International Journal of Transcontinental Discoveries (IJTD)
Volume 8, Issue 1, January-December, 2021
Available online at: https://internationaljournals.org/index.php/ijtd

Reducing Infrastructure Costs Via Cloud Automation and Infrastructure as Code (IaC)

Arun Kumar Reddy Goli

Independent Researcher, Cloud/DevOps Engineer

Article history: Received: 27 March. 2021, Accepted: 24 April 2021, Published online: 22 May 2021

ABSTRACT

The cloud automation and Infrastructure as code are providing improved management of IT infrastructure. The purpose of the study is to examine the role of Cloud Automation and IaC in reducing costs of the infrastructure. The study is using both quantitative and qualitative data from secondary sources to reach results. The explanatory design has been used. The findings are revealing the enhanced efficiency and cost reductions gained through the applications. There is efficient management of resources with automation and IaC. The development of robust security policies, training of employees and the cost analysis has been recommended for its implementation. The study has established the relevance of the application in saving costs.

Keywords: Cloud automation, Infrastructure as Code, Cost-efficiency of Cloud Automation, Challenges of Cloud automation, Cost Reductions of Infrastructure as Code

INTRODUCTION

A. Background to the Study

Nowadays, technology plays a major role in companies delivering their goods and services. Earlier, handling servers, storage, and networks involved a lot of manual effort, and this often resulted in higher costs, ineffectiveness and mistakes by staff. Due to cloud computing, automation, and Infrastructure as Code (IaC) have become important tools that allow users to scale and automate the management of their infrastructure [1]. AWS, Azure and Google Cloud use automation to give out resources as they are needed by users. With IaC, organisations can write the structure of their infrastructure as code and then apply version control, testing and fast deployment.

B. Overview

The Study focuses on the benefits of using both cloud automation and Infrastructure as Code, which include saving money and making operations more efficient. Dynamic provisioning and de-provisioning of resources is done through cloud automation to respond to and support demand. By using code with IaC, organisations can make their infrastructure more consistent, faster and easier to reuse [2].

Due to this, network users do not need to manually configure things, and companies rely less on large IT teams. Organisations are able to launch their products faster, encounter less downtime and use only the necessary resources. Moving away from fixed infrastructures to flexible and automated ones allows companies to handle expenses better and improve their operation, which saves them money in the long run.

C. Problem Statement

A lot of organisations face expenses from infrastructure costs because they do not manage resources well, still use manual configuration and purchase more than they need. General infrastructure models tend to result in wasted resources, delayed installation and more expenses for day-to-day operations [3].

The challenges also occur, which shows manufacturing inefficiency is worse when the demand in the market keeps changing. If automation and well-defined infrastructure practices are not in place, companies often have to deal with delays, downtime and costly problems. The solutions that perform well and can easily grow to handle more work with greater precision and less help from people. This study explores how using automation in the cloud and IaC can handle these issues and let modern IT teams run their infrastructure flexibly and affordably.

International Journal of Transcontinental Discoveries (IJTD)
Volume 8, Issue 1, January-December, 2021
Available online at: https://internationaljournals.org/index.php/ijtd

D. Aim and Objectives

The aim of the study is to analyse how making use of cloud automation and IaC can optimise expenses and workflow in modern IT areas. The objectives are: 1. To investigate how cloud automation impacts the expenses for infrastructure. 2. To measure how Infrastructure as Code boosts how fast and consistently a project can be deployed. 3. To identify challenges and the best solutions for applying automation and IaC in different organisations.

E. Scope and Significance

The scope of this study is to reveal the cost-cutting and practical gains that come with using cloud automation and IaC in organisations. It teaches about major cloud services, tools for automation and frameworks for IaC, which are essential for managing IT infrastructure nowadays [4]. The significance of the study points out that with automation and infrastructure built and managed using code, much of the manual work, scaling and accurate deployment tasks are taken care of by the systems. Organisations may achieve savings and more flexibility when competing in digital areas.

LITERATURE REVIEW

A. Impacts of cloud automation on the expenses for infrastructure

Cloud automation effectively impacts infrastructure expenses by optimising resource utilisation, streamlining operations, and decreasing manual efforts, leading to cost-effectiveness and improved performance. IaC and other cloud tools have made a wide difference in IT expenses. IaC creates an opportunity to automate and standardise costs [5]. Businesses with IaC automate infrastructure setup, configuration, and administration using programming, and thus, it is cost-effective. Additionally, with the help of IaC such as Terraform, AWS CloudFormation, and Azure Bicep, companies can ensure their environments are the same, and scaling becomes easier. For example, Netflix automates its wide AWS infrastructure with IaC and custom scripts, which helps both with agility and cutting costs [6].

Automation further makes it seamless to adjust resources immediately, avoiding additional demands. These systems perform well in areas such as e-commerce or streaming services, where the level of traffic changes with the utilisation. Furthermore, using AWS Lambda and Azure Functions in a cloud-native way makes servers unnecessary, thus reducing the required hardware.

B. Measuring How Infrastructure as Code Boosts Deployment Speed and Consistency

IaC or “Infrastructure as Code” effectively increases deployment speed and ensures consistency by initiating automation and configuration related to the infrastructure resources. This has been obtained with the incorporation of code to describe and manage infrastructure, leading to consistent and repeatable deployments. IaC speeds up the process of launching projects and makes processes more consistent by providing the infrastructure through the use of machine-readable code. IaC is the DevOps practice of describing complex and usually cloud-oriented deployments through “machine-readable code” [7]. The use of CI/CD reduces mistakes and makes deployment faster, which is significant in agile and DevOps work. Development and operations teams can edit infrastructure definitions and application code in the same tools and versions due to IaC. Due to this feature, users can track down changes, reverse them if needed, and check the history, all important for complying with regulations and finding bugs.

Tools such as Terraform, AWS CloudFormation, and Ansible enable team members to build infrastructure in a way that can easily be repeated and controlled by versions across several sites. Hence, environmental aspects stop the frequent problem of working on one developer's system only. Deployment speed improvements are best measured using DevOps metrics such as the time it takes to adapt code, how often deployment happens, and the average recovery time. Thus, IaC makes it easier to adjust infrastructure and decrease costs [8]. The more configuration drift drops, the fewer deployments fail, and the greater the success rate in CI/CD pipelines, the more consistent things are. Using IaC, teams can deploy their infrastructure quickly and consistently, encourage rapid changes, decrease the chances of errors, and promote teamwork in the cloud-native world.

C. Challenges and Solutions for Applying Automation and (IaC)

While IaC and automation have several advantages such as faster deployments, cost-effectiveness, and others, companies observe major challenges in their integration.

Knowledge and skill gap is a common threat faced by companies. For IaC to be implemented, the team needed to have coding, version control, and cloud architecture skills. Many traditional IT teams do not have these DevOps skills, which

results in inefficient scripts and poor upkeep. ***Difficulty in hiring skilled staff*** is the leading concern preventing many companies from using IaC [8]. On the other hand, "disagreement in confidentiality agreement" as a challenge led to the failure of IAC [9]. This is also significant to highlight the challenges of tool sprawl and complicated integration. Since several tools such as Terraform, Ansible, and AWS CloudFormation are available, companies find it problematic to choose the right tool and incorporate it into their current CI/CD workflows.

Security and governance issues also become important, mostly in industries that are regulated. Poorly configured IaC code can result in website security issues if it is not planned and assessed correctly. If coding standards and access controls are not applied the same way, the infrastructure is at greater risk.

Companies can offer ***extensive training*** to help staff learn automation, and how to use scripts, and cloud tools to deal with these issues. ***GitOps practices*** help by letting the code for infrastructure be stored, reviewed, and launched straight from Git repositories [10].

Due to tools such as ***Sentinel***, users can make sure policies are being fulfilled and maintained. Moreover, if IaC is conducted in a modular form that can be used again, teams have better control over organising complex infrastructure.

METHODOLOGY

A. Research Design

This study makes use of an ***explanatory research design*** to analyse how cloud automation and IaC help blockchain technology decrease its infrastructure costs. It works to relate causes and check how technologies play a role in affecting both cost and efficiency. IT practices are made easier to understand, and solid advice is given for improving infrastructure management.

B. Data Collection and Analysis

Secondary qualitative and quantitative data are used to study. There is qualitative data collected from industry reports and academic journals to explore Security-by-Design and threat modelling concepts. This entails quantitative data which is about the analysis from the graphs, charts and statistical data of reputable sources as well as providing the measurement of API vulnerabilities and attack trends in order to give a comprehensive understanding of its security landscape.

C. Case Studies/Examples

Case Study 1: Netflix – Auto-Scaling with Terraform

Netflix runs a streaming platform across the world that demands very reliable and strong infrastructure. For this purpose, it adds AWS cloud services to the mix along with using Infrastructure as Code tools, among them, Terraform. Automation on Netflix enables it to create and adjust cloud resources to meet the current user demand quickly [11]. Canadian Dream employs auto-scaling, so it does not need to use unused resources, which saves on infrastructure expenses. The company also utilises Spinnaker to make its regular software updates go faster with more consistency. All these features help Google save money, calculate results faster and manage systems more smoothly, even with millions of users.

Case Study 2: Airbnb – Standardised Deployments with Chef

The system used by Airbnb to support accommodation around the world is based heavily on cloud computing. To make its infrastructure more manageable, Airbnb began using Chef, which is widely known among Infrastructure as Code tools. Chef allows to manage servers, update applications and manage environments with scripts. Using this approach, Airbnb makes sure that its infrastructure is always the same in every development, testing and production environment [12]. Using this technology, the company can set up their funds and trading more quickly, thus reducing costs and lowering the risks of mistakes. Chef makes it faster to deploy software, increases a system's reliability and leads to less cloud resource usage and lower operational expenses.

Case Study 3: Google – Cloud Automation with Kubernetes and IaC

Google leads the way in cloud computing by heavily using Kubernetes and IaC to keep its big infrastructure running smoothly. Kubernetes looks after managing containers, while Google Cloud Deployment Manager handles automated and consistent creation of infrastructure [13].

International Journal of Transcontinental Discoveries (IJTD)
Volume 8, Issue 1, January-December, 2021
Available online at: https://internationaljournals.org/index.php/ijtd

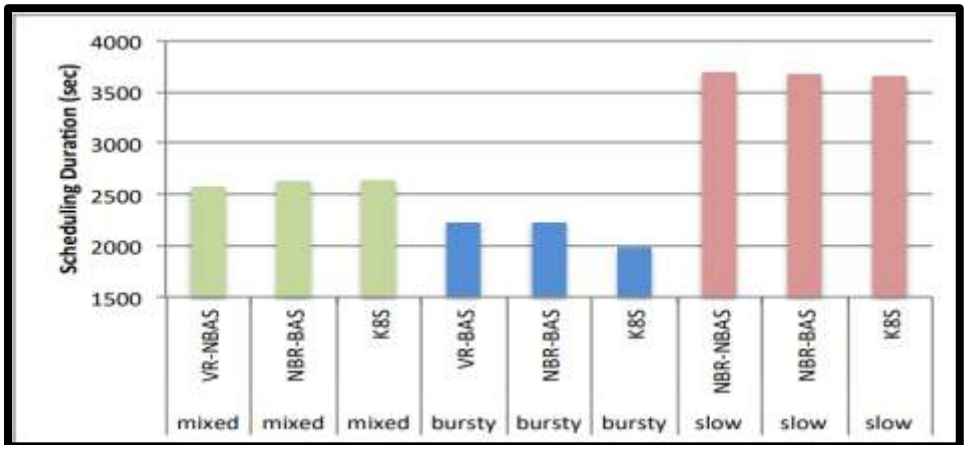
Google can introduce services quickly, use resources efficiently and avoid manual error in the process. Google improves how much it spends, boosts the stability of its systems and speeds up innovation on its worldwide platform by using automation and coded infrastructure.

D. Metrics of Evaluation

During the evaluation, priority is given to whether costs dropped, resources utilised enough, deployments are made, and the system stayed up. Some additional metrics are automation, mistakes in configuration and better scalability. They allow to judge if cloud automation and IaC tools make operations better and allow to do more using fewer resources.

RESULTS

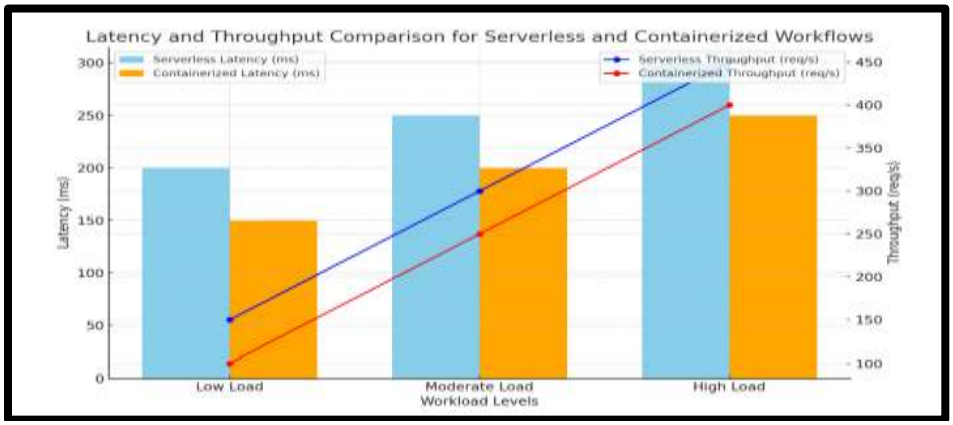
A. Data Interpretation



(Source: [18])

Figure 1: Comparison with Kubernetes Scheduler

The Kubernetes automates and deploys clouds with container applications. The performance of other schedulers has been compared to that of the Kubernetes Scheduler. The scheduling and costs for the Kubernetes comparison reveal its success in executing jobs. The Kubernetes default scheduler is achieving 58% cost reductions compared to the others [18]. Hence, it can be derived how significant cost reductions are possible with the automation of cloud infrastructure across organisations. There are fewer resources needed to enhance the outcomes and optimise workflows. Cloud automation is paving the way for improved results.

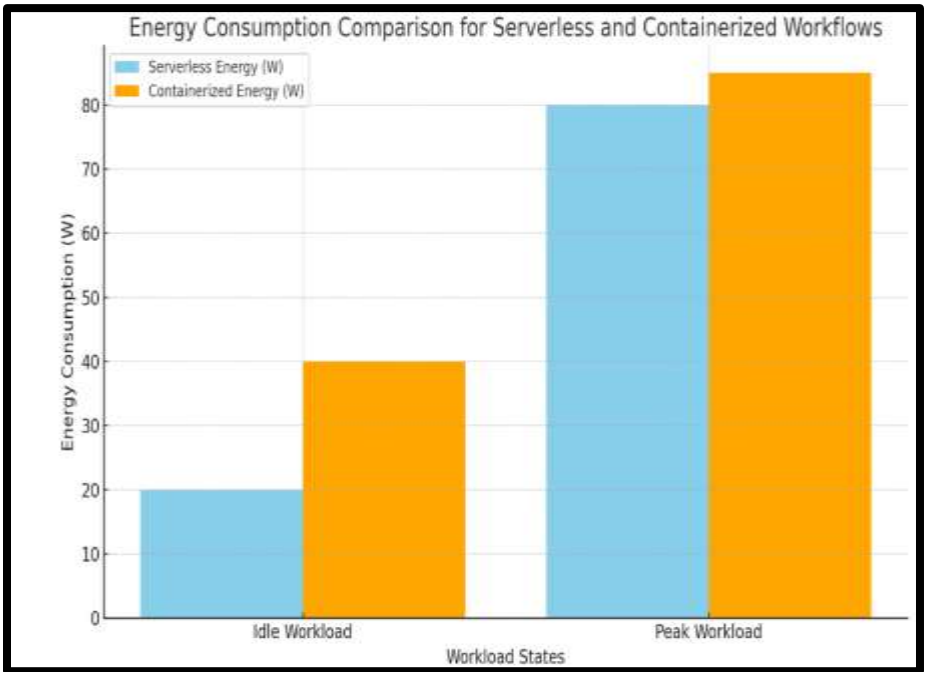


(Source: [19])

Figure 2: Increased throughput on using Kubernetes

International Journal of Transcontinental Discoveries (IJTD)
Volume 8, Issue 1, January-December, 2021
Available online at: https://internationaljournals.org/index.php/ijtd

The figure above reveals how the serverless workflows making use of Kubernetes is experiencing latency compared to serverless workflows. For moderate loads, there is a 25% improvement in latency. For high loads, there is a 14.4% improvement in latency [19]. However, the use of Kubernetes in serverless workflows is enabling them to process 20% more requests under high-demand context. There is dynamic scaling of functions possible with the use of Kubernetes. The graph hence reveals how enhanced throughput is gained with the integration of cloud automation. Cloud automation is supporting the able management of workloads yielding positive results.



(Source: [19])

Figure 3: Decreased energy efficiency

The cloud automation making use of Kubernetes is able to attain 25% energy efficiency [19]. The events-driven model does not make use of resources during idle periods.

Thus, the cloud automation is resulting in increased degrees of efficiency. There is reduced energy consumption during peak workloads as well. The efficient allocation of resources is helping to attain a resilient and energy-efficient workflow. The use of cloud automation processes is improving the companies' productivity.

B. Findings

The analysis reveals how cloud automation is enabling the processes and workflows leading to better functioning. There are 58% cost reductions attained with the use of cloud automation [18].

The streamlining of operations and effective scheduling are impactful in attaining results. There is greater throughput obtained on account of the elimination of manual tasks and effective distribution of workload.

Further, the analysis reveals the increased throughput achieved owing to the dynamic scaling possible through cloud automation. The usage is enhanced with cloud automation. The resource-efficient model ensures that less energy is consumed during the execution. The analysis reveals the validity of cloud automation and IaC in reducing costs with more efficient and balanced processes.

International Journal of Transcontinental Discoveries (IJTD)
Volume 8, Issue 1, January-December, 2021
Available online at: https://internationaljournals.org/index.php/ijtd

C. Case Study Outcomes

Table 1: Case Study Outcome

Case Study	Company	Case Study Outcome	Relevance to Current Research
Auto-Scaling with Terraform	Netflix	Achieved cost savings and efficiency through auto-scaling and rapid updates using IaC [11].	Demonstrates how automation reduces infrastructure costs and improves deployment speed
Standardised Deployments with Chef	Airbnb	Ensured consistent infrastructure and reduced errors, leading to faster, cheaper deployments [12].	Shows how IaC enhances consistency and lowers operational risks across environments
Cloud Automation with Kubernetes	Google	Improved scalability, resource efficiency, and deployment speed using Kubernetes and IaC [13].	Highlights advanced automation and IaC for boosting deployment speed and system reliability

[Source: Self-Created]

Table 1 highlights that companies such as Netflix, Airbnb, and Google benefit effectively from IaC and automation in the cloud, strengthening their effect on cost-effectiveness, operational consistency, and deployment speed around various infrastructures.

D. Comparative Analysis

Table 2: Comparative Analysis

Author	Aim	Findings	Gaps identified
[5]	This article aims to "identify the benefits of adopting IAC for efficient Financial cloud management."	Automation of IaC decreases human error, creates solid teams, and standardises APIs [5].	Lack of primary research
[7]	This article aims to identify "how practitioners develop infrastructural code in terms of good and bad development practices."	The domain of software maintenance and evolution of IaC is in its infancy and deserves further attention [7].	A wide sample size for interview analysis and a lack of a survey.
[8]	This article aims to create "a comprehensive understanding of Infrastructure as Code, from its origins to its current role in modern IT."	Leveraging IaC is core to maintaining a competitive edge in the evolving technological landscape [8].	Lack of primary research
[9]	This research aims "to contribute to the body of evidence in the area of IAC, for the benefit of researchers and practitioners."	The findings highlight that a lack of interest or commitment is the most highly observed threat in the projects [9].	Lack of descriptive research and a wider approach in sample selection.
[10]	This article aims to identify the "role of GitOps as a path of Self-service IT."	GitOps is empowering users to conduct IT operations through PRs [10].	Lack of primary research

[Source: Self-Created]

International Journal of Transcontinental Discoveries (IJTD)
Volume 8, Issue 1, January-December, 2021
Available online at: https://internationaljournals.org/index.php/ijtd

Comparative analysis in the above table supported the aim by highlighting diverse research areas on IaCs, their deployment, and threats, showing gaps and core findings that navigate IaC workflows and cost-effectiveness.

DISCUSSION

A. Interpretation of Results

The results reveal how cloud automation is playing a relevant role in reducing costs. The infrastructure as code using version controls can benefit in terms of reduced errors and faster deployment for the companies. The companies can execute faster operations at reduced costs. The outcomes reiterate the value of cloud automation and IaC in providing strong advantages within any organisation.

There is a reduction of manual errors and efficient use of resources considering the use of cloud automation. The analysis reveals how cloud automation is enabling the workflows to be more efficient. The costs are reduced on account of the cloud automation making use of an events-driven model [19]. There is no usage of resources during the idle period yielding improved results. The entire analysis depicts the reduced costs due to the efficiency in workflows.

B. Practical Implications

One of the potent practical implications is the tangible reductions in costs. Cloud automation is being recognised as being effective in terms of cost optimisation and enhancing productivity [14]. The companies will be obtaining considerable returns with the critical investments made in cloud automation. Organisations can obtain crucial results using cloud automation at strategic points. There can be error-free software development attained and faster deployment of products. The organisations can attain the needed competitive edge with the use of cloud automation. There are enhanced results gained with the impacts of the application.

C. Challenges and Limitations

Cloud automation and infrastructure as costs are providing great benefits to companies. However, there is a set of challenges associated with the implementation. The foremost challenge lies in the designing of a mobile cloud infrastructure that can support critical applications [15]. The workflows can be optimised only with the correct automation suited to their version. There are standards and compliances necessary for deriving benefits from the applications. The Infrastructure Cost is facing security concerns. There is a scope for data breaches and leaks within the system. The limitations can prevent the companies from gaining the expected benefits from the applications.

D. Recommendations

The companies seeking to adopt cloud automation require a systematic approach to tackle the vulnerabilities. The infrastructure costs are a major concern for all applications [16]. The companies seeking to implement cloud automation and infrastructure should reach decisions on the costs associated with cloud computing and the investments needed for securing it.

The sharing of resources can help then companies attain the needed coherence across the workflows [17]. Companies should train employees to apply the tools of cloud automation and infrastructure as costs deriving significant benefits.

CONCLUSION AND FUTURE WORK

The study has strived to assess how cost optimisation has been possible with the integration of cloud automation and infrastructure as cost. The study is revealing how IaC and cloud automation are optimising the workflows and costs for companies.

The fast and consistent deployments of projects is possible with the IaC. The scaling, accuracy and cost-cutting across companies are enhanced with the IaC and cloud automation. The future scope of work lies in determining the frameworks for implementation.

Cloud automation and IaC are facing challenges in terms of infrastructure and security. The analysis of proper security protocols should be the top concern for companies. Future work will aid in overcoming the threats and vulnerabilities in the system.

REFERENCES LIST

[1]. Rahman, A., Mahdavi-Hezaveh, R. and Williams, L., 2019. A systematic mapping study of infrastructure as code research. *Information and Software Technology*, *108*, pp.65-77.

[2]. Guerriero, M., Garriga, M., Tamburri, D.A. and Palomba, F., 2019, September. Adoption, support, and challenges of infrastructure-as-code: Insights from industry. In *2019 IEEE International conference on software maintenance and evolution (ICSME)* (pp. 580-589). IEEE.

[3]. Artac, M., Borovssak, T., Di Nitto, E., Guerriero, M. and Tamburri, D.A., 2017, May. DevOps: introducing infrastructure-as-code. In *2017 IEEE/ACM 39th International Conference on Software Engineering Companion (ICSE-C)* (pp. 497-498). IEEE.

[4]. Schwarz, J., Steffens, A. and Lichter, H., 2018, September. Code smells in infrastructure as code. In *2018 11Th international conference on the quality of information and communications technology (QUATIC)* (pp. 220-228). IEEE.

[5]. Chintale, P., Korada, L., Ranjan, P. and Malviya, R.K., 2019. Adopting Infrastructure as Code (IaC) for Efficient Financial Cloud Management. *ISSN: 2096-3246*, *51*(04).

[6]. Netflix.com, 2020. *Overview of the Company*,Available at:https://about.netflix.com/en [Accessed on: 24th December 2020]

[7]. Guerriero, M., Garriga, M., Tamburri, D.A. and Palomba, F., 2019, September. Adoption, support, and challenges of infrastructure-as-code: Insights from industry. In *2019 IEEE International Conference on Software Maintenance and Evolution (ICSME)* (pp. 580-589). IEEE.

[8]. Chinamanagonda, S., 2019. Automating Infrastructure with Infrastructure as Code (IaC). *Available at SSRN 4986767*.

[9]. [9] Garousi, V., Felderer, M., Fernandes, J.M., Pfahl, D. and Mäntylä, M.V., 2017, June. Industry-academia collaborations in software engineering: An empirical analysis of challenges, patterns and anti-patterns in research projects. In *Proceedings of the 21st International Conference on Evaluation and Assessment in Software Engineering* (pp. 224-229).

[10]. Limoncelli, T.A., 2018. GitOps: A path to more self-service it: IaC+ PR= GitOps. *Queue*, *16*(3), pp.13-26.

[11]. Netflixtechblog.com, 2020, *auto-scaling-production-services* Available at: https://about.netflix.com/en. [Accessed on: 29th November 2020]

[12]. Airbnb.co.in, 2020, *article* Available at: https://www.airbnb.co.in/help/article/1451 [Accessed on: 24th November 2020]

[13]. Cloud.google.com, 2019, *terraform* Available at: https://cloud.google.com/docs/terraform/iac-overview [Accessed on: 20th November 2020]

[14]. Garg, S. and Garg, S., 2019, March. Automated cloud infrastructure, continuous integration and continuous delivery using docker with robust container security. In *2019 IEEE Conference on Multimedia Information Processing and Retrieval (MIPR)* (pp. 467-470). IEEE.

[15]. Stevens, A., Dianati, M., Katsaros, K., Han, C., Fallah, S., Maple, C., McCullough, F. and Mouzakitis, A., 2017, June. Cooperative automation through the cloud: The CARMA project. In *Proceedings of 12th ITS European Congress* (pp. 1-6).

[16]. Villamizar, M., Garces, O., Ochoa, L., Castro, H., Salamanca, L., Verano, M., Casallas, R., Gil, S., Valencia, C., Zambrano, A. and Lang, M., 2016, May. Infrastructure cost comparison of running web applications in the cloud using AWS lambda and monolithic and microservice architectures. In *2016 16th IEEE/ACM international symposium on cluster, cloud and grid computing (CCGrid)* (pp. 179-182). IEEE.

[17]. Li, W., Xia, Y., Zhou, M., Sun, X. and Zhu, Q., 2018. Fluctuation-aware and predictive workflow scheduling in cost-effective infrastructure-as-a-service clouds. *IEEE Access*, *6*, pp.61488-61502.

[18]. Rodriguez, M. and Buyya, R., 2020. Container orchestration with cost-efficient autoscaling in cloud computing environments. In *Handbook of research on multimedia cyber security* (pp. 190-213). IGI global.

[19]. Patchamatla, P.S. and Owolabi, I.O., 2020. Integrating serverless computing and kubernetes in OpenStack for dynamic AI workflow optimization. *International Journal of Multidisciplinary Research in Science, Engineering and Technology*, *1*, p.12.

[20]. Yugandhar, M. B. D. (2020). Digital Operations in Fintech: A Study of Process Automation. International Journal of Information and Electronics Engineering, 10(4), 15-24.

[21]. Chintale, P. (2020). Designing a secure self-onboarding system for internet customers using Google cloud SaaS framework. IJAR, 6(5), 482-487.

[22]. Bucha, S. Integrating Cloud-Based Logistics Solutions: A Strategic Approach For E-Commerce Efficiency.

[23]. Venna, S. R. (2021). Regulatory Operations In Rare Diseases: Challenges And Strategies For Global Submissions Author Name: Sharath Reddy Venna Role: Senior Manager Regulatory Operations/Informatics Affiliation: Leadiant Biosciences, USA. *Available at SSRN 5270768*.