IJCSE International Journal of Computer Sciences and Engineering Open Access
Survey Paper Vol.8, Issue.7, July 2020 E-ISSN: 2347-2693

A Survey of Fog Computing Architecture and Its Applications

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DOI: https://doi.org/10.26438/ijcse/v8i7.136141 | Available online at: www.ijcseonline.org

Received: 03/July/2020, Accepted: 20/July/2020, Published: 31/July/2020

Abstract: Now days we can observe that so many advancements are happening in the technologies and new Generations using various programs, software and applications are progressively complicated and needs lower latency requirements. So that clients would be able to get to these applications and information from anyplace at any time without any delay. Cloud computing is one of these technologies designed to deliver computer resources platforms and other various computing facilities. In this on –demand services are provided to the users through the Internet. But network dependency, data security issues, lower bandwidth, variation of cost, location-awareness are some limitations that we are facing with cloud computing. To overcome inherent problems of this popular computing paradigm fog computing has come up as a promising framework to provide flexible and adaptable resources adjacent to network. Fog computing is generally an idea of a distributed network that brings the cloud services that are communication, computation and storage near upon edge devices and users. It is used to improve efficiency and Real-time processing of data. The major objective of fog computing is to shorten the particular data that should be delivered to the cloud for processing, study, storage and computational purpose. And at the present moment, fog computing appears to be the most alternate available that can handle all client requirements.

Keywords: fog computing, cloud services, Real-time processing, distributed network.

I. INTRODUCTION

As we know in cloud computing cloud hacking cases are increasing rapidly and network dependency is also a main issue. So Fog computing is basically referred to as fogging or fog networking, is a kind of decentralized computing framework in which computing resources application and services are distributed in a convincing and efficient place, along the continuity from the user or data source to the cloud. Fog computing emphasizes relatively to end users and client objectives like (resource exploitation and operational cost etc). To overcome all these issues Fog computing started in January 2014 by networking immense CISCO as a thought of exchanging cloud computing service and functionalities to the point of the network. So fundamentally fog computing system is a development of the cloud computing it would be troublesome to define fog computing without to begin with gets it cloud computing.

II. RELATED WORK

A. OVERVIEW OF FOG

If any service provided to the consumer through the Internet connectivity, it is called cloud computing. This service can be anything like offsite storage or computing resources. By making use of Internet technologies, facilities like infrastructure, application, platform and storage are provided in these services. And users can use these services according to their needs anytime at any place. For example, Google Apps provides several business applications online that can be accessed through a web browser. But it is indisputable that this system also has some limitations such as Risk of data confidentiality, network dependency, Compliance, Data Mobility, Low Connection etc. To defeat these problems Fog computing came out as a potential solution of these issues. Fog computing referred as a technique in which storage, applications, and data provided to the end-users. And all these services (storage, applications, data, computing) located somewhere between the data source and the cloud. However, fog computing is nearer to end-users devices and gadgets and has more extensive geographical dispersion. In this, the processing of data is done completely in the placed fog node if the data does not require higher computing control. Fog computing system gives organizations more choices for processing of data wherever it is most suitable to do so. Generally speaking, fog computing is best for organizations that need to be analyzed and react to data in less than a second. So fog computing ability to minimize latency makes it perfect for this task. Fog computing is basically a link that joints or ties these two environments. "What data has got to be sending to the cloud, and what data require to be analyzed on-the-spot at the edge?"

B.NEED FOR FOG

All IoT applications with big data analytics , Mobile and cloud computing where IoT is trending computerization, Internet of things gives assurance to execute high-range

capacities related to homes, automation of vehicles and smart workplace, Internet-connected devices. To expand the conceivable outcomes and requirements appraisal, IoT needs an advance creativity to make an application reliable at gateway execution. IoT collaborates with cloud to store the data assembled from devices but it requires reinforcement and more time to perform an action with regard to executing applications of IoT. Consequently, so it seems to be a major disadvantage; IoT needs advancement in smart way and require speedy activity. Fog computing permits computing, task-analysis and decision-making to perform through the IoT devices and only sends related data which is selected by fog to the cloud for historical and future analysis.

III.ARCHITECTURE OF FOG COMPUTING

Fog computing designed with ancient networking elements such as routers, hubs, switches, gateways etc. which is placed between user applications and cloud software. Clients can submit their requests for the specified services through the consumer layer where user devices are placed and communicate with the clouds by means of the Fog computing layer. In this layer Fog nodes which are the hardware devices like smart routers, edge servers and base stations are placed and most of the data handling takes place in these nodes. Fog computing layer is an observing layer which observes network and essential node activities. All processing and storage related operations ought to be executed by any device that has processing power and storage capacity. These devices having processing and storage capabilities basically known as Fog servers and Fog devices. This layer characterizes when and what task needs to be performed by which node additionally takes care of the consecutive task requirements that use to be executed to accomplish the most important task. The fog layer basically works as a central layer between mobile devices/gadgets and the cloud. And then followed upper layer which is cloud computing layer provides centralized control and variety of observing services. Long-term and complex behavior analysis will be performed at this layer to support real time decision making such as in a manufacturing use case where associated machines got to be able to reply to an incident as soon as achievable. In cloud computing layer, data processing takes place in inaccessible information centers that can be found around the globe, a thousand miles far from user devices.

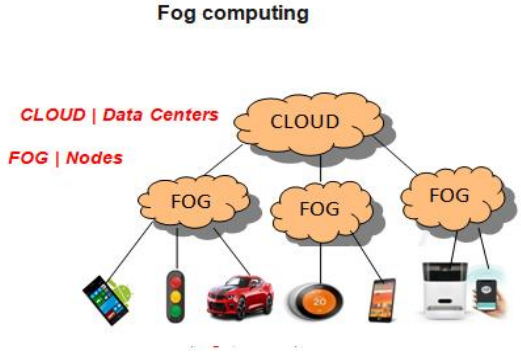

Figure 1: Architecture of Fog Computing

IV. FOG COMPUTING-DESIGN

Fog computing works by deploying fog nodes throughout your network. These fog nodes then can be deployed in targeted areas such as your office flour or within a vehicle. When an IOT device generates data this can be analyzed via one of these nodes without having to be send all the way back to the cloud. The procedure of Fog Computing service is described as follows:

1) The data is collected from multiple numbers of devices/things (e.g. - smart TVs, smart speakers, toys, wearable's and smart appliances, smart meters etc).
2) Fog nodes are distributed over the edges of internet to gather the data send through IoT application.
3) Fog nodes; retrieve the data which is generated by IoT appliances.
4) After the retrieving of data, the important data which can be useful for future references pass on to the Cloud.
5) Fog nodes are geographically scattered, the devices can change the location according to the fog topological Architecture.
6) The data after that stored in cloud according to the rules and design of fog data services.

At present it is obvious that the number of devices connecting with the Iot will increase in the future so based on this design Fog Computing provides secure and efficient management of data and services to the corresponding Iot devices while ensuring time sensitivity.

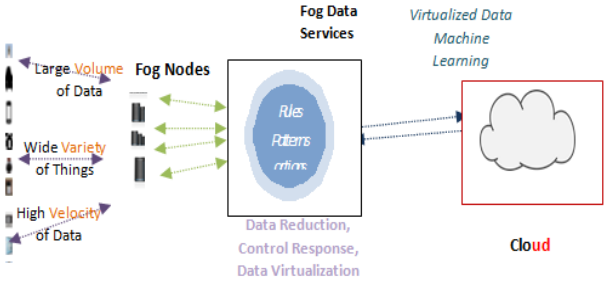

Figure 2: Fog Computing-Design

1) Hardware Platform:

To perform an IoT application or operation, hardware can be easily designed to use the Fog architecture. It's should have two property according to devices. Firstly, the platform should support developers to run scripts, compile code, and install their own operation system. To complete all these requirements, we have an alternative towards the embedded system which can be an ARM board. Secondly, a main purpose is to improve the speed of computing. Despite of the fact that, ARM has brilliant process essentialness to concern the utilization towards the complicated platforms/designs. ARM and FPGA collaborates the working between cloud and client application. To implement a suitable IoT application, ARM works to manage the design and FPGA on algorithms. It will be advantageous to put nodes between the application and software layer.

2) Software Platform
Hadoop, Spark and Open Stack software's are taken into consideration to perform activity on ARM datacenters. From PC server to embedded hardware, the data computing platform become a conceivable and aerobatic proceeding. The abstraction layer designs on Open stack. To test, analyze, set up the business amid gigantic data, the orchestration layer is deployed. We can consider an example, ARM core engaged with open stack along with Hadoop, Spark and a lot of facilities to figure the genus peps. This layer is virtualization with a bunch of cloud software's such as Open Stack.

3) Cloud Assist
Fog system has an issue for pleasant controlling the cloud and maintenance are clearly difficult to handle manually on an area device. As an example, the programs for processing are at the start put in within the RAM to perform storage Modifications can be performed on patch and configurations towards the downloaded stuff related to programming.

V. APPLICATIONS OF FOG COMPUTING

A)Smart Buildings Fog computing have its own fog node and it licenses free local operations such as emergency monitoring and response functions, climate control, lighting control, stopping space inhabitance, temperature and keycard per users. Fog computing benefits home security application with unified interface to integrate all totally different freelance devices.

B) Smart transportation system As the counting of vehicles grows; traffic efficiency is getting to be a worldwide issue. Existing systems confront a few challenges, e.g., maintaining a strategic distance from overwhelming sensors at the edge roads, safe malevolent vehicles and preventing single-point dejection. Smart transportation system aims to cope with those challenges by providing facilities like: a) Measure the distance and speed of approaching vehicles from every direction; (b) Accidents prevention; c)Provision of a constant flow of the traffic (green waves come up through Direct roads); (d) Accumulation of relevant and important data to compile, analyze and upgrade the system.

C) Health care and Activity chase Fog computing technology gives an organized proposal to enhance health and prosperity of mankind. One of the preferable ways to offer healthcare services based on Fog Computing framework is that we can monitor human's health in real-life using a common health monitoring systems which is able to catch and identify bio-signals from IoT/sensor and fog nodes then send the data to the gateway via a particular wireless Communication protocol. ECG signals are analyzed and monitored in smart gateways with capabilities like extracted including heart rate; via a flexible template based on alight weight wavelet transform mechanism. It provides data evaluation and responses that square measure essential in health care.

D) Visual security
Now days we are using Video cameras in parking areas, large buildings and different public and private domain to extend public safety. Suppose a busy airport or city center which is having many people and objects moving through an area at a particular time. If so Realtime monitoring and Commentary of anomalies pose Inflexible low-latency requirements on surveillance systems. Timeliness is critical for each detection and response. Through fog computing design, video processing is impressively distributed among fog nodes co-positioned along with cameras and the cloud. This permits real-time tracking, and collection of insights from statistics captured over long durations of time and efficiently.

E) Smart Meters
The smart meter receives data or information of a local area and transmits through a local computer network to a data retrieval point. In terms of the data processing, some data processing could be done at the local collection points, but in most of the cases, the data are transmitted to the utilities collection centre through a wide ranging network. The data gathered at the utility point are utilized for a no of business objectives, i.e. billing, analysis, network and service monitoring, prediction and planning, computing. Hence, Smart meter analytics will continue to evolve; making needs on the modern knowledge and technology existed.
Smart grid
Smart grid is the next generation electric power distribution net-
work. Smart grids contain transmission lines, substations, trans- former and so forth.

F) Smart Grid
Currently, the demand of electricity is increasing day by day which requires upgrading of the present power grid system. In SG, smart meters generate huge amount of data, which is very difficult to store, process and analyze using cloud computing. Fog computing acts as a bridge between smart grid and cloud computing to fill the gap between remote data centers and devices.

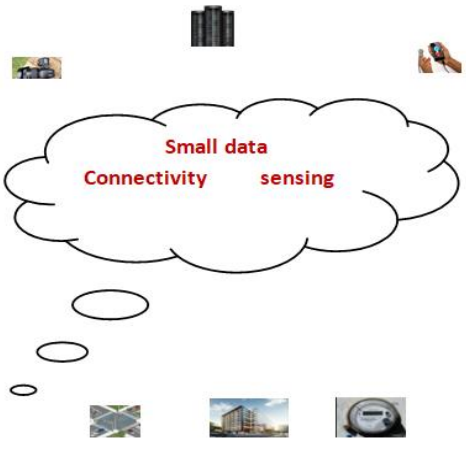

Figure 3: Applications of Fog Computing

VI. BENEFITS –FOG COMPUTING

Fog computing has many benefits when compared to cloud. The benefits are listed as follow:

1) Greater business activity: Fog computing applications quickly deployed and developed. Fog computing provides the manufacturing of raising-revenue based services and products more powerful and as a result is more cost-effective. It encourages in expedition of rollout cycles, decreasing costs and widens revenue bases. These applications can perform the work by using machines as per consumer requirement.

2) Low latency: Fog concept supports time-sensitive services whereas it works on data retrieval mainly. Fog computing is an expansion of cloud to the beginning or border of the network as well it diminish latency problem and traffic; so, it is very beneficial in IoT applications like healthcare applications, wearable's, real time transportation systems, and smart cities and other various time critical services and applications.

3) Geographical and giant-scale distribution: Fog distributive computing can store resources to large and cosmopolitan applications. The layer of Fog Computing may be organized in many different domains or areas. Also, it could be dispensed in one-of-a- kind geographical areas to be able to cover a wide area on large-scale IoT networks. Data communication among nodes inside the IoT domain can arise among edge-edge, edge-fog, fog-fog, and fog-Cloud nodes.

4)Real-time inter communications: Fog computing applications offer real-time cooperation among fog nodes instead of the batch processing utilized inside the cloud.

5) Versatility and diverseness: Fog computing basically permits different framework among various services relates to different situations. Fog nodes or edge devices are produced by different manufacturers and in this way are available in exclusive design and need to be expanding in keeping with their platforms. The fog has the flexibility to work on different platforms.

6) Support for mobility: One of the critical components of fog applications is the capacity to connect immediately to mobile devices and consequently enable mobility methods such as Evolution-Data Optimization Universal Mobile Telecommunications System (UMTS), which requires a distributed directory system.

7) Interoperability: Fog components can interoperate and work with different domains and across different service providers.

8) Platform for on-line analysis and collaborate with the cloud framework: The fog system is basically arranged between the cloud and client devices to act an important part in the consumption and execution of the data near to end devices.

VII. CHALLENGES Of FOG COMPUTING

The fog computing offers different advantages for various applications deployed through IoT. Whereas it has several Challenges to overcome and provide better outlook in Fog computing:

(1) Scalability: Iot devices/sensors can generate large amounts of data as lots of Iot devices manageable
Through fog nature. Hence, it requires adequate resources for fog servers such as to process power and storage.

(2) Complexity: Many IoT devices are organized and developed by different manufacturers as if choosing the best components are very complicated. It needs septic hardware and orders to operate, which will increase the difficulty of the operation.

(3) Dynamicity: Fog nodes can adopt their structure as fog supports mobility. It's become complicated to perform an operation because of this dynamical workflow.

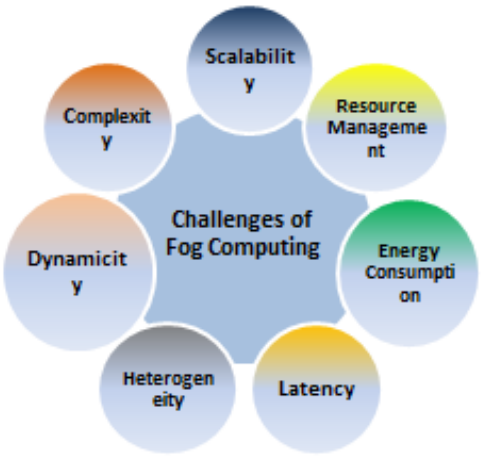

Figure 4: Challenges of Fog Computing

(4) Heterogeneity: Management and co-ordination of networks become a key challenge as per the application Resources.

(5) Latency: Fog has capacity to overcome latency issue. There are a several unit factors presenting a high latency of Application towards the application performance.

(6) Security: Security providence is directly not applicable to fog because of mobility, heterogeneity. The cryptography format is to enhance the network to safeguard the devices of fog environment.

(7) Resource management: Smart management of fog resources could be needed for effective operation analysis through fog servers.

(8) Energy consumption: Multiple fog devices can distributed regards energy efficiency becomes less. Therefore, reduction of energy can be a vital challenge.

VIII. OBTAINED RESULTS

Fog computing is emerging as attractive solution to the problem of data processing in IOT. The experimental results reveal that fog computing helps achieving more than 90% bandwidth efficiency and offering low latency real time response at the edge of the network. You can batter control the privacy and business productivity and agility can also be increased through fog Computing. It enables a wide range of benefits and these benefits make the fog an appropriate paradigm for many IOT services in various applications. This survey discusses the main features of fog computing and share many benefits related to various fields and several devices to enhance the response time and productivity in different scenarios. Fog Computing aims to reduce processing burden of cloud computing. Fog computing is bringing data processing, networking, storage and analytics closer to devices and applications that are working at the network's edge. That's why Fog Computing today's trending technology mostly for IoT Devices. Fog computing accelerates awareness and response to events by eliminating a round trip to the cloud for analysis. Although fog computing is widely used in wired environments but the wireless sensors spread on vast areas associated with IoT devices demand Different requirements related to analytics. Being adaptive in nature at the cluster level it is able to support the majority of functions like elastic compute, data load changes and network variations. And because of the connectivity of the fog nodes With efficient and smart end devices.

Table 1

Fog Computing	
Pros	**Cons**
Reduces amount of data sent to the cloud	Physical location takes away from the anytime anyplace, any data benefit of the cloud
Conserves network bandwidth	Security issues: IP address spoofing, mediator attacks
Improves system response time	Privacy issues
Improves security by keeping data close to the edge	Availability/cost of fog equipment/hardware
Supports mobility	Trust and authentication concerns
Minimizes network and internet latency	Wireless network security concerns

The analysis and generation of data by these devices are quicker. So fog computing introduce a platform to provide cloud computing-like devices closer to the devices to be monitored or controlled. And offer Low latency, location awareness etc.

IX. FUTURE RESEARCH DIRECTIONS

There are a few research issues currently available that want to be tended to. The aim of this paper is to highlight the feasibility and the benefits in improving the quality of service and experience by using fog computing. Driving commerce improvement through fog-enabled applications is the extreme objective of our work. The Open Fogs architecture is the fundamental system to build and test new concepts and products in real-world applications and test beds. More Smarter cities, drone-enabled savvy supply chains, remote energy extraction and investigation service , smart traffic system, video surveillance and virtual reality, natural conservation and crisis reaction are just few example of the rising use cases that are empowered and created through fog computing. Expanding the availability of a service through fog is a great challenge of research. To run Big Data IoT applications in Fog, stream processing is done in the Fog environment and Big Data processing will be done in the cloud. To do so, the major concern is cross-layer connection and optimization among Iot devices to cloud through the Fog and the client devices to the Fog. Moreover, integration of rising technologies such as 5^{th} Generation technologies, Software Defined Networking system and Virtualized network function technique is also mandatory to incorporate these technologies with Fog. Since the location is more important in Fog environment, placing Fog servers in the proper place is also challenging. Application emplacement of the resources is another big research challenge for time-crucial computing applications such as emergency responses, healthcare field, vehicular network system, augmented reality, online gaming, brain-machine interface and any other smart environment related applications. Besides the above challenges, energy management, programming Platforms, security, and privacy are also important research issues. Also user's privacy is most important that need to be exploring in Fog perspective.

X. CONCLUSION

Fog computing combines cloud and on-the-spot computing. Introduced in by a particular set of high-velocity digital business problems and growth opportunities, fog computing is rapidly gaining traction. This computing platform is a high-attainable computing model that is growing rapidly but it is not mature enough as many issues still need to be investigated extensively. This paper represented Fog computing architecture and also discussed challenges over the fog computing system to execute Big Data applications, especially in the IoT environment. Following the limitations of cloud, some challenges to execute Big Data application on Fog were presented. Consequently, the characteristics of some currently available commercial Fog related platforms and devices were discussed. Finally, several open research issues were presented. Hopefully, these will overlay future research directions among industry experts and academia.

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