FOG COMPUTING(FOGGING)

1. General: Fog computing, also known as "fogging" or “edge computing”, is a distributed computing infrastructure in which some application services are handled at the network edge in a smart device and some application services are handled in a remote data centre - in the cloud. Fog computing implies that rather than hosting and working from a centralized cloud, fog systems operate on network ends. It is a term for placing some processes and resources at the edge of the cloud, instead of establishing channels for cloud storage and utilization.

2. Goal: The goal of fogging is to improve efficiency and reduce the amount of data that needs to be transported to the cloud for data processing, analysis and storage. This is often done for efficiency reasons, but it may also be carried out for security and compliance reasons.

3. In a fog computing environment, much of the processing takes place in a data hub on a smart mobile device or on the edge of the network in a smart router or other gateway device. This distributed approach is growing in popularity because of the Internet of Things (IoT) and the immense amount of data that sensors generate. It is simply inefficient to transmit all the data a bundle of sensors creates to the cloud for processing and analysis; doing so requires a great deal of bandwidth and all the back-and-forth communication between the sensors and the cloud can negatively impact performance. Although latency may simply be annoying when the sensors are part of a gaming application, delays in data transmission can be life-threatening if the sensors are part of a vehicle-to-vehicle communication system or large-scale distributed control system for rail travel biometrics definition.

Cloud Computing	Fog Computing
Data and applications are processed in a cloud, which is time consuming task for large data	Rather than presenting and working from a centralized cloud, fog operates on network edge. So it consumes less time.
Problem of bandwidth, as a result of sending every bit of data over cloud channels	Less demand for bandwidth, as every bit of data's were aggregated at certain access points instead of sending over cloud channels
Slow response time and scalability problems as a result of depending servers that are located at remote places	By setting small servers called edge servers in visibility of users, it is possible for a fog computing platform to avoid response time and scalability issues.

Fig. 1: Comparison with Cloud Computing

4. Composition: Fog Networking consists of a control plane and a data plane. For example, on the data plane, fog computing enables computing services reside at the edge of the network as opposed to servers in a data-centre. Compared to cloud computing, fog computing emphasizes proximity to end-users and client objectives, dense geographical distribution and local resource pooling, latency reduction for

quality of service (QoS) and edge analytics/stream mining, resulting in superior user-experience and redundancy in case of failure.

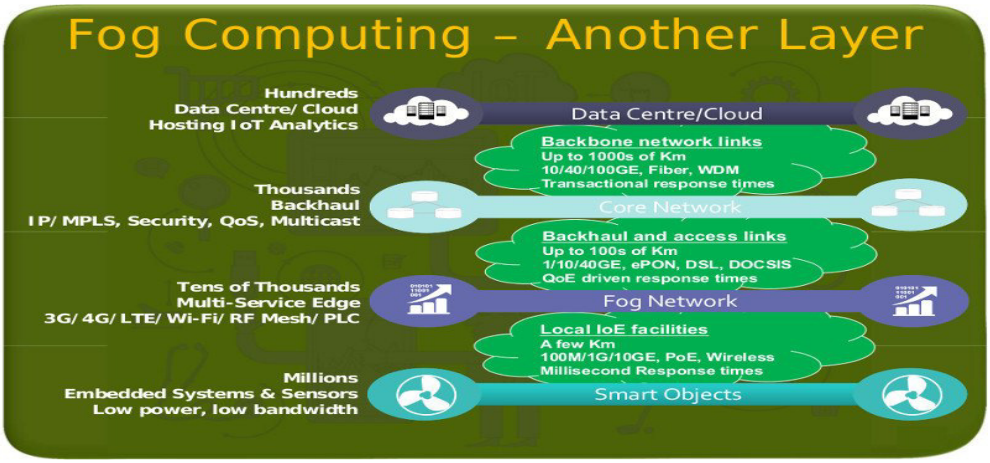

Fig. 2: Fog Computing Layer

5. Advantages: There are economical advantages to using fog computing. All that is needed is a simple solution (or multiple solutions) to train models and send them to highly optimized and low resource intensive execution engines that can be easily embedded in devices, mobile phones and smart hubs/gateways. To achieve this goal, fog computing is best done via machine learning models that get trained on a fraction of the data on the cloud. After a model is considered adequate, then it is pushed to the devices. Algorithms like decision tree or some fuzzy logic or even a deep belief network can be used locally on a device to make a decision that is cheaper than setting up an infrastructure in the cloud that needs to deal with raw data from millions of devices. Other advantages are:

(a) Fog computing tackles an important problem in cloud computing, namely, reducing the need for bandwidth by not sending every bit of information over cloud channels, and instead aggregating it at certain access points. This type of distributed strategy lowers costs and improves efficiencies. More interestingly, it's one approach to dealing with the emerging concept of Internet of Things (IoT).

(b) Fog computing extends the cloud computing paradigm to the edge of the network to address applications and services that do not fit the paradigm of the cloud due to technical and infrastructure limitation including:

(i) Applications that require very low and predictable latency.
(ii) Geographically distributed applications.
(iii) Fast mobile applications.
(iv) Large-scale distributed control systems.

Applications of fog computing

6. Tech giants like IBM are the driving force behind fog computing, and link their concept to IoT. Today, there might be hundreds of connected devices in an office or data centre, but in just a few years that number could explode to thousands or tens of thousands, all connected and communicating. Most of the buzz around fog has a

direct correlation with IoT. The fact that everything from cars to thermostats are gaining web intelligence means that direct user-end computing and communication may soon be more important than ever. The following are some of the practical examples:

(a) Connected cars**:** It's ideal for connected cars, because real-time interactions will make communications between cars, access points and traffic lights as safe and efficient as possible.

(b) Smart grids**:** Allows fast, machine-to-machine (M2M) handshakes and human to machine interactions (HMI), which would work in cooperation with the cloud.

(c) Smart cities**:** Fog computing would be able to obtain sensor data on all levels of the activities of cities, and integrate all the mutually independent network entities within.

(d) Healthcare**:** The cloud computing market for healthcare is expected to reach $5.4 billion by 2017, according to market reports, fog computing would allow this on a more localized level.

Way Ahead of fog computing

7. Fog computing can really be thought of as a way of providing services more immediately, but also as a way of bypassing the wider internet, whose speeds are largely dependent on carriers.

8. Google and Facebook are among several companies looking into establishing alternate means of internet access, such as balloons and drones to avoid network bottleneck. But smaller organizations could be able to create a fog out of whatever devices are currently around to establish closer and quicker connections to compute resources. There will certainly still be a place for more centralized and aggregated cloud computing, but it seems that as sensors move into more things and data grows at an enormous rate, a new approach to hosting the applications will be needed. Fog computing, which could inventively utilize existing devices, could be the right approach to hosting an important new set of applications.

9. However, the movement to the edge does not diminish the importance of the centre. On the contrary, it means that the data centre needs to be a stronger nucleus for expanding computing architecture. Hybrid computing models, big data and IoT have contributed to server requirements that may be shifting, but aren't really abating as some experts had predicted. The IoT is a relevant bridge to some of the biggest issues dividing the cloud and the fog (like bandwidth, which could lead to a hybrid fog-cloud model) as organizations seek to balance their enterprise-grade data centre needs with support for increasing edge network growth.

10. Conclusion: Fog Computing aims to Reduce Processing Burden of Cloud System. Fog computing is bringing data processing, networking, storage and analytics closer to the devices and applications that are working at the network's edge.

11. References:-

(a) Bar-Magen Numhauser, Jonathan (2013). Fog Computing introduction to a New Cloud Evolution. Escrituras silenciadas: paisaje como historiografía. Spain: University of Alcala. pp. 111–126. ISBN 978-84-15595-84-7.

(b) IoT, from Cloud to Fog Computing:

(c) http://www.wired.com/2012/07/fog-computing/