NavaJyoti, International Journal of Multi-Disciplinary
Research Volume 2, Issue 1, August 2017

# Hierarchical Computing Services and Internet of Things

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## ABSTRACT

In the present digital era of Internet of Things (IoT) human life across the globe is completely inseparable from the dependency of electronic devices. It is expected by Cisco and Ericsson that, in near future 50 billion devices will be connected to the internet which leads to ubiquitous computing. Applications like health care, smart cities, environment monitoring system, logistics and supply chain management system, home automation and many more adds massive amount of data to cloud and puts stress on cloud infrastructure. These data are to be processed intelligently, analyzed and stored. Edge computing, fog computing and cloud computing are used for processing the data generated by these devices at different levels. Here the objective is to provide Quality of Service (QoS) to ensure the data security, reduced latency, effective bandwidth utilization at different levels of computing [1][7] and [10].
**Keywords:** Internet of Things (IoT), Fog/Edge Computing, Cloud computing and Services.

## INTRODUCTION

Any electronic device or real world objects configured with an IP address becomes internet of things. Intelligence need to be incorporated for the things (devises) of internet of things. The different levels of computing decide where the intelligence should reside. An application like a home automation each appliance built with sensors, actuators and processors is assigned an IP address to be part of internet of things. The purpose of connecting these devices to internet is to send the status information to another machine or system or people where the status is evaluated and decision is made and in response the instruction is sent back to the device for further action to be taken [11][7][8].

For example i) a person before leaving his office after his work can instruct his coffee maker to prepare coffee at a specific time. The information reaches the local network gateway and in turn reaches the coffee maker.

ii) A heartbeat monitoring system with IP enabled, monitors the patient heartbeat, sends the status information with the current location to the cloud through the local gateway. The cloud evaluates the status, in case of emergency it triggers a message to the respective hospital with patient ID. The hospital will access the patient history from the cloud and takes necessary steps.

Now issues are i) where the intelligence or computing power is to be incorporated? ii) Whether all the data need to forwarded and stored in the cloud? iii) The privacy and security of the data

## LITERATURE REVIEW

In [1], it defines the internet of things, discusses the three and five –Layer architecture of IoT, protocols and applications, It also covers the Cloud and Fog Based Architectures and the components required. [8] Talks about cloud computing features and the limitations, and a Fog Computing model is proposed to overcome those limitations. [7][,[9],[12] Defines and differentiates Edge and Fog Computing and brings out the need for Fog computing. Scheduling algorithms for Load balancing [5] in Fog Computing is discussed. [3],[13] and [6] security features like encryption techniques , user decoy technique and Elliptic Curve Cryptography for authentication and confidentiality.

## 1. Levels of Computing

Edge/Fog computing compliments Cloud computing. The centralized processing of Could computing which completely depends on internet, puts the pressure on cloud infrastructure like quick response time, load balancing, cross platform access, interoperability, bandwidth, privacy and security of the data. Edge/Fog computing decentralizes and delegates the computing process to the local network gateways. Network gateways which are placed in the premises of the smart environment and can work without internet thus reducing the load of the cloud computing [7],[9]and[12].

## 2. Services at different levels of computing

The lower level should serve the higher level. Edge computing provides services to the Fog computing and Fog computing to Cloud Computing as shown in fig.1.

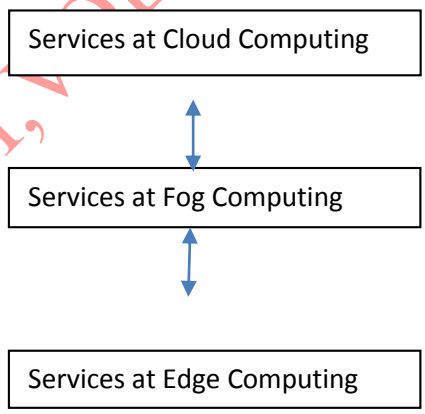


**Figure 1**. *Hierarchical Computing services*



### Services at Edge Computing Level

**Bandwidth Management and Privacy**: The data which are generated by the various devices are pooled to the network gateways. The authority of the smart environment should decide, depending on the sensitivity, cost of the data and the use of data, what

data can be stored at the local network gateways. The devices which are of least importance, a log can be maintained in the device itself. The data storing policy can be configured on the device as well as gateways. This storing policy reduces the overall amount of data travelling through the network. As a result efficiently of the bandwidth is taken care. Since the user sets the policy for devices and the information from the selective devices is stored in the local gateway privacy is ensured [8].

**Security**: Tunneling technique can be used at this level.

**Services at Fog Level Computing**

**Authentication- Decoy technique:** The user access pattern is recorded in an audit file, this information is used to check whether the user is legitimate or not to access the information from the fog network. Here the decoy information technique is used, with this technique if a user is found not legitimate by matching the access pattern of the user with the user behavior profile in the audit file, then to confuse the user, fake information is sent to the user where the original information is preserved [3]. Like RSA, Elliptic Curve Cryptography (ECC) is public key cryptography which uses elliptic curves on finite fields. ECC can be used for key agreement [13].

**Bandwidth management:**

Instead of forwarding the raw data to the cloud from fog networks, and allowing the cloud to involve in large processing for data analysis and adding additional traffic to the bandwidth, Extract Transform Load (ETL) tools can help in preprocessing the data and the data can be sent in the required format to store in the cloud data centers making the effective use of bandwidth.

**Availability and fault tolerance:** Mirroring of fog data is done and a secondary gateway should be configured in such a way that when primary gateway is down, the secondary gateway is up where it ensures availability and fault tolerance services.

**Confidentiality:** This is taken care by encryption algorithms like triple DES and AES.

**Services at Cloud computing Level**

There are several well matured and efficient services are running like virtualization, load balancing, delivery on demand, payment based on usage, dynamic prizing, encryption, authentication, data analytics and many more.

## 3. CONCLUSION

Hierarchical computing is a bottom up approach, where the services are provided from the IoT end node where the actual data is generated to the cloud where the data is processed ultimately. The Fog/Edge computing technologies uses primitive services to enhance the efficiency of the cloud computing technology by increasing the response time, maximizing throughput thus reducing the load of the cloud infrastructure.

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