EFFICIENT RESOURCE ALLOCATION AND QOS ENHANCEMENTS OF IOT WITH FOG NETWORK

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Abstract: The fog network that is the complementary for the cloud services, bring down the services of the cloud to its edge device with the easy and the early access of the information's for the task that are time sensitive for the internet of things. The enormous big data flow through the internet of things from various tasks in the variety of application has paved way to seek the efficient ways of resource allocation of the tasks in the fog network. So efficient way of resources allocation entailed to enhances the quality of service for the internet of things and improve the network performance, is proposed in the paper. The efficient resource allocation with reduced energy consumption and maximum resources utilization in the fog network is performed for the information's gained over the internet of things. The performance of the proposed method is validated using the network simulator to gain knowledge on the proficiency of the proposed method of resource allocation in the fog.

Keywords: Internet of things, Fog network, Cloud computing, Resource allocation, Energy utilization

1. Introduction

The Internet of things is emerged with the incorporation of the wireless technologies, the micro-electromechanical systems and the internet. It denotes the use of the devices that are connected intelligently to grasp the data accumulated by the sensors embedded, and the other tangible things around that are enabled by the internet. They influence the consumers, community and the concerns enormously enabling a life enhancing services in a broad variety of applications that are categorized as the intelligent living, environment and enterprise. The IOT's continuing to enhance quality of servicing in numerous of ways. They usually involve the embedded smart devices and the cloud to handle the critical issues of resource allocation, energy and the security. Cloud paradigm though seems to be promising, in the services provision that is devised as the software, infrastructure, platform and many more, often lags in the provision of the timely access as they are remotely located and the data stored in them are remotely processed. So the time and the power taken to transmission, processing and the retrieval of the data increases, resulting in inefficiency in the timely retrieval. The latency caused for the tasks with the deadline may result with the fatalities or any other illegal access causing alteration in the information. So there arises a need for the development of the network that is close to the devices or the sensors, in order to have a timely access. So the

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fog network was developed by the Cisco to extend the services of the cloud to the edge of the organization. The fog computing is a temporary storage service that provides the easy processing of the information close to the edge user devices, providing the results to the users within the time, in case of the time-sensitive tasks and stores the summary of the information processed to the cloud that provides with the permanent storage. Fig.1 below explains the activity of the fog that acts as a mediator between the cloud and the edge users.
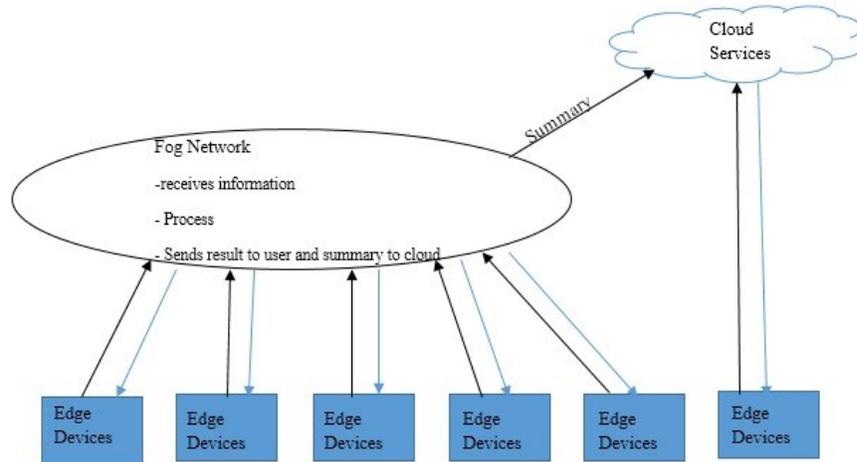

Fig. 1. The Fog Network

So from the figure it is understood that the fog extends the services of the cloud to the edge device, to enable an easy and early access of information. Since IOT handle a huge amount of data set from different applications, the handling of big-data and the resource allocation in the fog for the each tasks is a tedious and a complex job and the increased use of the information and the communication technologies require an efficient resource utilization scheme to reduce the energy utilization in the future [1] paving way to maximum utilization of resources. So the paper proposes the efficient methodology of resource allocation to reduce the energy consumption along with the enhancement in the utilization of the resources and the Cost.

The remaining paper is organized with the section.2 related works for the Fog network, its resource allocation, and the problem definition section 3. Proposed method, section 4. Result evaluation and 5. Conclusion.

2. Related Works

Considering the efficient resource allocation in fog network for the information's gathered over the internet of thing the paper proceeds with the related work exploring the efficiencies of the cloud computing proposed by Berl et al [1] find the alternative way of energy optimization based on the system operations and the networking in allocation of the resources, presenting the survey on the efficient methods of cloud computing to reduce the energy usage and Marinos, et al [2] details the benefits of framing the community cloud that helps in improving the efficiencies of the network in terms of the quality of the service. Though the cloud computing seems to be promising paradigm, it incurs more challenges in providing the services as presented in Moreno et al [3] that figures the challenges of the cloud-computing in the development of the future internet of things. Tan et al [4] gives the overview of the internet of things involved in a wide range of applications establishing a connections between the tangible things around with the help of the software embedded into it and connected to the other over the internet. The Internet of things employed with the huge range of applications experiences an enormous of data flow, so Chien, et al [5] presented with the resource allocation facilities for the data gathered through the internet of things using the H-STIN architecture that would enable a large scale resource allocation and Choi et al [6] presented the efficient resources allocation with the cloud computing for the internet of things, further Zhou et al [7] detailed the improved allocation of resources to the application of the of the internet of things but the cloud computing for internet o things faced few draw backs , due to its remote location and the unavailability of the timely access for the sensitized tasks that is detailed in Mishra et al [8] where the paper presents the challenges in the of the cloud computing in service provisioning's. So in order to reduce the processing time and have a timely access of the information's the fog network at a closer distance to the user was developed, in order reduce the time of the access, eluding the gap that could cause the unauthorized access so Mahmud et al [9] presents the survey on the fog network that was developed to handle the latency sensitive applications of the real-time. The fog computing provides a sustainable environment by reducing the energy consumption of the service provisions, that would be a challenge in the cloud computing Zanafi et al [10] proposes the fog network that provides with the sustainability smart environments by reducing the energy utilization of the services. Zhang, et al [11] gives the capable resource allocation that maximizes the resource utilization, but results with the increased cost other method proposed by Lan, et al [12] gives the use of the fog network for offloading, and resource allocation in D2D aided fog computing networks with the mixed integer non-linear programming problem. Provides with the better results for the resource utilization but does not show improvement in the energy consumption for the resource allocation. So the proposed method aims at an efficient resource allocation for the IOT based sensed data's that reduce the energy consumption, providing with the optimal utilization of resources.

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2.1. Problem definition

The enormous information gathered by the devices in the internet of things requires a reliable place for storage, the further processing to be used whenever needed. But the prominent cloud solution seems to be an incompatible for the tasks under the deadlock. So the fog network is framed as an extension of the cloud network, bringing down the service of the cloud to the at a reachable distance from the edge devices. Once again the huge flow of data from the IOT devices makes complicated the resource allocation in the Fog network.

So the problem of resource allocation in the Fog network is framed as the bipartite graph $G(I,E)$, where vertex I represents the no of devices of the internet of things for $I = \{ i_1, i_2, \ldots.. i_i\}$ and the edge E represent the objective to be achieved when allocating the resources for the Iot devices in the Fog network, they are the energy efficiency (E_e) and maximum resource utilization (RA_{max}) along with the QOS enhancement.

3. Proposed Method

The fog computing provides the resources at a closer proximity to the IOT devices or the sensors. Since the cloud network are located at distance that is beyond reach from the devices. The internet of things devices with the requirement of quick responses for its tasks, forwards the data to the fog for processing of the tasks. But for tasks that are void of latencies, requiring a permanent storage, transmits its data to the cloud network requesting for a permanent storage. The information with low latency and the requisition of the permanent storage are processed at the fog and the quick responses are sent back to the user and the summary are sent to the cloud for the permanent storage. So the paper proposing a resource allocation scheme with increased energy efficiency and the QOS, proceeds as two strides

(i)   Identifying the services that are to be processed at the fog network.
(ii)   Optimal resource allocation

3.1. Identifying the services that are to be processed at the fog network

The proposed method handling the problem of resource allocation for the devices of the internet of things, is assumed to have resource capacity as same as the cloud network. The capacity of the resource is defined as the set of resource module, comprised of the central processing units, storage provisions and the bandwidth along with the

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other tangible resources that are required. The proposed method proceeds with the identification of the fog services from the services requisitions posted by the IOT devices.

To identify the task to be performed by the fog, each task of the internet of things is transmitted to the fog over the internet, where a separator is engaged in identifying the tasks. The task (T) requested for is split to have, start time (SR_t) of the task, the processing time (PR_t) for the task and the deadline (Dl_t) of the task. The minimum (m_{PR_t}) and the maximum (M_{PR_t}) processing time of the fog network is set as the threshold for identifying the tasks to be serviced at the fog, the equation (1) is framed in regard of the task split up

$$\forall\ tasks\ T\ split\ (SR_{t,}PR_t,Dl_t)) \tag{1}$$

The tasks to be processed at the fog are segregated based on the deadline. The tasks with the minimum deadline, that falls below or between the deadline threshold (Dl_{th}) are identified to processed at the fog, and the tasks beyond the deadline threshold are send to cloud as they are void of latency. The equation (2) defines the identifying criteria (In_{Cr}) for the tasks that are to be computed at the fog.

$$In_{Cr} = \begin{cases} Dl_t \leq m_{PR_t}, & very\ low\ latency \\ m_{PR_t} \geq Dl_t \leq M_{PR_t}, & low\ latency \\ Dl_t \geq M_{PR_t}, & high\ latency \end{cases} \tag{2}$$

Where the $very\ low\ latency$ and the $low\ latency$ represents the deadline constraint tasks, that require quick responses and the $high\ latency$ represents the tasks void of deadline that could be processed in the cloud services. The tasks categorized based on the above equation (2) in the reserved in the fog for the computing and the rest of the tasks are directed to the cloud for computation and storage.

3.2. Optimal Resource Allocation

The devices of the internet of things identified with the deadline constraints, and in need of quick responses are retained within the fog network and allocated with the resources in the fog. The fog network gathering the information of the tasks based on its start, processing and the duration time, utilizes the information in identifying the perfect resource for the tasks that would process the tasks efficiently within the time and sends back the response before its dead line is reached. As each resource module in the fog has different computation time, the resource allocation is based on the processing time requirement and the deadline of the task. The fog network records the

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processing time of the resources and compares the recorded information each time it allocates the resources, the tasks with the very low latency (v_{LL}) is assigned with the resource module that has a minimum processing time, and the tasks with the low latencies(L_L) are assigned to the resources modules that are either with the m_{PR_t} or the M_{PR_t}, and the tasks with the high latencies void of deadlines are never allotted with the fog as they are forwarded to the cloud. The equation is (3) shows the resource allocation criteria (RA_{cr}) of the fog for the tasks.

$$RA_{cr} = \begin{cases} RA_{m_{PR_t}} \ assigned \ to \ v_{LL} \\ RA_{M_{PR_t}}, assigned \ to \ L_L \end{cases} \qquad (3)$$

Further the based on the PR_t of the tasks, the fog network maintains the computation information of the particular task in the resource module, where the computation information is the computation time required in processing of the task. The computation duration of each resource model is recorded to identify its idle state, to club it with the next task that requires the minimum processing time, this is done in order to save the energy utilization, that would be maximum if employed with the many number of resource modules. This also help in having a maximum resource utilization.

The proposed method employs the simple fuzzy based logic in identifying the tasks with the v_{LL} and L_L and the resource allocation with the m_{PR_t} and M_{PR_t} the rules for identifying the optimal task is shown below. The network is trained with the computation time, bandwidth ($band_{width}$) and the memory status ($memory \ _{status}$) of the resources to have befitting allocation of the resources. With the inputs given as computation time, bandwidth and the memory status. The SFBL is trained to identify the resource with the maximum ($band_{width}$ and $memory \ _{status}$) and minimum (PR_t), the values obtained are converted into the logic state as minimum and maximum applying the triangular and the trapezoidal formula. Further the idle state of the resource allocation is identified by gaining information of the processing duration of the tasks (du_t), to use the unused space of the resources for the next task to conserve energy and have a maximum resource utilization. The algorithm shown below in the fig 2 gives the details proposed process.

4. Performance Evaluation

The performance of the system is evaluated using the network simulator-2 to identify, the efficiency of the system in terms of resource utilization and the energy consumption. The method of resource allocation proposed based on the fuzzy logic in identifying the befitting resources for the task with the deadline constraints, and the record maintained with the duration of the task computation allots the empty space of the resources with the next task, thus employinga maximum utilization of resources and paving way for energy consumption by eluding the usage of more resources. The simulation done for varying number of IOT devices, for various number of tasks, gathering the information of

the processing time, the duration of the task computation and the deadlock using the SFBL is compared with the other dynamic method of resource allocations to prove the capability of the proposed method.

Input: Tasks $I = \{ i_1, i_2, \ldots i_i \}$ and Resources $R = \{ r_1, r_2, \ldots r_r \}$

Output: Befitting resource allocation

Start

// Identification of fog service //

∀ all tasks

Gather SR_t, PR_t, $Dl_t|$

Identify tasks with v_{LL} and L_L

Enumerate the tasks for fog using the eqn (2)

Next

End

// Allocation of Resources//

∀ all Resources

Gather $band_{width}$, $memory_{status}$ and the PR_t

//applying SFBL//

Enumerate resource with maximum ($band_{width}$ and $memory_{status}$) and minimum (PR_t)

Allocate it to the task

//to identify the non-used state of the resources//

Gather du_t

Allot the tasks to the non –used resources
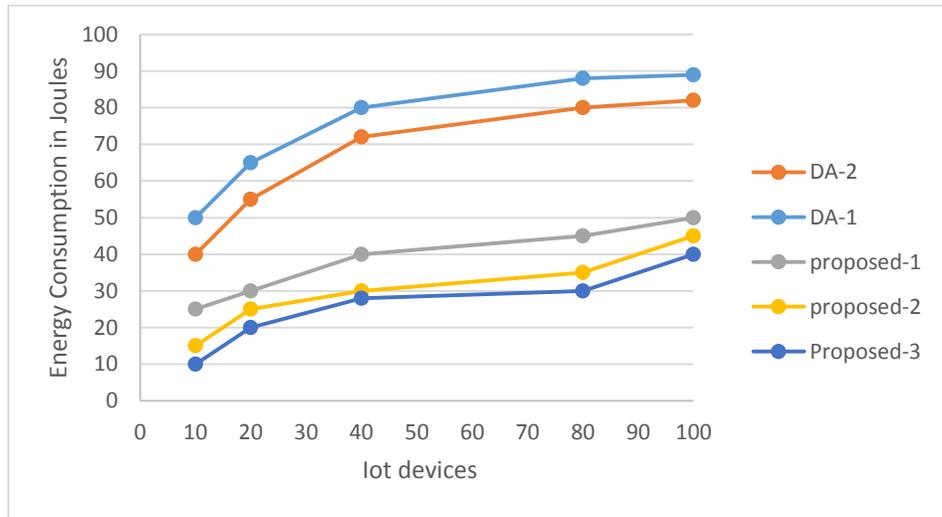
Next

End

Stop

Fig .2 Proposed Algorithm

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Fig.3 Energy Consumption

The Fig. 3shows the simulation result of the proposed methods energy efficiency, the simulation result on the average energy efficiency of the proposed method shows considerable improvements than the prevailing methods of resource allocation, the proposed SFBL based resource allocation shows an 45% and 28% of the improvement than the dynamic resource allocation methods in the fog computing for the IOT devices. Further the simulation to gain knowledge on the bandwidth utilization in the fog is performed.
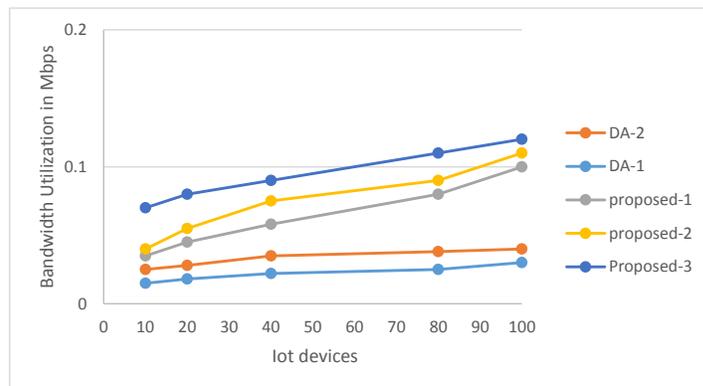

Fig .4 Band width Utilization

The fig 4 shows the simulation result for the bandwidth utilization of the proposed SFBL method for the resource allocation in the fog, the proffered method engaged with the identification of the, befitting resources for the tasks of the internet of things with the maximum bandwidth, memory and minimum processing time, ensure the maximum bandwidth utilization, when compared to the other methods of dynamic resource allocation for IOT devices.
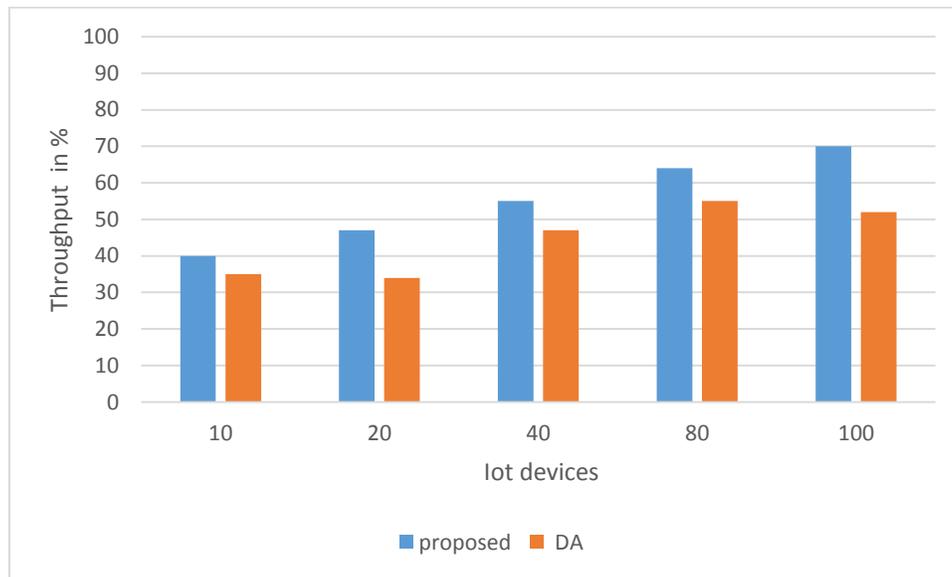
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Fig.5 Throughput

The fig.5 gives the average throughput percentage achieved by the fog resource allocation utilizing the proposed method when compared with the dynamic resource allocation. The simulation is performed for varying number of IOT devices engaged and found that the fog network based on the proffered resource allocation enables in having the quick response enabling an early timely access than the cloud network that is placed in a remote location. Despite the facilities of the fog with the early access and the timely delivery it is just the extension of the cloud as well as the temporary storage device that seeks the help of the cloud whenever required with the permanent storage and transmits the summary of the each process done in it to the cloud. So further the paper is to proceed with the study on improving the storage facilities of the fog and resource allocation with cost efficiency using the new optimization techniques evolved.

5. Conclusion

The internet of things devices, with the tasks with deadline constraints prefer the fog network to have low latency access than the cloud network. But the enormous data flow from the device of the IOT, make it necessary for the developing a proper resource allocation method in the fog network to have a reduced energy utilization and maximum resource utilization. The proposed method based on the SFBL determines the eminent resource for the tasks based on their deadline and the processing time. Further the idle status of the system is identified and engaged with the other tasks, thus maximizing the resource utilization and minimizing the energy consumption. The system trained with the bandwidth utilization enables to have maximum bandwidth utilization thus showing a heightened throughput. The performance evaluation of the system using the network simulator-2 show the considerable

improvement of the proposed methods quality of service over the other methods of dynamic allocation. Further the paper is to proceed with the study on novel methods improving the storage facilities of the fog and resource allocation with cost efficiency using the new optimization techniques evolved.

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