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Fog Computing: New Approach in the World of Cloud Computing

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ABSTRACT: Fog computing is the pattern that extends cloud computing and services to the edge of the network. This is similar to cloud computing. Fog provides data compute storage and application services to end users. The motivation of fog computing lies in a series of real scenarios such as smart grid, smart traffic lighters in vehicular networks and software defined networks. This paper discusses the new emerging technologies that lie within cloud computing. We can see many differences between cloud computing (CC) and the fog computing (FC). These two emerging technologies have similarities, differences, drawbacks, etc. and this paper elaborates on the advantages and disadvantages of both fog computing and cloud computing, how fog computing will overcome cloud computing in the future, and how Internet of things (IoT) is flexible with fog computing. Finally this paper suggests the future scope of fog computing in the both smart grid and in the computing based SDN (software defined networking).

KEYWORDS: Fog computing, Cisco, cloud computing, Edge, Internet of Things, software defined networking, smart Grid; cloud Service Provider.

I. INTRODUCTION

Fog computing is a term created by Cisco that refers to extending cloud computing to the edge of an enterprise's network. It is also known as **Edge Computing or fogging**. Fog computing facilitates the operations like compute, storage and networking services between end devices (Edges) and cloud computing data centres [1]. Fog computing, also known as **fogging/edge computing**, is a model in which data, processing and applications are concentrated in devices at the network edge rather than existing almost entirely in the cloud [2]. The concentration means that data can be processed locally in smart devices rather than being sent to the cloud for processing. Fog computing is one approach to dealing with the demands of the ever-increasing number of Internet-connected devices sometimes referred to as the Internet of things (IoT). Cisco recently delivered the vision of fog computing to run applications on connected devices that would run directly at the network edge. Customers can develop, manage, and run software applications on the Cisco framework of the networked devices. This includes the difficult routes and switches. Cisco brought this new innovation where they combined the open source Linux and network operating system together in a single network device. [3]

II. EXISTING CLOUD COMPUTING SYSTEM

Cloud computing is a type of Internet-based computing that provides shared computer processing resources and data to computers and other devices on demand. It is a model for enabling ubiquitous, on-demand access to a shared pool of configurable computing resources (e.g. computer networks, servers, storage, applications and services), which can be rapidly provisioned and released with minimal management effort. Cloud computing and storage solutions provide users and enterprises with various capabilities to store and process their data in third-party data centres that may be located far from the user. This distance could run from across a city to across the world. Cloud computing relies on sharing resources to achieve coherence and economy of scale, similar to a utility (like the electricity grid) over an

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electricity network.[4] Cloud computing provides many opportunities for the enterprises by offering their customers a range of computer services like Pay-As-You-Go (PAYG), flexible computing, data insurance, etc.
The cloud computing model is an efficient alternative to owning and running private data centers for customers using web applications. The private cloud gives you free space from 10 GB to 20GB. If the user wants extra storage, they have to pay only $1USD/67rs per month; this is very cost- effective. According to the cloud computing model, the more data you use, the cheaper it will be. If you are a regular and trusted customer they might give you a data insurance facility as well.

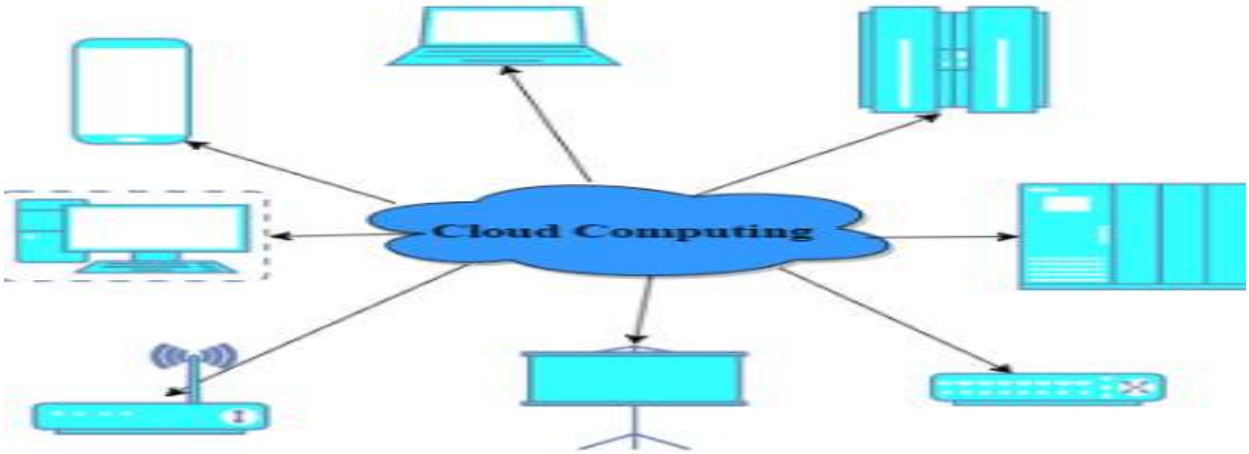

Fig 1.Existing cloud computing system

III. CLOUD COMPUTING SERVICES

Cloud computing services are useful for students as well as teachers. These are virtual machines (VM) that are changing the whole world of education in a good way. We use cloud computing for the education infrastructure, application, platform, and Software as a Service (SaaS). This service is helping to build Education as a Service (EaaS). EaaS is a specially designed service for online education (synchronized/unsynchronized). Cloud computing services are managing all the infrastructure, study services, study material and inventory. The services can be designed according to the machine the service is able to run on like the laptop, mobile, palmtop, personal computers or servers without internet connectivity. The service can also run from school/college servers, a data centre or third party servers that are accessed via the Internet. EaaS provides the updated tools that are useful for short operations like editing, inserting, deleting, etc. A private cloud can be best for establishing the EaaS at very low cost. EaaS is designed especially for education; that's why the purpose of this service is to be cost -effective, secure, reliable and flexible. The institution can totally rely on this service; everything is designed under the institution's circumstances. EaaS stores lesson plans for various subjects (as data storage) in private clouds that allow teachers and students to access the files anywhere and at anytime.

A. SOFTWARE AS A SERVICE (SAAS)

Software as a Service is a software licensing and delivery model in which software is licensed on a subscription basis and is centrally hosted [5]. Software as a Service is needed for computer laboratories. For educators, teaching materials are accessed via a web browser and are available on a paid basis (monthly/annually) according to the Cloud Service Provider (CSP). SaaS is different from the traditional model where the educational institute buys a license and ownership which requires installation and maintenance by the institute. SaaS is faster than the traditional way (Cluster Computing) and is a cost–effective option. Also, SaaS vendors provide the recent updates of software services.

B. PLATFORM AS A SERVICE (PAAS)

Platform as a service (PaaS) is a category of cloud computing services that provides a platform allowing customers to develop, run, and manage applications without the complexity of building and maintaining the infrastructure typically

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associated with developing and launching an app.[6] It is another variation of SaaS and delivers developmental environment as a service. Students and teachers can build their own application that is connected to the vendor's server. You can define your own data limit and make your own software too.

C. INFRASTRUCTURE AS A SERVICE (IAAS)

Infrastructure as a Service (IaaS) is a form of cloud computing that provides virtualized computing resources over the Internet. [7] This service of cloud computing provides the whole setup and infrastructure. The Consumer owns his/her own appliances like a server, machines, cooling equipment, etc. An organization is responsible for housing, running and maintaining it. The client typically pays on a per-use basis.

IV. TYPES OF CLOUDS

A. PRIVATE CLOUD

A private cloud is a data center owned by a single company for their own purpose, and the main purpose is to create their own network and to provide flexibility, scalability, provisioning, and automation and monitoring. The work of a private cloud is not to sell "as-a-service" offerings to external customers but instead to gain the benefits of cloud architecture without giving up the control of maintaining your own data center. A private cloud is more expensive compared to other clouds. The private cloud is not the best option for SMEs (small medium enterprises) or small businesses, startups, schools, or institutions. The maintenance of the private cloud is very high compared to other private clouds which are driven by concerns around security and compliance, and keeping assets within the firewall.

B. PUBLIC CLOUD

The public cloud is basically the Internet. Everyone can use it and it is free. Some companies are offering the free data usage limit of 10GB to 20GB. The public cloud is also known as Software as a Service (SaaS). Examples of public clouds include: Amazon Elastic Compute Cloud (EC2), IBM's Blue Cloud, Sun Cloud, Google AppEngine and Windows Azure Services Platform. These services are for common users. CSPs provide value for money offers to end/common users. This service is manageable because the user pays nothing for hardware, maintenance, and all is covered under the provider itself. The public cloud works under the pay-as-you-go (PAYG) model. You can pay only for what you use, including for extra storage. But in the public cloud, there are some limitations. It might not be the right fit for organizations because the public cloud has low security. It is hard to secure your valuable data in the public cloud because of the security.

C. HYBRID CLOUD

The hybrid cloud is the median cloud type of both private and public cloud services. Organizations rely on hybrid clouds when they use the private cloud during peak time. Public clouds die because of traffic. During that time, hybrid clouds help both the private and public clouds which is why they are called as the emergency cloud. The hybrid cloud is also beneficial during predictable outages, hurricane, warnings, scheduled maintenance windows and rolling brown/blackouts. The ability to maintain an off- premises disaster recovery site for organization is impossible due to cost. That's why most cloud customers rely on this hybrid cloud computing system.

IV. ADVANTAGES AND DISADVANTAGES OF CLOUD COMPUTING

Advantages

a) Reduced IT costs. With the help of cloud computing, the IT infrastructure cost is reduced.
b) People don't need too many servers...
c) The cost of system upgrades, new hardware and software may be included in your contract.
d) No longer need to pay wages for expert staff.
e) Energy consumption costs reduced.
f) Fewer time delays.
g) Scalability of business: Institution scaled up and down.
h) Cloud computing is always flexible and easily adjusts itself for any situation.
i) Flexible cloud computing allows teachers as well as employees to use it.

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j) Access to automatic updates about schools and institutions. It can be automatically updated with their new features and be bug-free.

Disadvantages

a) Downtime cloud computing systems are dependent upon the Internet. When there is no Internet your system won't work.

b) The security and privacy is a big issue for the cloud computing in these days. The AWS EC2 console was hacked and its all data deleted. This is enough reason for closing the company because of pressure. By leveraging a remote cloud based infrastructure, a company basically outsources everything it has.

c) Limited Control and Flexibility: cloud users have very limited control on their function infrastructure. Cloud provider EULAs and management policies might impose limits on what customers can do with their deployments.

V. HOW DOES FOG WORK?

Many times sensitive data is analyzed on the nearest fog node (near to any appliance) to generate the data in Cisco smart grid distribution network. For example, the most time urgent requirement (requirement is very sensitive and private) is to verify that the protection and the control loops are working properly or not. Therefore, fog nodes are close to them. Look for this particular sign problem and then prevent them by sending rescue (control) commands to that.

a) The data that need seconds or minutes to do action is passed through to the cluster node for analysis and action. In the smart grid example, each substation might have its own cluster node that tracks and reports the operational status of each downstream feeder

b) Data that is less time sensitive (normal data) is sent to the cloud (Historical analysis, big data analytics, and long-term storage).

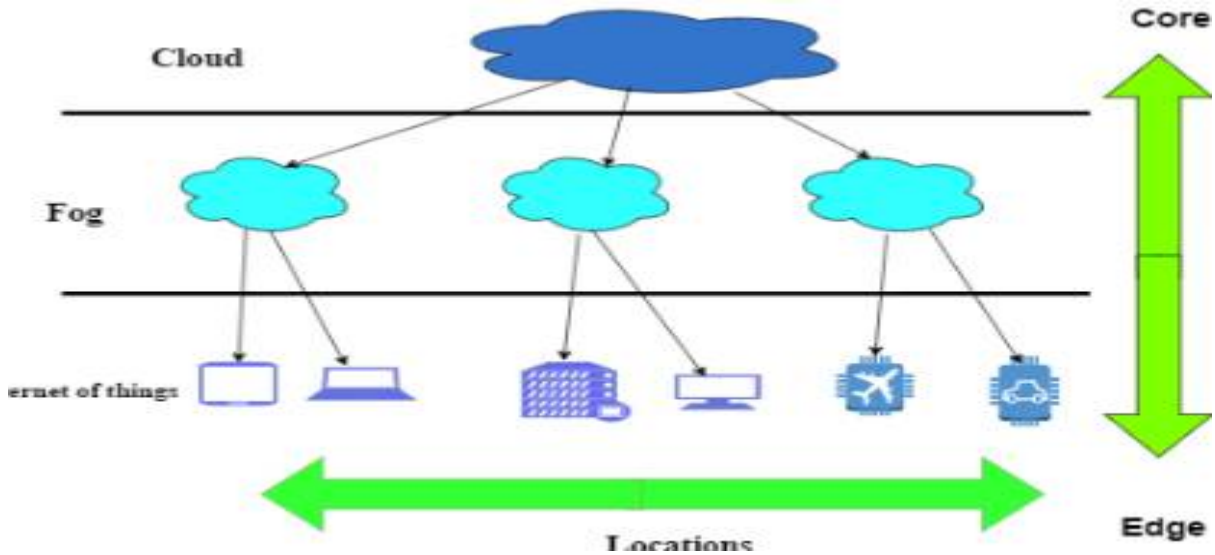

Fig 2.Proposed Fog Computing System

The above figure shows that each smart device (mobile phone, laptop, car, CPU etc.) Is connected with the fog devices, which are interconnected to the cloud.

A. WHAT IS THE NEED OF FOG COMPUTING?

Fog Computing extends the cloud computing pattern to the edge of the network. While fog and cloud both use the same resources (networking, compute, and storage) and share many of the same mechanisms and attributes (virtualization, multi-tenancy), the extension is a non-trivial one in that there exists some fundamental differences stemming from the reason that fog computing was developed: to address applications and services that do not fit the paradigm of the cloud .

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a. Disadvantages to overcome in fog computing

- Reduction in data movement across the network resulting in reduced traffic problem.
- Obliteration of bottlenecks resulting from centralized computing systems.
- Improved security of encrypted data as it stays closer to the end user.

B. WHAT HAPPENS IN THE FOG AND THE CLOUD?

Fog nodes

- Receive data from IoT devices using any protocol, in real time.
- Run IoT-enabled applications for real-time control and analysis,

In nanosecond response time.

- Provide erratic storage, continually for 1–2 hours.
- Send periodic data summaries to the cloud.

Cloud platform

- Receives and aggregates data summaries from many fog nodes.
- Performs analysis on the IoT data and data from other sources to gain business insights.
- Cloud computing can send new application rules to the fog nodes based on these insights.

The following table shows that difference between Fog Computing and Cloud Computing.

C. FOG VS. CLOUD

Service	Cloud Computing	Fog Computing
Latency	High	Low
Delay jitter	High	Very Low
Location of server nodes	With in internet	At every edge of the local network
Distance between the die and server	One or more Hops	One hop
Security	Undefined	Can be defined and it's good
Attack on Data Encounter	High possibility	Less possibility
Geographical distribution	Centralized	Distributed
Num of Server Nodes	Less	More
Support for Mobility	Limited	More Supported
Real time Interactions	Supported	More Supported
Type of Last mile Connectivity	Leased/Wired	Wireless

Fig3. Fog Computing vs. Cloud Computing.

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D. SECURITY ISSUES IN FOG COMPUTING

The main security issues are authentication at different level of gateways as well as at the smart meters installed in the customer's home. Each smart meter and smart appliance has an IP address.
A malicious user can tamper with its own smart meter, repeat false readings, or spoof an IP addresses.

Let's take one example of Man-In –Middle-Attack

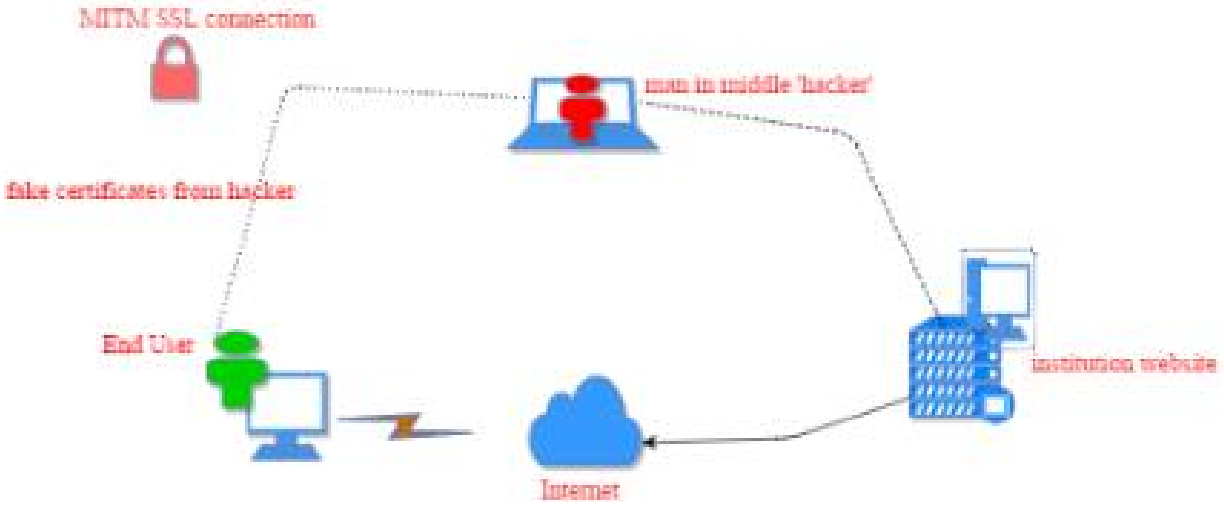

Fig 4. Man-In –Middle-Attack

This paper overlooks the security of fog computing, for that purpose, we take the example of MAN-IN-THE-MIDDLE-ATTACK. This is the security problem of gateways services of fog devices. Fog edges are decrypted or one can change edges with fake devices. In this attack, gateways serving as fog devices are compromised or replaced by fake ones.

E. PRIVACY ISSUES IN FOG COMPUTING

In smart grid computing, the issues are related with privacy. Secured information in the grid system such as appliances and priorities (which the fog machine is used for the allocation of time) get stolen often, because it isn't private. These privacy issues occur with the allocation of a specific task for a specific appliance, and then the machine's information is not safe. This privacy issue still remains.

VI. **IOT TODAY**

As with many new concepts, IoT's roots can be traced back to the Massachusetts Institute of Technology (MIT), from work at the Auto-ID Centre. Founded in 1999, this group was working in the field of networked radio frequency identification (RFID) and emerging sensing technologies. The labs consisted of seven research universities located across four continents. These institutions were chosen by the Auto-ID Centre to design the architecture for IoT. [7]

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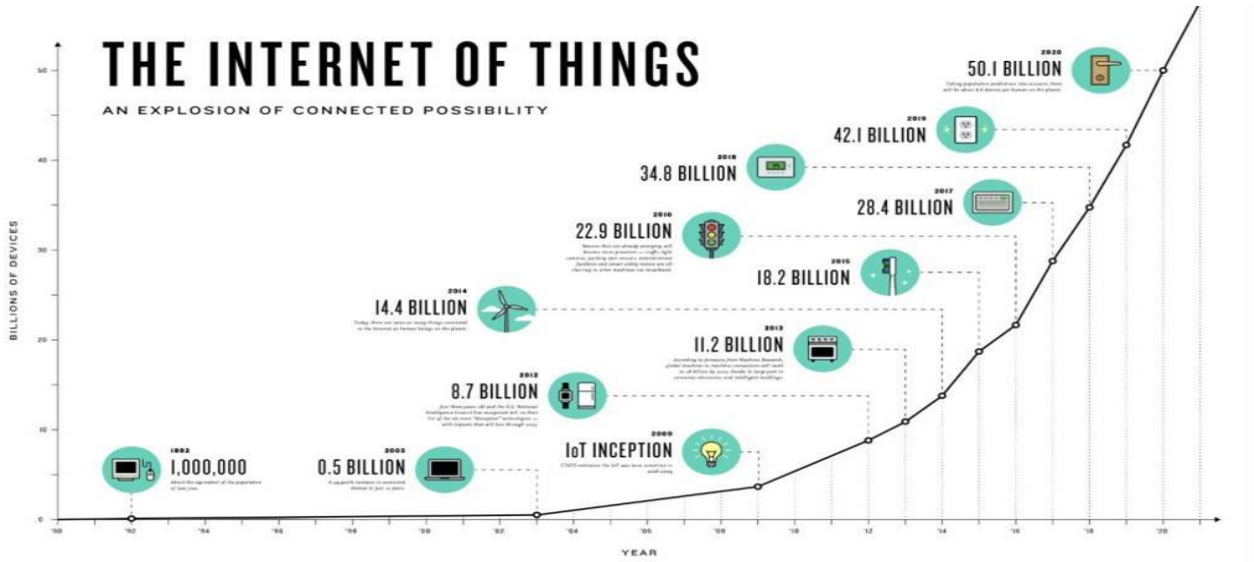

Fig 5. The Internet of Things, users in billions.
(Info graphic The Connectives based on Cisco data)

VII. CONCLUSION

Fog computing advantages for services are in several domains, such as Smart Grid, wireless sensor networks, Internet of Things (IoT) and software defined networks (SDNs).This paper examined the general security issues and main privacy issues in fog and cloud computing.
Fog computing has a great future ahead partly because of its flexibility and reliability. However, the security issues, like internet distribution, are still big in fog computing compared to cloud computing.

VIII. FUTURE SCOPE

Future work will concentrate on the fog computing paradigm in the smart grid. In this case, two models for the fog devices can be developed. Separate fog devices can communicate with each other directly. They can share information and regulate with each other for the periodic updates on economical things like price, demand, etc.
Also, fog computing based SDN (software defined networking) in transportable or movable (vehicular) networks needs more attention.

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