Fog Computing Architecture in higher education institutions

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ABSTRACT

The internet of things (IoT) and cloud computing are two contemporary innovations that have altered academics and business as well as influenced our daily lives in many ways. By moving processing to network edge nodes like mobile collaborative devices or stationary nodes with integrated data storage, computing, and communication devices, fog computing expands the capabilities of cloud computing.

The researcher in this study suggested an architecture model for higher education institutions.

Keywords: Fog computing , IOT, architecture, latency, higher education

Introduction

In recent years, the IoT has grew status and has been an important part lives of people because of the ability to connect with everything. Nevertheless, the existence of conventional centralized clouds has significant drawbacks, like excessive latency and network failure. Fog computing therefore serves as a unifying concept that will aid in reducing latency, particularly for time. Additionally, it will aid in the delivery of a fresh batch of developing services, and new apps will also be created. Therefore, corporations and businesses who depend on a third party's data center for the storage of their data would need to take into account Fog computing, a rising trend [1].

Both the internet of things (IoT) and cloud computing are new innovations that have altered academics, industry, and our daily lives in many ways [2].

The newest paradigm in computing, cloud computing, makes computer resources available through the Internet for a utility cost. Users of cloud computing can benefit from lower costs, the removal of system administration tasks, more flexibility, improved dependability, and geographical independence.

The Internet of Things (IoT) is the newest technology that is equally significant to the Internet. It is a system that links all objects to the Internet so they may communicate and exchange information using devices that follow to predetermined standards by being identified, located, watched over, and managed[3].

Numerous challenges have been experienced by the cloud computing, mainly in maintaining the request for the IoT application. Certain of the popular apps, including some gaming and live video streaming apps, are not well supported. Cloud computing lacks location awareness since it is constantly centralized. Fog computing must be used in order to aid in the real-time analysis of produced data owing to the growth in efficiency of IoT applications. When used to address problems or bridge the gap between cloud computing services and IoT devices, fog computing functions within the cloud where it is available in huge servers.

Low latency, the mobility support, and the location awareness are rarely ever satisfied by the traditional cloud computing model. The fog computing paradigm, which provides low latency and the location awareness in the realm of wireless sensor networks, industrial automation, and transportation systems, is developed to address these issues [4]. It also increases quality of services (QoS) for real-time applications and streaming.

To reduce latency and increase reaction time, it is necessary to combine different IoT device messages utilizing mobile of cloud computing closer to the device of user. A low latency collection point is required to handle the numerous protocols, message delivery, and the processing of analytics from data gathered from multiple IoT deployments. The Edge Cloud server has the capacity to overcome these difficulties[3].

We provide a creative solution that combines systems in the higher education system while taking use of fog computing. A flexible architecture based on fog computing has been created. The main contributions of this study may be summed up as follows: • The suggested architecture comprises fog nodes; • It contains a solution that students and academic staff advocate that a higher education institution implement. All higher education institutions are advised to use this fog computing architecture.

Related work

Different analyses of the fog application were made in various areas. Smart cities, healthcare, the commercial sector, agricultural systems, and financial systems are where fog computing is most commonly used.

The research for [5] looked closely at a multiplicity of high-level services that smart gateways might provide to the end users and sensor in a distributed method at the network's edge (e.g., local processing, storage, notification, standardization, firewall and web services). They demonstrated a proof of concept implementation of a Smart e-Health Gateway-based IoT-based remote health monitoring system.

The proposed architecture contains fog nodes where intelligent agents handle data in a similar manner. It features a recommender system that merges predictive systems for a banking company. This architecture provides the chance to enhance customer service in the bank's physical channels while simultaneously generating technology support to enhance office managers' capacity for problem-solving, enabling staff to take on a more adaptable and flexible role. Additionally, it enables the development of a one-stop shopping model for the operations underpinning the financial services model in offices[6].

Fog computing:

The idea behind fog computing is to locate networking resources close to the data-generating nodes, which are located at the lowest perception layer. The processing, storage, and networking services between the end nodes in an IoT environment and the conventional clouds are provided by highly virtualized platform known as fog [7].

A concept known as fog computing brings cloud computing and its services out to the network's edge. Like Cloud, Fog offers end users data, computation, storage, and application services[4].

By moving processing to network edge nodes like mobile collaborative devices or stationary nodes with integrated data storage, computing, and communication devices, fog computing expands the capabilities of cloud computing. The benefits of fog include increased competence, improved security, efficient data transport, and adaptability [8].

Characterization of Fog Computing

1- Geographical distribution: The service and application targeted by the Fog necessitate highly scattered installations, in striking contrast to the more centralized Cloud. For example, The Fog will dynamically contribute in providing high quality running to moving cars via proxies and access points placed along roads and railroad tracks [9].

2- Scalability: The surrounding environment is monitored by large-scale sensor networks. The fog offers resources for distributed computation and storage that can accommodate such massive end devices.

3- Assistance with movement Being able to connect directly to mobile devices and so enable mobility techniques like the locator ID separation protocol (LISP), which requires a distributed directory system, is one of the key features of fog applications.

4- Location Awareness: To enable devices with gorgeous services at the network edge, the location of the nodes can be tracked passively . Fog computing focuses on local Internet of Things applications that are accessible for devices in certain locations via particular fog nodes. As a result, it is aware of the areas where the fog nodes are located[10].

5- Heterogeneity: Fog nodes or end devices come in a multiplicity of figures and sizes and need to be placed in accord with the platforms for which they were made. The fog may operate on a variety of platforms[11].

6- Decentralization: The architecture of fog computing is distributed because there is no single server in charge of overseeing all resource and service. The fog node self-organized to work together to offer consumers real-time services and Internet of Things applications [10]

Fog computing application

1- Fog computing in healthcare: MediFog is a fog computing application in the medical field. The current urgent demand has always been healthcare. This industry is extremely important since it directly affects a person's health. For this sector, several technologies have previously been suggested. Fog computing technology is one such innovation. Any uncommon scenario involving a patient, such as cardiac arrest or high rises and falls in blood pressure, may be detected and predicted using the suggested approach. A sensor will record this information, which will then be sent to the fog servers. Hospitals will have access to patient data and be able to respond right away. Only the information of patient that registered with a certain hospital can be seen by that hospital. This data has been confidential, thus it has been secured to prevent illegal access. The hospitals do not need to physically get data from the patients in order to access the vital information needed anytime the patient wants a checkup [12].

2- Connected Vehicle (CV)
The implementation of connected vehicles shows a rich scenario of connection and interactions, including connectivity and interactions between automobiles and access points (Wi-Fi, 3G, LTE, roadside units [RSUs], and smart traffic signals), as well as between access points and cars. The Fog is the best platform for delivering a wide range of SCV services in safety, traffic support, and analytics because of its geo-distribution (across cities and along highways), mobility, location awareness, low latency, heterogeneity, and support for real-time interactions[9].

3- FoAgro is the use of fog computing in farming and agriculture. In nations like India, where farming is a very common profession. These folks support their families by working in this field. However, poor management of the farming grounds results in the destruction of crops. This actual problem addressed by the using of a fog computing resource. In farming areas, sensors like as moisture sensors, video sensors, etc., have been strategically positioned to collect data, store it, and transmit it to fog nodes and servers. The camera sensors will be able to take real-time pictures of the crops and the farm, and the moisture sensors will be able to determine how much moisture is in the crops. The farmer who owns the field in question has access to this information. He may access the agricultural data for his farms after providing the correct login information. The farmer may use this information to analyze his acreage and take the necessary measures. This information is kept secure and secret so that no one else may access it [12].

4- Purchasing Cart Management: Fog computing can enhance customers' online shopping experiences. A cart shopping foe users is often kept in the cloud, and depending on network speed and server traffic, updating the shopping cart display may take some time. As a result of the wireless network's limited bandwidth, this delay can be longer for mobile devices. When the users visits the shopping cart using fog computing, the fog node stores it and updates it up until the user logs out of the cart. The fog node uploads the final version of the shopping cart to the cloud in order to maintain consistency. As a result, fog in management of shopping cart can shorten the time between updates and boost consumer satisfaction[10].

5- Smart grid for energy

The energy grid is a system for distributing power that installs smart meters at various sites to track real-time data on energy production, supply, consumption, and invoicing. In order to optimize energy while minimizing costs, smart energy refers to the use of networking and IoT technologies, which incorporates decision-making and action-taking subsystems. In order to stabilize the power grid, directives are sent from a central server known as the supervisory control and data acquisition (SCADA) system to respond to any change in demand or emergency. For instance, the Los Angeles Smart Grid will provide service to more than 4 Million users of the country's largest public utility[13].

The importance of fog computing in IOT

Fog computing can solve various of IoT challenges

1- Big data

IoT is quickly becoming one of the most major sources of Big Data, and when it works with Fog, the latter has access to a wealth of valuable information that it can utilize to conduct highly accurate prediction algorithms [5].

Due to the necessity for location awareness and quick answers, a new age of big data that exhibits geo-distribution is becoming more and more alluring with the growth of the Internet of Things. Data should thus be processed and examined as soon as possible once they are created. The characteristic of fog computing enables big data management close to the source of the data. Parking occupancy data must be gathered and aggregated by each Fog node. Then, the Fog node processes big data, especially batch processing, which enables quick discovery of vacant parking spaces [5].

2- Reduce Latency: Fog Computing (FC), primarily has been introduced by Cisco, appeared as a new topic to solve the problem of latency . In the platforms of edge computing, FC processes data nearby rather than remotely over a cloud. Transmission delay has been reduced by the data source nearness geographically to the processors [7].

Proximity has a strong correlation with latency. Getting close to the end customers helps to lessen it. It also affects how quickly reactions occur and how likely congestion is to occur [14].

In order to decrease latency and the expense of sending data to a distant cloud, fog computing (FC), a new distributed computing platform, brings computation near to its data sources. For many Internet-of-Things applications, especially those that require mission-critical and latency-sensitive services, this characteristic and its associated benefits are desirable[7].

Placing processing near to the devices, as opposed to a device-to-cloud design, can decrease latency since the physical distance is reduced and the possibility of a data center reaction time is gone[15].

3- Network bandwidth constraints

Classified data processing from the cloud to devices of IoT is made possible via fog computing. This makes it possible to carry out data processing in accordance with application requirements, available networking, and computing resources. As a result, less data must be uploaded to the cloud, hence utilizing less network bandwidth [11].

4- Support for mobility

Direct mobile device communication is crucial for fog computing. Additionally, a variety of mobile devices may speak with one another directly. The base station or even the cloud do not need to receive the data. In order to fully realize mobile data analysis, end devices or intermediary devices handle the vast amounts of data produced by the Internet of Things. Consequently, it may offer services to nodes with greater range.

5- Resource-constrained devices

When actions that need a lot of resources can't be transferred to the cloud, fog computing can be employed to carry out those processes on behalf of devices with limited capabilities. This enables lowering the complexity, lifespan costs, and power consumption of devices [11].On sensor devices with limited resources, heavy tasks can be transferred to fog computing nodes with higher power[15].

Fog computing issues :

1- **FAILURE MANAGEMENT**

Fog devices failure possibility is continuously high because the devices has been distributed and the Fog management of devices is not central. Consequently, the devices may fault for a diversity of causes, excluding failure of hardware, failure of software, or human error. As well as, to these issues, numerous other causes consist of connection, mobility, and the power supply, all of that are important. As wireless connections are regularly used to link the common of the devices in a fog environment, it goes without saying that they are not always dependable. Since most wirelessly linked devices are portable, they may regularly switch locations among multiple clusters[16].

2- Security

The same security issues that can affect any virtualized network can affect the Fog network. A significant problem is the assurance of a trustworthy computing base and techniques for authentication for a network with such great flexibility and high mobility [12]. The security standards are strict due to the sensitivity of patient data and the potentially serious repercussions of tampered with or altered devices and systems. Increased device connection increases attack surfaces in terms of remote monitoring[15].

3- Energy consumption: The fog environment uses a lot of fog end points, and because processing is spread rather than centralized, it may use more energy. As a result, it is crucial to solve the difficulty of lowering the energy used in fog computing [11].

Fog computing layer

The Fog computing architecture used in this study is made up of a number of layers and different Fog computing architecture components. Various sets of components are created based on the components' functionality, or layer. These features will make it possible for IoT devices to connect to different Fog devices, servers, gateways, and the cloud[16].the layer as follow in figure 1 :

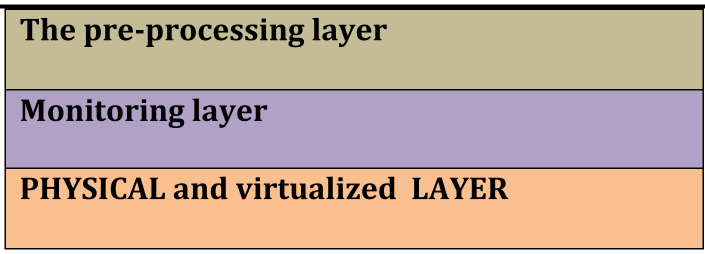

Figure (1) Architecture layer of fog computing

Physical and virtualized LAYER

The numerous types of data released by the sensors serve as the primary data source for fog computing. Smart appliances , sensors temperature, humidity sensors, also smart dwellings, the system of CCTV, and systems of traffic monitoring may all create this data. In addition to physical sensors, virtual sensors play a significant role. Based on their kinds and service needs, physical nodes, virtual nodes, as well as virtual sensor networks are controlled at the physical and virtualization layers [17]. A virtual sensor might facilitate quick decision-making on traffic multiplexing, traffic rerouting, and road conditions. Therefore, any data generating device might belong to either of these categories on the physical layer, which comprises of physical and virtual sensors [16].

Data management duties are carried out by the pre-processing layer. To extract useful information, collected data are examined, and data filtering and trimming are used in this layer. After then, the preprocessed data are momentarily stored in the temporary storage layer. The data can be deleted from the temporary storage medium once it has been sent to the cloud, eliminating the requirement for local storage [11].

Storage layer:

It connected in computer systems with network attached storage, fiber channel, and storage space virtualization [7].

Security layer

Data encryption and decryption are used at the security layer. The data may also be subjected to integrity checks to guard against tampering[17]. Encryption and decryption are carried out via the security layer, which also protects data privacy and integrity [18].

Transport layer

In the transport layer, the pre-processed data are uploaded and preprocessed secure data to the cloud[17].

Proposed architecture for a system

The Internet of Things will completely transform the Internet of the future. Smart healthcare, smart cities, smart retail, smart agriculture, and IoT systems are emerging concepts based on IoT [19]. Numerous computational technologies, such as fog computing, have been suggested to provide computing methods for these applications. Smart healthcare, smart cities, smart agriculture, and smart finance are some of the most significant IoT applications. The use of fog computing in healthcare, smart cities, finance, and agriculture was highlighted in several research. However, no research on employing fog computing in higher education was highlighted. As a result, a concept for the higher education system based on fog computing is offered.

In contrast to cloud computing, fog computing-based IoHT applications increase speed and reliability while reducing latency and utilizing less energy. The truth is that cloud computing remains a foundational computing technology. The purpose of fog computing is to make cloud capabilities more accessible to end users. Fog computing is superior than cloud computing because it reduces the distance between end users and the database, making it particularly ideal for real-time IoHT applications.

Therefore, we propose to modify the fog computing architectural model from the work of [19] in order to suit the user in higher education, such as staff, academic researchers, and students.

The proposed System layer

The Architecture of higher education System based on the fog Computing contains of three layers, which are: the devices , the fog layer, and the cloud computing layer, as shown in Figure 1 that adapted from the study for [20]

Figure (2) Fog computing Architecture in higher education

Devices Layer that it is responsible for collecting the student and researcher staff data from devices that transmit data through a network WiFi to fog layer and then process and execute the tasks. The layer of Fog computing that acts like a bridge between the devices and the cloud computing layer, which will receive the data that collected from diverse IoT devices.

Conclusion

We suggested an architecture paradigm for fog computing in this paper. The suggested architecture presents a chance to enhance user satisfaction in the higher education setting. As a result, both students and staff may resolve their issues quickly and effectively, while also helping the college's management become more adept at doing so. This design enables faculty and staff to adopt a more adaptable and flexible use, enabling them to answer user demands thoroughly and uniquely and to foresee their needs.

We want to apply our fog computing model—which was not finished in this paper—at higher education institutions in the future. Furthermore, future research on fog computing has to concentrate on a number of challenges, such as security.

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