Architectural Framework for Resource management in Fog Computing

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***Abstract*— Internet of Things is a newer Technology and it is very popular among modern IT users. IoT devices are connected with Internet and resources are stored in cloud. Since IoT devices are energy constrained it can't directly connect with internet or cloud. Fog Computing is used for IoT devices to connect to Internet or Cloud. Fog Computing is an extension of cloud computing, in which computation done in edge devices or nearby localized data centers or cloudlets. Resource management is one of the key factor affecting performance of fog computing .This paper narrates an architectural framework for Resource management in fog Computing. The Framework contains six components they are resource co-coordinator, scheduler, request handler, resource estimator and allocator, work load analyzer. Request handler is used to classify and handle different types of requests from the user. Scheduler is used to schedule user requests and it enables user to utilize maximum amount of resources. Allocator used to allocate the resources, requested by the user and estimator is used to allocate resources to the user in advance based on history of service consumers. Work load analyzer is used to analyze workloads and balance the workload of the system and it also reduces average waiting time of the user. Resource co-ordinator enables to co ordinate fog resources to the cloud. In future, this model can be implemented using real world IoT simulation environments for fog computing.**

Key words: - Fog Computing, Resource management, Allocator , Scheduler, Workload Analyzer , Resource estimator

I. INTRODUCTION

Internet of Things (IoT) is a boon for modern Technology World. The Technology is made available to ordinary users by connecting all real world entities with the Internet. The IoT is a new paradigm, which can connect, communicate and computes the resources from the real world environment. The term IoT defined by Kevin Ashton in the year 1999. The IoT is defined as a seamless integration of real world objects with a uniquely identifiable address are interconnected with standard communication protocols [1][2].

Cloud Computing is a modern Technology used to deliver services in the Internet. Cloud supports IoT in the means of storage and computation. Even though cloud, has many features such as unlimited storage and virtualized platform, it affects latency time and its performance based on internet connectivity. Since cloud is entirely depend on internet, some of the end devices such as sensors, actuators are not capable to connect directly through internet. IoT devices (end devices) are mainly low power energy constrained devices. So there is a need of additional supplement technology to store communicate resources to the cloud from end devices.

The Cisco had coined term "Fog Computing" as an extension of cloud computing. Fog Computing is a new paradigm, in which storage and computation are done in edge devices. Bonomi defines fog as a" Highly Virtualized platform in which storage and computation are done on edge devices instead of traditional Cloud servers and this environment is also called as mini cloud or micro data center". Fog Nodes helps to connect more physical devices and it has the capability to store and process little data collected from the end devices [3].Fog Node acts as an Intermediate between cloud and end devices. Fog Computing is not an alternative of cloud, it can't store or process large amount of data gathered from end devices. Fog, just summarizes data or information gathered from end devices and it sends to the cloud at end of day. Fog layer acts as a model of communication to the cloud [4]. Fog will be able to deliver high-quality streaming to mobile nodes, like moving vehicles, through proxies and access points positioned accordingly, such as along highways and tracks[5].

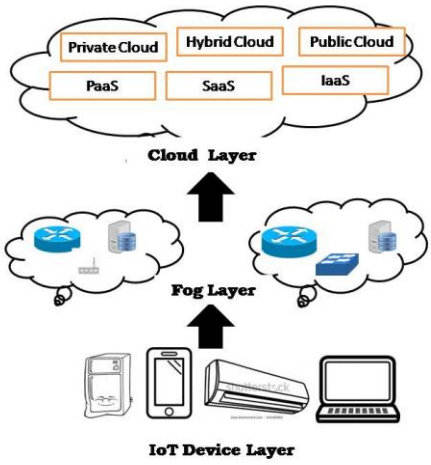

Fig 1: Fog Computing in an IoT Platform

This figure clearly depicts the usage of fog computing in an IoT environment. This Figure contains three layers they are IoT Device layer (end device) , Fog Layer and Cloud layer. IoT device layer consists sensor, actuator, devices, etc. It is used to sends or transmits data to the fog layer.

Fog layer comprises of node it enables process, store the data transmitted from the IoT device layer. Fog layer acts as mini cloud or micro data center, it pre processes the requests and data from the end devices. This layer sends the data to the cloud and it acts as communication layer between cloud and end devices.

The processed data (Resources) or information from the fog is sent to cloud layer. Large amount of data or tedious uncertainty data or resources is directly sent to the cloud layer. Fog layer completes its work only by sending its processed or computed resources (data) to the cloud.

This paper focuses on the objectives such as

1. Design an framework for managing resources in an fog environment
2. Balance work load of the system and manage large number of resources
3. Estimate resources in advance and allocate to the user to reduce wastage of underutilized resources.

The Remaining of this paper is organized as follows .Section 2 comprises of Related Work, Section 3 contains Framework for Fog Based Resource Management Section 4 includes conclusion of this paper.

II. RELATED WORK

Olena et al, [6] proposed a model for resource provisioning for IoT services in a fog environment .This methodology is used to optimize delay sensitive utilization for fog based computational resources. The results proved that this approach has decreased delay by 30 % compared to previous baseline approach. Short rounder-trip time and make span are two parameters that yield benefits from this approach. The authors had suggested a fog computing framework for resource management. The framework consists of fog cells, fog orchestration node and cloud fog middleware Fog cells are the single IoT device which co ordinate other IoT devices and provides virtualized resources to the edge of the network. Fog colonies are micro data center which comprises large number of fog cells. The fog colonies enable the network move from centralized to decentralized processing and aids resource provisioning task requests from the fog cells. Fog orchestration has control over the fog colony by orchestrating fog cells and it provides resource provisioning service to fog cloud interface

Mohd Aazam et al, [7] suggested a mechanism for a fog based micro data center to estimate resources and established a pricing model for an IoT. This work had covered issues such as resource estimation, reservation, and pricing strategy for old and new customers based on their characteristics. The resources allocated to their old customers based on the historical record of resource utilization of the cloud service customers. Therefore prediction and pre-allocation of resources also depend upon their user behavior and probability of usage of resources in the future. This mechanism is easier to adapt for all type of cloud service providers (CSP) to predict the usage of resources to its Cloud service Consumers (CSP).

Mohd Aazam et al [8], proposed a mechanism to provide resource estimation based on relinquish ratio and Net Promoter score (NPS). This model predicts the resources from the heterogeneous devices and it is used to enhance QoS in IoT. This method helps to minimize resource underutilization and enhance service quality of Cloud service Provider (CSP). NPS score is calculated based on QOE (Quality of Experience) which was provided by their user. The presented method help to determine service quality of their customers and predicts resource and pricing model to prevent underutilized resource in the cloud servers.

The authors proposed a novel mechanism [9] for IoT based Probabilistic resource estimation in a fog environment. Fog requires an effective and efficient resource management framework, and it must deal with mobile nodes and IoT, which involves objects and devices of different types having a fluctuating connectivity behavior. They proposed methodology for resource estimation and management through Fog computing, formulates resource management on the basis of fluctuating relinquish probability of the customer, service type, service price, and variance of the relinquish probability The model had been implemented on basis of Amazon pricing plans and provider reserves resources cautiously .

The authors, [10] suggested a mechanism for resource provisioning in a fog based Micro data center. This paper clearly states that resources are estimated and managed based on fluctuating relinquish probability of the service customer. This model provides best suitable service to its customers based pre estimated resources from the service provider. This Mechanism is tested on Cloud Sim toolkit and probabilistic model is used for resource prediction and this methodology helps to determine right amount of resources needed to the customer. It also reduces the resource wastage and increases profit and it can be extended for all types of scenarios for different type of cloud service providers.

Lin GU et al, [11] had proposed a mechanism for cost efficient resource management in fog using heuristic method. Mixed linear Programming and mixed non linear programming forms basics for the formulation of this problem .They suggested two phase non linear heuristic algorithm for reducing the cost in Medical Cyber physical systems. They compared the algorithm with existing greedy approach and they proved that this algorithm works better than existing algorithm. Mixed Integer linear programming model has high computational complexity, so they utilized two phase linear heuristic model to reduce the costs for medical cyber physical systems.

The authors [12], suggested a mathematical formula to find delay and power consumption in fog and cloud. They have developed an approximate approach to decompose the primal problem into three sub problems of corresponding subsystems, and solve them respectively. They have conducted extensive simulations to demonstrate that the fog can significantly complement the cloud with much reduced communication latency. They proved that significantly the fog computing improves the performance of cloud computing.

Hong Yao et al, [13] suggested a mechanism for cost efficient deployment of cloudlets in a heterogeneous fog environment. The authors devised an Integer linear programming heuristic method to reduce computational complexity. Bin-Packing algorithm is used to reduce cost in deploying cloudlet in a fog. This approach doesn't affect of QoE of the user and SLA

terms are not violated by the service provider. Their research work mainly focused on user satisfaction within less cost. The simulation results proved that this approach is more suitable for deployment of cloud lets in a fog environment.

Deze Zeng et al, [14], proposed a mechanism for task based scheduling to support software defined image placement in a fog environment. . The authors devised a methodology to solve the issues such as balance workload between end devices and computational servers. The resource management are done through image placement using mixed integer non-linear programming model. Their approach proved that , this mechanism minimizes task completion time and reduces the workload of the system.

Lian et al [15], devised a mechanism for cost aware resource allocation system for fog environment .Their mechanism mainly focused on reducing expenses of service provider. The cost is estimated based on four factors they are energy cost of data centers, network bandwidth cost, revenue loss of WAN propagation and economic compensation for fog devices. The authors utilized heuristic algorithm to reduce cost of fog service providers. Jacobian Alternative Direction Method of Multipliers (JADMM) are used to determine active fog data centers and work load allocation for active cloud data centers.

III. RESOURCE MANAGEMENT IN FOG COMPUTING

Fog devices are the devices which have additional capability of storing and processing the data from the end devices, whereas traditional cloud servers are incapable to manage resources from the IoT devices .Since there is a need for judicious resource management for fog computing devices.

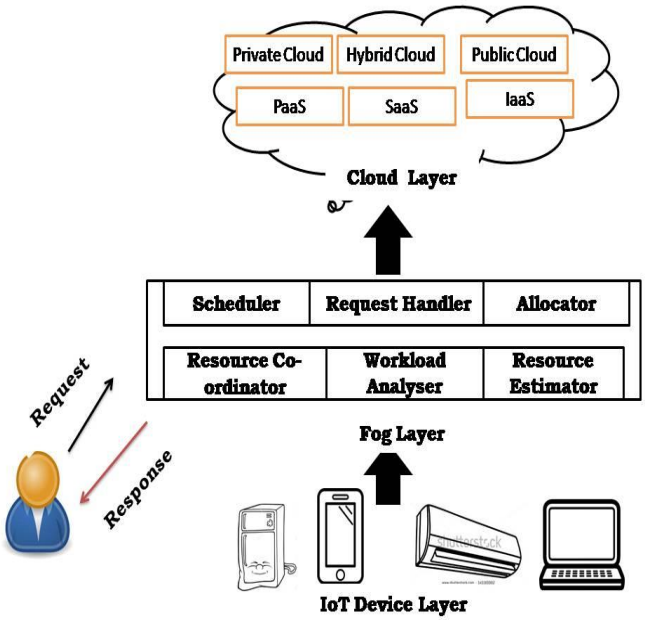

Fig 2: Framework for Resource Management in fog

Resource Management is one of the issue in fog computing. Managing resources from the IoT devices is a tedious process and it requires more novel mechanism and techniques to solve this problem. We illustrate an architectural framework for fog based resource management. This framework contains three layers as we have already mentioned earlier. In fog layer comprises of six features related to resource management. They are Resource co-ordination, Scheduler, Request handler, Resource allocator and Work load analyzer.

Resource Co-Ordinator:

Resource co-ordination is used to co-ordinates the resources gathered from different IoT devices. Since IoT devices are energy constrained, it is very less capable to handle large number of resources. So Resource co-ordination is used to gather little resources form IoT devices and it summarizes the resources to the cloud. Fog to cloud resource co-ordination plays a vital role in this mechanism E.g.: In a smart home environment, little resources are collected in different means such as video surveillance in kitchen, room, hall, etc all the resources are co-ordinate and it sends to the fog node. Fog node summarizes data or resource in a cloud.

Scheduler:

Scheduler is process assigning tasks to complete the job. Scheduler plays vital role in managing user resources in fog. It schedules the requests from the user, when the user requests for a resource to the fog server. Fog server schedules request and it sends to allocator, to allocate resources required by the user. In Real time applications for fog, scheduler helps to assign tasks and process tasks with less latency time [16]. Fog based Scheduling Algorithms is used to schedule requests for resources from the user. Scheduler is also used to enhance QoS [17] factor in this architecture .E.g.: Scheduling is done, when a registered user , request resource or compute resources in a real time environment or mission critical application such as hospital environment. In a smart healthcare, if patient is in ICU, doctor monitors patient , report is given immediately in minutes basis Doctor requests to access patient resource immediately fog based micro data center schedule the requests from the doctor, nurse , etc.

Request Handler:

Request handler is used to handle request from the user, when user requests for the resource. Request handler is used to classify the requests for the resource from the user. Priority is to handle requests from the user. Request Handler predicts the resource usage based on the previous requests given by the particular user. Resource estimation techniques are used in the request handler, to satisfy the needs of the customer. Request handler must be capable of handling more number of requests from the user with very less delay constraint.

Allocator:

Resource Allocator or Allocator is used to allocate the resources assigned to the user. Resource Allocation is used to allocate the resources to the user for particular time especially for real time applications. It is used to provision more limited number of resources to its user. Idle time is reduced when the resource allocated to the user within limited stipulated time.

Workload Analyzer:

Workload Analyzer is used to analyze computational workloads from the resource provider and resource consumer. Workloads are managed by using standard load balancing mechanism to reduce latency time and for managing resources in a fog environment. Workload analyzer is used to balance workloads it must reduce power and energy

consumption from the end devices. It is used to maximize utilize the resources requested by the user and minimizes the usage of underutilized resources. Work Load Analyzer, is used to balance work load between active cloud datacenter and micro fog data centers.

Resource Estimator:

Resource Estimator used to estimate the resources advance and activates allocator to allocate the resource to the user. Resource estimation is usually done based on service give up ratio of the previous customer. Resources are also estimated based on previous record of the consumed resources of CSC (Cloud Service consumer). The main job of resource estimator is reserving resources in advance, before the consumer request and immediately provides the resources to its consumer. This process reduces the cost of wastage of underutilized resources from the cloud service provider.

The components involved in this framework are integrated to satisfy to goal of maximization utilization of resource and minimization the cost of service provider and consumers.

IV CONCLUSION

Fog computing is one of the recent technology which supports cloud in an IoT environment. In Fog Computing, the computation, storage is done at edge devices. So, it reduces latency time of end devices. . Resource Management is one of the key factor, which affect the performance of fog. Resources collected from end devices are transmitted to fog nodes and it summarizes data (resources) to the cloud. Fog acts as an intermediate layer between cloud and end devices. The proposed framework is designed to achieve the goals such as maximum utilization of resources and minimizes the cost of service providers. This architecture gives overview of resource management mechanism in a fog computing environment. In future, this architecture can be implemented in a real time IoT environment.

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