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Research Article

Improved QoS in Fog Computing by Efficient Resource Allocation in an Internet of Things Environment

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Abstract: Large-scale application migration to fog computing is now being seen in the IT industry. The IoT is a prototype for connecting everyday objects to the web, such as sensors, gadgets (including those used in healthcare), and smart cameras. By analysing the data produced by the device, the IoT proposes a paradigm that simplifies infrastructure management and disaster recovery, hence improving the quality of life for humans.Fog Computing is a new computing paradigm that has emerged in recent years to meet the needs of latency-sensitive, geographically dispersed applications with high computational requirements. Fog computing is popular because it may be deployed near to the IoT nodes. Fog computing expands the computational, storage, and network capabilities of the cloud and serves as an intermediary layer between IoT devices and sensors. The nature of fog nodes makes resource management more difficult in fog. With fog computing, services and resources may be made available outside the cloud, close to the end devices. The inclusion of several heterogeneous devices, some of which may be mobile, makes ensuring adequate quality of service (QoS) in a fog system very difficult. Several quality-of-service considerations are accounted for, and QoS-aware techniques are provided in various portions of the fog system. So, in this article, we take a look at what's been done so far to ensure quality of service in fog computing. FogQSYM (Fog Queuing System) is an analytical model for Fog applications that helps to partition the application into many tiers and efficiently distribute resources based on factors such as memory, network speed, and processing power. When the infrastructure is built with lightweight computing devices, effectively allocating resources in the fog environment becomes a challenge. In a unified fog computing setting, we discuss how to assign tasks and locate virtual machines.

Keywords: Fog computing, Fog layer, Smart device, IOT, iFogSim , iFogSim, Simulation,Wireless Communication,Fog nodes,Sensors,Actuators,Cloudlet

Introduction

Fog computing is a distributed computing system that sits between the cloud datacenter and the sensors of the Internet of Things (IoT). Computing, networking, and storage are just few of the many services made available by the fog computing model. Cisco created the fog to address concerns in the Internet of Things (IoT) and cloud computing by deploying sensors over the whole network and analysing the data in light of service needs. Concentrated datacenters struggle to manage billions of sensors and actuators, leading to frequent outages. Because of this congestion, the network has high latency and low QoS. Fog infrastructure, including switches, bridges, routers, base stations, and servers, is often set up in close proximity to IoT sensors and actuators. Some of the features provided by the fog are model portability, interactivity in real time, and scalability. As a result, the fog achieves desirable results across a range of measures, including response time, energy consumption, network throughput, and cost. As a consequence, applications built on the IoT may benefit more from fog computing. Because of the Internet of Things, knowledge management has undergone a substantial revision; real-time knowledge management now makes use of distributed sensors. Smart sensor data must be saved and put to good use. The number of sensors or devices based on the Internet of Things is expected to increase fast, and by 2025, it might number more than 50 billion. In the event that existing cloud computing fails to provide improved outcomes, such as increasing traffic, traffic congestion, and low latency, other approaches must be found to deal with the massive amounts of information or data. Low latency and quick responses are essential for many service sectors, including healthcare, defence, agriculture, and transportation management. A proposed alternative architecture called fog computing is intended to solve the existing problem. Fog computing involves locating "fog nodes," which handle the client's service, in close proximity to the user. If you're using fog computing, your data won't even leave your local server before being processed and backed up in the cloud. Finding fog nodes and data caches are two of the biggest obstacles for fog computing. Fog computing networks are those in which data storage, processing, and service delivery are all virtualized to better serve end users. Connecting the cloud and IoT devices that provide networking, storage, computation, and the network that delivers services to the end-user is what fog computing is all about. To facilitate networking, computation, data management, and storage near IoT devices, fog computing links the cloud with these devices. Generating GPS data is compressed locally in an intelligent transportation system before being uploaded to the cloud. In terms of horizontal system-level architecture, the Open Fog Consortium defines fog computing as a computing paradigm in which services including storage, networking, processing, and control are distributed near to the consumers. While vertical system design enables single or isolating applications, horizontal system architecture in fog computing allows for the distribution of services like storage, networking, and computation across several sectors and platforms. Loosely linked, dynamic, and diverse best describe IoT settings. There are two distinct categories of data in this setting: little data and large data. Bigdata are the persistent data gathered, created, and stored in the cloud by Internet-of-Things devices.

Because of this, a new computer paradigm emerges that is physically near to the Internet of Things sensors and cloud services. Edge devices are those that exist on the fringes of a network and are responsible for the creation of fog computing. With the use of fog computing, cloud services may be brought to the network's periphery. Devices such as smart gateways, routers, and others that act as sensors at the network's periphery are also included. Fog is distinct from the cloud in that it may accommodate latency-sensitive programmes. Decentralised fog nodes are placed in close proximity to IoT devices. Due to its distributed nature, a fog node may act as a client or a computational node. Cloud computing has high resource availability and low power consumption, whereas fog computing has intermediate resource availability and low power consumption. While enormous datacenters are required for cloud computing, modest hardware components are all that are needed to make fog work. To be deployed in close proximity to IoT devices, fog computing gear must be compact; this is not possible on the cloud. Fog RAN (F-RAN) refers to the way through which Radio Access Networks (RAN), such as 5G networks, are used to integrate fog computing with mobile technologies. Fast content retrieval via edge network caching is made possible by the resources of F-RAN. Another approach to cloud computing is the Cloud Radio Access Network (C-RAN), which employs Remote Radio Head Stations (RRHS) linked to a Base Band Unit (BBU) in a random fashion.

Characteristics of Fog Computing

Between the edge and the cloud, fog computing serves as a happy medium.The peripheral devices that provide data persistence, computing power, and networking functions are known as fog nodes. Fog nodes may be anything from switches and routers to servers and cameras.Fog computing will be characterised by low latency, location awareness, geographical dispersion, scalability, portability, real-time interaction, heterogeneity, and interoperability. Not only are infrastructure and fog node energy use and application uptime tracked, but also the status of installed apps. The data from level 2 is analysed, filtered, and trimmed at the third level of pre-processing before being sent on to the fourth. The fourth tier involves the temporary storage of data via the use of replication, duplication, and storage space utilisation. Data encryption, decryption, and integrity checking are all part of the fifth degree of security. In the last phase, information is uploaded to the cloud.

Resource Management Techniques for Fog Computing

Data produced by the Internet of Things may be processed and stored locally thanks to a fog computing architecture. Because fog is so dynamic, variable, and varied, a reliable method for managing its resources is essential. Application placement, scheduling, offloading, load balancing, allocation, and provisioning are the six types of resource management approaches that are discussed in this study within the context of a fog computing environment. The first group is concerned with the location of applications, which has a direct effect on resource use. Congestion in a distributed fog environment may be caused, for instance, by improperly deploying an application with a lot of data. The second kind is resource scheduling, which aids in allocating a service's requests to the most suitable available resources. Scheduling in a fog environment is broken down into near, remote, and collaborative, all of which contribute to meeting IoT requirements. The third kind, "task offloading," involves passing the workload from low-powered devices to those with more resources in order to meet performance goals. Load balancing, the fourth kind, is useful for managing the placement, scheduling, and unloading of applications that all deal with the same problem. The fifth kind is resource allocation, which is used to distribute available fog node and cloud resources to the devices that need them. Scaling up or down the available resources is the sixth category for improving the efficacy of the fog's resources in terms of energy, cost, time, etc. Fog computing's resource management taxonomy is shown in Figure.1 below.

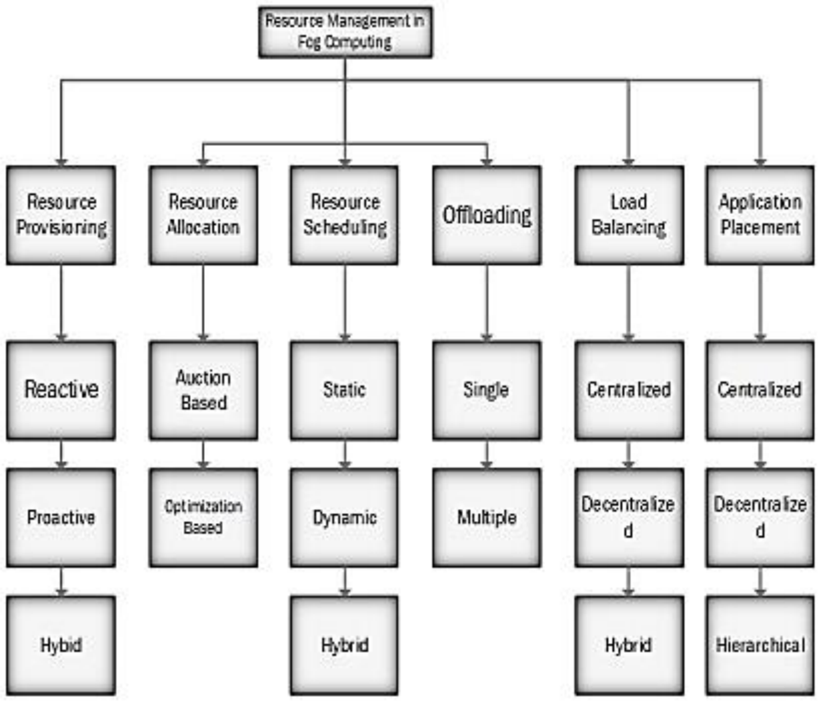

Figure.1 Resource management taxonomy in fog computing

Literature Review

Haruna Abdu Manis et.al (2017) Supporting Internet of Things (IoT) devices and analytics, fog computing is a decentralised computer architecture. Since various applications have varied needs, particularly in terms of reaction time, new kinds of mobility, resource allocation, and management are impending in Fog infrastructures in light of the rapid expansion in the number of ubiquitous network devices, generally referred to as IoT gadgets. Additionally, certain IoT devices' application execution requests are transmitted to geographically scattered cloud data centres through fog layer, without taking into account user mobility at now, which increases response time. However, the fog layer's ability to manage data production, processing, and dissemination at the network's periphery means that network traffic may be kept to a minimum, resulting in little latency. Our research expertise in tackling the issue of resource allocation and user mobility from the network edge to the dispersed cloud data centres is detailed in this article. To address this issue of user mobility and shorten response times for applications, we present an effective method that cooperates with the Seamless Handover Scheme for mobile IPV6 and recommend scheduling principles.

Gopal Chandra Jana et.al (2017) As we go farther into the IoE age, more and more things will be brought online, yet traditional cloud data processing won't be able to keep up with our expanding data needs. Deadline-driven cloud services, such as health monitoring, experience performance drops because of the time and resources required to transport data to and from the cloud. Fog computing, in which cloud resources are brought closer to the region where they are needed, has emerged as a potential means of alleviating network congestion and latency. Fog computing is a paradigm for managing a highly dispersed, cloud-based computing and networking infrastructure that provides services to end users and cloud data centres. In this study, we suggest a method for more effective resource management by taking execution time into account.

Sagar Verma et.al (2016) In this research, we offer a load-balancing method that operates effectively in a Fog-Cloud environment. The algorithm's reliance on the data replication approach for keeping data in Fog networks is one way in which it lessens the load on large central data storage facilities. Also included is a comparison between the given 'Cloud-Fog' pair and the current load balancing approaches used in 'Cloud-based' infrastructure. The eventual objective is to have data accessible closer to the user end of the internet and distribute the load across Fog networks.

Deze Zeng et.al (2016) In this study, we focus on a software-defined embedded system that is backed by fog computing, with the storage server housing task pictures and the embedded device or server doing the calculations. For better user satisfaction, it's crucial to plan effective job scheduling and resource management with fast task completion in mind. In this work, we explore these three topics to achieve this goal: Task scheduling, resource management, and I/O interrupt balancing are all ways to ensure that the client device and compute servers are not overburdened at any one time. Both are taken into account simultaneously, and the resulting issue is a mixed-integer nonlinear programming one. Our formulation, verified by rigorous simulation-based research, provides a computation-efficient solution to its high computational complexity.

Resource Assessment Method Using Qos In Fog computing

Devices, smart objects, and sensors have all expanded steadily as IoT has developed. By 2020, CISCO predicts, there will be 50 billion internet-connected devices. Since these devices and the cloud are geographically distant, there will be a significant lag time before any responses are made available. High bandwidth with low latency is essential for quality of service in IoT applications like video streaming in linked automobiles. Fog computing plays a crucial part in ensuring the Quality of Service (QoS) of an application by processing the request locally using the closest available resources to provide QoS with decreased latency. In between the cloud and the devices themselves is where fog computing resides. Mobile latency is reduced because to the proximity of fog devices to their users. This contributes to an improvement in QoS. The number of connected things is growing rapidly, as was said previously. All of these Internet-of-Things devices are making identical requests. More gadgets means more people want those devices to do more. It might be challenging for users to choose which of the available resources will best meet their needs. In contrast to cloud computing, fog computing makes use of very less resources. There is an effect from resource prediction among these available resources on the availability and performance of the application dependent on the user's desired QoS. Through an examination of resource utilisation and user quality of service, the resource prediction technique aids in the selection of suitable resources.

As a result, job allocation in fog computing relies heavily on accurate assessment and selection of available resources. In this paper, we offer a similarity-based resource estimation methodology to enhance fog computing's quality of service. There are two parts to similarity matching: a grey index and a penalty index. The Markovin chain model of linear regression is utilised to analyse the load-based similarity matching.

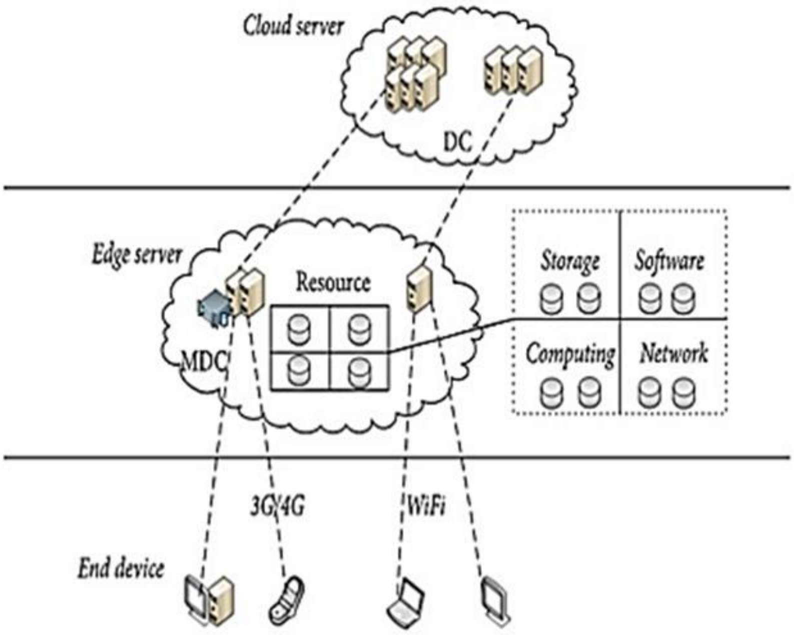

Figure 2. Fog computing architecture

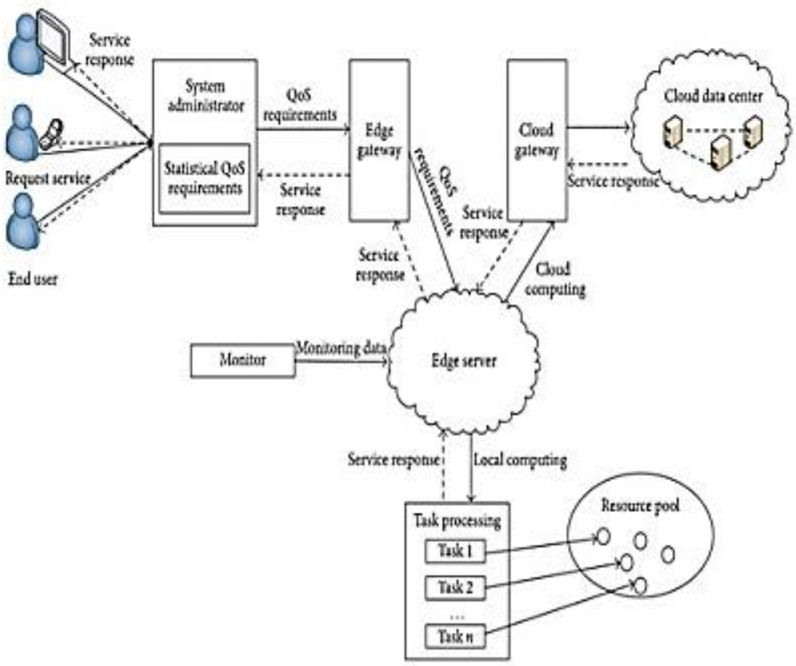

Figure 3. Request process service in fog computing

Experimental Analysis

The F-measure is a weighted average of other metrics like accuracy and recall to determine how well a system performs as a whole. Increasing the F-measure also modifies the assessment procedure used to determine the system's efficacy. There are a variety of QoS needs that must be met by the available resources. The simulation is designed to meet the QoS requirements, which include characteristics like availability, response time, and cost. The closeness measure and the relative importance factor are both set to 0. By using a threshold value (k) we may eliminate the low-similarity irrelevant resources. Figure 4 illustrates the conflict between accuracy and recall. Precision increases and recollection decreases as matching degree decreases. Figure 4 shows that the best accuracy and recall may be achieved when the threshold value (k) is between 0.5 and 0.6.The F-measure with a multiple matching threshold is shown in Figure 5. It is known that lowering the threshold progressively raises the F-measure.

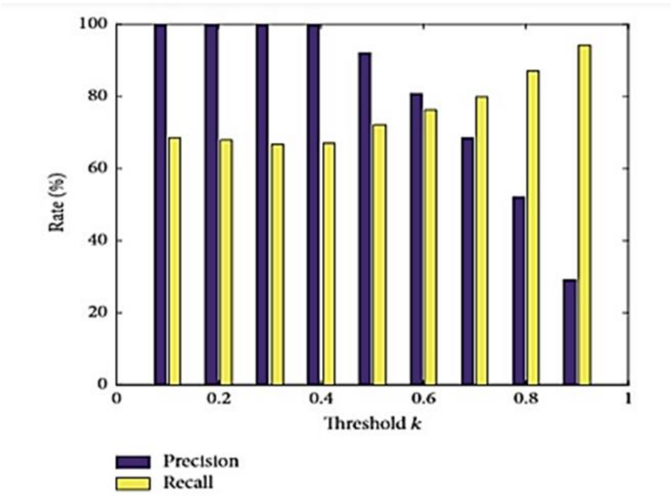

Figure. 4 Precision and recall variations under different matching threshold

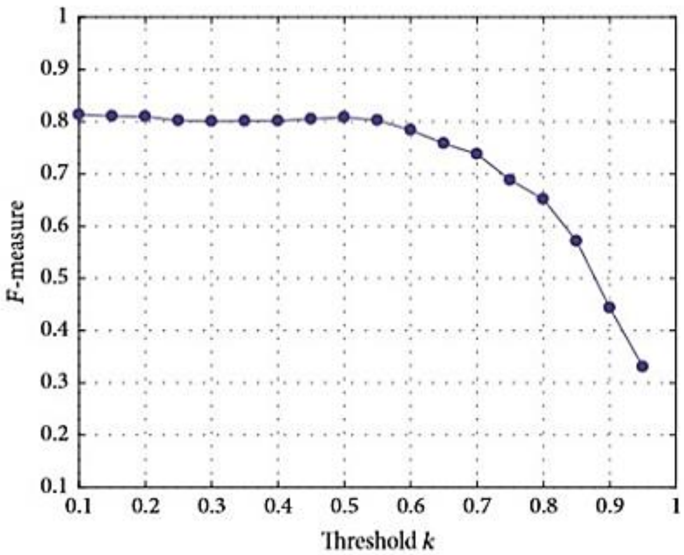

Figure. 5 f-measure with multiple matching threshold

Conclusion

Due to the rapid expansion of the Internet of Things, new computing paradigms have emerged, making it more difficult than ever to meet the expectations of end users. In order to reduce latency and enhance user demand, it is helpful to have both storage and processing capabilities on-site. In the work, the QoS characteristic is employed to allocate resources using a weighted Euclidean and similarity distance. In the end, a combination of similarity matching and markov chain prediction is used to choose the appropriate assets. Since the system's QoS attributes are fixed and the users' QoS needs are ever-changing, accurate resource estimate and matching are crucial. Using accurate resource assessment, provisioning, and utilisation, the suggested technique helps to meet the user demand in terms of Qos..

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