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A Review on the Improvement in Internet of Things Development using Fog Computing

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ABSTRACT: In the current scenario Internet of Things (IoT) with Fog Computing is a burning research area. The fundamental idea of this technology is to provide services and specifying customer's needs based on internet services. In daily life, billions of physical objects collect and exchange data for a variety of applications and these applications connect with the Internet of Things. When the huge amount, of data, is collected and processed by these devices it becomes complicated to manage and store the data and other major problem is that IoT technology works on real-time application. Working IoT with cloud computing faces such types of problem latency, lack of mobility support, and lack of location-awareness. This problem or gap can be solved by a technology which is known as Fog Computing. Fog Computing has many benefits like reducing latency, solving the problem of insufficient storage and high bandwidth, and many more. So Fog Computing is a suitable concept for better utilization of IoT services. In this paper, authors go through the concept of the Internet of Things with Fog Computing, comparison with cloud and issues, and its applications. This paper presents how IoT is more compatible to provide its full uses when it integrated with Fog computing. This review will also center of attraction on the architecture of the fog computing and its rising IoT applications that will be better by using the fog model. We also analyze the issues and challenges faced at the fog layer and future research directions concerning fog computing and the IoT are discussed.

Keywords: Internet of Things (IoT), Architecture of Fog Computing, Cloud Computing, Challenges of Fog Computing With IoT, Applications of IoT using Fog Computing.

I. INTRODUCTION

The prospect is the Internet of Things, which has the capability of transforming real-world objects into smart virtual objects. The main purpose of IoT has to combine everything in our world under a universal infrastructure, giving us not only control of things around us but also keeping us informed of the position of the things. The IoT is an uprising technology that represents the opportunity of computing and communications for developing technical innovation in various important areas using wireless sensors to nanotechnology [1].

Internet of things (IoT) is a collection of embedded sensors, software, and actuators for interconnecting between physical and digital worlds where things are connected by whether using wireless and wired connections. In IoT, all the smart devices and appliances used by us are connected to a network to achieve multifaceted tasks that require a high level of intelligence. The concept of "the Internet of Things" was firstly presented in the presentation at Procter & Gamble in June 1999 by K. Ashton Executive Director of Auto-ID Labs at MIT. In his presentation, he pooled Radio-Frequency Identification (RFID) with the, at that than now, up and the result came out in terms of the Internet of Things. According to him, RFID is the requirement for the IoT and at present days, RFID is one of the most imminent services for consideration of IoT applications [2].

The IoT is at present prospering technology development discussed all over the world and it becomes an essential part of human life. In this technology things or objects connected smartly and this will reduce human workload. Things have identification and this identification denoted by a unique address. Everything or objects have their address and by this address, they can interact and assist to provide services such as smart homes, smart cities, smart energy, and smart grids, smart transportation and traffic management, and also capability of creating new applications of IoT. There are some IoT devices are used in this technology are Embedded Sensors, Actuators, Processors, and Transceivers.

Cloud computing is simply a collection of various types of networks, which provide many services to different types of users to according their requirements. Many services offered by cloud technologies are shared recourses such as software development platforms, server storage services, and software's over the network and some other features are Broad network access, Measured Services, Rapid Elasticity, and Recourse Pooling. According to the requirement of infrastructure for IoT devices Cloud computing networks facing some challenges and these challenges are: high-latency, not providing real-time services and another big problem of managing billions of data details gathered from geo-circulation IoT devices/sensors. To overcome this difficulty CISCO innovates Fog computing.

This technology is most promising for devices in IoT to scuttle at edge networks [3].
A technology that extends cloud computing and their services to the next level is called Fog computing. Fog computing is a rising technology that is essentially used implementing for the Internet of Things.

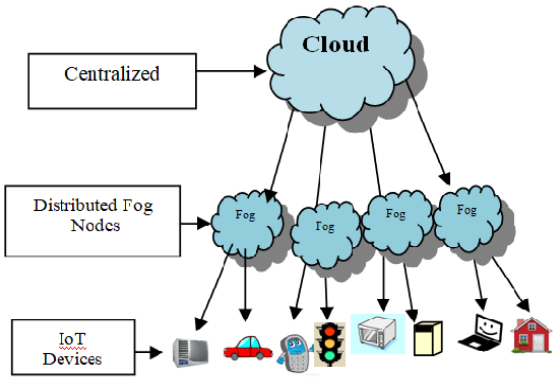

Fig. 1. Architecture of Fog Computing.

Fog is an appearance of the cloud closer to the ground. Fog computing technology was introduced as the most suitable and best use of IoT devices for the IoT by Bonomi *et al.*, (2012) [4]. This new distributed computing technology has the capability of providing computational and storage capabilities and gets closer to the edge of the network. This new distributed computing technology has the capability of providing computational and storage capabilities and gets closer to the edge of the network. The Basic concept behind Fog computing is to reduce the distance and improve services for the users by their distributed nature [5]. This technology provides services like data, computing, storage, and application services to users. The Fog has many features like Low latency, geographical distribution, location awareness, and Heterogeneity and also provides improved quality, better performance, and cut the amount of data send to the cloud for processing, explication, and storage. The Functioning of sensors is to collect data generated by IoT devices and sent to network edge devices for processing and short term storage and not send to the cloud for minimizing network traffic and latency [6]. Summary of year-wise references cited in this paper is mentioned in Table 1 and Fig. 2.

Table 1: Tabular representation of year-wise references used in paper.

Years	No. of References
2003	01
2004	01
2009	01
2011	01
2012	03
2014	04
2015	11
2016	08
2017	20
2018	21
2019	18

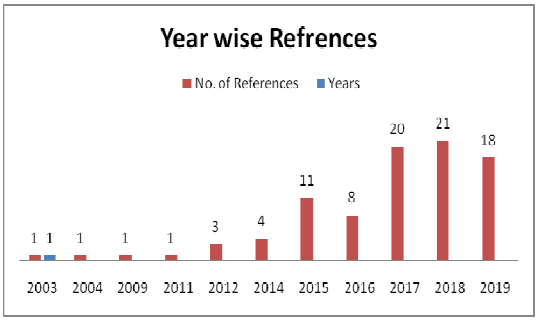

Fig. 2. Graphical representation of year wise references used in paper.

This paper provides an overview of fog computing with the IoT and its characteristics. We also present a comprehensive survey on IoT with fog computing within various areas and a study shows that there are still lots of challenges with fog computing to provide their full capabilities in improving capabilities of IoT.
This paper is divided into sections. Section I is the introduction and the background of the work. Section II is an overview of the Internet of things and Fog computing. Section III focused on a Literature review of IoT with Fog Computing. Section IV is the Challenges of Fog with the IoT with three different most important areas and the last section V is the applications of IoT with Fog computing.

II. INTERNET OF THINGS (IOT) WITH FOG COMPUTING

Internet of Things (IoT) is the intellectual environment that allows shared communication between users and things and things and things by linking all things through wired or wireless networks using the Internet [7]. Exactly IoT is a different type of network of objects or " Things" ingrained with Software, Sensors, actuators and to provide facilities and services by providing data or information to different users through protocols without human interaction.
The first collaboration of IoT with cloud computing to provide services and facilities by gathering data from smart devices, processing, and managing backups but it takes more time to perform all actions due to the centralized nature of the cloud.
The main concept of cloud computing and IoT is to increase efficiency and reduce workload. Cloud and IoT have a complementary relationship. The IoT devices generate huge amounts of data, and the working of the cloud is to provide a pathway for this data to travel. Cloud computing accessing data and programs from a centralized pool of computing resources. On the other hand, cloud computing is not competent to solve all problems because of their limitations. Like real-time Applications, High latency, the security of sensitive data sensitive. Cloud computing has centralized infrastructure and for this reason, data are transmitted from the data center through multiple gateways and it becomes the reason for high latency. Now, these days cloud models are not perfect for the data generated by IoT. Probability 50 billion —things will be connected to the Internet by 2020 and it becomes a problem for the cloud to handle (analyze) the vast amount of data and this data require high bandwidth [8].

For handling this problem of IoT requires a new model or technology that supports to remove or decrease problems like Latency, volume, variety, and velocity of IoT data, save network bandwidth, High security, etc. Fog Computing is wished-for to address the above problem. It provides a novel and new multiplicity of applications and services, and Fog is the generative extension of the cloud to provide services at the edge of the network for giving better services to users for using the best services of IoT devices. Fog computing is a vastly virtualized platform but not a replacement for cloud computing. It provides services like storage, computing and networking services, Location awareness, and low latency, edge location among end to end nodes as well as traditional Cloud Computing Data Centers. Fog Computing extends edge network and this edge network consists of a lot of distributed endpoints and these endpoints called nodes. These nodes provide localization and support end devices with higher services at the edge of the network and the outcome is low latency and context awareness [9]. The fog has distributed computing infrastructure to provide better services like reduction in data traffic, compute, storage, increased security of data, and cover considerably wide areas, etc.

This is true when we require the best use of IoT services then Fog computing best suitable for this Reason e Fog nodes provide localization and it enables low latency and context awareness. Cloud computing provides comprehensive centralization. Most of the time many applications require both technologies at localization and globalization level, for analysis. Fog computing is designed for improving limitations which are not handled by cloud computing. The concept behind both technologies is to provide services to the user according to their requirement. But some parameters are different [10]. Table 2 represent these parameters or dissimilarity between clouds and fog computing.

Table 2: Comparative study between Cloud Computing and fog computing.

Parameter	Cloud Computing	Fog Computing
Security	Undefined	Defined
Geo-Distributed	Centralized	Distributed
Mobility	Limited	More
Latency	More High	short
Bandwidth utilization	High, as all data sent over the cloud	Low, as only time-sensitive data is sent to the fog node
Number of Server Nodes	Few	Large
Speed	Accessing speed High	Assessing speed high more than Cloud

III. LITERATURE REVIEW

Fog computing is an innovative distributed computing paradigm to meet increasing recognition of the Internet of Things and distributed applications. Fog computing is finely situated for real-time big data analytics that supports closely distributed data collection points and provides many more advantages in different areas like entertainment, advertising, personal computing, etc. Fog computing is a rising topic in IoT and according to researchers and industry, practitioners suggest that fog enabled IoT in different sectors. The efficient and conversant acceptance of fog for IoT requires lots of understanding in-depth and from every core of the topic. Till date, lots of contributions have been made in this field but still, the work is in progress, we have mentioned some selected of them:

Fog computing with their characteristics, architecture, and benefits are discussed [11] and the author discussed how fog computing is helping provide services to IoT applications, Challenges of Fog with the IoT, Open Issues of Fog with the IoT. This paper represents the precise working of fog computing with IoT and also discussed issues regarding fog computing with the IoT.

Important aspects of IoT like Architectural framework of IoT, Sensors, and Actuators with their areas and uses are discussed [12], with their working and Focused on problems of IoT with cloud computing and explain how to come over these problems using Fog Computing communication Middleware, Applications of IoT. and discussed Design Considerations in an IoT System with their limitations and focused on more upgrading is required for the IoT applications with their best utilization and the future of the technology is full-grown and impact human life in incredible ways over the next decade.

Fog computing is a burning topic in the current scenario and for this reason, a proper study is required for this technology. Required technologies and infrastructure for fog computing, platform, and applications, resource allotment and scheduling, fault tolerance, simulation tools, and microservices in Fog computing are discussed [13] and also outline the difference between cloud and fog services. As a final point, In this paper, they assessed there are some challenging issues like infrastructure-related, platform-related, and application related. Fog computing is the current growing research area and the still requirement for more development for achieving its goal to provide the best services by their capabilities.

Best utilization of all recourses (storage, computation, networking, etc) by fog computing are discussed [14] and some problems like latency (data send to cloud for the computation it takes time reason is centralized behavior of cloud computing), local awareness which kind of problems faced by IoT technology worked with the cloud. Fog computing technology can resolve these problems because in nature fog computing is distributed and worked on edge of the network (close to IoT devices). Fog computing is new technology its has many good results but still needs lots of work. An Architectural Framework for fog computing and derived a system model for fog resource provisioning and compared and in result decrease, 39% delay in this paper and another aspect of the paper is focused to improve the system model for resource provisioning and systematic assessment of a fog landscape to get real-world network data for evaluations for future.

The Importance of fog computing for cloud computing and an essential constituent of the IoT are discussed [15] and introducing a framework for improving delay minimization. This framework working for managing IoT requests in the fog layer and an analytical model for providing their services in IoT –Fog - cloud scenarios.

The focus in this paper is to represent fog node collaboration policies and whole activities regarding fog nodes working for giving their services and facts behind the delay and how can minimize delay time and also introduce analytical model can support other fog computing policies. The paper focused mainly on the future scope for research is studying the delay-cost substitution in the fog computing could be a prospective research area.

Growing usage of cloud computing still cloud computing faces some challenges of their centralization are discussed [16]. According to the requirement users need is mobility hold up and location-awareness, real-time services, etc. In their survey focused about a scenario of IoT with cloud computing and then as a solution fog computing, their working, and applications, and problem faced by fog computing like network regarding the problem, Quality of Service, interfacing, and programming model requirements, Computation Offloading, resource management, security, and privacy these problems highlighted. For future scope fog computing is capable but still, needs more effort to make better this technology for the future.

Capabilities of Fog computing are discussed [17] which are improving latency, bandwidth, and traffic problems. Fog is an extension of cloud computing not the replacement of fog computing. The reason behind the fog computing is reduced workload of cloud computing and also discussed IoT devices and their functionalities, challenges in fog computing in various fields (Resource Management, Heterogeneity, etc), Fog computing architecture & framework and their significant improvement topics like Motivating Scenario Using Fog Computing, Fog Offloading, IoT-Fog based Architectures, etc.

IoT technology increased digitalization and provide many benefits in different areas like manufacturing, transportation, education, healthcare, and many more areas are discussed [18] and how IoT devices improved way of working and reduce human efforts. The paper focused on IoT technology and connected devices generate a massive amount of data and data moving IoT device to cloud and the cloud is not capable to handle large amount of data due to its bandwidth constraints and discussed cloud computing their services and constraints and compare with Fog computing and comparison between edge computing.

Cloud computing and how cloud computing supports the development of the Internet of Things (IoT) to support their users are discussed in[19]and how due to the dynamic nature of IoT application it needs quick response time and increased privacy cloud computing not satisfying these conditions. To reduce these problems two new paradigms proposed one of them called Fog Computing and the second one is Edge Computing. Both Paradigms discussed in depth in this paper and also discuss future challenges from different aspects. To overcome the problems of cloud computing researchers focused on fog computing and edge computing. In their work, they combine both technology (fog and edge computing) for introducing a smart city-state and provide the facility to their users to download different IoT applications from a platform.

The Integration of IoT applications with cloud computing for their betterment and providing benefits of IoT applications to users are discussed [20]. But IoT applications requirements fast and work on real-time environment then-new smart technology presented its name was fog computing. Its main concern is close to IoT devices, share the workload of cloud computing, improvement in latency. This technology becomes smart gateways to provide a prosperous assortment of services. This paper focused on the Internet of Things, Cloud computing with its merits and demerits, and then fog computing and performance growth. The extensive work could be on the impact of heterogeneous storage and performance based on miscellaneous applications.

The design of the mobile Fog programming model with a new upbringing for the Internet of Things (IoT) with many features is discussed [21] and constraints of cloud computing like local awareness applications are vulnerability and latency discussed. As a solution Fog computing technology presented as an appropriate platform for a variety of applications, including connected vehicles and smart cities, healthcare, and many more areas. future Internet applications and presents the possible benefits of fog computing in provisions of effectiveness and latency while our work focuses on the right programming model for developing applications on the fog Computing.

IoT- Fog and cloud computing system examine and how these technologies provide various benefits to applications [22] and what are challenges faced by these technologies in their infrastructure. Fog computing is probable to execute necessities that cloud data centers are not able to provide due to its limitations. The Researcher focused on some future directions for research like Fog and 5G for IoT, Serverless Computing, Data Management, and Locality Applying, Federation Concepts to Fog Computing and IoT, Orchestration in Fog for IoT, Urban Computing, etc. These areas required more attention to improving the IoT and Fog computing scenarios.

Fog is a substitute for cloud and exists between IoT and the cloud. Its use is to supervise or manage different applications, perform data filtration, storage, preprocessing, and security, manage resources [23]. To provide their efficient services Fog requires a well-organized resource management framework for IoTs according to their capability authors proposed model to eliminate issues related resource forecast, reservation, and services for new and existing IoT customers, according to their requirement

IoT applications rising with a growing rate in numerous domains, quite a lot of technical challenges are being raised. Handling these challenges required more intelligence and efficient utilization of communication and computing resources [24]. The author proposed the Adaptive Operations Platform (AOP). This platform delivers end-to-end functionality of the enabling Fog Computing infrastructure according to the requirements.

Fog computing has various capabilities and resources to provide services to IoT applications. Another fog has a responsibility to accomplish the user requisite by providing balanced and efficient pairing or matching strategy for edge IoT nodes [25]. Authors proposed system model for improvement in the traditional stable

matching or pairing algorithm edge computing with superior service factor.

Fog computing is a distributed platform that extends cloud computing [26] The Author focused on key aspects of Fog computing with a use case diagram and discuss the higher-level description of Fog's software architecture, different technologies, components.

The first criteria are to fulfill the user's requirements and make responsive people about the appropriate traffic rule. The author realized cloud computing is not fully satisfied with IoT to solve these limitations the author introduces fog computing in this phase [27]. The author proposed a new fog-based intelligent decision support system (DSS) for driver safety and traffic violation monitoring based on the IoT.

Fog computing is not a replacement for cloud computing. It provides services and resources in real-time with low latency [28]. The author presents an inclusive study on fog computing and includes architectures and the algorithms that make fog systems, also discussed the important role of fog computing into up-and-coming technologies such as Tactile Internet.

Fog computing has the main concept to make the clouds decentralized and localized and provide services to the user at the edge of the network. Fog contains specific data and information that used frequently used by the users and it specifically working in real time [29]. Three-layer data flow architecture discussed by the author and offer different novel architectures.

Despite the increasing usage of Internet-linked devices raises a lot of challenges for the conventional network architecture, due to limited functionality, not cable to handle a large volume of data and real-time processing [30] and author present a new model of IoT which merge capability of two rising technologies: software networking and Fog computing and also discussed the positive outcomes of the proposed architectures and their probable services.

Due to advancements in technology, the number of Internet-connected devices increased day by day and this creates a challenge in the traditional cloud computing framework. Users required services like real-time processing, low-latency [31] for this reason author proposed fog computing paradigm to serve these challenges and evaluate the fog computing paradigm by mathematically with their characteristics in form of power consumption, service latency, cost, and calculate its working capability for an environment with real-time service.

Discussed different challenges and problems challenges to expand an orchestration framework across all layers within the Fog resource stack [32], and the author discussed an ideal orchestration system deal with these challenges by using distributed genetic algorithm in this context.

The most used software architecture in IoT is the Service Oriented Architecture (SOA). The main focus of this architecture is to provide loosely coupled systems to control and reuse of IoT services but still, there are many challenges in this infrastructure [33] author proposed IoT integration framework using by intelligent API layer to handle different services like assembler, service auditor, service monitor and service router component to coordinate service publishing, subscription, decoupling and service combination within the architecture.

Most of the Fog applications such as video mining and event monitoring, which are extremely admired in the Cloud, but not investigated in the context of Fog architecture [34] author proposed models and architecture of Fog data streaming with different characteristic applications and discuss four important dimensions; system, data human, and optimization where both novel design challenges and the problems arise from leveraging offered methods are investigated.

Fog computing is an expansion of traditional Cloud computing to the edge of the network it provides different services to the users with low latency, high bandwidth, real-time processing [35] for the proper utilization of the capability author proposed a fog computing architecture for providing services and processing data on real-time to the corresponding IoT applications and also provides the functionality of power management, appropriate communication between sensors and protected management of data in IoT device.

IoT devices are appropriate technology for providing electronic services but still in most cases due to its some limitation in infrastructure or functionality not sufficient to deliver its full services. To overcome these limitations there is a technology known as Fog computing [36]. The author discusses the working of fog computing and how fog computing supports IoT and also discuss the presented Fog computing software and hardware platforms for the IoT.

Fog computing is an electrifying extensive version of Cloud; it can provide services and functionality in real-time scenarios. Fog is the explanation of the variety of flaws that are coming from cloud computing [37]. Fog is the prospect of cloud it provides various IoT-enabled time reactive applications in real-life scenarios.

Internet of Things generates a huge amount of data and the major problem is how to manage and process data effectively [38]. The author proposed architecture and techniques for efficiently working on IoT in the geographically distributed hierarchical cloud and fog computing and also offered high-quality performance for applications.

Now, these days the Internet of Things provides many services and applications in different areas and for providing better services and achieving their targets it is more compatible with the Fog platform [39]. The author discussed the concept of Fog computing and focus on capabilities of fog computing for IoT to increase the network resources' efficiency, low latency any more services.

IoT application has many capabilities like high data processing, real-time response. But for these services required a decentralized platform for expanding their services in to close to every domain with low latency and location awareness [40]. The author discussed fog computing is an area that provides services to the users according to their requirement and the reason behind the fog concept is it worked on a decentralized concept and its nodes, can be deployed everywhere with a network with the integration of edge and cloud resources.

IoT is a system of interrelated computing devices these devices generate huge amounts of data and these data and services handled by Cloud computing, but the main issue is the increasing requirement of real-time processing, low latency, location awareness services is not fulfilled by cloud computing [41]. the author discussed solution known as Fog computing and present overview of fog computing model architecture, technologies, issues also present applications from the different areas to explain the importance of fog computing.

IoT is a collection of smart devices and these devices communicate with each other. Smart devices increased day by day and generate a huge amount of data [42]. It is not easy to handle a large amount of data by the devices and when data is handled by the network it increases complexity. The author presents a review of obtainable IoT devices, complexity, and fog network.

Fog computing is a growing standard to balance the cloud computing platform. The basic concept behind fog computing is to get closer to the IoT application to the end devices. Fog computing has great potential to provide services according to users' requirements [43]. For improving user satisfaction and resource allocation author investigate a joint radio and proposed a framework for provided that explanation for the formulated joint resource provision problem.

For the growing trend of IoT applications, a novel platform developed known as Fog computing. Fog computing has great capabilities like bandwidth, latency, and location awareness but still, there are many challenges in many points like telecommunication systems, energy consumption [44]. The author focused on factors and technologies in the system design and present a survey for network designers and policymakers to focus on developing energy-resourceful IoT applications.

In the improvement in health care by providing real timing monitoring system IoT has a big role [45]. The author proposed IoT and with the Fog layer-based low-cost health monitoring system that offers incessant remote monitoring of ECG together with regular investigation and notification and useful in decision making.

Fog computing/edge computing can reduce communication bandwidth and low latency [46]. The author proposed a method for designing a smart services based edge computing paradigm. The purpose of this architecture or method is to the improvement of the existing system with better services using machine-learning platforms and AI paradigms and this model is based on two-level architecture edge and fog layers.

The emergence of Internet-of-Every Things brings lots of concerns. IoT generates lots of data and this data required more analysis and real-time processing systems [47]. The author proposes an extensive cloud IoT model that provides low latency, bandwidth while allowing edge devices for real-time processing, and author also focused on how can data send to the cloud without latency and with data quality so spine-leaf Fog computing network (SL-FCN) is offered for dropping latency and network overcrowding.

IoT is an advanced application and his multidirectional progress create various similar IoT ecosystem these system called verticals [48]. The author introduced the Fog of Things (FoT) paradigm and proposed the design and development of a self-organizing platform. This platform knows as a SOFT-IoT: Self-Organizing Fog of Things and its work is to provide services locally with low latency.

The revolutionized dream of IoT has combined various devices and these devices generate a huge amount of data and these data are not managed by the cloud so there are many challenges in the traditional network [49]. Rapid expansion in the variety and number of devices in IoT connected to the internet and old infrastructure and technology is not designed to handle this issue author proposed a model is a disseminated cloud architecture based on blockchain technology. This model provides computing infrastructures in an IoT network at low-cost, safe, and according to requirement access.

IV. CHALLENGES OF FOG COMPUTING WITH IOT

Integration of fog computing and IoT have a significant role to improve distributed computing. Even though the fog computing paradigm offers numerous potential for various IoT applications, still it faces many challenges like complexity, heterogeneity, power consumption, and security. These challenges become the hurdles in the way of its successful deployment IoT with Fog computing. Authors focused on some main issues like latency, lack of local awareness, and virtualization of the resources in the IoT system.

A. Latency

Latency is considered as the total time required for data travel between sender and receiver. One of the major bases behind the replacement of Cloud with Fog is low latency. Still, there are many issues of high latency in Fog computing due to the data aggregation process, over usages of Resource e reduce the effectiveness of services by the Fog server. Table 3 shows some selected significant contributions in the field of latency.

B. Local /location-awareness

Location awareness or location awareness is one of the most important key factors of the Fog computing that delivers information about a device's physical location to another user or application. Location awareness is the rising trend in hardware and software. In the architecture of Fog, it is located at the edge of the network and the basic propose of fog is to provide services to their users according to their requirements and on time. So it is necessary to aware of the location of the application and their position. But still, there are lots of challenges in location awareness. The Fog server, however, desires to adapt its services, which additional management and maintenance cost. Table 4 shows some selected significant contributions in the field of local/location awareness.

Table 3: A summary of contributions.

Author	Year	Summary of Contributions
Kotamsetty *et al.,* [50]	2016	Proposed an IoT architecture for implementing the latency-hiding method and algorithm on adaptive latency aware query processing.
Hu *et al.,* [51]	2017	Provide a detailed summary of the structural design, technologies, applications, challenges, and open problems like security, programming platform, and energy consumption.
Yousefpour *et al.,* [52]	2017	Proposed a framework and delay minimizing policy to reduce the service delay for IoT applications and develop an analytical model to estimate policy.
Fan *et al.,* [53]	2018	For minimizing the latency of data flow in the communications and processing procedures proposed a workload balancing scheme.
Raptis *et al.,* [54]	2018	The proposed method for evaluating performance for identifying a limited set of proxies in the network where data are cached and calculate latency tolerated by consumers.
Shi *et al.,* [55]	2018	Proposed a mechanism of task reallocation and retransmission for reducing latency in the failure of fog nodes by using algorithm real-coded genetic algorithm.
Rahbari *et al.,* [56]	2018	Proposed a method for minimal latency and energy-efficient development in IoT application using fog computing using concurrent, and delay priority algorithms.
La *et al.,* [57]	2018	Discuss the approach for reducing energy consumption and latency in fog computing by involving device-driven and human-driven intelligence by two case studies.
Avasalcai *et al.,* [58]	2018	Proposed algorithm for minimizing latency by enabling faultless integration and deployment of different applications in an IoT infrastructure
Mahmud *et al.,* [59]	2018	Propose a management policy for a latency-aware Application Module that focuses on a deadline based QoS of applications and resource optimization by applying two algorithms that support management policy.
Alsalman *et al.,* [60]	2018	For reducing, latency author proposed a framework for the location of the Fog server and Fog network. In this framework, two important aspects focused by author one is Network size determination and second is network formation.
Alghamdi *et al.,* [61]	2019	Propose an approach regarding novel content delivery network (CDN) based on the Fog computing environment and the Information-Centric Networking (ICN) for reducing the workload on CDN servers.
Chen *et al.,* [62]	2019	To minimize energy overhead of Industrial Internet of Things propose energy-efficient computation offloading scheme and developed algorithm for minimization of energy.
Maiti *et al.,* [63]	2019	Proposed 4-tier architecture based on the Device-Gateway communication model that model is an expansion of the 3-layer high-level architecture for latency-aware fog smart Gateways deployment for IoT service.
Shukla *et al., [*64]	2019	To conquer the limitation of high network latency in healthcare IoT and cloud. Improved fog computing 3-tier architecture is proposed.

Table 4: A Summary of contributions.

Author	Year	Summary of Contributions
Minch, [65]	2004	Discuss the importance of location awareness for computing and communications devices and how it is impactful in business and community and discuss how Location or local awareness reflects on the privacy implications of the technology and provide safety.
Giang *et al.,* [66]	2015	Proposed a Distributed Dataflow (DDF) programming model based on Node-RED.That support IoT for utilizing computing infrastructures diagonally the Fog and the Cloud.
Truong *et al.,* [67]	2015	Proposed a novel SDN-based architecture supporting Fog Computing for both safety and non-safety services. This architecture provides flexibility, scalability, programmability at the same time as Fog Computing provides delay-sensitive and location-awareness services that could satisfy the demands of future VANETs scenarios.
Syed *et al.,* [68]	2016	Discuss the working of Fog computing and how location awareness is a very important part of Fog computing also discuss Cisco IoT solutions present Connected Mobile Experiences (CMX) and this component helpful in location awareness.
Rajat, [69]	2017	Discuss localized and location-based service applications to mobile users by fog computing.
Raj *et al.,* [70]	2018	Discuss the approach of CLAP, a collaborative data processing that exploits device heterogeneity for shared data processing. CLAP, in combination with a data collection protocol it can decrease the volume of traffic, energy saving.
da Silva *et al.,* [71]	2019	Discuss the approach and solution of difficulty of locating fog node services in a fog-cloud scenario Author proposed solution for time unstable demand in terms of latency and the proposed model is the mixed-integer linear programming formulation with different criteria.
Calcina-Ccori *et al.,* [72]	2019	Proposed a location-aware finding method for the IoT based on a decentralized service-oriented platform called Swarm. This model depicts the geolocation information of services in a network of IoT devices.

C. Virtualization of the resources

Virtualization is a method that can run multiple virtual machines on a single hardware and provide services to the client as the real server. The major aim of virtualization is to increase the use of hardware resources and decrease management and resource costs and reduce response time. Cloud computing has some restrictions and to conquer the restrictions there is a novel approach as fog computing. Table 5 shows some selected significant contributions in the field of virtualization of the resources.

Table 5: A summary of contributions.

Author	Year	Summary of Contributions
Agarwal *et al.,* [73]	2015	Provide a summary of virtualization and its concept, methods, and its techniques, various issues, threats, and attacks and proposed a new computing model named cloud-fog architecture to resolves the limitations of cloud computing environment and issue of resource allocation in fog situation.
Rikvant *et al.,* [74]	2016	Discuss the approach of virtualization, its techniques, and its important role in fog computing with its advantages also provide an overview of various simulation tools used in virtualization architecture.
Liang *et al.,* [75]	2017	Proposed design of software as a service called Open Pipe, which enables network-level virtualization and also proposed an incorporated architecture for software-defined and virtualized RANs with fog computing and Using Network virtualization slices network resources to shares these sliced resources to miscellaneous applications.
Li *et al.,* [76]	2017	Proposed virtual Fog framework that applied on the smart living case for verification of low latency, low operating expense, high multi-tenancy and scalability and how to overcome delay by virtualization and this framework is easy and scalable, capable of helpful varied objects to be with dynamism managed and collective among diverse applications also explain three layers of virtual Fog flawlessly integrates the two separate IoT domains.
Roca *et al.,* [77]	2017	Proposed three innovations to improve Fog first a new orchestration policy, second the creation of constellations of nodes and third is Fog Function Virtualization and discussed how all these three innovations helpful in reduced to the development of the application code, the fact that brings the democratization of the Fog Computing paradigm through the ease of deployment and cost reduction and how Virtualization provides huge elasticity and flexibility.
Hong *et al.,* [78]	2018	Discuss architectures, infrastructure, and algorithms for managing resources in fog computing and most challenging issues in technology to manage limited resources in fog computing some challenges remain to be made to improve and uses lightweight virtualization.
Varghese *et al.,* [79]	2018	Discuss the challenges and opportunities in making accelerators accessible at the Edge and discuss the most important views regarding Fog architecture. Focus on difficulties faced in the development of independent subsystems within the Fog and the importance of the context of accelerators for the Edge with six challenges.
Zahoor *et al.,* [80]	2018	Provide a summary regarding of Virtualization and the Internet of Things and discuss the importance of virtualization in resource management and how to manage the limited resource in IoT environments also focus how IoT adopted virtualization to overcome various problems like device heterogeneity, presentation issues, and resource management
Gedeon *et al.,* [81]	2018	Provide a detailed summary of how the promising technologies of lightweight virtualization via cloudlets and SDN/NFV can support fog computing and discuss how Virtualization of network functions provide the cloud advantages, like energetic scaling and better cost-effectiveness hardware is replaced by economical commercial off-the-shelf (COTS).
Akintoye *et al.,* [82]	2019	Proposed two algorithms one is task allocation algorithmic solution and second is Genetic Algorithm Based Virtual Machine Placement and proposed a model for improving the quality of services in the cloud/fog computing environment that model is known as virtual machine placement problem models.

V. APPLICATIONS OF IOT WITH FOG COMPUTING

The IoT represents a significant revolution of the way for interaction sooner with our world. It is real and applications of it almost everywhere. Fog computing is an extremely virtualized platform but not a substitute for cloud computing. For betterment in communications and handling big data, manage IoT devices, improve management and provide better services to their users the rise in more than a few new distributed computing has taken place Fog is one of the improved distributed computing technology. Fog computing has one of the great advantages is getting attention from academics and industry in both industries.

This technology provides various benefits in different areas to its users. Some areas are listed below:

A. Connected Vehicle

Digital technology has to pay attention to optimizing vehicles in internal functions. Connected Vehicle technology is a vast and extensive network and one of the rising application of IoT. This network is a blend of different technologies like sensors, antennas; embedded software. The purpose of Connected Vehicle has connectivity and communications: vehicles-to-vehicles, vehicles to access points. Fog computing provides the best platform by mobility, low latency, and supports real-time interactions. The basic concept behind the

connected vehicle is making decisions with uniformity, accuracy, and speed. It also has to be reliable [83].

B. Smart Traffic Lights

Fog computing is helpful in allows traffic signals to sensing lights. Sensing flashing light to senses about all things regarding roads like pedestrians and cyclists and calculate or understand the distance and speed of the close-by vehicles. If the Sensor senses any actions they activate and send to the report nearby node. WiFi, 3G, smart traffic lights and roadside units are used for interaction between fog and vehicle [84].

C. Smart Home

Smart Home connected by lots of sensors and devices. IoT has many different sensors and when these different sensors connected some problems arise because it is very difficult to work different sensors working on different platforms and another problem is managing all the data for computation and storage. Fog computing can handle many of these troubles. It provides integrated platforms for different devices for working and with high bandwidth, low latency, and real-time working [85].

D. Healthcare

There is a strong and very important role in Fog computing in healthcare by providing on-demand or real-time processing for decisive in healthcare. For improving health care activity Internet of Things (IoT) technology is a proficient and structured approach. In this area IoT sensor senses or monitors humans health by the health monitoring system. the working real time-based. Mohapatra et al. discuss a hybrid framework for remote patient monitoring via a sensor cloud [86]. Yang et al. present a personal health monitoring gateway based on smartphones [87]. IoT applications, fog computing is entirely cooperated and well-suited with the cloud to improve obtainable IoT applications from the aspects of location awareness, low latency, scalability, real-time interactions, heterogeneity and interoperability [88].

E. Augmented Reality

For handling latency-critical applications such as augmented reality and many applications of IoT which produce a high volume of data and this data send to the cloud for computation and storage is no easy task. For this problem the best technology designed known as Fog computing. Thus, fog computing has the probable to become the most important performer in the augmented reality area. Zao *et al.,* [89] built a Fog computing based game that game known as Augmented Brain-Computer Interaction. Ha *et al.,* [90] for reducing mental acuity author proposed a Wearable Cognitive Assistance system based on Google Glass devices.

In this section, we analyzed applications of IoT with Fog computing. Fog can manage the huge amount of data produced by IoT devices and provide services to the user in real-time.

VI. DISCUSSION

In this paper author's main contribution is about how Fog Computing is a valuable technology for handling IoT based devices. Also, design architecture of Fog computing and made discussion about working of Fog as an extension of Cloud Computing. The paper also includes the application of IoT with Fog Computing and challenges in developing Fog Computing and theses challenges described as latency, location awareness, and virtualization of resources.

VII. CONCLUSION AND FUTURE DIRECTIONS

To date, a significant contribution has been made in this area but still, it requires more efforts for improvement and plan to address these challenges in future work. This paper represents a literature review on how the Internet of Things (IoT) is implemented on Cloud computing and what kind of troubles face in giving their full services to their users. Then discuss how to come out from these dilemmas by using Fog Computing. It helps to eliminate problems like local awareness, latency, low bandwidth, and real-time working, etc. Fog computing technology is referred to as edge computing it can provide guaranteed QoS in an Internet of Things (IoT) device by its different characteristics like Low latency, Edge location, Geographical distribution, Interoperability. To conclude, this paper has highlighted fog computing and how they improve the services of the Internet of Things (IoT). Fog computing is a current and promising research area that still required more effective Advanced Policies, Fault Tolerance Mechanisms.

According to the previous work discussion, Fog computing supports a variety of applications belongs to the IoT. Until now, most of the research work still waiting or uncertain towards the progress and development due to such issues as latency, local awareness, improving the virtualization of resources, and many others. we proposed some competent research directions that can be pursued in the future and the further expansion of fog computing could thus help the IoT reach its enormous prospective.

Conflicts of Interest. The authors state that they have no conflicts of interest.

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