Fog Computing, or, quickly, Fog, basically in light of the fact that the haze is a cloud near the ground. We additionally assert that as opposed to tearing up Cloud Computing, Fog Computing empowers another type of utilizations and administrations, and that there is a productive exchange between the Cloud and the Fog, especially with regards to information administration and examination.

Increase in the huge number of devices getting associated to the network is mainly by two sources: Devices and sensors or actuators. In IoT, devices assemble and communicate information straight with each other via internet and the cloud manages to gather record and examine data blocks. But the 'things or devices' that area unit manufacturing large quality of information is processing out every day that has to be treated manages, analyzed and furnished at cloud.

Power grids are getting more efficient and smarter as the new paradigm of micro grid has been introduced. A micro grid is contained distributor generators, energy storage, and loads which may associate with the power grid or work self-sufficiently. Subsequently, a energy administration framework is fundamental to control the power generation and utilization. The micro grid has been appeared to enhance the dependability, effectiveness, and gainfulness for private and business establishments. In any case, in this paper, we center around the private area for request side vitality administration.

Consequently, the requirement for energy proficient structures and homes is developing quickly. Besides, the headway in innovation, the likelihood of incorporating low-power and superior electronic gadgets have empowered us to assemble progressed inserted frameworks. Likewise, diminishment in the cost and size of gadgets like: sensors, actuators, arrange connectors, switches, and so forth, have furnished us with the chance to manufacture modern and ease vitality administration frameworks. Ordinarily, the lessening in energy utilization might be finished utilizing intermittent vitality cost input and remote observing the brilliant gadgets (request reaction). In this paper, we center around particular private structures homes for dealing with their energy utilization. Keeping in mind the end goal to actualize a energy administration framework, a stage is required which gives intelligence and interoperability amongst gadgets and adaptability of task.

A home energy administration has been actualized over a systems administration stage so as to meet the specified necessities in bring down cost, be that as it may, the working spaces of the framework, versatility, heterogeneity, delay-delicate gadgets, and controlling expense have not been thought about legitimately. A standout amongst the most vital properties to be considered is the likelihood of infiltrating into the buyer market and reasonableness of the stage for a standard shopper. Significant prerequisites for the engineering which impact this penetration and affordability are:

- Scalability
- Open architecture
- Local and remote monitoring.
- Interoperability
- Plug-n-play capability and
- Ease of deployment

Additionally, meeting these prerequisites in a solitary bundle ought to likewise be financially savvy. Since customers in private structures have constrained spending plan and space for sending the stage, we are thinking about them as the contextual analysis.

A. Fog Computing over Internet on Things

The Internet of things (IoT) are going to be the net of future, as we have got seen an enormous increase in wearable technology, smart grid, good home/city, good connected vehicles. International knowledge corporation (IDC) has foretold that within the year of 2015, "the IoT can still quickly expand the normal IT industry" up Bastille day from 2014. Since good devices area unit sometimes inadequate in computation power, battery, storage and information measure, IoT applications and services area unit sometimes protected by sturdy server ends, that area unit largely deployed within the cloud, since cloud computing is taken into accounts as a promising resolution to deliver services to finish users and supply applications with elastic resources at low value.

However, cloud computing cannot solve all issues thanks to its own drawbacks. Applications, like real time diversion, increased reality and real time streaming, area unit too latency sensitive to deploy on cloud. Since knowledge centers of clouds area unit settled close to the core network, those applications and services can suffer unacceptable round-trip latency, once knowledge area unit transmitted from/to finish devices to the cloud knowledge center through multiple gateways. Besides this, there also are issues unsolved in IoT applications that typically need quality support, geo-distribution and location-awareness.

The latest trend of computing paradigm is to push elastic resources like computation and storage to the sting of networks, that motivates the promising computing paradigm of fog computing as results of prevalence of ubiquitously connected good devices hoping on cloud services. Fog computing keeps knowledge and computation on the point of finish users at the sting of network, and so provides a replacement breed of applications and services to finish users with low latency, high bandwidth, and location-awareness, and so gets the name as fog is analogously a cloud on the point of the bottom. We have a tendency to decision those facilities or infrastructures providing resources at the sting of the network fog nodes. Besides resource-rich servers, fog nodes are often resource-poor devices furthermore, like good TVs/set-top-boxes, gateways, and finish devices.

II. Related Work

Several integrative reviews have concisely summarized the key features of fog computing. Vaquero and Rodero-Merino [2014] tried to define fog computing by discussing a set of technologies that drive it. Yi et al. [2015a] briefly examined fog computing platform and pointed out representative applications that are well suited for computing near the network edge. Chiang and Zhang [2016] compared cloud and fog in detail and showed several case studies of fog computing. Kitanov et al. [2016] introduced the emerging fifth-generation (5G) network and its potential impact on fog. While the above reviews present a good overall picture of the fog, they only cover a limited number of papers and do not compare the methodology and technologies in detail. Recent years have witnessed a growing number of papers in this rapidly changing field. It is crucial to synthesize new findings from them.

There have been a few papers that tried to provide a fairly comprehensive survey of the fog computing paradigm. Yi et al. [2015b] identified various problem domains of fog computing, including networking complexity, quality of service (QoS), programming model, resource provisioning and etc. Mahmud and Buyya [2016] proposed a taxonomy of fog computing and gave a broad review on component types, general metrics and design objectives. Nevertheless, these works do not provide a classification of architecture and topology. Detailed explorations on resource management and system optimization approaches are absent as well. A few recent studies have been concentrated on certain specific design issues of edge-oriented computing solutions. Wang et al. [2017] gave a detailed survey on mobile edge computing, with an emphasis on wireless communication and edge networking. Driven by economic and environmental concerns, Buzzi et al. [2017] provided a detailed survey on energy-aware designs for 5G networks. Recently, Osanaiye et al. [2017] discussed the security and privacy issue of fog computing in a virtualized environment. These prior works do not provide a detailed comparison of different architecture designs in the edge-oriented computing era. Their discussions are also limited to just one or two resource management strategies.

Over the year an efficient energy management system has been focus of research for building or set of building using smart meters. Researchers have suggested improvement to energy management system by focusing and incorporating components such as Building energy management system, home energy management system, shifting of energy load and looking at dynamic pricing [10]. To overcome challenges in conventional energy management system, such as central point of failure or scalability due to limited memory and limited bandwidth to handle large request [3], researchers have proposed cloud based energy management system. Keeping the challenges in mind and to overcome them a cloud based demand response system was proposed that introduced data centric communication and topic based communication models [13]. Their model was based on a master and slave architecture in which the smart meters and energy management system at home acted as slave where as the utility acted as masters.

The authors advocated that a reliable and scalable energy management system can be built using their model. In another approach the energy management system was built by considering the energy pricing to be dynamic[16]. While building this model the authors considered the peak demand of the building and incorporated the dynamic pricing while handling customer requests. In another approach researcher had proposed an architecture for control, storage, power management and resource allocation of micro-grids [28] and to integrate cloud based application for micro-grids with external one. The bigger and distributed the smart grid infrastructure becomes the more difficult it is to analyze real time data from smart meters. [43] Suggested a cloud based system is most appropriate to handle analysis or real time energy data from smart meters. In another approach power monitoring and early warning system facilities were provided using cloud platform [12]. A mobile agent architecture for cloud based energy management system was proposed to handle customer request more efficiently [33]. In another approach a dynamic cloud based demand response model was proposed to periodically forecast demand and by dynamically managing available resources to reduce the peak demand [31]

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For the intelligent pickup , a wise alert system has been propose whereby a alert signal, generated through an associated in Nursing unhearable detector(interfaced with Arduino UNO), is provided to municipal internet server. On receipt of such alert, the motive force visits the actual location and performs the task of voidance the ash bin. In this method RFID is being used for auto-detection of standing of ash bin i.e. empty or stuffed. Once the task of voidance is completed, signals are sent back to server concerning the accomplishment of the task. An integrated module with RFID and IOT has been designed and projected during this work. The mechanism to priorities the gathering supported the situation e.g. colleges or hospitals has been integrated along and, in that approach, a dynamic waste management system has been projected. Further, the similar priorities are known for the harmful waste (i.e. causing the short health impact to people living areas).The mentioned goal is achieved by suggests that novel algorithms that optimizes the priority and connected value. In current methodology information is evaluated with real time and artificial information is retrieved by municipality of Saint military campaign, Russia and for this they need designed and developed models like dedicated trucks model, detour model, minimum distance model, and duty assignment model.

Currently there are a few existing works on the concept of fog computing. Stojmenovic et al. [8-9] have surveyed [10–14]. Our previous work [3, 15] has surveyed additional related work [16–21]. In this paper, we further identify work [22-23] on fog computing. References [4, 10, 16, 19] are about designing and implementing fog computing nodes. Cloudlet [4, 19] was built before the proposal of fog computing, but inherently coincides fog computing concept. ParaDrop [16] is a fog computing platform implementation based on wireless router, using OS-level virtualization. Hong et al. [10] have proposed a high-level programming model for fog computing platform. References [11, 13, 14, 18, 22, 24] are about how exiting or new applications and services can benefit from fog computing. J. Zhu, et al. [11] have provided dynamic customizable optimization to web applications based on client devices and local network conditions collected by fog nodes. Ha, et al. [24] have designed and implemented a real-time wearable cognitive assistance on Google Glass backed by loud let. Work [18] has designed a cloudlet mesh based intrusion detection system (IDS). Work [13] and [14] are about how rich information collected by fog computing platform can optimize operations or migrations for data processing in fog computing. Cao et al. [22] have explored to use fog computing in health monitoring such as real-time fall detection. Mohammed et al. [23] have conducted an experimental study by utilizing fog computing to assist mobile application in terms of computation offloading and storage expansion. There are also work related to underlying technologies of fog computing, security and privacy, readers can refer to our previous surveys if interested [3, 15].

IIII. Background Study

Smart home definition and its usefulness objectives have advanced persistently because of the quick development of various advances, rising up out of the examination movement in home automation related technologies and from home networking developments. The sensor devices, e.g. Telos B mote modules, m ay use the standards based, low power wireless technology ZigBee to communicate with each other. Moreover, the standard used for the communication between different nodes may be Smart Energy Profile (SEP 2.0), which is a standard for IP-based control for home energy administration and it is upheld by these gadgets, however this profile isn't prepared yet (standard, convention stack and equipment). Advance more, the adaptability of the ZigBee systems can deal with around 65535 gadgets in a system. All the devices are tagged u sing a unique Identification (ID) number. These IDs are hard coded into the sensor gadgets while at the same time programming and perhaps utilized for directing and moving information in a similar system. Additionally, the administrations enable the HEM to control board to find new gadgets included through attachment n-play. The HEM control board will confirm and approve the new gadgets associated with the HEM stage. ZigBee is a low power neighborhood convention in light of IEEE802.15.4 standard. ZigBee innovation is a sort of remote correspondence innovation with short separation and low power utilization. The ZigBee remote correspondence module is utilized to get and transmit control charges from the control load up, and observing data of the home apparatus will be gathered and transmitted to the control load up in the meantime. Regular Gateway Interface (CGI) is a standard for the correspondence between Web servers and outside projects. It can make outside projects to create HTML, pictures, or other substance. In this way, it can achieve the data trade between the customer side and the server side. Finally, through the three parts of the system testing, it can be seen that users can access to the WEB browser through the Internet at anytime and anywhere to view the information of home appliances or send instructions to control the operation of home appliances, which can improve the convenience and safety of the home life. Control system can be widely used in smart home remote monitoring because of reliable data transmission.

The perception layer is the terminal hub of the ZigBee remote correspondence module. Its function is to collect information form appliances of kitchen, bedroom, living room and bathroom, mainly including home appliances, lighting equipment and security equipment, etc. Therefore, comprehensive perception of family environment can be realized due to the perception layer, and the data interaction between perception layer and network layer can be completed by the smart home gateway.

The application layer includes all kinds of terminal devices carrying with Web browsers, such as mobile phones, computers, etc. Users can access to the website to implement the management and the control of smart home system.

ZigBee technology is a new wireless communication technology, which has the personality of low transmission and low power consumption rate. The wireless sensor arranges is made out of ZigBee organizer and ZigBee terminal in the home condition, which can understand a wide range of home gadgets' association and wise. The ZigBee coordinator is responsible for the entire wireless sensor network and routing maintenance. The monitored data of the home appliances, which are collected by wireless sensor network, are uploaded to a variety of terminal devices with WEB browsers in real-time. Meanwhile the control data from the terminal devices can be received and transmitted.

The smart home control framework by IoT in view of ZigBee is composed and executed in this paper. In this system, the local communication between the control center and the subsystems is realized by ZigBee technology. And communication between

WEB browser and embedded WEB server is completed by CGI technology. This system is simple, low cost and easy to be accepted by users. Through the test, the system can be well qualified for smart home monitoring. What's more, it can be widely used in smart home system due to its high efficiency and accuracy.

IV. Proposed Methodology

In this section, we illustrate what is our purposed smart computing architecture, we design a three-layer fog computing structure for house. Each layer has several nodes such as terminal nodes (smart socket), the second layer (room), a third layer (home), and cloud. Fog node would have independent ability to compute, store data, the ability will depend on the level of the layer. Enhancement system intelligently, the packet is sent from upper layer will provide information of higher decision, so fog node can adjust its configuration like sending address and packet structure. In the third layer, fog nodes in this layer have two aspects of work to do. However, fog nodes in this layer require better processing capability than nodes in the second layer because it needs to gather more data and even connect to cloud in our model. We can treat a node in the third layer as one home unit.

The computing nodes implement controllers to gather, store, process, and analyze data and manage devices. The open source and client configurable switches run a circulation of Linux accessible in on a MIPS processor. Using these routers as computing nodes m ay help the developer to easily program the controllers, compile, and run them o n the router. The sensor dev ices, e.g. TelosB bit modules are good with Tiny OS which is an open source working framework (accessible in) composed for low-control remote sensors. In this manner, the calculations actualized for screen getting, ordering the sensors and accepting information from them might be customized effortlessly and powerfully on the sensors.

This adaptability may assist the engineers with program the sensors based o n their prerequisites. As it were, discovery algorithms and different routing for various types of sensors (e.g. temperature, humidity, and light) may be implemented in different scenarios. The control panel's f or each subsystem manages their devices in its own network through a predefined protocol. In any case, every one of the subsystems and gadgets associated in the primary system need to take after a one of a kind convention characterized by the HEM control board (e.g. ZigBee). Therefore, the communications between devices are built around Devices Profile for Web Services (DPWS) from the Web Services for Dev ices (WS4 D). In addition, it relies on SOAP, SOAP-over-UDP, XML Schema, and WSDL.

In a heterogeneous platform the protocol stack is used for sending secure messages from device to device. The developers may utilize the WS4 D - g SOAP toolkit available in to implement the services needed for each device. Gadgets may have different DPWS-compliant services utilizing the gadgets in the stage impart utilizing the current compliant services and interfaces. For instance, the routers in the HEM platform may have Wireless, Ethernet, Bluetooth, Universal Serial Bus (USB), etc., according to their specifications. Since a unique protocol (e.g. Zig Bee) should b e used for the main network, these interfaces need to be converted using gateway devices for the desired protocol, if necessary. To further extend the range that sensor network supports, we may utilize a two level hierarchical network. In other words, so me of the sensor devices are programmed to only sense, which are called End Devices (ED) and m ay be placed in different corners of a room. Then, a sensor node may b e programmed to act as an Access Point (AP) and connects to all the end devices in that room. Also, in a higher level, another sensor device may act as a Base Station (BS) which connects to multiple access points in all the rooms. The end devices transfer the data through their access points and then to the base station. The number o f access points connected to each base station o r the number of end devices connected to the access points are the variables which are adjusted based on the structure of the build in g and the requirements. The base station sends every one of the information assembled from all end gadgets to the HEM control panel directly or indirectly (using gateway), at the last stage. The gateway used here is a Raspberry Pi. The sensor nodes m ay communicate with a Raspberry Pi using serial connection over Zig-Bee standard, and then the Raspberry Pi connects to the HEM control panel through Ethernet. However, if the router has the capability of communicating via Zig-Bee directly, or the router had the compatible driver to control the sensor module through USB, the Raspberry Pi would be eliminated.

V. Node Efficiency

Sensor nodes in health monitoring systems are typically small and resource-constrained, such as small battery capacity, but it is required that sensor nodes must be able to operate in an appropriate duration such as a whole day or even a few days. In order to fulfill these requirements, sensor nodes must operate efficiently in terms of energy consumption. Several methods including software and hardware-based techniques can be applied for achieving the task. For instance, sensor node's hardware should be designed for particular purposes instead of general tasks. This method helps to save energy consumption by avoiding unused components or high power consuming components. However, it is more challenging for designing energy efficient nodes than customizing software running at the nodes. Particularly, the software must be able to perform primary tasks sensor nodes while it must be extremely simple for reducing computation time. For example, sensor nodes in IoT-based fall detection

VI. Conclusion

We have seen that energy management is essential for micro-grids, homes, and buildings. A Novel energy management is presented in this paper, over a fog computing it is implemented as a service. The implementation over fog computing platform provides the flexibility, interoperability, connectivity, data privacy, and real-time features required f or energy management. Also, open source software /hardware and the ability to be customized provide the user to add the control as a service to the energy management platform. Therefore, the implementation cost and time to market will decrease significantly.

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