Smart Home Energy Management Using Machine Learning

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Abstract: As the Internet of Things (IoT) continues to expand, traditional Centralized cloud computing is encountering various difficulties, including prolonged delays, restricted capacity, and the possibility of network interruptions. To address these difficulties, fog computing (FC) has been suggested as a remedy. Unlike conventional cloud computing, FC enables local handling and collection of IoT data, bringing the cloud near to the system's periphery. This leads to enhanced reaction times and a higher level of services, making fog computing a hopeful method for providing IoT services to a wide range of users. This article provides a comprehensive outline of the present state of FC and its combination with IoT. The article highlights the advantages of this integration, including faster response times and improved overall quality of services. The article also presents the framework of FC and discusses the potential applications of IoT that could benefit from this model. In addition, the article addresses many of the issues linked with fog computing and IoT, such as protection concerns and the need for standardized protocols. The article concludes with a conversation of the remaining queries and areas for future research related to fog computing and IoT. Overall, fog computing and IoT hold great potential for enhancing the quality and efficiency of IoT services. As the field continues to evolve, it will be necessary for scholars to focus on the issues and questions that remain to fully realize the potential of FC in IoT.

Keywords: *Fog Computing, Analytical Review, Internet of Things (IoTs)*

1 Introduction

One of the inventions now receiving a lot of attention is the IoT, which has the potential to offer endless advantages to our culture. The evolution of IoT has revolutionized how we live and work, with connected devices becoming an integral part of our daily lives. The future of IoT looks bright, with the potential for even more advancements and innovations in the years to come. IoT is around to achieve a phase in which several of the items already in our environment can link to the Internet to interact with each other without the participation of a human [1].

Initially, the Internet of Things was envisioned as a way to cut down on the amount of time humans spent manually entering data, as well as to make use of a variety of devices to take information from their surroundings and to enable automated storage and processing of all these dataThe COVID-19 pandemic has accelerated the adoption of IoT, as remote work and virtual learning became the norm. IoT devices have increased dramatically in various industries, including healthcare, retail, and agriculture. The rise of 5G networks has also provided faster and more reliable connectivity for IoT devices [2].

As a result of the restricted calculations that the IoT is characterized as employing in times of computing energy as well as space, it experiences various difficulties, including performance, security, privacy, and dependability. IoT has the potential to improve our lives in countless ways. In healthcare, IoT devices can be used to examine patients online, minimizing the requirement for in-person visits and increasing access to care. In retail, IoT gadgets may enhance the customer experience with features such as smart mirrors and interactive displays. IoT gadgets may be employed in agriculture to examine crops and soil conditions, leading to more efficient and sustainable farming practices. To solve the majority of these problems, the IoT should be combined with cloud computing to create what is seen as the Cloud of Things (CoT) [3].

The CoT expedites and reduces deployment and integration costs for complicated data handling and adoption. The implementation of CoT can bring numerous benefits, including improved traffic management, increased energy efficiency, enhanced public safety, and improved air and water quality. For example, by collecting and analyzing traffic data, cities can optimize traffic flow, reduce congestion, and improve the overall mobility experience. In energy, CoT can help cities monitor energy consumption and reduce waste, leading to a more sustainable and environmentally friendly city [4]. All while minimizing the time it takes to receive and analyze the IoT's information. As a result of combining IoT and cloud computing, several benefits flow to various IoT applications. On the other hand, the creation of new IoT apps is a difficult job due to the enormous number of IoT devices that run on various platforms. This is because apps built for the Internet of Things produce enormous volumes of data from sensors and other devices. The following analysis of these massive amounts of data results in judgments about various courses of action. You will need a very high network bandwidth to upload all of these files to the cloud [5].

The use of cloud computing (CC) and other forms of FC may help solve these problems. Cisco was the company that first promoted the phrase "fog computing." It is a new platform that enables various advantages to various areas, particularly the IoT. However, IoT also brings new security and privacy concerns with it. As more and more devices become connected, there is a greater risk of cyber-attacks and data violations. It is essential for manufacturers and users to be mindful of these risks and to take steps to secure their devices and data. Users of the Internet of Things may make use of services such as data processing and storage that is provided via fog computing, which is analogous to cloud computing. It makes use of fog computing to enhance efficiency and performance while simultaneously cutting down on the quantity of data that must be sent to the cloud for management, evaluation, and space. Because of this, the data acquired by sensors will not be transferred into the cloud for managing as well as short-term storage; instead, they will be routed to edge nodes for this purpose, reducing network traffic and delay. The Internet of Things is renovating the way we live and work. It can potentially improve our lives in countless ways, but it is essential to be mindful of the hazards and take steps to secure our devices and data. The future of IoT looks bright, with the potential for even more advancements and innovations in the years to come [6].

Function-as-a-Service (FaaS) is a cloud technology concept that makes it possible to create and execute applications and services without the requirement for infrastructure management. FaaS enables creators to concentrate on building and delivering code rather than worrying about the network arrangement. The cloud provider manages the infrastructure, including servers, storage, and networking, and the developer only pays for the resources used when the code is executed.FaaS has become increasingly popular in recent years as more and more organizations adopt cloud computing and look for ways to streamline their development processes. With FaaS, developers can quickly and easily deploy new code, test, and iterate, and scale their applications to meet changing demands. This results in faster time-to-market, increased efficiency, and reduced costs. it is made possible by integrating FC and the IoT. In this model, a specialist organization develops a game plan of haze hubs across its geographic impression. It goes about as a bank to many from a wide range of vertical business sectors. Each haze hub has nearby capacities for handling, systems administration, and capacity [7]. FaaS will enable new business model types to be used to deliver services to clients.In contrast to clouds, which are typically run by large companies that have the financial resources to construct and maintain enormous data centers, FaaS will make it possible for both large as well as minor businesses to organize besides run isolated or public computing, storing, as well as regulator facilities at a variety of scales. This will allow businesses to better cater to the requirements of a diverse range of customers [8].

2 2 Challenges of the cloud of things

The implementation of CoT also brings new challenges and concerns, particularly in the areas of protection and safety. As more and more information is collected and analyzed, there is a more significant threat of information violations and cyber threats. It is necessary for cities to be mindful of these hazards and to take action to secure their systems and protect the privacy of their residents. For example, it makes it easier to manage the resources of the IoT and delivers IoT facilities that are more efficient and cost-effective. In addition, it improves the transfer of data and processing for the Internet of Things. It offers fast, low-cost operation and integration for the deployment and processing of complex data [9].

In addition, the existing cloud model is unsuitable for Internet of Things products in which operations must be completed professionally, even if Internet access is inadequate. Milliseconds may be of critical importance in a variety of contexts, including telemedicine and the provision of medical treatment to patients. This situation applies to vehicle-to-vehicle communications, where the delay produced by the centralized cloud solution cannot be tolerated to prevent collisions or accidents [10]. Therefore, to tackle these issues, an enhanced paradigm of cloud computing that increases capacity and latency restrictions is necessary.

3 3 Fog computing

Fog computing, or fog connectivity or edge computing, is a decentralized computing structure that moves processing resources toward the data source. Unlike cloud computing, where data is processed and stored in centralized data centers, fog computing distributes computing power, storage, and networking across a network of edge devices, such as routers, switches, and sensors. This enables applications to be executed and data processed at the network's edge rather than in the cloud. Computing in the fog is a paradigm similar to traditional cloud processing in that it distributes computing, storing, and networking supplies across various end devices. However, fog computing has fewer capabilities than cloud computing. It offers an effective solution for Internet of Things applications that place a high priority on low latency [11,19,20].

From the perspective of its features, fog computing functions as an intermediate among the cloud and end devices. As a result, managing, storage, and networking facilities are brought nearer to the point machines themselves. These pieces of equipment are referred to as fog connections. Any location with an active network connection is suitable for their installation. Fog nodes may be any device with processing power, storage space, and the ability to connect to a network [12]. Some examples of fog connections are modern controls; knobs, etc, are shown in Figure 1.

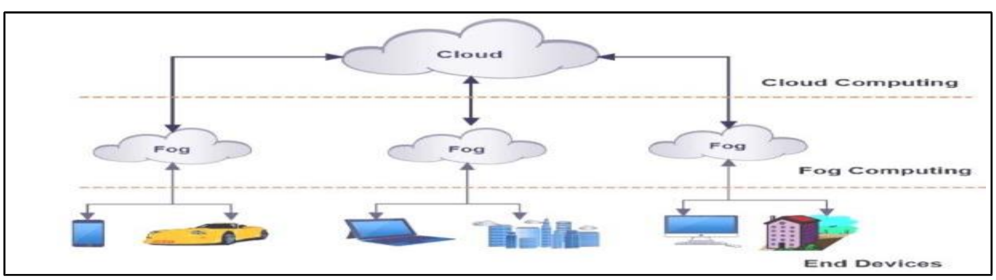

Figure 1: Fog computing and end devices interlink

IoT devices may get various advantages from using fog computing [13]. The following is a condensed version of these advantages:

3.1 A greater degree of business agility

More business agility: using the appropriate technologies makes the rapid development and deployment of fog computing applications possible. In addition, these apps can program the machine to operate following the requirements of the client. Due to the fog's low latency, it can offer real-time services (such as gaming and video streaming), among other things [14].

3.2 Geographical as well as large-scale division

Fog computing can deliver dispersed computing and storage resources to big applications. These resources may be used by applications deployed throughout a vast geographic area. Operational costs may be reduced by analyzing data locally rather than uploading it to a cloud storage service for processing. This will also save network bandwidth. Flexibility and heterogeneity are hallmarks of fog computing, enabling the integration of various physical environments and infrastructures across several distinct services [15].

3.3 Scalability

Scalability is enabled by the proximity of fog computing to end devices, which allows for an increase in the number of linked devices and services. Fog computing also brings with it some challenges and limitations. One of the main challenges is the need for a robust and scalable infrastructure to support the distributed computing and storage requirements of fog computing. Additionally, fog computing can be more complex to deploy and manage than traditional cloud computing, as it involves multiple edge devices and requires coordination between multiple stakeholders. The fog supplies a few computing, storing, and networking facilities in a decentralized fashion between the closed machines and the traditional cloud computing information facilities. The main goal of fog processing is to deliver time-sensitive Internet of Things applications with as low and predictable latency as possible. The design of fog computation is made up of 6 layers: the basic as well as virtualization layer, the checking layer, the pre-processing layer, the interim storage capacity layer, the protection layer, as well as the transit level.

4 4 IOT With fog computing

IoT refers to a linked network of devices and sensors that are internet-connected and capable of gathering, transmitting, and processing data. In contrast, fog computing is a decentralized computing architecture that puts computer resources closer to the data source, enabling real-time data processing at the network's edge. Fog computation is a subclass of cloud computation that relocates the "cloud" to a position physically closer to the network's edge. It provides a highly integrated computing, storage, and networking architecture that bridges the disparity between end devices and standard cloud services [16]. To improve the efficacy of Internet of Things applications, real-time processing, and assessment of the bulk of data provided by IoT objects and devices are necessary (IoT) Smart cities are one example of how IoT and fog computing are being utilized in tandem. Smart cities collect data on many elements of the city, such as traffic, air quality, and energy use, using a network of sensors, cameras, and other IoT devices. This information is then processed and analyzed, utilizing fog computing at the network's edge to give real-time analytics and inform judgment. The real-time problem that IoT devices face will be resolved thanks to fog computing, which will also deliver IoT applications that are safe and efficient. Fog computing will bring networking, computation, and space services of the cloud down to the side of the system.

Table :1 Cloud computing with Fog computing

Items	Cloud Computing	Fog Computing
Latency	Superior	Small
Hardware	Scalable collection and computing energy	Limited collection and computing energy
Location of server nodes	Within the Cyberspace	At the edge of the local system
Distance between client and server	Many hops	Single hop
Deployment	Central	Dispersed

Computing in the fog offers a variety of services and applications that are deployed in a broad variety of locations. Because the proxies and access points in the fog are arranged following lengthy roads and tracks, the fog can provide effective and timely communication between various Internet of Things applications, such as linked automobiles. Applications that need a low amount of latency, such as video streaming, gaming, augmented reality, and other similar applications, are thought to benefit most from using fog computing.

Cloud computing and end-user machines that are linked to IoT machines are the only two sources of computing power that are relied on by existing computing architectures. he field of industrial automation, where IoT and fog computing are used to improve the efficiency and safety of industrial processes. For example, sensors and other IoT devices can be used to gather data on industrial equipment, such as temperature, vibration, and pressure, which is then processed and analyzed at the edge of the network using fog computing. This enables organizations to identify potential issues and take proactive measures to prevent equipment failure, improving overall equipment reliability and reducing downtime.Fog computing has the potential to overcome many of the limitations that are associated with these two sources of computing power more efficiently and effectively.

Table:2 Overcome IoT challenges using Fog computing

IoT Challenge	How the Fog Can Answer the Challenge
Latency restrictions	Fog computing is a decentralised computing framework that conducts all calculation operations near end-users, such as data management and analysis and other time-sensitive activities. This is the best approach for dealing with the latency limitations of various IoT applications.
Network bandwidth constraints	Edge computing helps to overcome network capacity limits by reducing congestion problems and increasing performance of the network. Use data compression, optimisation, wireless mesh networks.
Source-constricted machines	source-constrained machines are a common challenge in IoT applications, but organizations can overcome these limitations through the adoption of appropriate technologies and strategies. By optimizing their use of available resources, organizations can ensure that their source-constrained machines are able to deliver the performance and reliability required to meet the demands of the IoT.
IoT security challenges	IoT security is a critical issue that must be addressed to ensure the safe and secure use of IoT devices and the protection of sensitive data. Organizations must take a proactive approach to IoT security and implement appropriate security protocols and solutions to address the various security challenges in the IoT.

5 Critical Analysis

The Internet of Things (IoT) makes use of fog computation intending to enhance speed and reliability while simultaneously cutting down on the quantity of data that must be sent to the cloud for processing, analysis, and storage. This novel chance for facilities is known as fog as a facility (FaaS), and it is made possible by the combination of fog computation and the Internet of Things. The purpose of this review research is to offer an outline of the incorporation of fog computation with the Internet of Things. This necessitates an examination of the features, advantages, and government-of-the-art of fog computing. Looking at potential new research fields in fog computing and the internet of things. The Internet of Things is altering our way of life and working. It has the potential to improve our lives in innumerable ways, but we must be aware of the hazards and take precautions to protect our gadgets and data. The future of IoT is promising, with the possibility for even more improvements and developments in the coming years. The inclusion of IoT and fog computation is also investigated, with a focus on the benefits of integration as well as newly developing IoT applications and the challenges that may occur. IoT integration with fog computing is discussed, along with related models as well as papers on the topic. Also included are open research questions on the internet of things and fog computing.

The next is a summarized version of the contribution that the paper makes:

- A review of current research that investigates how fog computing may be combined with a wide range of Internet of Things applications.
- Researching the issues created by the Internet of Things and identifying ways to solve those challenges through the combination of the Internet of Things with fog computation.
- Creating a variety of Internet of Things products that will benefit from the combination of the Internet of Things and fog computation.
- Have a discussion on the challenges that come with combining fog computing and the internet of things.

Table 3: Related works summary of integrated fog computing and IoT

[1]	Give a synopsis of potential open doors as well as difficulties of fog processing pipeline in principally on the systems administration setting of the IoT
[2]	Suggest a system for fog asset provisioning to give pause-delicate use of accessible fog-based computation assets
[17]	Intend VFC design to work with a joint effort between end clients to perform correspondence and calculation in light of the assets of every automobile
[3]	Suggest a component that utilizes the haze to work on the dispersion of endorsement repudiation data amongst IoT gadgets for a safety upgrade
[7]	Suggest a system to comprehend, assess as well as show administration interruption in IoT-fog cloud presentation situations
[18]	Suggest cross-layer engineering of VFC to make sense of the systems of the dynamic cycle as well as how various sorts of administrations are disseminated amongst automobiles
[5]	In a fog environment, mobility support refers to the ability of IoT devices and users to move around and access services and data from different locations. In this context, three common scenarios that pose challenges for mobility support in a fog environment
[19]	This review aims to identify the common security issues in fog computing applications by analyzing the various applications of fog computing in the Internet of Things (IoT).
[14]	A comprehensive taxonomy of fog computing can be developed based on the challenges and features of the technology. This taxonomy would classify and categorize the various aspects of fog computing, including its architecture, data processing, security, and deployment models, among others.
[15]	The outcomes show that web of things information exchange security, changeability, specialized abilities, execution quality, and administrative execution are the principal

benefit of Fog processing in utilizing web of things

Table 3 gives a rundown of linked articles that get examined the joining of the IoT with haze figuring, featuring the commitment of every paper organized by distribution year.

5 CONCLUSION AND FUTURE DIRECTIONS

Devices connected to the IoT often have limited capacities for data storage and processing, making it challenging to maintain reliable and low-latency systems. To address these limitations, fog computing has begun as a transformative solution. This innovative computing architecture enables the handling of data processing at fog nodes with the support of IoT gadgets, resulting in reduced latency and improved reliability. The fog computing model expands the cloud to be quicker to the things that generate and act on IoT data, allowing for computing, decision-making, and action-taking to occur directly via IoT devices. Only relevant data is then pushed to the cloud. This article offers a summary of the recent state of the art in fog computing, discussing its features, design, and advantages. Additionally, this review article aims to summarize recent advancements in fog computing research and the integration of IoT to address challenges such as security, transformability, technical capabilities, and performance quality. The integration of IoT and fog computing presents opportunities for real-time processing, cyber-physical system control, improved app functionality, pooling of local resources, and the facilitation of rapid innovation and affordable scaling. In future, fog computing represents a transformative solution for overcoming the limitations of IoT devices and maintaining reliable, low-latency systems. By pooling local resources and enabling real-time processing and decision-making at the boundary of the system, fog computing is poised to play a major role in the evolution of the IoT.

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