Fog Computing: An Efficient Platform for the Cloud-resource Management

Ab Rashid Dar
Research Scholar,
Department of Computer Science
St. Joseph's College (Autonomous), Tiruchirappalli, Tamil Nadu, India

Dr. D. Ravindran
Associate Professor,
Department of Computer Science
St. Joseph's College (Autonomous), Tiruchirappalli, Tamil Nadu, India

Abstract

Datacenters in cloud paradigm are storing enormous data size, and have an impact on both the energy consumptions as well service costs. Although centralized cloud computing is still more convenient, feasible platform for most of real-time applications and services but not the best. As in centralized distributed environment, resource provision and optimal usage of the configurable resources is somewhat neglected and quality of services are ignored, oversized data communication with low bandwidth network capability leads to the congestion in network data transportation, high latencies, delays and network jitters. Lack of proper resource provisioning leads to the unsophisticated energy management which burdens and laden high energy costs on the end-users. These heavy sized cloud macro data centers have negative impact on the environment as these exchange excessive heat while processing. Recent times marvelous research is being taking place that will provide the new horizons to explore and exploit the new horizons of the distributed technologies. The latest one in the town is the Cisco's fog-edge computing and is being considered as the next step in the distributed computing paradigm. Here in this paper, we the authors, consider Fog computing as a convenient and an energy efficient computational platform for resource provisioning, and its impact on optimal costs for the computing resources like services and applications.
.

Keywords— Centralized Cloud, Real-Time applications, Resource Provisioning

1. Introduction

Distributed Cloud computing is the core platform for various evolving technologies likes IoT, Mist, Edge and Fog computing as it sophisticatedly changing ways, the various resources, computational processing, network bandwidth and unlimited storage is being offered with minimal interference and less costs on demand basis [1]. Fog computing main purpose is to take the computational processing and intelligence at the edge of network rather than at macro-core cloud network. Fog is mini-cloud with advantageous features reducing the flaws and limitations i.e. bottlenecks, high latencies, geographical and widely dispersed aerial locations of cloud computing. Fog computing is convenient platform for IoT enabled scenarios i.e. smart (grids, cities, connected vehicles, traffic lighting systems), geographically distributed, real-time sensitive latency bounded applications and act as an intermediate layer between cloud and edge computing, serves various benefits and is now considered to be the future alternative of it[2]. The storage and computational power is being severed at the nano data centers (micro servers) in fog-edge network, rather than sending it to the centralized core cloud network lowering the further latency and time delays, Since the data transformation from the end user devices to the macro-core data centers is a cumbersome process and is energy inefficient, the more is the hops count, the more delay jitters are occurring and cause the highest latencies and time delays. In this paper the more attention is on applications running in fog-edge network and are energy efficient compared to same applications and services running over entirely core-cloud centralized network [3]. The efficient energy management model is of importance to monitor and control the energy consumptions. Proliferation in technology paved more opportunities and possibilities to minimize the energy constraints by enabling the portable less power consuming and high performing RFID tagged end devices enable to make energy efficient systems [4]. These systems make possible cost feasibility and portability, reduction in physical shape and size (Sensors, Actuators, Network-adapters, Switches, Routers, and Fog-Smart Gateways) [5]. In this article our motto is to consider and introduce Fog platform as a novel platform for some of cloud constraints like flexibility, interactivity, scalability, and interoperability among various fog-edge devices, lowering the energy management costs. In this paper, we the authors present the computing resource management with fog computing and the remaining portion of the paper is being categorized in sections. Section I is an introductory part, Section II present the related work, while as Section III present the research challenges, Section IV describe briefly on the problem statement, Section V, fog-based cloud resource management and finally in Section VI, we conclude the paper.

2. Motivational Related Work

Fog computing is a novel computing paradigm which needs more interactive programming prototypes, designing dynamic applications that will monitor the end-users edge devices efficiently and require the proper interoperability, sustainability and proper energy resource management.

Mohammad Abdullah Al Faruque et al. [6] proposed a novel energy management system that is of high importance in microgrids, households, corporate buildings on fog platform, and implementing it on fog will offer the services like better flexibility, network-connectivity, and secured data privacy. The proposed energy management model will reduce the energy cost when used as a service on fog domain for both home and microgrid energy management. Fatemeh Jalali et al. [7] proposed the use-flow and time-based energy consumption models and compared the centralized datacenters in cloud domain. The predictive analysis of their carried out work in network scenario predict that nano datacenters on fog platform will be the energy efficient than the centralized macro datacenters on cloud platform for applications that generate the bulk of data and operate in real-time environment. Zijiang Hao et al. [8] proposed and designed a flexible MW-FOG Architectural approaches. Implementing WM-FOG on fog platform, rather than cloud, the underutilized hardware resources can be utilized utmost level. This architecture can define proper workflows or workloads for proper load balancing, and can be better choice to return the data back to user end rather than to cloud and improve data offloading schemes. Mohammed A. Hassan et al. [9] authors put forward and discuss their ideas for mobile application offloading and storage expansion by leveraging the intelligence at the edge network provided by fog computing platform, Authors have highlighted the latency constraints of cloud for these the light weighted mobile applications proving to be unworthy. Mohammad Aazam et al. [10] Cloud being universal platform offers its services with feasible price to the small, medium and large enterprises (SMLEs), Authors have suggested and proposed Smart Gateways in collaboration with Fog computing an alternative to send only the trimmed data over the network and reduce the network congestion Benedikt Martens et al. [11] the authors proposed the total cost ownership and cost-oriented approach model for cloud services. Here in this proposed model, the authors consider the cost for the cloud computing services and consider it as an important decision making factor for both cloud service provider as well for the cloud service user. Ravindran et al. [12] have proposed the model for management of cloud resources with autoscaling and scalability is the central idea of the manuscript. Provisioning and de-provisioning of resources on the bases of thresholds calculations will decide the proper workload distributions. But the autoscaling on threshold bases is prone to faults and failures because of network, software and hardware specifications.

3. Problem Statement

From the review of literature, we here highlighted some of the challenging issues in Cloud Computing and how the novel approaches with intermediate fog-layer will overcome these limitations, Fog will be the feasible and convenient platform for the real-time sensitive applications consuming low-power energies and effective (cost, storage, and communication), we put forward hypothesis and mathematical model that can defend our assumptions that Fog computing being the ideal platform for futuristic ubiquitous, pervasive devices, services and applications in decentralized distributed computing environment.

A. **Network Congestions & Internet Bandwidth**: Bandwidth is an important thing for the smooth communication across the various computing nodes in a network, cloud offering seamlessly services, it is mandatory that the maximum network bandwidth utility should be available for accessing the resources. As lately, with introduction of 3G, 4G yet to come 5G, need high internet bandwidth, became challenging issues in centralized cloud paradigm.

B. **Resource Management Challenges:** Proper management of resources is important for efficient resource provisioning. But in recently with IoT applications, generating excessive data size, cloud is not the ideal and suitable for the resource management for this real time application in real scenarios.

C. **Highest peaks in hopcount:** As the length in hops increase so increases the high latencies and network jitter, delay times. Hopcount provides the better understanding and properties among the various nodes in the network, it has its impact on IoT enabled environment were the correspondence among the arbitrary nodes decides the end to end quality of service (QoS) in terms of network delays, jitters and packet loss and message passing.

D. **Bottlenecks and internet traffic:** Access to the various resources is being provided geographically or locally across the globe. Cloud availability offers the resources to the clients 24 hours on the go. But being accessed centrally, the internet traffic generated possesses the various service denial issues, because of the deadlock situation known as Bottleneck.

E. **Cloud Computing's Security & Data Privacy Issues:** The worst side of cloud computing is its security parameters, where users data violation is matter of concern for both the service provider as well as the service user. Fog is not offering the complete solution to this problem of cloud but since the data remain near the end users, chances are rare of data violation.

F. **Carbon dioxide emission and electricity usage:** Cloud data centers consume much energy as 25000 average households consume in USA and the CO_2 emissions is ½ of the overall vehicles produce in a calendar year, and have the negative impact on the environment bio-diversities.

G. **Energy Consumptions:** The cloud data centers in the world utilize almost 1 ½ times energy in a year as a city in the USA.

Below in the table shows some of the daily statistical report of active users, data usage and CO_2 omissions & electricity consumptions. This statistical data is being taken from *internetlivestats.com* [22] and data is being captured at noon hours, and will be not the same for same, the statistical analysis keep on changing.

Table 1: Daily-based social media usage, network traffic and carbon dioxide emission & electricity consumption

Social Media	Number of Active User	Social Media	Number of Active User
Internet Users in the World	4,071,830,200..	Skype active users	150,834,120..
Total Number of Websites	1,930,215,575..	Internet traffic daily	2,800,123,680.. (GB)

Emails sent daily	123,040,501,123	Electricity used daily	1,901,400.. (MWh)
Google search daily	3,049,201,400..	Carbon Dioxide emissions daily	1,606,123.. (Tons)
Tweets sent daily	375,388,130..	Twitter active users	340,851,720..
YouTube viewed daily	3,303,730,140..	Google+ active users	653,105,029..
Photo uploaded daily	38,172,100..	Facebook active users	2,373,511,100...

4. Fog Computing

Fog Computing is the recent addition to the distributed computing paradigms and refers to a decentralized platform for local computation at the edge of network, extend the cloud capabilities very near to underlying fog nodes. Compared with the Macro-data cloud centers, fog comes with light weighted micro-cloud or nano- datacenters (*m/nDCs*). Fog computing offers the same functionalities what the cloud is offering to its end-users but with greater extent and proximity. It Transfer the computing capabilities from core network to local edge network and offers the decreased latencies for real-time application in IoT environment. Since its commence, this paradigm is becoming popular and an important backend to the various real-time sensitive applications geographically dispersed in local network [3].

According to the CISCO in collaboration with IEEE, Fog computing is considered to be the future and is as an alternative of cloud centralized applications. As of now, Fog computing is in its embryonic stage, most of the research works carried out are only in reviewing and survey domains, most significance is being given to the IoT enabled environment, where the real-time analysis is occurring in RFI-tagged objects while the energy utilization both at transportation and network layers are being overlooked. Here in this paper the novel fog computing approaches are being into consideration to overcome the energy inefficiencies. Fog is an ideal platform for efficient energy management. In IoT, Fog plays a vital role to overcome the gaps by using minimal network distance i.e. hops count by providing the internet connectivity amount the various configurable edge devices. With IoT-enabled environment, energy management with fog computing will be the boost for the future modern evolving fog scenarios like smart cities, traffic management system, smart houses, smart grid and healthcare systems[4].

Fog will make ensure Fog-scenarios energy management. However, integration and involvement of cloud will continue to be the supportive backend for fog-edge computing and will offer the end-users the platform, software and network as the services, with guaranteed reliability, availability, performance quality of service parameters. Unpredictable nature of smart enabled-connected-devices leads to the unmanageable workloads, service offloading, energy management is not feasible with cloud paradigm because of delay time responses and high latencies. The intervention of fog computing will offer some comforts and reliefs like scalability, adaptability, interoperability to the end-users. The various hardware components of computing like (Fog-Smart Gateway, Connectors, Sensors Actuators Storage), and these devices with proper light weight software communicate with each other in real-time scenario [13].

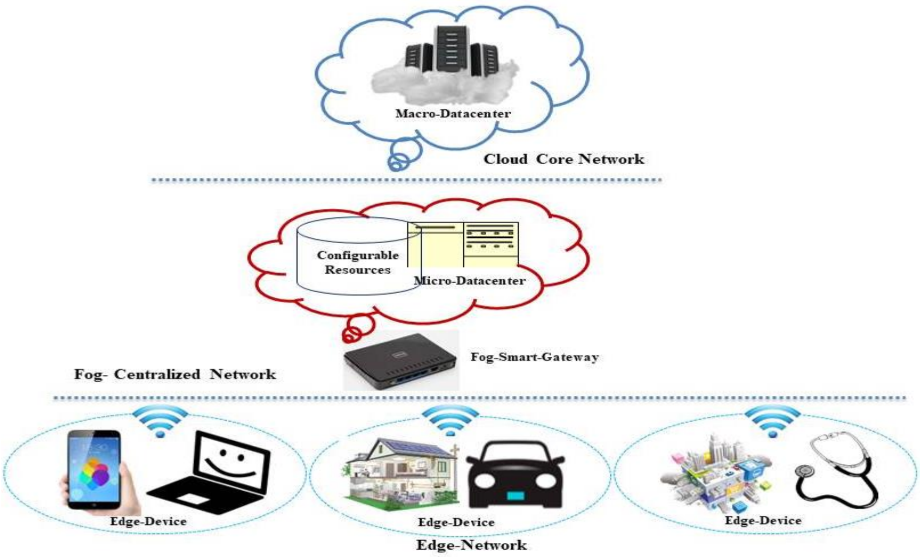


Figure 1: Fog Computing Layered Architecture

5. Fog-Based Resource Provisioning Management Model

Nowadays, the smart devices and pervasive computing peripherals are the first priority of every individual connected to the internet. Users prefer the smart gadgets over the static desktops, and so is the cause that growth of IoT-based mobile applications is prolific. Cloud computing considered as being an ideal platform, but lately for the real-time applications, cloud is not the convenient and energy consumptions in cloud data centers is huge, and had its impacts on service costs, as well as on the biological environment and same can be reflected by statistical data in Table 1. The network congestion of cloud is another factor that causes the low bandwidth and high latencies. As of today's pervasive, the small portable WiFi routers are installed both at homes and public spots like traffic camera surveillances, home theatres, community centers. To utilize these edge-network devices utmost, Fog is the best suitable platform for collaborating the edge and cloud computing functionalities together and will continue to be the ideal and the efficient platform for energy consumptions.

A. Formulation of Problem

In making the decisions on resource management, it is important to monitor actively the computing system resources. The dynamism and resource availability, we might be able to predict the system utilization and performance of various jobs of computing and figure out to locate resource at edge-network. Here in this paper we take some parameter from some of the cited manuscripts and in additional relate the energy cost and throughput of both the cloud and fog paradigm we examine and explore that from most of parameters like latency, network bandwidth, memory, CPU clock, throughput and energy costs, Fog is having exponentially improvements in every aspects expect the few like CPU clock and RAM. Figure 2, is real time scenario of the data (raw) from different end-users send to the network. Instead of sending to the core distributed servers, fog servers in local network offload the data in fog nano datacenters [8].

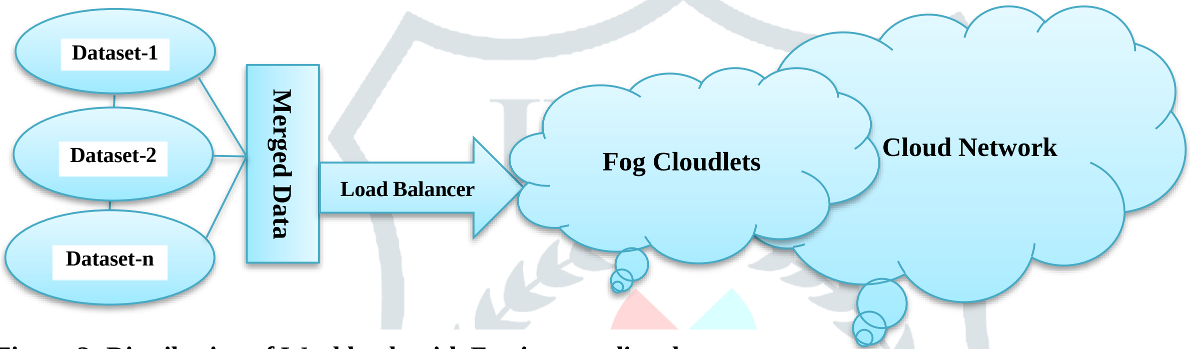


Figure 2: Distribution of Workloads with Fog intermediate layer

Impact of Low latencies in edge network domain plays a vital role for smooth function of the real-time applications and proving to be the energy efficient as it saves much of active network sessions. Once the data from the end users is being generated and the routers in the local network will directed it to the desired network. The workloads (workflows) are being offloaded to the intermediate fog storage layer for some time and keep the network active for other processes and reduce the network congestion. Fog intermediate layer will lower the hops count in the network, it will automatically will lower the focused workloads and will enhance the data mobility. Localizing the fog node and smarts gate in local public network will reduce the workloads of the cloud core-network, the network speed dominance in fog offer better performance than cloud [9].

Table 2: Network-bandwidths of Fog & Cloud nodes

Network Nodes	Bandwidth(Kbps)	Memory(Mb)	Throughput
Cloud Node 1	5000	2024	Low
Cloud Node 2	3000	2024	Low
Cloud Node 3	1500	2024	Low
Cloud Node n	500	2024	Low
Fog Node 1	20000	1024	High
Fog Node 2	15000	1024	High
Fog Node 3	10000	1024	High
Fog Node 4	9000	1024	High
Fog Node n	5000	2024	High

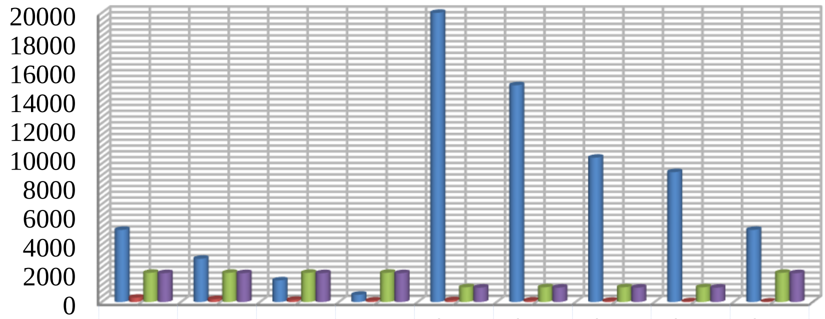
From statistical analysis, it quite evident that cloud distributed computing is rich in computing synchronization clocks (CPU clock) and have better memory as compared to cloud, The network congestions and low bandwidths and network delay jitters are the worst scenarios in cloud while as low latencies, maximum bandwidths in fog make it an ideal platform for low computing synchronization and low memory for WiFi/routers installed in local network and these devices act in real-time to reduce the network latencies jitter delays of the network[7].

Network Nodes	Network Latency(ms)	CPU Clock(GHz)	Energy Cost
Cloud Node 1	300	2	Max
Cloud Node 2	200	2	Max
Cloud Node 3	150	2	Max
Cloud Node n	100	2	Max

Fog Node 1	125	1	Min
Fog Node 2	100	1	Min
Fog Node 3	80	1	Min
Fog Node 4	50	1	Min
Fog Node n	30	2	Min

Table 3: Network-Latencies of Fog & Cloud nodes

Fog is offering them the reduced latencies, and the devices in local network are reducing the response times, and only the desired data is being sent over the network, which in return saves the network costs, improve the network speed, and reduce the congestion. All these factors of fog computing making it an ideal platform for resource management. The idle time is less, the throughput and energy costs are much improved than ever before [9].



	cn -1	cn -2	cn -3	cn -n	fn-1	fn-2	fn-3	fn-4	fn-n
Network Bandwidth (Kbps)	5000	3000	1500	500	20000	15000	10000	9000	5000
Network Latency (ms)	300	200	150	100	125	100	80	50	30
RAM (Mb)	2024	2024	2024	2024	1024	1024	1024	1024	2024
CPU Clock (MHz)	2000	2000	2000	2000	1000	1000	1000	1000	2000

Figure 3: Network bandwidth and latency comparisons

B. Fog Issues and Challenges

Fog computing is best suitable for IoT environment, and offer better services to the light weighted mobile applications, But still this possess some of key issues and concerns in cloud-based fog computing resource energy management pose the following issues and concerns[8].

- Cloud availability is predominant while as fog might lack the same.
- Since localizing the network, devices like WiFi/Routers reliability and security is the need of an hour
- Heterogenetic end-user devices, it is feasible to overcome the high latencies.
- Fog-node multitenancy, will it be possible for fog-nodes interoperability.
- What about the energy utilizations, support to mobility portable devices, various algorithms for storing data efficiently?.
- Load balancing, for proper workload distribution across the various fog nodes.
- Cloud computing being centric, in contrast to it, fog nodes are dispersed decentralized fashion, location of node to node are quite effective to transfer the information to the active node, need proper discovery service management.
- How is performance, interactivity affected cloud based fog computing in congested multitenancy?
- Customization of services like scalability, adaptability for various independent fog end-users.

6. CONCLUSION

In this research article we, define distributed computing terminologies especially cloud based fog-edge computing. Fog computing will benefit the portable devices like smart phones, smart wearable gadgets, IoT and Big data analytics, enhance and reduce the high network latencies, increase the throughput, consolidating the computing resources, saving the energy costs, and improve security and privacy concerns. Optimal energy management is essential for daily usage gadgets, reduced costs and proper resource provisioning. Fog computing platform for energy management offers the connectivity, flexibility, connectivity, privacy and real-time scenarios. Macro-data centers are consuming much energy than the nano-data centers. Interestingly reduction in hopcount also improve network energy costs, implementing fog computing platform as an alternative of cloud computing will improve and enhance both the energy as well as service costs, and will make it better platform for smart devices with lower RAM and CPU. Fog computing is not entirely a solo platform, for better and smooth functioning, it needs coordination and integration of already existing distributed paradigms. Since fog devices often operate in local network through wireless network protocols, the unavailability of the network can bring the node under complete halt, the

Acknowledgement: Authors are very thankful to Mohammad Aazam (Ph.D, Senior Member, IEEE), Prof. Mohammad Al Faruque and Fatemeh Jalali (Ph.D) for the kind gestures to access their valuable research work especially in the fog domain.

REFFERENCES

[1] Abdullah Alsaffar, Aymen & Hung, Pham & Hong, Choong Seon & Huh, Eui-nam & Aazam, Mohammad. (2016). An Architecture of IoT Service Delegation and Resource Allocation Based on Collaboration between Fog and Cloud Computing. Mobile Information Systems. 2016. 1-15. 10.1155/2016/6123234.

[2] Aazam, Mohammad & Huh, Eui-nam. (2016). Fog computing: the Cloud-IoT/IoE middleware paradigm. IEEE Potentials. 35. 40-44. 10.1109/MPOT.2015.2456213.

[3] Ab Rahid Dar, Dr. D Ravindran, "Fog Computing Resource Optimization: A Review on Current Scenarios and Resource Management", unpublished

[4] Aazam, Mohammad & Huh, Eui-nam. "Fog computing: the Cloud-iot/ioe middleware paradigm,", IEEE Potentials. 35. 40-44. 10.1109/MPOT.2015.2456213. 2016

[5] Mohammad Aazam, Sherali Zeadally, Khaled A. Harras, "Offloading in Fog Computing for iot: Review, Enabling Technologies, and Research Opportunities", Future Generation Computer Systems, IF: 4.639, 2018.

[6] Al Faruque, Mohammad Abdullah & Vatanparvar, Korosh. (2015). Energy Management-as-a-Service Over Fog Computing Platform. IEEE Internet of Things Journal. 3. 1-1. 10.1109/JIOT.2015.2471260.

[7] Jalali, Fatemeh & Hinton, Kerry & S. Ayre, Robert & Alpcan, Tansu & S Tucker, Rodney. (2016). Fog Computing May Help to Save Energy in Cloud Computing. IEEE Journal on Selected Areas in Communications. 34. 1-1. 10.1109/JSAC.2016.2545559.

[8] Hao, Zijiang & Novak, Ed & Yi, Shanhe & Li, Qun. (2017). Challenges and Software Architecture for Fog Computing. IEEE Internet Computing. 21. 44-53. 10.1109/MIC.2017.26.

[9] Hassan, Mohammed & Xiao, Mengbai & Wei, Qi & Chen, Songqing. (2015). Help Your Mobile Applications with Fog Computing. 10.1109/SECONW.2015.7328146.

[10] Aazam, Mohammad & Huh, Eui-nam. (2014). Fog Computing and Smart Gateway Based Communication for Cloud of Things. 464-470. 10.1109/FiCloud.2014.83.

[11] Martens, Benedikt & Walterbusch, Marc & Teuteberg, Frank. (2012). Costing of Cloud Computing Services: A Total Cost of Ownership Approach. Proceedings of the Annual Hawaii International Conference on System Sciences. 1563-1572. 10.1109/HICSS.2012.186.

[12] Mahmood Hussain Mir, Dr. D. Ravindran, "LETISA: Latency optimal Edge computing Technique for IoT based Smart Applications", 2017 IJSRCSEIT, Vol. 2, No.4, pp.688-694

[13] Aazam M., St-Hilaire M., Lung CH., Lambadaris I., Huh EN. (2018) IoT Resource Estimation Challenges and Modeling in Fog. In: Rahmani A., Liljeberg P., Preden JS., Jantsch A. (eds) Fog Computing in the Internet of Things. Springer, Cham.

[14] Yousefpour, Ashkan & Fung, Caleb & Nguyen, Tam & Kadiyala, Krishna & Jalali, Fatemeh & Niakanlahiji, Amirreza & Kong, Jian & Jue, Jason. (2018). All One Needs to Know about Fog Computing and Related Edge Computing Paradigms: A Complete Survey.

[15] Vishwanath, Arun & Jalali, Fatemeh & Ayre, Rob & Alpcan, Tansu & Hinton, Kerry & Tucker, Rod. (2015). Energy Consumption of Interactive Cloud-Based and Local Applications. IEEE Journal on Selected Areas in Communications. 33. 616 - 626. 10.1109/JSAC.2015.2393431.

[16] Jalali, Fatemeh & Ayre, Rob & Vishwanath, Arun & Hinton, Kerry & Alpcan, Tansu & Tucker, Rod. (2014). Energy Consumption of Content Distribution from Nano Data Centers versus Centralized Data Centers. ACM SIGMETRICS Performance Evaluation Review. 43. 49-54. 10.1145/2695533.2695555.

[17] Chen, Feifei & Schneider, Jean-Guy & Yang, Yun & Grundy, John & He, Qiang. (2012). An Energy Consumption Model and Analysis Tool for Cloud Computing Environments. 2012 1st International Workshop on Green and Sustainable Software, GREENS 2012 - Proceedings. 10.1109/GREENS.2012.6224255.

[18] Gorlatova, Maria & Inaltekin, Hazer & Chiang, Mung. (2018). Characterizing Task Completion Latencies in Fog Computing.

[19] Aldossary, Mohammad & Djemame, Karim. (2016). Energy Consumption-based Pricing Model for Cloud Computing.

[20] Soni, Aishwarya & Hasan, Muzammil. (2017). Pricing schemes in cloud computing: A review. International Journal of Advanced Computer Research. 7. 60-70. 10.19101/IJACR.2017.729001

[21] Aazam, Mohammad & Huh, Eui-nam. (2015). Fog Computing Micro Datacenter Based Dynamic Resource Estimation and Pricing Model for IoT. 687-694. 10.1109/AINA.2015.254.

[22] Ab Rashid Dar, Dr. D Ravindran, "Fog Computing: An Extended Version of Cloud Computing", unpublished

[23] http://www.internetlivestats.com.

[24] Stephen, Raju & Arockiam, L. (2018). RIAIDRPL: Rank Increased Attack (RIA) Identification Algorithm for Avoiding Loop in the RPL DODAG. International Journal of Pure and Applied Mathematics. 119. 1203-1209.

[25] Dr. D Ravindran, Ab Rashid Dar, "Cloud Based Resource Management with Autoscaling", 2016 IJSRSET, Vol. 2, No. 4, pp.758

Authors Profile

Ab Rashid Dar received his Bachelor's, Master's and Master's in Philosophy degrees in Computer Science from the University of Kashmir, Baba Ghulam Shah Badshah Shah University, and Bharathidasan University respectively. He is presently pursuing PhD in Computer Science at St. Joseph's College (Autonomous) an affiliated college of Bharathidasan University Tamil Nadu. His current research interests include Scalability, Load Balancing in Cloud Computing, Fog & Edge Computing.

Dr D. Ravindran received his PhD degree in Computer Science from Bharathidasan University, Tamil Nadu. He is working as an Associate Professor and Research Supervisor of Computer Science at St. Joseph's College, Tiruchirappalli, Tamil Nadu. His current research includes Cloud Computing & Virtualization, Mobile & Pervasive Computing, Distributed Computing, Service Oriented Architecture and Virtual Reality. Besides that, He actively is acting as the resource person for various national and international workshops and conferences.