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A Survey of Tools, Techniques, and Best Practices: CI/CD Integration in DevOps Workflows

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Abstract: *The modern software development requires quickness, dependability, and flexibility that are not always provided by traditional methodologies. DevOps, as a collaborative model, has been developed to overcome these challenges by combining development and operations through automation and continuous feedback. This paper provides a detailed discussion of the CI/CD integration in DevOps processes, the tools, techniques, and practices that should be considered in order to improve performance, scalability, and efficiency of automation. Some of Infrastructure as code (IaC), automated testing, performance optimization methodologies, continuous integration and delivery pipelines, and other important topics are discussed in the research. The results show that DevOps implementation enhances software delivery speed and collaboration, and increases system reliability by simplifying development and deployment. Also, the cloud-native approaches like service meshes and micro services architecture are compatible with scalability and resilience even more. In general, this paper highlights that properly executed DevOps principles can help to transform the software delivery process into a fast, automated, and efficient activity that allows organizations to deliver the releases on time and realize operational efficiency.*

Keywords: Cloud Computing, DevOps Practices, Continuous Integration (CI), Continuous Delivery (CD), Cloud-Native Architecture

I. INTRODUCTION

DevOps concept was developed to overcome the lack of connectivity between the software development phase and the implementation of the same software into production in the big software organizations [1]. The primary goal of DevOps is to implement the agile software development lifecycle's foundational principle of continuous software development, which is achieved through microservices and continuous delivery and deployment. More and more software is being delivered online, either directly to the customer's device or through server-side models like Software as a Service. Another development in this area is the widespread use of mobile platforms and technologies that power this software.

Continuous Delivery (CD) is one of the fundamental movements among DevOps. It allows software teams to develop deployable software in short and iterative cycles, which means that new releases are possible at any point with minimal risk [2]. Those organizations that effectively embrace CD have a high level of enhancement in the deployment frequency, lead time as well as system stability. Not all application domains are however easy to implement CD especially where the old architecture and poor automation hamper scalability and uniformity. Most of the studies focus on the build, test and deployment automation but the architectural as well as the organizational issues involved in the adoption of CD are not well researched.

A recent trend named DevOps is likely to help software organizations achieve these objectives. It has been defined that DevOps is an organizational strategy that sought to establish empathy and cross-functional collaboration [3]. DevOps has also been referred to as a" stub on more global company cooperation. DevOps has been defined to achieve the aim of reducing the duration of software development and deployment without sacrificing quality [4]. Agile, scalable, and resilient enterprise system architectures are required because of the dynamic nature of enterprise systems in the digital age. The convergence of artificial intelligence (AI), DevOps, and Datapost is defining cloud-native solutions to redefine the blueprint of most modern enterprise architectures [5]. All these technologies are focused on tackling the problem of

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escalating complexity in business operations by providing simplified business procedures, accelerated innovations, and decision-making abilities.

CI/CD is a technique of releasing applications to customers regularly, through the introduction of automation in the application development stage. The fundamental concepts of CI/CD are continuous deployment and continuous integration. The introduction of CI/CD would be able to enhance the efficiency of the development team, speed up the development process, and improve the quality of the final product [6]. However, there are usually resistive forces that organizations face in the implementation of CI/CD, they encompass things like inefficient operations, sluggish execution, lack of motivation to change behaviour, and the lack of automation. These challenges have the power to disrupt the pipelines delivering products and waste systems resources. Therefore, the consideration of the effects of human factors has made improving software development studies on the efficacy of continuous integration and continuous delivery.

Data pipelines are significant to the machine learning lifecycle because they guarantee the availability of quality data to be used in training and inference. Unchecked pipelines can create inconsistencies in data, biases and ineffective use of resources [7]. The need for strong, automated data pipelines keeps increasing with the increase in the size of AI programs of organizations. Companies are also committing more capital to tools and technologies that qualify data pipeline automation, and hence, workflow efficiency [8]. ML capabilities such as intelligent automation, anomaly detection, and predictive analytics are key to DevOps. For example, ML algorithms can process logs and metrics in real time and detect performance problems before they affect end users.

A. Structure of the Paper

The paper is structured as follows: Section I introduces DevOps and CI/CD concepts. Section II covers key DevOps tools, pipelines, and practices. Section III explains cloud-native environments. Section IV discusses their benefits and challenges. Section V reviews related literature, and Section VI concludes the paper with future directions.

II. DEVOPS CI/CD PIPELINES AND TOOLS

Cloud technology utilizes resources and infrastructure to develop and deploy applications and software, which builds a runtime environment in the shortest time possible. The cloud, therefore, provides an enabler to continuous development and integration where the resources are released on demand to general application life cycle management [9]. When using cloud computing, a company need not be concerned with infrastructure anymore; therefore, any tool required in the development can be purchased in a timely manner. The development process is accelerated and products are supplied on time because of this. Both updates can be completed in a fast and efficient manner.

A. Overview of DevOps Pipelines

The infrastructure DevOps pipeline is used to bring structure to infrastructure management by supporting efficient, scalable, and reliable deployment. Its primary objective is to enable the continuous integration and continuous delivery (CI/CD) of infrastructure changes. Automation provides control over the construction, testing, and deployment of infrastructure changes through the pipeline, enabling faster and more reliable implementations, as shown in Figure 1. Continuous integration enables regular combination and experimentation of updates, whereas continuous delivery helps to set up these changes to the production system smoothly and efficiently.

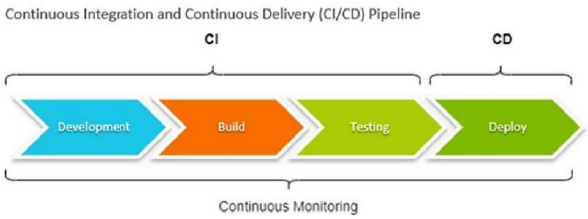

Fig. 1. CI/CD Pipeline

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Continuous Integration (CI)

It is a common practice in software development teams to regularly merge and integrate development tasks, sometimes even many times a day. Software organizations may enhance software quality, boost team efficiency, and establish quicker and more frequent release cycles with the help of continuous integration [10]. In this process, there is automated software building and testing. Whenever a developer makes some changes, an automated building and testing system is initiated, as indicated in Figure 2. This guarantees that any new change does not conflict with the current code, and hence, there is no integration error. Without CI, code developed by different team members can become highly unsynchronized, ultimately affecting quality and performance.

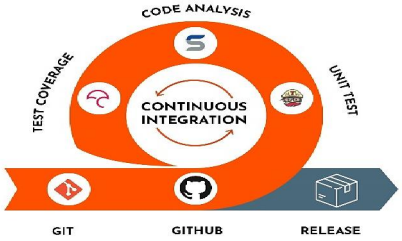

Fig. 2. Continuous Integration Flow

Continuous Delivery

The software engineering method known as continuous delivery (CD) involves many yet brief iterations of the software development life cycle. The cycle's speed and reliability are guaranteed by relying on automation at each stage. It uses a series of procedures to automate software deployment and delivery to a setting that mimics production [11]. Application developers may more easily send updates to the container registry or code repository using the Continuous Delivery (CD) strategy. As can see in Figure 3, it also demonstrates the automated error testing that goes into making these modifications.

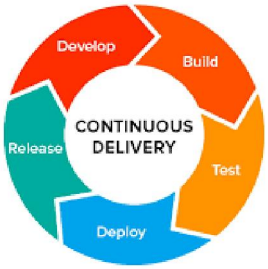

Fig. 3. Continuous Delivery Flow

Continuous Deployment (CDE)

A software engineering method known as continuous deployment involves testing, vetting, and deploying incremental software upgrades to production settings in a continuous fashion (see Figure 4). It is possible to deploy updates to the program within hours after they are made [12]. Agile software development, which emerged in the late 90s and is currently utilized in some form by most businesses, is one of the main advances that have allowed and incentivized continuous deployment.

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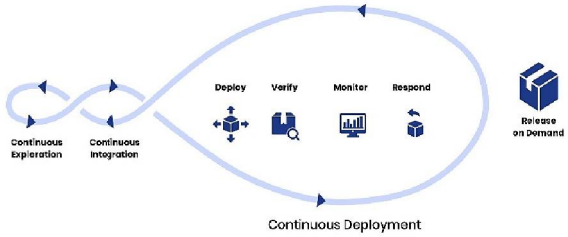

Fig. 4. Continuous Deployment Flow

B. DevOps Tools

The development and operations paradigm is being superseded by DevOps. There has been a paradigm change that unites the operations and development teams. Figure 5 depicts the many components of the DevOps methodology, including a shift in mindset, new approaches to management, and technological resources for implementing best practices.

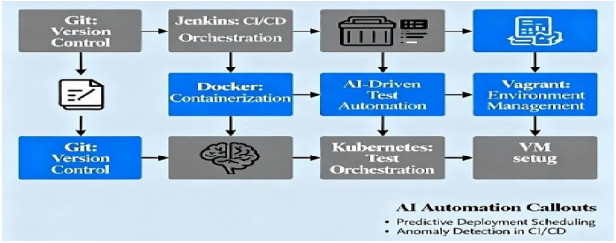

Fig. 5. DevOps Automation Tools

- **VAGRANT:** Vagrant is a platform for creating and managing remote environments for developing applications. It separates the project's settings and dependencies from other projects so they won't interfere with the tools the app uses. By utilizing the same settings as the machine, it may quickly create identical environments on other machines.
- **Jenkins:** Jenkins automates continuous integration and delivery (CI/CD) using an open-source automation server. Its functionality is extended via plugins, enabling build, test, and deployment automation across various languages and technologies [13]. This allows code changes to automatically trigger builds, tests, and deployments, improving efficiency and reliability. Supported by a strong open-source community, Jenkins is a key tool for CI/CD automation.
- **Container:** A program and all of its necessary libraries, dependencies, and other binaries are contained within a container, which serves as a comprehensive runtime environment. The whole lot is included in this bundle [14]. Application and infrastructure dependencies may be eliminated with containerization. Docker is one of the most prominent software firms that helps us develop and bundle apps for deployment.
- **Docker:** Docker is the platform for building Linux containers. A virtualization approach known as Docker employs a Docker engine rather than containers [15]. Virtual machines rely on hypervisors, while Docker facilitates the execution of several programs on a single host computer. Every one of them is executed in its own little container.
- **Git:** Git enables programmers to keep their own local repositories and either pull updates from the central repository or submit pull requests to the central node. Whenever necessary, the previous code version is utilized [16]. Using Git, can also monitor how far along are in the development process. It has the capability to save many versions of source code and restore an earlier version if needed.

The Table I present a comparative overview of CI, CD, and CDE, emphasizing their automation scope, benefits, deployment frequency, dependencies, and distinct roles in enhancing software delivery efficiency and reliability

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Table 1: Comparative Overview of DevOps Pipeline Practices

Aspect	Continuous Integration (CI)	Continuous Delivery (CD)	Continuous Deployment (CDE)
Key Practices	Automated building and testing; frequent code merges.	Extends CI with automated release pipelines up to production readiness.	Fully automates deployment to production without manual approval.
Level of Automation	Automates build and test phases.	Automates build, test, and staging deployment phases.	Automates build, test, staging, and production deployment phases.
Main Benefit	Identifies conflicts and bugs early, thereby improving software quality and team productivity.	Enables fast, reliable releases; reduces human errors; and provides quick responses to feedback.	Delivers changes to users immediately; maximizes speed and agility.
Deployment Frequency	Multiple integrations occur daily, with releases dependent on manual steps.	Ready for release anytime; production deployment may still be manual.	Production deployments occur automatically and frequently (even multiple times a day).
Dependency	Foundation for CD and CDE.	Builds on CI; required for CDE.	Builds on CI and CD; full automation.
Typical Use Case	Any modern software development team.	Teams aiming for frequent, predictable releases.	Organizations need continuous customer-facing updates.
Key Difference	Focus on integrating and testing code.	Adds automation up to staging and release readiness.	Pushes automation through to production deployment.

III. TESTING AND IMPLEMENTATION STRATEGIES IN DEVOPS

The best practices and implementation methods of DevOps place a heavy focus on mechanization, teamwork, and ongoing enhancement. Implementing practices like infrastructure-as-code, automated testing, and CI/CD pipeline execution, and promoting a culture of shared ownership can lead to quicker and more reliable software delivery (Figure 6).

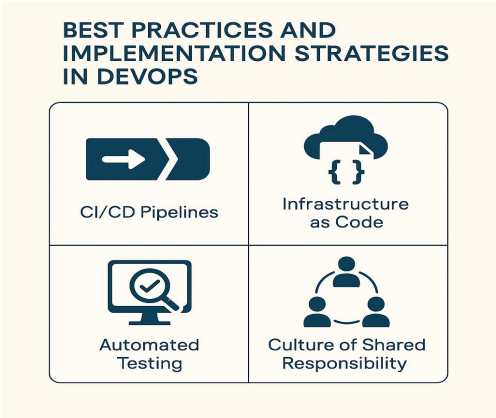

Fig. 6. Practices and Implementation

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A. Best Practices of DevOps

To streamline DevOps pipelines by integrating performance testing, several best practices have been developed. These practices are aimed at accurate and complete performance testing; through these, the organizations are likely to identify and remedy performance problems at the earliest stage and provide quality software systems. The above best practices outline the main approaches to incorporating performance testing into DevOps.

- **DevOps test culture:** In a software company, the culture is crucial for the teamwork involved in testing and analyzing test findings [17]. The preparation and implementation of tests should be handled by a multidisciplinary team. The time, money, equipment, and resources needed to conduct tests may be better planned with the aid of this test architect.
- **Continuous test strategy:** The term "continuous testing" refers to the practice of include testing at every stage of creating software. As a result, the DevOps software development pipeline's necessary test activities are precisely specified in terms of both scope and breadth.
- **End-to-end test integration:** The end-to-end integration is made feasible by integrating the DevOps tests into all levels and phases of the delivery pipeline that is always running. Whenever there is a modification to the continuous delivery process pipeline, these tests are updated accordingly.
- **Test Data Optimization:** Optimizing test data focuses on using minimal, representative, or synthetic datasets. That way, can test all of important situations thoroughly while reducing memory utilization and execution time.

Implementation Strategies for Cloud-Native Systems:

Cloud-native systems have Infrastructure as Code (IaC) to code and manage the physical and virtual infrastructure in a version-controlled code, to provide consistency and repeatability [18]. They also adopt service meshes to manage and monitor service-to-service communication in microservices, improving reliability, security, and observability without adding complexity for developers.

- **Infrastructure as Code (IaC):** The "code (rather than manual commands) for setting up (virtual) machines and networks, installing packages, and configuring the environment for the application of interest" is the core principle of infrastructure as code (IaC). Physical hardware ("bare metal") as well as software-defined networks, containers, and virtual machines are all part of the infrastructure that this code controls. Just like any other software, this code has to go through a development and management pipeline that includes design, testing, and a version-controlled repository for storage [19].
- **Service Mesh:** In microservices architectures, a service mesh acts as an underlying software infrastructure layer that regulates and tracks communication between services. A "data plane" that contains the application code and network proxies is the usual structure, and a "control plane" that allows the application code to communicate with the proxies is also common. Operators ("platform engineers") in this architecture are given additional tools to ensure visibility, security, and stability, while developers ("service owners") are completely oblivious to the service mesh's existence.

IV. BENEFITS AND CHALLENGES OF DEVOPS

Cloud services are provided in cloud computing environments, which makes use of the internet or an internal system [20]. The meaning of trust in an organization is the assurance of the customers of the capabilities of the organization to deliver the demanded services in a reliable and accurate manner [21].

A. Benefits

DevOps is used to assist organizations in developing quicker, more dependable and superior software. They enable them to integrate continuously, conduct automated testing, and release continuously, thus improving release speed, team collaboration, and reducing error rates. DevOps also enhances scalability, efficiency and responsiveness to the dynamic requirements of business.

- **Speed:** Automation helps to quicken the development and deployment processes, and therefore, it enables the team to release features and updates faster.

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- **Reliability:** Automation also eliminates errors on the part of human beings, making the behaviours of the system more stable and predictable.
- **Scalability:** The automated systems are able to cope with more workloads without the proportional rise in manual efforts since they do not interfere with the growth of the business.
- **Consistency:** The uniformity of the deployments is guaranteed with standardized automated processes, and therefore, they reduce differences between the environments.
- **Enhanced Collaboration:** The automation culture promotes a shared responsibility culture between the development and operations teams since it enhances communication and efficiency.

B. Challenges

The IT firms and software products can vary in terms of maturity and implementation, posing challenges on transforming design and implementation within teams and organizations. Therefore, implementing an effective DevOps transformation is not an easy task in itself [22]. DevOps must be more than tooling and automation in practice to actually provide value; merely installing a solution is not enough. DevOps should incorporate culture, process and technology.

- **Data Management:** A notable researched area of cloud computing is cloud data management. The physical security system of the data centres is usually inaccessible to the service providers, hence they need the infrastructure provider to ensure maximum protection of the data [23]. Although in the case of a personal cloud, the service provider can just define the security environment remotely and does not know whether it is being fully applied.
- **Security Concerns:** The fast delivery cycle, utilization of cloud-native computing, and complicated environment present emerging security threats. Conventional security gates are obstacles to swift growth and implementation [24]. It may be difficult to implement a solid security practice further up the DevOps pipeline since it involves a change of mindset and the implementation of new processes and tools.
- **Complexity in Tools Selection:** The needs of every organization are varied, and it is very difficult to choose the best DevOps tools to achieve a successful DevOps strategy. Tools available in the market range from version control systems and automation tools to monitoring and deployment platforms. Therefore, choosing the appropriate toolkit is key to DevOps success.

V. LITERATURE REVIEW

This review of the literature mostly discusses how DevOps approaches and continuous integration and delivery (CI/CD) pipelines contribute to the new software development paradigm. It emphasizes the role of automated pipelines and cooperative working processes in solving the problems of the deployment speed, system maintainability, and the flexibility of the processes.

Gupta et al. (2022) have proven that by utilizing container-based applications, a number of complex CI/CD concerns, such as version control, portability, elasticity, and visibility, may be resolved. More specialized teams may handle particular containers under the modular method, making development easier, faster, safer, and more effective. In this respect, Gi tops—a relatively new area of focus in software development—offers a faster, more efficient, more dependable, and more agile way to optimise performance with a cloud-native applications [25].

Putra and Kabetta (2022) have shown how to implement DevSecops on an a web-based Agile software development life cycle (SDLC) information system created using the Node.js, Dart, Express.js, and Flutter frameworks. The five-stage cycle outlined in this paper consists of continuous development, testing, integration, deployment, and monitoring. The technologies used to achieve this cycle are GitLab and Docker. When compared to the manual process of system development in the past, this approach shortens and streamlines the time it takes to create, test, and deploy [26].

Thobari et al. (2021) adapted the DevOps toolchain—a collection of automated technologies that enable DevOps and CI/CD—to the game development situation. Game construction, Steam deployment, and error reporting are the primary areas of automation for this tool. The DevOps toolchain may optimize several processes and decrease contact costs,

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which can enhance developer productivity by as much as two times, according to user reviews done on innovators and early adopters [27].

Garg et al. (2021) Provided a broader view of the MLOps and DevOps processes, as well as the machine learning lifecycle generally. It delves into the methods and resources utilized to establish continuous integration and continuous delivery pipelines for ML frameworks while utilizing the MLOps methodology. Pull and push deployments in Gi tops are also covered in the conversation. Last but not least, we highlight ongoing research obstacles to help direct future research efforts [28].

Zhao et al. (2020) presented the software engineering community's Cloud DevOps infrastructure and demonstrated its effective use for diverse agents to reproduce research in domains pertaining to computer science. With the help of DevOps, researchers may more reliably communicate the results of their experiments with others by utilizing publicly accessible computer resources in the cloud for studies of a medium size, as well as self-hosted computing engines for massively parallel computing[29].

Rangnau et al. (2020) suggested a way to integrate three types of automated dynamic testing into a pipeline for continuous integration and delivery, and provided an assessment of the associated overhead. The research identifies specific technological and research obstacles the DevSecOps community may face and proposes potential solutions. Decisions on the use of DevSecOps methods in corporate security and agile enterprise application engineering might be based on the results [30].

Zdun et al. (2019) conducted a comprehensive qualitative analysis of 25 practitioner-authored deployment practice descriptions that included informal deployment pipeline models. also produced a well-defined model of designs for deployment pipelines. Furthermore, when contrasted with the pipelines in the original sources that were informally simulated, the formal model significantly improves the modeling precision [31].

Table II provides a summary of the recent works on CI/CD and DevOps with an emphasis on the approaches, tools, and main results. Such challenges are the complexity of integration and scalability, and the future trends are regarding standardization, interoperability, and abatement to a variety of environments.

Table 2: Summary of Previous Study on DevOps CI/CD Pipelines and Practices

Reference	Study On	Approach	Key Findings	Challenges / Limitations	Future Directions
Gupta et al. (2022)	Container-based applications in CI/CD pipelines	Introduced container-based modular development with GitOps integration for CI/CD optimization.	Version control, transparency, flexibility, and portability are all enhanced. Facilitated development that was quicker, safer, and more efficient.	Implementation complexity in large-scale distributed systems.	Enhance GitOps automation and container orchestration for cloud-native systems.
Putra and Kabetta (2022)	DevSecOps integration in Agile SDLC for web-based systems	Streamlined the development, testing, integration, deployment, and monitoring phases of DevSecOps with the help of GitLab and Docker.	Significantly reduced manual effort; streamlined build, testing, and deployment processes.	Limited to web-based applications; scalability not tested on enterprise systems.	Extend DevSecOps practices to other development environments and evaluate performance on larger systems.
Thobari et al. (2021)	Automation tools for DevOps and	Designed a DevOps toolchain to streamline the	Increased developer productivity by 2× due to reduced	Focused only on game development; lacks generalization	Expand the DevOps toolchain framework for

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	CI/CD in game development	process of building, deploying, and reporting errors for electronic games on Steam.	manual interaction and pipeline optimization.	to other domains.	multi-domain software development.
Garg et al. (2021)	Integration of CI/CD in MLOps lifecycle	Compared DevOps and MLOps frameworks, analyzing CI/CD tools and GitOps-based deployments.	Highlighted operational differences between DevOps and MLOps; discussed push and pull deployment strategies.	Implementation challenges in ML model reproducibility and lifecycle automation.	Address automation and reproducibility gaps in MLOps pipelines.
Zhao et al. (2020)	Cloud DevOps infrastructure for reproducible experiments	Proposed using cloud-based and self-hosted computing for experiment sharing in computer science.	Enabled reliable reproduction of research experiments using scalable DevOps infrastructure.	Resource constraints for large-scale computation on limited infrastructure.	Enhance the accessibility and scalability of cloud DevOps environments to support scientific research.
Rangnau et al. (2020)	Integration of automated testing in CI/CD for DevSecOps	Included three forms of automated dynamic testing into CI/CD and evaluated the practical cost.	Recognized critical issues with and potential solutions to integrating DevSecOps into agile systems.	Performance overhead from dynamic testing; complexity of maintaining pipeline stability.	Develop optimized testing techniques with reduced overhead for DevSecOps environments.
Zdun et al., (2019)	Formal modeling of deployment pipeline architectures	Conducted qualitative analysis of 25 practitioner-defined pipeline models and developed formal specifications.	Enhanced precision of deployment pipeline modeling compared to informal approaches.	Focused on qualitative analysis; lacks quantitative validation.	Enhance the formal model by incorporating empirical validation and real-world CI/CD case studies.

VI. CONCLUSION AND FUTURE WORK

The increasing pressure placed on the software industry to deliver swiftly, reliably and within the scope of a scaled environment has led to the necessity of new development practices that would help to emulate the constraints of old practices. DevOps has become a revolutionary methodology that fills the divide between the development and operations, putting focus on automation, development, and improvement. In this work, we have introduced the idea of DevOps using CI/CD pipelines in order to evaluate DevOps's function in modern software engineering. The results also reveal that automation, Infrastructure as Code (IaC), and continuous testing are the key factors to increase the speed of deployment, consistency, and quality of products. Service meshes and microservices are implemented as cloud-native and an addition to make the architectures flexible and resilient. Moreover, DevOps pipelines have performance optimization practices, which guarantee greater reliability and more rapid feedback. All in all, this research shows that CI/CD created on the basis of DevOps do not only help reduce the software delivery but also promote innovation and flexibility, creating a sturdy base on which companies can attain sustainable development in a highly dynamic cyber-

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environment.

Future studies are needed to improve standardization and solve DevOps adoption issues, such as interoperability between tools, data management, and security integration. The research of AI-powered DevOps (AIOps) can help to improve analytics, anomaly detection, and automation. Scalability and performance can be enhanced by developing frameworks of serverless, edge, and hybrid applications and adaptive models of large-scale microservices.

REFERENCES

[1] M. Senapathi, J. Buchan, and H. Osman, "DevOps capabilities, practices, and challenges: Insights from a case study," *ACM Int. Conf. Proceeding Ser.*, vol. Part F1377, pp. 1–11, 2018, doi: 10.1145/3210459.3210465.

[2] L. Chen, "Microservices: Architecting for Continuous Delivery and DevOps," 2018. doi: 10.1109/ICSA.2018.00013.

[3] F. Erich, C. Amrit, and M. Daneva, "A Qualitative Study of DevOps Usage in Practice," *J. Softw. Evol. Process*, vol. 00, 2017, doi: 10.1002/smr.1885.

[4] G. Abbas and H. Nicola, "Optimizing Enterprise Architecture with Cloud-Native AI Solutions: A DevOps and DataOps Perspective," 2018, doi: 10.13140/RG.2.2.15898.04803.

[5] B. R. Cherukuri, "Future of cloud computing: Innovations in multi-cloud and hybrid architectures," *World J. Adv. Res. Rev.*, vol. 1, no. 1, pp. 068–081, Feb. 2019, doi: 10.30574/wjarr.2019.1.1.0002.

[6] Q. Liao, "Modelling CI/CD Pipeline Through Agent-Based Simulation," in *2020 IEEE International Symposium on Software Reliability Engineering Workshops (ISSREW)*, 2020, pp. 155–156. doi: 10.1109/ISSREW51248.2020.00059.

[7] V. M. L. G. Nerella, "A database-centric CSPM framework for securing mission-critical cloud workloads," *Int. J. Intell. Syst. Appl. Eng.*, vol. 10, no. 1, pp. 209–217, 2022.

[8] R. Sinha, "Automation of Data Pipelines in Machine Learning Workflows: Trends, Tools, and Challenges," *Int. J. Artif. Intell. Mach. Learn.*, vol. 17, no. 4, 2017.

[9] A. Chaudhary, M. Gabriel, R. Sethia, S. Kant, and S. Chhabra, "Cloud DevOps CI -CD Pipeline," 2021.

[10] I. Karamitsos, S. Thabit, and C. Apostolopoulos, "Applying DevOps Practices of Continuous Automation for Machine Learning," *Information*, vol. 11, no. 7, p. 363, Jul. 2020, doi: 10.3390/info11070363.

[11] I. C. Donca, O. P. Stan, M. Misaros, D. Gota, and L. Miclea, "Method for Continuous Integration and Deployment Using a Pipeline Generator for Agile Software Projects," *Sensors*, vol. 22, no. 12, 2022, doi: 10.3390/s22124637.

[12] T. Savor, M. Douglas, M. Gentili, L. Williams, K. Beck, and M. Stumm, "Continuous deployment at Facebook and OANDA," in *Proceedings of the 38th International Conference on Software Engineering Companion*, May 2016, pp. 21–30. doi: 10.1145/2889160.2889223.

[13] K. Akshaya, HL; Nisarga, Jagadish S; Vidya, J; Veena, "A Basic Introduction to DevOps Tools," *Int. J. Comput. Sci. Inf. Technol.*, vol. 6, no. March, pp. 1–4, 2015.

[14] C. Singh, N. S. Gaba, M. Kaur, and B. Kaur, "Comparison of Different CI/CD Tools Integrated with Cloud Platform," in *2019 9th International Conference on Cloud Computing, Data Science & Engineering (Confluence)*, IEEE, Jan. 2019, pp. 7–12. doi: 10.1109/CONFLUENCE.2019.8776985.

[15] J. Shah, D. Dubaria, and J. Widhalm, "A Survey of DevOps tools for Networking," *2018 9th IEEE Annu. Ubiquitous Comput. Electron. Mob. Commun. Conf. UEMCON 2018*, pp. 185–188, 2018, doi: 10.1109/UEMCON.2018.8796814.

[16] A. Agarwal, S. Gupta, and T. Choudhury, "Continuous and Integrated Software Development using DevOps," in *2018 International Conference on Advances in Computing and Communication Engineering (ICACCE)*, 2018, pp. 290–293. doi: 10.1109/ICACCE.2018.8458052.

[17] S. Rafi, M. A. Akbar, S. Mahmood, A. Alsanad, and A. Alothaim, "Selection of DevOps best test practices: A hybrid approach using ISM and fuzzy TOPSIS analysis," *J. Softw. Evol. Process*, vol. 34, no. 5, p. e2448, 2022, doi: https://doi.org/10.1002/smr.2448.

[18] A. Sharma and S. Kabade, "Serverless Cloud Computing for Efficient Retirement Benefit Calculations," *Int. J.*

Curr. Sci., vol. 12, no. 4, 2022.

[19] E. Chirivella-Perez, J. M. A. Calero, Q. Wang, and J. Gutiérrez-Aguado, "Orchestration Architecture for Automatic Deployment of 5G Services from Bare Metal in Mobile Edge Computing Infrastructure," *Wirel. Commun. Mob. Comput.*, vol. 2018, 2018, doi: 10.1155/2018/5786936.

[20] V. Verma, "Big Data and Cloud Databases Revolutionizing Business Intelligence," *TIJER*, vol. 9, no. 1, pp. 48–58, 2022.

[21] M. F. Mushtaq, U. Akram, I. Khan, S. Naqeeb, A. Shahzad, and A. Ullah, "Cloud Computing Environment and Security Challenges: A Review," *Int. J. Adv. Comput. Sci. Appl.*, vol. 8, no. 10, pp. 183–195, 2017, doi: 10.14569/IJACSA.2017.081025.

[22] A. Hasan, "A Review Paper on DevOps Methodology," *Int. J. Creat. Res. Thoughts*, vol. 8, no. 6, pp. 2320–2882, 2020.

[23] M. Nazir, "Cloud Computing: Overview & Current Research Challenges," *IOSR J. Comput. Eng.*, vol. 8, no. 1, pp. 14–22, 2012, doi: 10.9790/0661/0811422.

[24] V. Shah, "Managing Security and Privacy in Cloud Frameworks : A Risk with Compliance Perspective for Enterprises," *Int. J. Curr. Eng. Technol.*, vol. 12, no. 6, pp. 606–618, 2022.

[25] S. Gupta, M. Bhatia, M. Memoria, and P. Manani, "Prevalence of GitOps, DevOps in Fast CI/CD Cycles," in *2022 International Conference on Machine Learning, Big Data, Cloud and Parallel Computing (COM-IT-CON)*, 2022, pp. 589–596. doi: 10.1109/COM-IT-CON54601.2022.9850786.

[26] A. M. Putra and H. Kabetta, "Implementation of DevSecOps by Integrating Static and Dynamic Security Testing in CI/CD Pipelines," in *2022 IEEE International Conference of Computer Science and Information Technology (ICOSNIKOM)*, 2022, pp. 1–6. doi: 10.1109/ICOSNIKOM56551.2022.10034883.

[27] A. J. A. Thobari, U. Sa'adah, F. F. Hardiansyah, and R. C. A. Putra, "Toolchain Development for Midcore Scale Game Products through DevOps and CI/CD Approach," in *2021 5th International Conference on Informatics and Computational Sciences (ICICoS)*, 2021, pp. 81–86. doi: 10.1109/ICICoS53627.2021.9651738.

[28] S. Garg, P. Pundir, G. Rathee, P. K. Gupta, S. Garg, and S. Ahlawat, "On Continuous Integration / Continuous Delivery for Automated Deployment of Machine Learning Models using MLOps," in *2021 IEEE Fourth International Conference on Artificial Intelligence and Knowledge Engineering (AIKE)*, 2021, pp. 25–28. doi: 10.1109/AIKE52691.2021.00010.

[29] F. Zhao, X. Niu, S.-L. Huang, and L. Zhang, "Reproducing Scientific Experiment with Cloud DevOps," in *2020 IEEE World Congress on Services (SERVICES)*, 2020, pp. 259–264. doi: 10.1109/SERVICES48979.2020.00058.

[30] T. Rangnau, R. V. Buijtenen, F. Fransen, and F. Turkmen, "Continuous Security Testing: A Case Study on Integrating Dynamic Security Testing Tools in CI/CD Pipelines," *Proc. - 2020 IEEE 24th Int. Enterp. Distrib. Object Comput. Conf. EDOC 2020*, pp. 145–154, 2020, doi: 10.1109/EDOC49727.2020.00026.

[31] U. Zdun, E. Ntentos, K. Plakidas, A. El Malki, D. Schall, and F. Li, "On the Design and Architecture of Deployment Pipelines in Cloud- and Service-Based Computing - A Model-Based Qualitative Study," in *2019 IEEE International Conference on Services Computing (SCC)*, 2019, pp. 141–145. doi: 10.1109/SCC.2019.00033.