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INTRODUCTION TO THE SPECIAL ISSUE ON RECENT TRENDS AND FUTURE OF FOG AND EDGE COMPUTING, SERVICES, AND ENABLING TECHNOLOGIES

Cloud computing has been established as the most popular as well as suitable computing infrastructure providing on-demand, scalable and pay-as-you-go computing resources and services for the state-of-the-art ICT applications which generate a massive amount of data. Though Cloud is certainly the most fitting solution for most of the applications with respect to processing capability and storage, it may not be so for the real-time applications. The main problem with Cloud is the latency as the Cloud data centres typically are very far from the data sources as well as the data consumers. This latency is ok with the application domains such as enterprise or web applications, but not for the modern Internet of Things (IoT)-based pervasive and ubiquitous application domains such as autonomous vehicle, smart and pervasive healthcare, real-time traffic monitoring, unmanned aerial vehicles, smart building, smart city, smart manufacturing, cognitive IoT, and so on. The prerequisite for these types of application is that the latency between the data generation and consumption should be minimal. For that, the generated data need to be processed locally, instead of sending to the Cloud. This approach is known as Edge computing where the data processing is done at the network edge in the edge devices such as set-top boxes, access points, routers, switches, base stations etc. which are typically located at the edge of the network. These devices are increasingly being incorporated with significant computing and storage capacity to cater to the need for local Big Data processing. The enabling of Edge computing can be attributed to the Emerging network technologies, such as 4G and cognitive radios, high-speed wireless networks, and energy-efficient sophisticated sensors.

Different Edge computing architectures are proposed (e.g., Fog computing, mobile edge computing (MEC), cloudlets, etc.). All of these enable the IoT and sensor data to be processed closer to the data sources. But, among them, Fog computing, a Cisco initiative, has attracted the most attention of people from both academia and corporate and has been emerged as a new computing-infrastructural paradigm in recent years. Though Fog computing has been proposed as a different computing architecture than Cloud, it is not meant to replace the Cloud. Rather, Fog computing extends the Cloud services to network edges for providing computation, networking, and storage services between end devices and data centres. Ideally, Fog nodes (edge devices) are supposed to pre-process the data, serve the need of the associated applications preliminarily, and forward the data to the Cloud if the data are needed to be stored and analysed further.

Fog computing enhances the benefits from smart devices operational not only in network perimeter but also under cloud servers. Fog-enabled services can be deployed anywhere in the network, and with these services provisioning and management, huge potential can be visualized to enhance intelligence within computing networks to realize context-awareness, high response time, and network traffic offloading. Several possibilities of Fog computing are already established. For example, sustainable smart cities, smart grid, smart logistics, environment monitoring, video surveillance, etc.

To design and implementation of Fog computing systems, various challenges concerning system design and implementation, computing and communication, system architecture and integration, application-based implementations, fault tolerance, designing efficient algorithms and protocols, availability and reliability, security and privacy, energy-efficiency and sustainability, etc. are needed to be addressed. Also, to make Fog compatible with Cloud several factors such as Fog and Cloud system integration, service collaboration between Fog and Cloud, workload balance between Fog and Cloud, and so on need to be taken care of.

It is our great privilege to present before you Volume 20, Issue 2 of the Scalable Computing: Practice and Experience. We had received 20 Research Papers and out of which 14 Papers are selected for Publication. The aim of this special issue is to highlight Recent Trends and Future of Fog and Edge Computing, Services and Enabling technologies. The special issue will present new dimensions of research to researchers and industry professionals with regard to Fog Computing, Cloud Computing and Edge Computing.

Sujata Dash et al. contributed a paper titled Edge and Fog Computing in Healthcare- A Review in which an in-depth review of fog and mist computing in the area of health care informatics is analysed, classified and discussed. The review presented in this paper is primarily focussed on three main aspects: The requirements of IoT based healthcare model and the description of services provided by fog computing to address then. The architecture of an IoT based health care system embedding fog computing layer and implementation of fog computing layer services along with performance and advantages. In addition to this, the researchers have

highlighted the trade-off when allocating computational task to the level of network and also elaborated various challenges and security issues of fog and edge computing related to healthcare applications.

Parminder Singh et al. in the paper titled Triangulation Resource Provisioning for Web Applications in Cloud Computing: A Profit-Aware proposed a novel triangulation resource provisioning (TRP) technique with a profit-aware surplus VM selection policy to ensure fair resource utilization in hourly billing cycle while giving the quality of service to end-users. The proposed technique use time series workload forecasting, CPU utilization and response time in the analysis phase. The proposed technique is tested using CloudSim simulator and R language is used to implement prediction model on ClarkNet weblog. The proposed approach is compared with two baseline approaches i.e. Cost-aware (LRM) and (ARMA). The response time, CPU utilization and predicted request are applied in the analysis and planning phase for scaling decisions. The profit-aware surplus VM selection policy used in the execution phase for select the appropriate VM for scale-down. The result shows that the proposed model for web applications provides fair utilization of resources with minimum cost, thus provides maximum profit to application provider and QoE to the end users.

Akshi Kumar and Abhilasha Sharma in the paper titled Ontology driven Social Big Data Analytics for Fog enabled Sentic-Social Governance utilized a semantic knowledge model for investigating public opinion towards adaption of fog enabled services for governance and comprehending the significance of two s-components (sentic and social) in aforesaid structure that specifically visualize fog enabled Sentic-Social Governance. The results using conventional TF-IDF (Term Frequency-Inverse Document Frequency) feature extraction are empirically compared with ontology driven TF-IDF feature extraction to find the best opinion mining model with optimal accuracy. The results concluded that implementation of ontology driven opinion mining for feature extraction in polarity classification outperforms the traditional TF-IDF method validated over baseline supervised learning algorithms with an average of 7.3

Avinash Kaur, Pooja Gupta and Manpreet Singh in the paper titled Hybrid Balanced Task Clustering Algorithm for Scientific workflows in Cloud Computing proposed novel hybrid balanced task clustering algorithm using the parameter of impact factor of workflows along with the structure of workflow and using this technique, tasks can be considered for clustering either vertically or horizontally based on value of impact factor. The testing of the algorithm proposed is done on Workflowsim- an extension of CloudSim and DAG model of workflow was executed. The Algorithm was tested on variables- Execution time of workflow and Performance Gain and compared with four clustering methods: Horizontal Runtime Balancing (HRB), Horizontal Clustering (HC), Horizontal Distance Balancing (HDB) and Horizontal Impact Factor Balancing (HIFB) and results stated that proposed algorithm is almost 5-10

Pijush Kanti Dutta Pramanik et al. in the paper titled Green and Sustainable High-Performance Computing with Smartphone Crowd Computing: Benefits, Enablers and Challenges presented a comprehensive statistical survey of the various commercial CPUs, GPUs, SoCs for smartphones confirming the capability of the SCC as an alternative to HPC. An exhaustive survey is presented on the present and optimistic future of the continuous improvement and research on different aspects of smartphone battery and other alternative power sources which will allow users to use their smartphones for SCC without worrying about the battery running out.

A. Dhanapal and P. Nithyanandam in the paper titled The Slow HTTP Distributed Denial of Service (DDOS) Attack Detection in Cloud proposed a novel method to detect slow HTTP DDoS attacks in cloud to overcome the issue of consuming all available server resources and making it unavailable to the real users. The proposed method is implemented using OpenStack cloud platform with slowHTTPTest tool. The results stated that proposed technique detects the attack in efficient manner.

Mandeep Kaur and Rajni Mohana in the paper titled Static Load Balancing Technique for Geographically partitioned Public Cloud proposed a novel approach focused upon load balancing in the partitioned public cloud by combining centralized and decentralized approaches, assuming the presence of fog layer. A load balancer entity is used for decentralized load balancing at partitions and a controller entity is used for centralized level to balance the overall load at various partitions. Results are compared with First Come First Serve (FCFS) and Shortest Job First (SJF) algorithms. In this work, the researchers compared the Waiting Time, Finish Time and Actual Run Time of tasks using these algorithms. To reduce the number of unhandled jobs, a new load state is introduced which checks load beyond conventional load states. Major objective of this approach is to reduce the need of runtime virtual machine migration and to reduce the wastage of resources, which may be

occurring due to predefined values of threshold.

Mukta and Neeraj Gupta in the paper titled Analytical Available Bandwidth Estimation in Wireless Ad-Hoc Networks considering Mobility in 3-Dimensional Space proposes an analytical approach named Analytical Available Bandwidth Estimation Including Mobility (AABWM) to estimate ABW on a link. The major contributions of the proposed work are: i) it uses mathematical models based on renewal theory to calculate the collision probability of data packets which makes the process simple and accurate, ii) consideration of mobility under 3-D space to predict the link failure and provides an accurate admission control. To test the proposed technique, the researcher used NS-2 simulator to compare the proposed technique i.e. AABWM with AODV, ABE, IAB and IBEM on throughput, Packet loss ratio and Data delivery. Results stated that AABWM performs better as compared to other approaches.

R. Sridharan and S. Domnic in the paper titled Placement Strategy for Intercommunicating Tasks of an Elastic Request in Fog-Cloud Environment proposed a novel heuristic IcAPER,(Inter-communication Aware Placement for Elastic Requests) algorithm. The proposed algorithm uses the network neighborhood machine for placement, once current resource is fully utilized by the application. The performance IcAPER algorithm is compared with First Come First Serve (FCFS), Random and First Fit Decreasing (FFD) algorithms for the parameters (a) resource utilization (b) resource fragmentation and (c) Number of requests having intercommunicating tasks placed on to same PM using CloudSim simulator. Simulation results shows IcAPER maps 34% more tasks on to the same PM and also increase the resource utilization by 13% while decreasing the resource fragmentation by 37.8% when compared to other algorithms.

Velliangiri S. et al. in the paper titled Trust factor based key distribution protocol in Hybrid Cloud Environment proposed a novel security protocol comprising of two stages: first stage, Group Creation using the trust factor and develop key distribution security protocol. It performs the communication process among the virtual machine communication nodes. Creating several groups based on the cluster and trust factors methods. The second stage, the ECC (Elliptic Curve Cryptography) based distribution security protocol is developed. The performance of the Trust Factor Based Key Distribution protocol is compared with the existing ECC and Diffie Hellman key exchange technique. The results state that the proposed security protocol has more secure communication and better resource utilization than the ECC and Diffie Hellman key exchange technique in the Hybrid cloud.

Vivek Kumar Prasad et al. in the paper titled Influence of Monitoring: Fog and Edge Computing discussed various techniques involved for monitoring for edge and fog computing and its advantages in addition to a case study based on Healthcare monitoring system.

Avinash Kaur et al. elaborated a comprehensive view of existing data placement schemes proposed in literature for cloud computing. Further, it classified data placement schemes based on their assess capabilities and objectives and in addition to this comparison of data placement schemes.

Parminder Singh et al. presented a comprehensive review of Auto-Scaling techniques of web applications in cloud computing. The complete taxonomy of the reviewed articles is done on varied parameters like auto-scaling, approach, resources, monitoring tool, experiment, workload and metric, etc.

Simar Preet Singh et al. in the paper titled Dynamic Task Scheduling using Balanced VM Allocation Policy for Fog Computing Platform proposed a novel scheme to improve the user contentment by improving the cost to operation length ratio, reducing the customer churn, and boosting the operational revenue. The proposed scheme is learnt to reduce the queue size by effectively allocating the resources, which resulted in the form of quicker completion of user workflows. The proposed method results are evaluated against the state-of-the-art scene with non-power aware based task scheduling mechanism. The results were analyzed using parameters– energy, SLA infringement and workflow execution delay. The performance of the proposed schema was analyzed in various experiments particularly designed to analyze various aspects for workflow processing on given fog resources. The LRR (35.85 kWh) model has been found most efficient on the basis of average energy consumption in comparison to the LR (34.86 kWh), THR (41.97 kWh), MAD (45.73 kWh) and IQR (47.87 kWh). The LRR model has been also observed as the leader when compared on the basis of number of VM migrations. The LRR (2520 VMs) has been observed as best contender on the basis of mean of number of VM

migrations in comparison with LR (2555 VMs), THR (4769 VMs), MAD (5138 VMs) and IQR (5352 VMs).

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