A Comprehensive Solution to Evaluate the Performance of Openstack Cloud Platform for E-Governance

Dr. Bhushan Jadhav[1][a], Dr. Arun Kulkarni[2][b], Dr. Nikhilesh Joshi[2] and Prof. Sonali Jadhav[3]
[1]*Department of Artificial Intelligence and Data Science, Thadomal Shahani Engineering College, Bandra, Mumbai, India*
[2]*Department of Information Technology, Thadomal Shahani Engineering College, Bandra, Mumbai, India*
[3]*Department of Computer Engineering, Thadomal Shahani Engineering College, Bandra, Mumbai, India*

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Abstract: The evolution in Information and Communication Technology (ICT) has made enormous digitalization in every one of the parts over the globe. In E- governance, this digitization has profoundly changed the method for connections among citizens and governments. Because the government is responsible for delivering basic contributions and administrations to its citizens and other stakeholders, modernization is essential for improving the administration and efficiency of government activities. The traditional E-governance lacks in computational speed, storage strategies, automation and intelligence in deployment of applications. As a result, modern technologies such as cloud computing, big data analytics, and DevOPs can help them satisfy the exponential demand for e-governance services while also providing additional benefits that were never conveyed. The Openstack is a popular cloud computing platform that has built-in Big data analytics support and DevOPs automation solutions that can meet current e-governance requirements while overcoming the existing challenges. As a result, the purpose of this research paper is to provide a methodology for leveraging the benefits of cloud computing with integrated big data analytics and DevOPs by implementing them over the Openstack cloud platform. This paper has covered all the important aspects of deploying Openstack for E-governance that leverage built-in Big data analytics and DevOPs to facilitates the colossal benefits which were never before. Finally, the paper also covers the implementation and performance analysis of Openstack cloud platform for E-governance using MaaS and juju along with the benchmarking results.

1 INTRODUCTION

The E-governance is nothing but digitalized provisioning of government services over the web that has been expanded powerfully to the public in getting access to their services and products [1]. The main focus of E-governance should be efficient service delivery of E-governance portals and applications to each and every stakeholder stays in urban and rural areas for making E-governance popular among stakeholders. The benefits of E-governance lead to an increase in transparency, effectiveness, less corruption and the convenience of access at low cost [3]. The present E-governance isn't always being broad next to startling mark because of limited funds, infrastructure and other insufficiencies which made the impact on its usage [4]. So, in the beginning, the usage of E-governance was quite limited, but today it has increased, possibly due to various schemes of governments and population [5]. Despite developments in digitization, present technologies are unable to match the current demand for E-governance. So the government needs to look about technological improvements to satisfy the existing demands at lower costs [2].

Cloud computing is a distributed computing approach that allows users to access a shared pool of resources, applications, and services from any connected device, at any time [8]. Rackspace and NASA developed Openstack, an open-source cloud architecture, to promote cloud standards and lays a strong foundation for cloud development. Cloud computing is emerging and demanded technology to address existing problems with computing, whereas big data analytics can overcome constraints in data acquisition, storage, processing, and analytics [6]. It is the most extensively used technology for creating private and public clouds; hence it has the greatest

[a] https://orcid.org/0009-0000-6456-0515
[b] https://orcid.org/0009-0008-7699-8272

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community of developers and contributors who utilize it. [18]. The Openstack and Hadoop are Open source Cloud computing and Big data analytics technologies, which are analogous to each other in most of the aspects. As both the technologies can be run on commodity hardware and compatible with each other, they can be integrated together for saving the infrastructure. As a result, same hardware can be used for performing cloud computing as well as processing Big data over the virtual clusters provided by Openstack cloud [14]. The unmatched benefits provided by integrated Openstack with Hadoop and DevOPs would be mechanism for data capture, storage and processing thus saves the capital expenditure on infrastructure and man- power, facilitates huge storage and highly scalable clusters for data processing etc.

Therefore, the aim of this research paper is to propose an Openstack-based model for E-governance that includes all facets of a modern computing environment. The re-search paper has presented the way to implement and integrate different E-governance services on the top of Openstack platform along with complete validation and testing. Finally, the benchmarking results of Hadoop deployed on Openstack using E-governance data and DevOPs tools deployed on Openstack for automation have been presented. Upon implementation of proposed model, it is expected that the integrated approach of Openstack cloud platforms for e-governance can provides many features such as integrated DevOps tools, software- defined datacenter operations, software-defined storage, software-defined networks, self-healing for failures, automated service provisioning, integrated monitoring of services, high availability, disaster recovery, load balancing, auto-scaling, high security, efficient data processing with insightful analytics, and graph-based analysis which were never before.

2 RELATED WORK

Many researchers have already researched and proposed the need of using cloud computing in E-governance projects. The overall research focuses on justifying the need of technology improvement in the domain of E-governance. Some of them are discussed as follows.

Muzahidul Lalitha, Bhavani Jivandham et al. [6], speaks about the adoption of ICT that can dramatically reduce the corruption from a society and improve the govern-ance. Tamara Almarabeh, Yousef Kh. Majdalawi, & Sasikala P, have emphasised the necessity of E-Governance and how cloud computing can provide integration management with automated problem resolution, control end-to-end security, and assist in budgeting based on actual data usage. On a global scale, cloud designs can help governments eliminate duplicative operations and boost resource efficiency [5, 7]. Pusp Raj Joshi, Shareeful Islam et al., has proposed the strategic framework for integrating cloud computing in E-governance applications [10]. John Carlo Bertot, Heeyoon Choi, emphasised the promises and capabilities of Big Data in transforming digital government services by governments, as well as the importance of the interaction between governments, citizens, and the business division in moving from Smart government to Transformational government [11]. Arun.J Mohamed and Hazaruthin.M suggested the advantages of cloud computing and big data in enterprise applications. They have also outlined two unmistakable and highly clear patterns that are defining enterprise computing, revealing a tremendous lot of potential for a new era of integrated applications [12]. According to Shubham Awasthi and Anay Pathak, the Openstack cloud platform is massively scalable and multi-tenant, with numerous linked services that manage storage, compute, and network resources in the data centre. These services work together to provide an IaaS. The application programme interface (API) facilitates the integration of several services [15]. H. T. Ciptaningtyas, R. R. Hariadi, and Shubham Awasthi et al. have revealed the insights of the Openstack cloud platform, which is massively scalable and multi-tenant, with numerous interconnected services that manage storage, compute, and network resources in the data centre [15], [19]. Jadhav B., Patankar A., Shubham Awasthi et al. discussed the several services launched with the Juno version of Openstack, including Nova, Swift, Horizon, Glance, Neutron, Cinder, Heat, Keystone, Ceilometer, Sahara, and Trove [6],[15].

In light of the research presented above, no researcher has explored the adaptability of cloud solutions for E-governance, as well as their evaluation for production deployment. As a result, the purpose of this study is to propose an Openstack-based model for E-governance that incorporates all features of a modern computing environment, as well as to examine its verification and validation utilizing the Openstack cloud platform.

3 METHODOLOGY

The methodology for proposed research paper carries out different methods to vali-date the

successful implementation of proposed cloud computing and big data analytics enabled E-governance. The methodology involves the following aspects.

3.1 Proposed Model

The proposed model of E-Governance is made up of seven separate layers. Each Layer contributes distinct capabilities to the development of cloud and Big Data enabled E- governance. The proposed model's architecture follows a bottom-up approach, with the lower layer supplying functionality to the upper layer, as illustrated in Figure 1. The proposed Model has seven layers, which are discussed below. The bottom layer of the proposed architecture is the Technology Infrastructure Layer, which outlines the use of infrastructural components such as servers, networks, and storages to build high- performance data centers that will be used for automated cloud service creation and delivery. A data center is a facility that houses IT hardware such as computing devices, storage systems, and networking equipment. Its primary purpose is to keep IT resources up and running with little downtime. [9]. This layer also creates a software-defined data center that leverages a bare metal hypervisor to automate virtual resource deployments.

The Openstack Cloud Deployment Layer is in control of getting resources from the technology infrastructure layer and building an Openstack cloud on top of that [6]. It acquires resources like CPU, Memory, IO, Storage and network from virtualized re-source pool provided by SDDC. The Openstack is built over the supported hypervi-sors like KVM and Xen.

The proposed model's Big data analytics layer is in responsible for collecting, storing, processing, managing, and analysing the massive amounts of data created by various E-governance websites. The proposed approach incorporates a big data analytics layer into the Openstack cloud platform using the Openstack Sahara Project. The Sahara project is the Hadoop data processing module within the OpenStack that enables organisations to create Hadoop clusters or run Big Data analytics applications in the cloud [7]. Various NOSQL databases can also address the Big Data problem. The Openstack Trove component includes many NOSQL databases for capturing, storing, and processing unstructured data supplied by various E- governance websites [17].

The DevOps layer provides various tools to make collaboration between development and operation phases in software development life cycle. DevOps in Openstack can fulfill the different stages of software development such as planning, coding, building, testing, releasing, deploying, operating, and monitoring by providing tools such as GIT, Jenkins, Puppet, Ansible, Saltstack, Chef, Docker, Nagios, and Kubernetes [6]. In E-governance, these DevOps steps can help construct sophisticated software products such as web portals and applications fast and easily. The public network layer makes the communication between different stockholders of E-governance using internet while User access layer allows different stockholders of E- governance like citizens, employee, enterprises and other Government departments to access the E- governance services and applications by means of using the different delivery channels and user access devices like Desktop, laptop, mobile, tablets, kiosk etc.

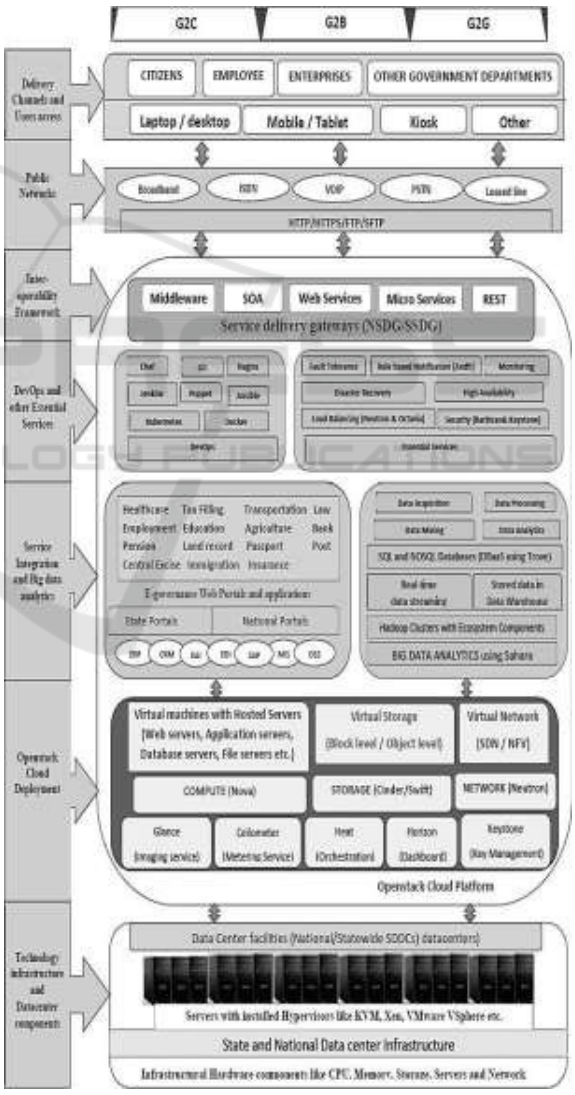

Figure 1: Openstack based proposed model for E-governance.

The Inter-Operability Framework layer is responsible

for delivering different E- governance services to the various stack holders by means of service delivery gate- ways. It uses various Inter- operability standards provided by middleware technologies, web services, SOA, micro Services and REST.

The integrated approach of Hadoop and Openstack cloud platform for E-governance gives many features like integrated DevOPs tools, Software defined datacenter operations, Software defined Storage, Software defined network, self- healing for failures, automated service provisioning, integrated monitoring of services, high availability, disaster recovery, load balancing, auto scaling, high security, efficient data processing with insightful analytics and graph based analysis etc.

3.2 Experimental Setup for Implementing Proposed Model

The experiment for implementing proposed model is conducted on a DELL Studio Workstation Server XPS 9250 with Intel Core m5 X980 processor at 3.3 GHz, 256 GB RAM, Seagate 250 GB SSD, SATA 3Gb/s disk, and 1 Gbps network connection [6]. Here, Ubuntu Linux version 21.10 64-bit distribution is used for the deployment of Openstack Mitaka release with the help of MaaS and juju. [9]. Metal as a Service (MaaS) is used for data centre management (DCM) by automating MaaS in combination with Juju, can easily model and deploy complex environments and has optimized provisioning for production hardware. The default services deployment of Openstack MaaS using juju is shown in Fig. 2. Once Openstack is deployed the required VMs for Web server, Application Server, Database Server etc. can be deployed using Openstack dashboard Horizon. The Hadoop clusters can be created by installing Sahara Component over the compute node using Juju. On the top of Hadoop using HDFS, the E-governance multi variety data can be restored for testing purpose. In this way, the proposed model can be deployed over Openstack.

4 RESULTS AND DISCUSSION

The performance of proposed model over the Openstack is tested over the three test cases. The test case one calculates the response time and average speed over the standalone machine and Openstack VM, test case two calculates the execution time between Hadoop deployed on Standalone system and Openstack Sahara cluster with same configuration while test case three test the performance between two databases deployed on Openstack like Mysql and Hadoop Hbase by comparing the execution time and average latency between them.

4.1 Test Case 1

The compute performance of Openstack is tested by calculating response time and average speed over the physical server and VM over the Openstack server [13]. For testing the performance the hardware configuration used for both are kept same. The response time of the proposed system is calculated by recording the time taken by standalone machine and Openstack VM to perform read operation with different file size shown in Fig. 3.

Figure 2: Deployment of Openstack MaaS using juju.

From Fig. 3, it is seen that the Virtual machine running over Openstack gives better response time in performing read operation over different file sizes.

The average speed is calculated by counting the IOPS by transferring the file be- tween standalone system and Openstack based cloud Virtual machine which is shown in Fig. 4.

From Fig. 4, it is seen that the average speed for performing IO operations over Openstack cloud is performing well in all the aspects.

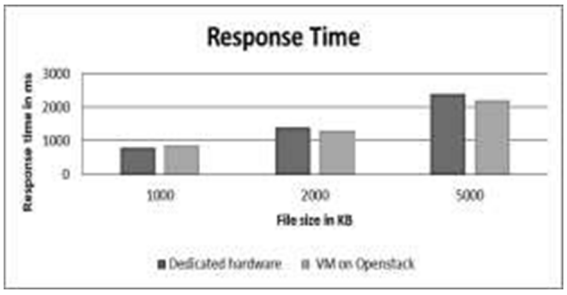

Figure 3: Response time for dedicated hardware and VM Openstack.

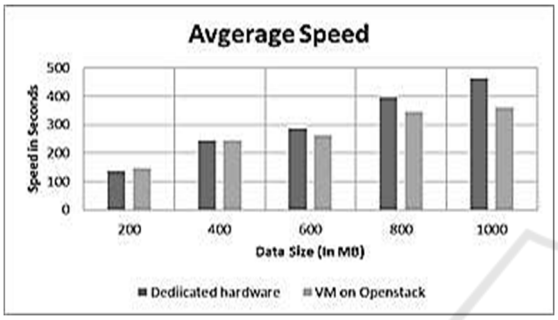

Figure 4: Average Speed for dedicated hardware and VM Openstack.

4.2 Test Case 2

In this test case, the performance of Hadoop system over the proposed model is tested by calculating the execution time for two Map- reduce programs like Word count and Sorting. The execution time is calculated by recording the time between Hadoop running on dedicated hardware and Hadoop running on Openstack cloud platform with same hardware configuration [14].

The execution time for the sort program is recorded with three input datasets of size 100 Kb, 1 Mb and 100 Mb. The time command is used to calculate the elapsed time of a map- reduce operations. The output of above command calculated over the dedicated Hadoop deployment is shown in Table 1.

Table 1: Execution time for sorting by dedicated Hadoop deployment.

Input Size 100KB		Input Size 1MB		100 MB	
real	0m14.544s	real	0m16.621s	real	0m41.080s
user	0m1.045s	user	0m1.033s	user	0m1.111s
sys	0m0.094s	sys	0m0.102s	sys	0m0.126s

Similarly, the execution time for Hadoop over the Openstack cloud in proposed E- governance model with same hardware configuration is recorded which is shown in Table 2.

Table 2: Execution time for sorting by proposed Hadoop deployment.

Input Size 100KB		Input Size 1MB		100 MB	
real	0m14.652s	real	0m15.648s	real	0m40.211s
user	0m1.103s	user	0m1.094s	user	0m1.115s
sys	0m0.106s	sys	0m0.155s	sys	0m0.153s

The Fig. 5 Shows the comparative analysis of execution time between dedicated Hadoop deployment and Openstack integrated Hadoop deployment in proposed model.

Figure 5: Evaluation of execution time for sorting.

From Fig. 5, it is concluded that for smaller input dataset the dedicated deployment works well but as soon as the data size grows the dedicated Hadoop takes more time than the Openstack integrated Hadoop. Likewise the execution time is calculated for Word count program with input size 100kb, 200kb and 5000kb.

The output of Execution time on dedicated Hadoop deployment and Openstack inte- grated Hadoop deployment in proposed model is shown in Fig 6.

Figure 6: Execution time for Word count app by Dedicated and Openstack Hardware.

4.3 Test Case 3

In test case 3, the rural health statistics dataset is

utilized to compare the performance of MySQL with Hadoop's NoSQL database, Hbase [17]. The data set includes healthcare records of numerous residents from rural India [10], [17].

The first test measures the execution time in seconds for MySQL and Hbase by querying a healthcare dataset with varying numbers of records. In MySQL, the show profile command is used to record the execution time. In Hbase, the execution time is presented by default in the query results [17]. Fig. 7 shows a comparison of execution time in Hbase and MySQL . Fig. 7 shows that the MySQL database takes significantly more execution time than the Hbase database.

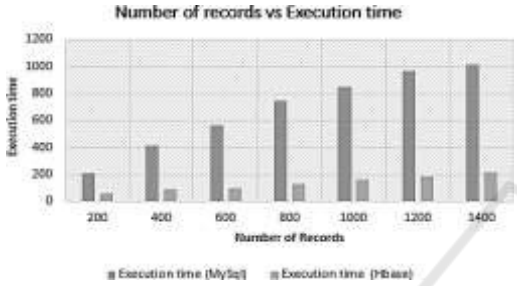

Figure 7: Execution time in Mysql and Hbase.

The second test records the average latency generated by Mysql and Hbase databases using Mysql's built-in performance schema and Hbase latency command given below [17].

$hbase .regionserver.fsReadLatency_avg_time

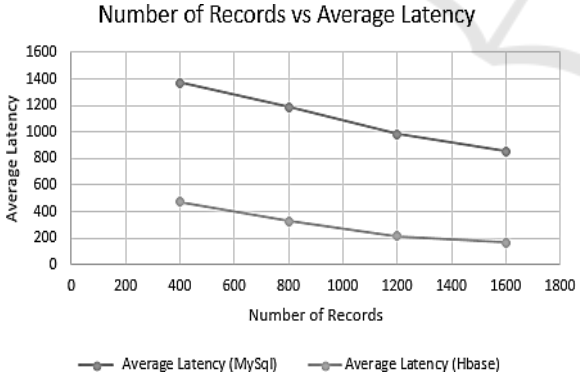

Fig. 8. Evaluation of Average Latency in Mysql and Hbase.

Figure 8 shows the comparison of average latency between Hbase and MySQL. It shows that the MySQL database has a higher average latency than Hbase [17].

4.4 Benchmarking Results

The benchmarking results of Openstack cloud platform are calculated over bench- marking tool Rally installed on the controller node of the Openstack. The Rally is an Openstacks Open source benchmarking tool that automates and monitors the Open- stack deployment for benchmarking & profiling [11].

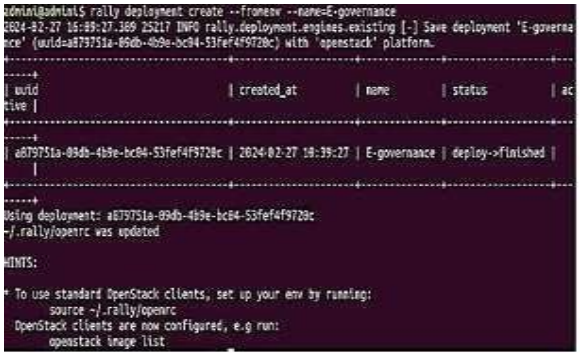

Figure 9: Rally deployment command on Openstack.

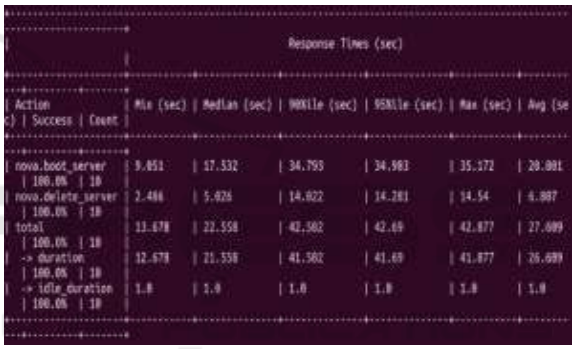

Figure 10: Response time for boot and delete instances.

It tells you how Openstack per- forms in a load at scale. It can be used for validating the performance tests and benchmarking the deployment over the pluggable benchmark scenarios provided by Rally [12]. The Rally has big ecosystem of cooperative services which notifies when something fails or performs slowly or does not scale [13]. The Rally benchmarks can be calculated over the Cloud compute node using various built-in scenarios. To de- ploy a benchmark, the rally deployment create command is used which is shown in Fig 9.

The Rally task start command calculates the response time for deployed scenario with parameters like boot server and delete server instance is shown in Fig. 10. After executing the task start command, the benchmarking report in html format is generated and can be seen using task report command shown in Fig. 11.

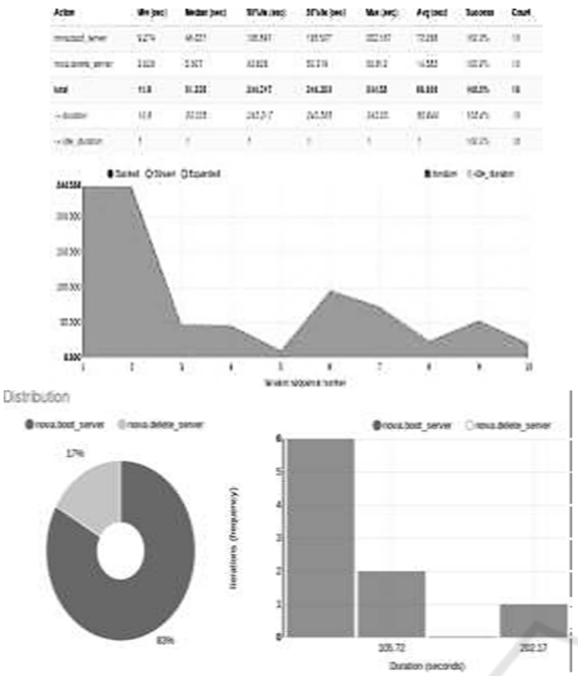

Figure 11: Rally Benchmarks for Nova Instances.

Similarly detailed statistics for creating and booting a nova instance can also be seen using rally start over soon as shown in Fig 12. The benchmark for above scenario is depicted in Fig. 12.

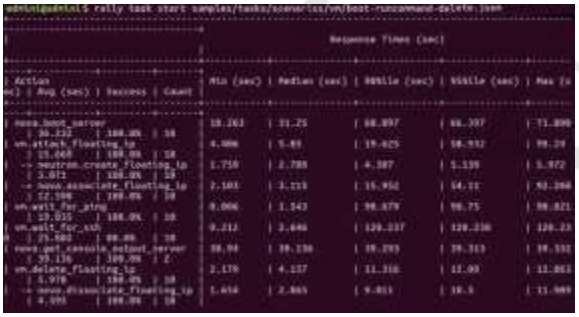

Figure 12: Rally statistics for creating and booting a nova instance.

Figure 13: Rally deployment scenarios.

Likewise for each scenario the benchmark results can be calculated. The different benchmark scenarios provided by rally are depicted in Fig. 13.

From above benchmarking results, it has been observed that, Openstack cloud platform gives better benchmarking results than the other private/public cloud platforms in terms of load testing, responsiveness, storage deployments and the scalability.

5 CONCLUSION

In this way, it is concluded that the Openstack based proposed model for E- governance benefits governments in all the aspects. The coupling between Openstack cloud platform and Hadoop framework gives the unique solution for E-governance practices and offer plethora of features which can be customized profitably. The efficiency and effectiveness of the proposed model is tested by implementing it over the MaaS and juju deployment of Openstack. The deployment results using different test cases conclude that response time and average speed of Openstack cloud platform for E-governance gives faster computing power as well as Hadoop deployment gives minimal latency and better execution time than existing deployments. The benchmarking results demonstrates the Openstack for E-governance is faster in provisioning and releasing cloud resources using faster boot and delete response time. By implementing the Cloud enabled E-governance, Government may get tremendous accomplishment in every aspect on account of unexceptional advantages like cost reduction in service delivery, improved interaction between the government and the stakeholders, eliminated manual processing in government offices by automation, faster service delivery, efficient processing of applications, location independence, reduction in corruptions, and ease of access. These benefits of E-governance attracted most of the governments in developed and developing nations to leverage it for effective government operations.

Finally, we can conclude that the Openstack cloud platforms for E-governance can provides many unique features which were never before such as high availability, disaster recovery, load balancing, auto-scaling, high security, integrated DevOps tools, self-healing for failures, efficient data processing with insightful analytics, and graph-based analysis etc.

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