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A SURVEY ON RESOURCE MANAGEMENT FOR FOG-ENHANCED SERVICES AND APPLICATIONS

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Abstract-Fog computing is a recent invention and it is new emerging technology. The birth of fog computing is directly related to the growth of IOT. It is very difficult to provide the requested resources for cloud due to the day by day increase in the number of devices and the user data. Thus, as a supplement to the cloud computing and as a extension to it, fog computing concept can be used. It acts as a bridge between cloud and users. Thus, it provides lot of benefits by minimizing the burden on cloud and solving issues related to cloud like latency, distribution, mobility etc. With the more research in the field of fog computing the main issue needs to be handled is the resource management. Thus this survey paper presents fog computing and issues related to fog computing. This paper also gives the details of various techniques proposed by the researchers for the resource management in fog computing.

Keywords: Fog computing, cloud computing, resource management

I. Introduction

Day by day cloud computing is becoming popular and gaining greater importance. Due to the increase in the number of devices and increase in the user data, the need for the storage, computation and many more resources arise. This all is provided and fulfilled by the cloud computing. Cloud computing provides network accesses to the pool of computing resources like storage, servers, network, applications and services on demand. With the tremendous growth in IOT, the fair and efficient resource allocation for each user at all time is very challenging task. Fog computing is a supplement to the cloud computing. It is the extension of the traditional cloud computing which brings the computing nearer to the users i.e. at the edge of the network. Similar to the cloud computing it provides storage, servers, application and services to the users. It is just situated between the cloud and end users. Fog computing acts as bridge between the cloud computing and the end users as shown in fig 1.

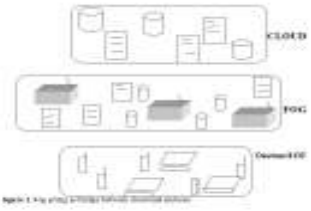

Figure 1 Fog Acting As Bridge Between Cloud And End Users

Any infrastructures capable of providing the resources at the edge of network for the services then they are named as the fog nodes. The fog nodes or edge nodes are also servers where the part of the cloud servers are offloaded from the cloud servers and these edge nodes host those servers. Any device capable of providing resources for service whether devices like setup box, base station, accesses points, routers, switches, cloudlets are also know as fog node in the fog computing.

The advantages of fog computing are great. The very important thing for the real time application is delay or latency. This minimum latency can be achieved by the fog computing as it is situated close to the user at the edge of the network whereas the cloud servers are far away. Thus, a very little time compared to cloud is required for computing and to retrieve the data or to the send. With the closeness of fog computing , the security can also be achieved as the data has to travel very less distance within a fraction of seconds or minutes compared to hours in cloud where the chances of attacks are more**.** Some of the advantages compared to cloud computing is listed in below table 1

Table 1:Comparision of FOG Computing and Cloud Computing

Parameters	Cloud computing	Fog computing
Distance between server and client	Multiple hops	One hop
Latency or delay	High	Low
Jitter	High	Low
Security	Not defined properly	Can be defined
Mobility support	Very limited	Can be supported
Server location	Within the internet	At the edge of the network

The rest of the paper is organized as follows: Section II presents issues and motivation related to resource allocation in fog computing. Section III discusses various fog computing resources allocation techniques proposed by researchers Section IV presents conclusion and section V gives referred references.

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II. Issues

As more research in the field of the fog computing, the issues which need to be addressed are as follows one of the main issue is a networking of fog i.e. **fog networking** [15] which provides network management , connectivity and services. The management of fog network is challenging as the mobility is more in this type of the network. Some of the techniques are proposed like SDN (software defined network)and NFV(Network function virtualization).Virtualization is the most important thing in the fog computing where virtual machines (VMs) has to be dynamically created, destroyed and if needed offloaded. Fog computing is mainly based on the virtualized gateways, load balancing, switches and placing those on fog nodes. But there is very little research carried out for this. Another issue is the **billing and accounting**[15]. To minimize the revenue and to efficiently utilize, it is important to concentrate on the pricing policies in the fog computing along with the monitoring and accounting.

Security and privacy [15]is another issue need to be addressed in the fog computing. In fog network attacks are more common between the fog nodes and the centralized system. Alost same issues that are pertaining in cloud computing related security exists in the fog computing. **Data security** is challenging as data stored for computing purpose at the edge or fog nodes can be used by the third party. Another main thing concerned is the user privacy. In fog computing the data delivery occurs the edge of the network i.e. at the fog node, there are more chances of leaking and misusing of the confidential data. **Accesses control** and **authentication** are again concerned security issues in the fog computing[15].

Fog interfacing for each and every device is challenging. Interfacing with the different applications require a unique **interfacing and programming model**. Fog nodes are nodes with dynamic mobility therefore a dedicated programming and interfacing model need to be designed.

III. Resource Management and Resource Allocation in Fog Computing

Resource management is the main issue which we are concentrating in this survey paper. First of all the brief explanation of resources is given and the techniques proposed by the researchers for the resource management and resource allocation in fog enhanced services is discussed in detail in this paper**.**

Resources are of many kind, these are as shown below

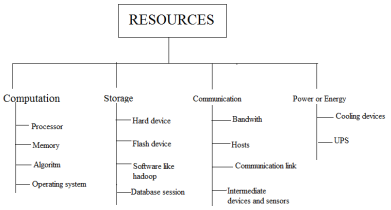

Figure 2. Classification of Resources

As fog nodes like routers, accesses points or any edge devices have very less computational resources they can be easily overloaded with increase in the data.

The resources are mainly classified as

1.computation resources

2.Storage resources

3.communication resources

4.Power or Energy resources

Computation resources are classified as processor, memory, algorithm and operating systems. Storage resources includes like hard drive, flash devices, software like hadoop and database session. Communication resources like bandwidth, hosts, communication link and intermediate devices. Power or energy resources include cooling devices and ups.

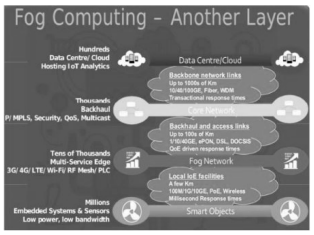

Figure 3 Layers of Fog Computing[18]

Different layers of fog computing is shown in the figure 3. Thus, fog servers need to have resources to support large data and for this resource management and resource allocation techniques need to be designed.

IV. Survey Findings

Different methods/techniques proposed by the researchers for resource allocation in fog enhanced services and applications are as follows

In [3] researchers proposed a designed a crowd funding algorithm which creates dynamic pool of resources by integrating sporadic resources. A concept of punishment and comprehensive reward was introduced to encourage supporters of resource towards resource pool.The results and advantages they obtained are SLA (service level agreement) violation rate is reduced by encouraging and monitoring the resource sharing by the resource owners towards the contribution of spare

resources. Increase in working efficiency is also achieved.The future work of this paper is to concentrate on the energy consumption as well.

In [12] Jun Li et al.[4] developed two local resource management schemes like FRR and FRL i.e. fog resource reallocation and fog resource reservation. Reserving the resources using traffic flow prediction methods was proposed. Exchanging the resources from low priority vehicles and reallocation to high priority vehicles was concentrated in this paper. The results obtained were

1. One hop accesses probability for high priority vehicles is increased effectively. **2** .30% increase in one hop accesses probability compared to the benchmark where resource management is not carried out. **3** .Quality of service is also increased.Drawbacks of this proposed method is that only high priority vehicles are concentrated and degraded performance of LP services. Future scope is to study FRL and FRR for low priority vehicles.

In[9] researchers proposed Zenith model for allocating computing resources in an edge computing. In this model independent of service provider the infrastructure management at the edge computing is performed. Authors also proposed auction based mechanism. Results/Advantages: are **1**.Increase in performance efficiency is observed **2**.Maximized the utility for both service providers and edge computing infrastructures. Future work include to work on more parameters like QOS.

In [1] researchers proposed a framework for managing edge nodes. Carried out auto scaling of resources. Results/Advantages include **1**.Improved QOS is obtained **2**.Application latency is reduced between 20 to 80 % when compared to cloud only model **3.**Reduction 95%in data traffic and the communication frequency between edge node and cloud server is achieved. Future scope and drawbacks of this work are **1**.Considered only static priorities **2**.To work on dynamic priorities which are more realistic in real world.

In[4] Lina Ni et al.[4]proposed algorithms like fog resource dynamic allocation algorithm, algorithms for predicting the time cost of task and mapping fog resources to user directory (MFR's). Algorithm were proposed to compute the credibility, evaluation of resources, to predict completion of time task and to allocate fog resources dynamically. The results obtained are **1**.From a group of pre allocated resources user can select the satisfying resources autonomously according to the price cost and time cost of task as well as credibility evaluation of both user and fog resources**. 2.**Thus, improved utilization of fog resources and efficient resource selection can be performed. Future scope is to apply strategy and verify for other performance metrics such as fairness, average completion and so on.

In[15] authors proposed three layer hierarchical game framework for resource management. Introduced a stackelberg game between data service operators and authorized data service subscribers. Developed moral hazard model in contract theory between data service operators and fog nodes to offer efficient physical resources. Higher utility of ADSS in fog computing compared to cloud computing is obtained. Future work includes to solve more challenges related to fog computing by utilizing different game theory models.

In [16] researchers proposed FC-MCPS i.e. Fog computing Medical cyber physical system by forging fog computing into MCPS. Proposed two phase LP-based(Linear Program) heuristic algorithm to liberalize MILP and to tackle the high computational complexity of solving MINLP(Mixed Integer Linear Programming).The result obtained were**1**.Minimized the overall cost while satisfying quality of service requirements **2**.Showed this proposed algorithm proved better than greedy one .Future work is to extend fog computing to other healthcare applications.

In[17**]** authors developed a model for resource utilization and incorporated Relinquish Probability and performed resource estimation. Exact deviation and irregularity factor in resource estimation is calculated. Amount of resources required is rightly determined and resource wastage is eliminated. Future work includes to extend model to various scenarios according to the type of CSC, considering monetary matters.

In[12]Emil Eris ton et al.[4] proposed an approximate algorithm and transformed the problem to a generalized assignment problems. The dependent profits sensors were assigned to computing resources at or near to base stations and the total number of multi views are maximized which were processed within time. Results obtained are **1**.Good performance at low computational complexity is achieved by the approximation of dominating sets of items.**2**.Compared to greedy algorithm, the proposed DZ (Dyer-Zemel) algorithm provided significant savings in bandwidth. Future scope and drawbacks includes **1**.To extend the work to mobile sensors and to consider constrained processing resources. **2**.To extend with interesting applications like vehicular safety and urban networks.

In[2] authors proposed a Markov-based analytical model. This model is integrated with a reinforcement learning process to optimize the server activation policy. Optimized battery management according to the size of the Renewable- Energy Generator system and the number of available servers is carried out.

In[14] researchers designed a fog-based region architecture to provide computing resources nearby and proposed heuristic-based algorithm. Efficiency of the

proposed model in terms of latency response is increased Resource utilization compared to Region based and Cloud-based resource managements is also more.

V. Conclusion

As Fog computing is a new technology, there are a number of challenges faced by various researchers in resource allocation and resource management. This paper discussed a detail survey on various fog resource allocation techniques and result and includes advantages and methods of each technique. The conclusion of this paper is that every technique has some advantages and disadvantages and still more research has to take place.

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