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Fog withIoT Architecture: Potential applications and Challenges

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Abstract

With the speedy progression of application using Internet of Things (IoT) applications, the typical integrated cloud computing archetype aspects numerous challenges such as low capability, high latency, and network letdown. To tackle these challenges, fog computing carries the cloud nearer to IoT strategies. The fog offers IoT information dispensation and storing nearby at IoT devices in place of transmitting them to the cloud. In dissimilarity to the cloud, the fog delivers amenities with quicker reply and excellence quality. Consequently, fog computing may be reflected the preeminent choice to permit the IoT to offer proficient and protected facilities for several IoT users. This paper deliberates the state-ofthe-art of fog computing and its assimilation with the IoT by prominence assistances and operational challenges. Finally, open issues and upcoming research guidelines concerning fog computing and the IoT have been deliberated.

Keywords

Fog Computing, IoT, Cloud Computing, Issues and Challenges in Fog Computing.

IIntroduction and Related Work

The data generation ability of electronic devices has been enlarged, which affects the volume of gathered information from natural resources and human activities [I]. On enhancing, it might to be possible that all the people and devices will be connected through internet in future [II]. This connectivity of objects with internet produces the need to handle voluminous amount of data. This data handling includes information transmission, processing and storage [III].

The best suitable and easily available platform for this data processing and storage is cloud. The infocomposed is transferred to the cloud which results in useful information. Though the enhanced acquisition of cloud computing is a ramification of easily available market for numerous application on very low or null expenditure but it also faces few constraints to consummate the essentials of some applications such as volume, latency and congestion. The devices and people at edge level are often far from the cloud which causes delay in communication [IV]. The combination of omnipresent cloud computing and day to day expanding devices configured at edge level consumes and produces various types of data through multiple resources. This combination requires a proper and pre-established architecture in fulfilling the need of heterogeneous applications. The current cloud model i.e. the communiqué with the cloud is inadequate to grip the problem of IoT such as volume, latency and bandwidth. To deal with these problems the concept of fog computing was proposed [V].

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If there exist any agreement regarding Internet of Things, then it must be about the quantity of devices connected through a network [VI]. These systems will be efficient to communication with each other through miscellaneous sensors and actuators. This enormous number of devices produces a vastinfo thatrequires further dispensation and storage. The IoT devices are myriad and heterogeneous in many aspects such as infocommuniquéstrategies, power requirementand much more. So it is congenitally challenging to manage IoT devices during data communication and storage. The data produced by IoT devices may not be applicable in raw form. This vast data demands consequential processing and information retrieval, this consequential processing and information retrieval is apprehended through IoT applications. To tackle this kind of problem two computing paradigms are used: cloud computing and fog computing [VII].Three layer fog computing e-technology is shown in Fig. 1.

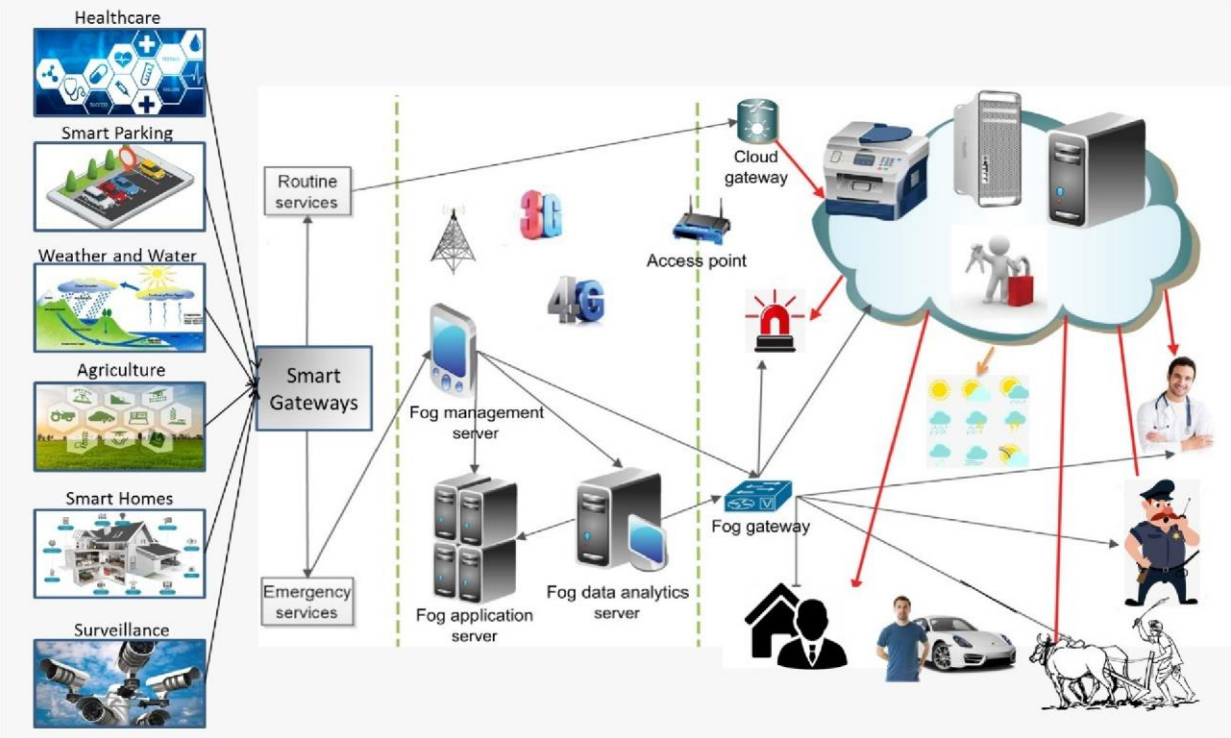

Fig. 1Three layers fog computing e-technology

IIApplications of Fog with IoT

There are various IoT application which provides a platform for easy and efficient implementation. In this section we will discuss miscellaneous IoT applications that may be proliferated with fog computing [VIII].

Energy Consumption

Smart cars and smart parking are one of the most indispensable applications of IoT. Rush and careless driving causes many accidental cases, which generates the demand for autonomous vehicle trend. The autonomous vehicle requires automatic steering, self-decisions about directions and smart parking. These automatic features are going to be enhanced in near future, so the cars may be able to interconnect with other adjacent cars, traffic signals and internet. They will have the prior indication about the traffic on the upcoming route. This communication will necessitate a real time interaction of data collected through sensors and cloud. The problem of latency and congestion in cloud computing which results in collision and accidents. To reduce this problem fog computing may be advantageous over cloud computing as it overcomes the problem of latency. Thus use of fog computing with smart vehicle application can save the human lives [X].

Smart Homes

A smart home has many devices and sensors connected with each other. These devices and sensors are collected from different vendors. Thus it makes them difficult to work on single platform. The data generated from sensors need to be processed and stored. This computation requires high data processing. FCoffers ease over CC in the time penetrating applications of IoT. Such as fire hazard the data transfer need to be very fast. A small delay in data processing and decision making can result in loss of human lives. FCproduces integration among various devices and makes them enable to work on high data processing and low latency [XI].

Smart Traffic Lights

Smart traffic light is the concept of communication among traffic signals and vehicles. The integration of fog computing with smart traffic signals facilitates to sense the existence of pedestrians [XII].

Healthcare and Activity Tracking

Healthcare is the field in which the data collected through sensors and devices is highly time sensitive because the data to be work on is real time data and delay in processing can cause mishappening. Fog computing contributes to overcome this problem of healthcare [XIII]. Application of fog layer usingIoT is revealed in Fig 2.

Fig. 2Role of fog layer in IoT applications

III Issues and Challenges of Fog with IoT Issues

The incorporation of FC with IoT merges numerous aspects for future research trends. It has various issues which are covered in this section.

Communication between the Fog and Cloud

FC has risen as an enhancement of CC. The fog servers positioned on various lactations are centrally controlled by the cloud, which manages the data values and applications of the whole method.. The same act requires dual task performance by cloud i.e. delivering the info and its updating. This dual functioning faces the difficulty in fog node processing. The proper communication selection amidFC and CC should ensure high data transfer rate and low latency. Achieving the same is a huge challenge extending cloud to fog computing with IoT application [XIV].

Communication amid Fog servers

A Fog server maintains a sufficient number of assets deployed at various positions. To achieve the efficient working structure of these resources, the fog servers require a properly maintained communication and association. The communication efficiency affects the system performance. More efficient communication results in better performance. The deployment criteria of fog servers are decided by owners. The data

transfer among fog servers is a crucial task. They require internet connectivity to communicate with each other. To provide a proper deployment of fog servers and internet connectivity is a challenging task [XV].

Security

The fog computing contains large amount of data in comparison with cloud computing. The security measures which are suitable for cloud computing are not sufficient to protect data of fog computing. The data gathered through sensors and fog servers are heterogeneous with wide ranging characteristics. This heterogeneity creates obstacles in data processing. Due to voluminous data amount fog data can be easily targeted by cyber assailants [XVI].

End User Privacy

The fog nodes are the nearest object to the user. Because of this they receive the most sensitive data of the user. This data may include confidential, official as well as private data. So this data of end users demands confidentiality. Controlling the scattered deployment of fog node at centralized point is ainterestingjob as the number of nodes is large and this dispersed node arrangement may provide a room for attacker to proceed towards the confidential data of user. This data protection is a challenging task for researchers [XVII].

Challenges

Scalability

In evaluation with CC the FC associates billions of IoT devices and sensors which results a voluminous volume of info, large data dispensation and storage. To handle the high info growth and increasing number of IoT devices is a challenging task [V].

Heterogeneity

The IoT devices and sensors are manufactured by miscellaneous organizations. Thus they all may have few similar and dissimilar properties and configurations. To maintain these miscellaneous devices and sensors for working together under single platform is a big challenge [III].

Latency

The fog computing provides lower latency benefit over cloud computing in time sensitive applications. But in few cases it may not be possible to achieve low latency via fog computing. Hence it results in use dissatisfaction. Reducing latency in highly time sensitive application is a big challenge [VI].

Security

As the Fog computing contains moving resources, heterogeneous data and vast distribution of sensors and devices, the existing security parameters of cloud are not sufficient to secure the data of FC. The fog nodes are nearest to the end user and are more vulnerable towards the cyber-attacks. It is required to focus on more research on authentication and security [XI].

Energy Consumption

The fog environment can be fewerpower sensitive than CC model as the number of sensors and devices are large as equate to CC. Hence reducing the energy consumption in FC is a challenging issue which needs to be tackle [IX].

Dynamicity

The IoT devices should have the ability to expand their working capabilities dynamically. Because it affects the performance of the fog. The working of various hand held devices is also affected by software and hardware aging. Thus, the automatic restructuring and smart redeploy able configuration of fog nodes is indispensable [VII].

IVRelated Work

B.Mukherjee et al.[XVIII][XX] proposed a design execution of suppleIoTsafety for fog communication using applications smart devices and cloud hosts. They used 'session Resumption' algorithm to offersafety in recurrent network environments to reuse previous encrypted session. To achieve the finestprobable selection of end-to-end safetysystem, 'Optimal Scheme Decider' algorithm is described..

Tarek R. Sheltami et al.[XX] proposed a system to provide the service of content delivery to mobile users with the help of fog computing. The fog nodes are distributed at the edge of the network, in the middle between the cloud and mobile users. These edge nodes are requested through users and responded back either immediately if the service has already been downloaded in fog server or by bringing the servers either from the cloud server or other fog nodes.

PeiYun Zhang et al.[XXI] discussed and analyzed the architecture of FC. They focused on the safety and trust problems.The problem solving methods to resolve those issues are also discussed in the paper. The report of various challenges in fog computing related with security and trust are highlighted by the authors.

A reconfigurable architecture that suggests the lithe amalgamation of Fog and cloud networks was proposed by Limei Peng et al.[XXII].The architecture was named as iCloudFog. iCloudFog allows to build diverse Fog types that may be wired or wireless or hybrid, which may be suitable for many dissimilar features of IoTresources, sensors, info and fog nodes. The challenges and the resolving solutions are proposed by the author. The approach suggested in the article would explore the benefits of iCloudFog to accomplish the effective provisioning of upcomingIoT application and amenities if designed and implemented appropriately.

To overcome the problem of traffic congestion and increased latency the fog–enabled IoT applications are introduced. In such systems the fog resources are deployed at the edge of the system. Due to the deployment at dispersed unsecure location these fog nodes are easy target for attackers, Alexandre Viejo & David Sanchez [XXIII] proposed the idea of fog composition. Fog adaptation enables the system to be self-tailored for the delivered services to achieve a safe and efficient delivery of services. The article illustrates a number of safe and protected protocols to fog-enabled IoT services through orchestration. The mainly exigent scenario of exchanging the data openly in potentially unsecured networks which can be easily targeted by attacker are considered for the assumption.

Ryuji Oma et al.[XXIV] proposed a TBFC model of fog computing. Using this tree based FC model the distribution of the processes and infocomposed from sensors can be professionally managed. This specified model reduces the electric energy consumption while delivering the info.

The IoT-Fog-Cloud ecocystem was illustrated by Luiz Bittencourt et al.[XXV]. The article provides a literature study on assimilation of FC with IoT applications. The organization of data,its management and the application which are going to be implemented through this integration has been discussed in this article.It also covers the issues and challenges of IoT-Fog –Cloud infrastructure.

AbdisalamYassine et al.[XXVI] presented an innovative platform to enable pioneering analytics on data gathered from smart home appliances. A smart home is well established place of connected appliances and devices which generates a momentous amount of data. IoT applications that are not able to meet the requirements of today's era are being emerged with fog computing. This amalgamation needs analysis of various solutions of the difficulties and challenges. A combined architectural model based on a new organization was presented by Paolo Bellavista et al.[XXVII] .This organization compares a huge number of solutions for the expansion of FCIoTsolicitations.

FiratKaratas and Ibrahim Korpeoglu [XXVIII] proposed aIoT. They also illustrated various techniques for configuration of IoT data into data centers of cloud and fog. Data is assumed to be heterogeneous required by enormous applications. The problem for data placement has been considered as an optimization problematic and an effectual algorithm is proposed for the effectual configuration of info produced and expended by the IoT nodes which have been distributed geographically. Data is once stored at a specific location which can be accessed by different applications according to their requisites.

BaharFarahani et al.[XXIX] presented the usability of IoT in healthcare. They proposed an IoT eHealth ecosystem architecture .Inadequate and less effectual services of healthcare are not sufficient to cure the chronic diseases of growing population which is making healthcare the most challenging application of IoT. This article suggests a patient centric treatment instead of clinic centric treatment in which the patients , hospitals and services are treated as objects and they are connected with each other through internet.This patients centric treatment systems connects enormous entities together resulting as vast amount of info. For the group and processing of that data there is proposed a multi-layer architecture which includes devices, FC and CC. This integration reduces the problem of congestion and increased latency.

Aparna Kumari et al.[XXX] categorized the healthcare industry between 1.0 to 4.0 generations. Healtcare 3.0 has been considered as hospital centric which requires multiple visits of the patients to the hospitals which affect the patients in physical as well as economic aspects. With the technological evolution of Fog and cloud computing it has been almost painless to implement patient centric treatment.

Table 1: Fog computing approaches with merits and demerits

Proposed Approach	Merits	Demerits
Session Resumption Algorithm [18]	Flexible choice in optimal security scheme, Speedup secure communication,	Lack of trust and security among IoT devices at network-edge.
Advanced of FC and its addition with the IoT [19]	Detailed illustration of fog characteristics, architecture and benefits	
COAP protocol [20]	Squatdormancy for all amenitiestransferred to fog servers.	Stable power consumption

Taxonomy of offloading schemes proposed for fog, cloud computing and IoT domains [17]	Proliferation of various offloading techniques for edge computing in the cloud-IoT environment	Not able to make decision on when and how much to offload
Safety and trust concerns of FC [21]	Analysis of fog from a general to detailed architecture	
iCloudFog architecture for integration of fog and cloud network [22]	Network dimensioning and formation, sourceorganization, infoconfidentiality and safety	expenditure of additional equipment and preciseconnection in the preparation phase
Methodicalworksevaluation	A total of 99 articles were used to	
of the technology for FC [16]	examine their design, submissions and recitalassessment	
Fog orchestration [23]	A safe and privacy-by-design scheme for fog arranging and carrying fogenabled IoT services	Unable to contract with the incessant stream of info
Tree Based Fog Computing (TBFC) model [24]	Reduced electric energy consumption for fog computing model than cloud computing model	-
IoT-Fog-Cloud ecosystem [25]		-
IoT agriculture platform for cloud fod computing [15]	Hardware computational efficiency,reduced computational cost, accelerating calculations to reflect response time, reducing network service cost, returning of useful data, reduced space capacity	No field model is considered
Case study for smart homes [26]	Analysis for automation of smart home appliances	Optimal distribution and configuration of fog nodes
Unifies architectural model, taxonomy for comparison of various solutions for the growth of IoT application based on fog [27]	Useful outcomes which can be reused to design IoT application based on fog computing	Smart connected vehicle and smart building applications are not covered

Geologicallydispersedgraded FC based on IoT [28]	Increased latency and bandwidth	Lack of connection amidFCinfocentres and IoT nodes, no comparision of proposed algorithm with meta heuristic algorithm
Patient centric IoT Health system [29]	Addresses the challanges of IoT health such as data management, scalabilty are primary concern.	-
Three layer patient-driven info collection [30]	Persevering centric medicinalinfostudystructure	-

V. Conclusion

Recently, IoT has engrossed the consideration of both academe and profitable organizations. It is flattering an essential part of our survives. It has the capability to attach nearly everything in our surroundings. IoT devices are energetic in nature and have imperfect storage and dispensation proficiencies. Though, the outmoded unified cloud has numerous concerns, such as network letdown and high latency. To tackle these issues, fog computing has been advanced as a postponement of the cloud, but nearer to IoT devices in which entire information dispensation will be achieved at fog nodes, thus dropping latency, mainly for applications of time-sensitive. The assimilation of fog computing with the IoT will carry several assistances to diverse IoT applications. In this paper, we have conversed the stateof-the-art of fog computing, with a conversation of fog features and assistances. The conversation also engrossed on dissimilar IoT applications that will be upgraded using the fog. Challenges of assimilating the IoT with the fog and exposed.

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