International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 05 | May 2020 www.irjet.net p-ISSN: 2395-0072

A Review of Emerging Trends in Cloud Computing

Vaishnavie Sangam[1], Rohan Sanghvi[2], Dr. Hemavathy R[3]

[1]*B.E. Student, Dept. of Computer Science and Engineering, RVCE Bengaluru, Karnataka, India*
[2]*B.E. Student, Dept. of Computer Science and Engineering, RVCE Bengaluru, Karnataka, India*
[3]*Associate Professor, Dept. of Computer Science and Engineering, RVCE Bengaluru, Karnataka, India*

Abstract - *The emerging practice of using a network of remote servers for resources including and not limited to data storage, management, compute, instead of a local self managed server or a personal computer is known as Cloud Computing. Cloud computing has an ever increasing set of applications in today's digital world, allowing organizations and individuals alike to outsource the management of all forms of computer resources and infrastructure, and to focus their time and talent on more important tasks. In this paper, we survey different state of art papers on cloud computing to examine recent trends and its impact on the industry.*

Index Terms—abstraction, cloud, networking, compute, inter- cloud

1. INTRODUCTION

Cloud computing is the on demand delivery and management of computer resources and infrastructure such as storage, computing power, databases, network infrastructure, graphical processing units, and so on. Cloud services typically involves an organization that handles and controls all the hardware, software, and the general infrastructure from their data center, making it instantaneously available to their clients when required over the internet.

Before the trend of cloud computing swept the industry, organizations had to purchase and maintain their computer resources themselves, often requiring an IT or infrastructure team in place to handle maintenance. This is an expensive endeavour, as the costs of purchasing, maintaining and provid- ing power to various electronic resources is expensive. These assets also depreciate in value, as electronics fail with time and use, and replacing them adds to the costs of running the company. Add to that the cost of paying a team of engineers to maintain them, and it can far outweigh the benefits. Thus with the advent of cloud technologies and fast internet speeds, cloud computing finds applications in many fields that were previously unable to make use of the advantages of such computer resources by outsourcing their management and bringing down costs drastically by leveraging economies of scale. It has allowed for a myriad of popular tools such as remote file storage(Dropbox, Google Drive, etc), collaborative editing of documents(Google Docs, Microsoft's Office 365 Online, etc), multimedia streaming(Netflix, Amazon Prime Video, Spotify, etc) and many more that are now tied to our daily work flows and are practically unavoidable.

2. LITERATURE REVIEW

Cloud computing came into existence in the early 2000s, and has undergone massive development in technologies and practices with the rise of many vendors such as the AWS EC2, Google App Engine, Microsoft's Azure services, and many more since the mid 2000s. The advent of virtualization has been an enabler for cloud computing, and a lot of research has been dedicated to virtualization and cloud computing. A large number of companies are choosing to converge their data-centers and provision resources from these data-centers for their use as and when required, rather than invest in a large number of on-premise machines. This has allowed data and resources to become accessible from anywhere and has resulted in an increase in productivity.

Nikoley Grozev and Rajkumar Buyya [1] present an overview of using inter-cloud architecture instead of using a cloud computing model where single cloud data centre is used. Unavailability of cloud services can make thousands of customers losing access to the essential resources. Implementation of quick responsiveness to customers is difficult while relying on a single cloud data centre. These problems can be solved by using multiple clouds which provide better Quality of Service, reliability and flexibility. They did research on the current inter-cloud projects facilitating the brokering of different kinds of application across the multiple clouds. They introduced classifications of Inter-Cloud architectures and discussed about the brokering requirements. They also identified that the most academic projects focus on developing inter-cloud federations whereas industry projects provide services/libraries for direct provisioning and scheduling across the clouds.

Volunteer cloud computing is a model in which idle com-putting resources from the users computer or devices can be offered in the cloud which are utilized by the others thereby reducing the operational costs. Alimohammad Shahri and Mahmood Hosseini [2] presents an approach to increase engagement of people towards volunteer cloud computing. Gamification is a technique for increasing peoples' motivation and changing their conduct towards certain tasks in non-game context. Gamification is seen as potential means to increase the people engagement and retention in volunteer cloud computing projects. They also discuss about different classes of volunteers and their characteristics.

Veerawali Behal and Anil Kumar[3] presents performance analysis of the load balancing algorithms in heterogeneous

cloud environment. Load balancing algorithm mainly deals with the management and allocation of new requests to the nodes such that resources are used effectively and to enhance responsiveness. They did comparative study between Round Robin load balancing algorithm and Throttled load balancing algorithm by using cloud analyst simulation tool. They found that Throttled load balancing algorithm fares better with the response time in the heterogeneous cloud environment.

Reliability of the cloud is one of the main concerns while using the cloud for the remote storage and computing purpose. Sifat Ferdousi and Ferhat Dikbiyik [4] present novel techniques for content management in cloud networks and disaster-aware data center placement that can mitigate losses by avoiding the placement in natural disaster-vulnerable areas. They provided a solution called Disaster Aware Dynamic Content Management (DADCM) for content placement and disaster-aware placement of data centre which aims to reduce the overall risk of the cloud network and satisfy Quality of Service requirements.

Cloud of Things is an upcoming area of Research that integrates the two fields of Internet of Things (IoT) and Cloud Computing. Cloud of things aims to move the access points to various connected IoT devices to the Cloud. Mukhtar M.

E. Mahmoud Et al. [5] discuss the different Architectures and platforms that help enable the concept of Cloud of Things. They also discuss applications for the Cloud of Things in the Healthcare sector. They mention the use of various types of sensors (RFID, Heartbeat etc.) which are used to collect the required data. This data is then sent to the cloud for storage and processing. However, since the data is very sensitive and shouldn't be accessible by everyone, the authors propose using fog-computing and moving the data processing closer to the local gateways (Healthcare Providers). They have also identified some key issues in implementation of Cloud of Things namely, Energy Efficiency, efficient data management, data security and privacy and scalability.

Richard Sanders Et al. [6] have developed CloudStore which is a performance monitoring / benchmarking application for different types of cloud deployments. Enterprises use a variety of cloud environments such as public, private or a combination of the two resulting in a hybrid cloud. The application makes use of Apache Jmeter, an open source load generation tool for distributed load generation used for benchmarking. They make use of the concept of dynamic ramp, which refers to gradually increasing the amount of load generated over time, either by the use of multi-threading or by using more machines for load generation. The application also makes use of load balancers. A load balancer is a service provided by the cloud platform which automatically distributes incoming application calls to a pool of servers present behind the load balancer. The application collects a set of performance metrics relevant to the service being tested and stores it in a database in the cloud for access at a later time.

Kasumi Kato Et al. [7] propose a distributed infrastructure to process streams of data for image processing applications by using Ray and Apache Kafka. Ray is used for distributed processing. Ray also functions as the producer for the Kafka system. A producer is an application which pushes data to the Kafka cluster on the cloud. Then the Kafka Streams API is used to perform operations on the data streams present in the Kafka cluster to constitute a complete data stream pipeline that takes images for input, processes them and stores the input back into the Kafka cluster. Kafka is then used as a messaging queue and the processed streams are read by an application known as a Consumer in order to view the output.

Stelios Sotiriadis Et al. [8] have suggested the use of a framework known as Inter-Cloud. The Inter-Cloud acts as a bridge between multiple cloud deployments. This is used for resource provisioning across all clouds connected by the Inter- Cloud and hence it is highly scalable as new clouds could be added with access to the Inter-Cloud on demand. They also go job scheduling across different cloud deployments for resource provisioning to illustrate the same The performance metrics corresponding to the scheduling is also monitored such as execution time, turnaround time etc. Finally they conclude that this framework is a decentralized one and hence offers high flexibility and robustness. As a result the framework can be used to greatly improve the performance of the clouds.

Satyanarayanan (2017) [9] discusses the emergence of Edge Computing as an alternative to cloud computing where the computational resources are placed in close proximity to the source of the data. In the context of cloud computing this may refer to mobile devices or an IoT device that may be connected to the internet. Proximity of the computational resources ensures high availability of the data. It also decreases the latency and provides a high bandwidth to the services located in the cloud. Most of the processing is done on the edge nodes and only a fraction of the data is transmitted to cloud. This also ensures a finer grain control over the transmission of data and protocols can be implemented at the node level. This also solves the problem of insecure data transmissions in cloud.

Zafar et al. (2017) [10] talk about data integrity in cloud based systems and define a taxonomy based on the attributes of the data schema and discuss all aspects of data integrity in terms of data verification and validation, meta data man- agement and deployment scenarios. They introduce the future trends in data integrity schema over cloud and discuss how SLA violations may risk data over different geolocations. It is therefore important to integrate checks for SLA violations in the data schema. In cloud computing based data schema data deletions should be ensured to prevent data breaches. The authors introduce FADE which is version controlled system that provides

assurance of data deletion. In order to improve storage costs there is a need to implement algorithms that prevent deduplication of data and delete any unwanted copies. This should be done keeping the data integrity intact. The cloud service providers must ensure there is no re-outsourcing of client data and provide computational assurance to the customers. At the same time, the data schema should be redesigned to increase the computational and storage efficiency. Lastly, the security of the schema must be high priority task making sure that meta data is tamper evident and using randomness in challenge-response protocol.

In [11] Stergioua et al. (2018) discuss the different ways that IoT and cloud computing may be integrated and discuss the security threats associated with it. They address the issue of traditional IoT devices that were developed using old and unpatched embedded systems that did not take security into consideration. Therefore they suggest two security models that use decoding and amplifying algorithms. These algorithms broadcast their encoded symbols to trusted relays and use a re- coding algorithm to transmit it to the destination while using the RSA algorithm for encryption. They introduce the different ways mobile cloud computing may be achieved highlighting two perspectives: infrastructure based and ad-hoc mobile com- puting based. They discuss the various advantages of cloud computing including its compatibility and scalability. Security issues are prevalent in mobile cloud computing as well and the provider should guarantee a secure cloud infrastructure to their customers. Since most of the mobile cloud computing services are hosted on third party clouds customers should also take measures to secure their application using strong passwords and secure authentication methods. Integrating cloud comput-ing with IoT can be achieved by using the AES algorithm with the two IoT security models that are discussed above. They conclude presenting a comprehensive algorithm that would help in the integration of the two technologies and also provide a secure communication path between them.

Varghese et al. (2018) [12] discuss the effects of changing cloud computing infrastructure on areas such as Big Data computing and Service Space highlighting the shift from traditional single provider data centers. They introduce the idea of a Federated cloud model that integrates the features of public and private cloud models as well as the multi-cloud model making the cloud systems portable and facilitate easy migration for small vendors. This approach will lead to the development of more comprehensive computing architectures that leverage the computing resources towards the edge re- sources. These approaches include Fog Computing and Edge Computing that plant edge nodes near the source of the data rather than in distributed geographical locations. This will require additional efforts to guarantee enhanced security by the service provider to prevent malicious attacks including the Distributed Denial of Service (DDoS) attack that prevents a customer from utilizing the cloud resources. If such concerns are not handled by the provider it may negatively affect the customer trust and impact adoption of integrated cloud techniques. It is therefore necessary to introduce managing strategies for an efficient cloud computing environment.

Wang, Chen et al. (2015) [13] introduce a framework for workload balancing and resource management for Swift, a popular cloud based distributed storage system. They attempt to eliminate bottlenecks in the system and improve utilization by designing workload monitoring and analysis algorithms to recognize under-loaded or overloaded nodes in the cluster. Then the workload is balanced among the nodes by split- ting, merging and/or pair algorithms to regulate the physical machines, and resource reallocation algorithms control the virtual machines on the cloud. Empirical study showed that this framework is lightweight and required no modification to the guest operating system's source code or its storage system. It also tunes the performance of the system and improves resource utilization and reliability of storage system by leveraging live VM migration.

Finally, Boru et al. (2013) [14] introduces an energy-efficient data replication method for data centers in the cloud. In this approach, every data object is stored permanently at the Central Data Base (Central DB) and is replicated in data center DBs and Rack DBs dynamically depending on the access pattern. Failures in data center DBs can be recovered from central DB, and likewise the central DB can be recovered from the data center DBs on failure. This approach implements a dynamic replication strategy to improve both availability and the QoS of cloud applications. It ensures only an optimal number of nodes are maintained, and hence decreases the energy and bandwidth consumption of the system. In addition, this technique also improves quality of QoS due to the reduced communication delays. Moreover it also improves communication delay and network band-width between geographically dispersed data centers as well as inside of each data center.

3. CONCLUSION

It is evident that the ever growing paradigm of cloud computing is transforming how organizations and businesses operate around the world. By outsourcing the management of hardware and software resources, they tremendously reduce the cost and man hours spent on self-hosting and managing such resources, and allow organizations to spend time and money on more important needs. Cloud computing today has grown to be easy to use and cost efficient, with services such as DigitalOcean, Microsoft's Azure services, Amazon's AWS and Google's GCP providing cloud computing services at ever reducing prices. The purpose of this review paper was to highlight the state of art and trends in cloud computing, and provide a sense of direction to where it is heading in the near future. In this paper we've discussed emerging trends and techniques, such as Inter-cloud networks, Volunteer cloud computing, resource optimization on the cloud, workload management and various other techniques.

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BIOGRAPHIES

Vaishnavie Sangam, B.E. (RVCE, VTU), Department of Computer Science and Engineering. She is an enthusiastic student exploring many concepts of Computer Science including Software Development, Database Management, Machine Learning.

Rohan Sanghvi, B.E. (RVCE, VTU), Department of Computer Science and Engineering. He is an passionate student exploring many concepts of Computer Science including Machine Learning, Artificial Intelligence, Neural Networks.

Dr. Hemavathy R, B.E, M.Tech. Ph.D (VTU), Associate Professor, Department of CSE, R. V. College of Engineering, Bangalore, She has 18 years of teaching experience. Research on Computer Vision, Machine Learning, She has guided many UG, PG students. Worked on research and consultancy projects. Authored more than 15 journals, ISTE, IEEE member.