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Cloud-Native Applications: Best Practices and Challenges

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Abstract

This report aims at presenting the potential and issues of cloud-native applications as the new generation applications in software development. Microservices architecture, using the concept of containers, and CI/CD have helped in providing flexibility and improved time for the organization needed to deploy the application. However, the report reveals that the applications of microservices have some drawbacks, including- security issues, managing the microservices paradigms, and lack of skilled people. Therefore, the future cloud-native technologies will include artificial intelligence; machine learning; serverless; and security. This paper is beneficial to any organization that wishes to evaluate, design or implement cloud-native environments.

Keywords: *Cloud-native applications, Microservices architecture, (CI/CD)*

Introduction

Cloud native applications are those that have been specifically programmed to take advantage of cloud computing environments for their operation and development paradigms Basic cloud characteristics such as flexibility, scalability, and agility are inherent qualities of cloud native applications. These applications are based on micro-service architecture and containers along with CI/CD to bring new products and features to the market at a faster and more efficient rate. In contrast to monolithic applications where the application is divided into microservices that are designed to work best under cloud platforms like AWS Azure, and Google cloud for maximum service. The increased popularity of cloud solutions in organizations leads to the increased popularity of cloud-native applications for digital transformation. This paper presents the way of creating and utilizing cloud native applications, what obstacles that organizations are likely to encounter, and potential further development of this fast-growing area which aims to assist organizations that are interested in implementing or improving cloud native solutions.

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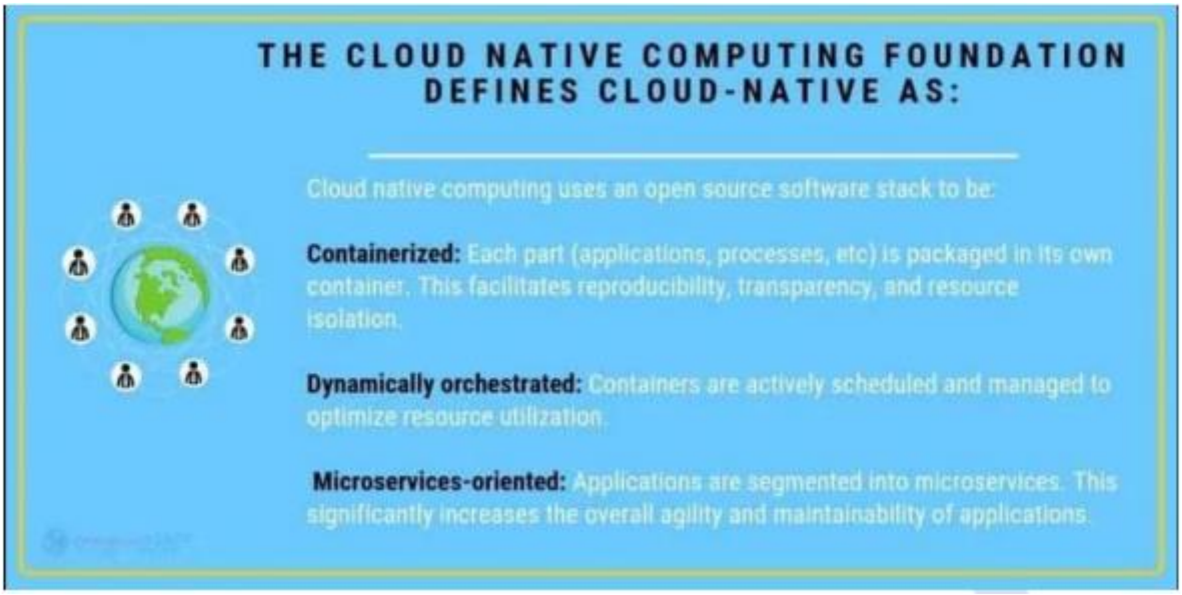
Literature Review

Cloud-Native Architectures: Design Principles and Best Practices



THE CLOUD NATIVE COMPUTING FOUNDATION DEFINES CLOUD-NATIVE AS:

Cloud native computing uses an open source software stack to be:

Containerized: Each part (applications, processes, etc) is packaged in its own container. This facilitates reproducibility, transparency, and resource isolation.

Dynamically orchestrated: Containers are actively scheduled and managed to optimize resource utilization.

Microservices-oriented: Applications are segmented into microservices. This significantly increases the overall agility and maintainability of applications.

Figure 1: definition of cloud-native

(Source: Kanchepu, 2023)

According to Kanchepu, 2023, Modern service-based architectures are based on the new paradigms of development aiming at scalability and system resilience and copied with such fundamentals as microservices, containers, and container orchestration. As an architectural pattern that constitutes the basis of cloud-native architecture, microservices can be described as subdividing an application into small independent services that are responsible for only a limited number of business functionalities. This makes scalability good as well as encourages agility since new features, services or even a new service version can be developed independently as well as deployed and scaled. This is covered by containerization, where the application and all of its requirements are bundled inside a container that may run on different environments and improve the consumption of resources and protection. Containers are used more today and Kubernetes and other forms of the orchestration platform help to manage these containers, they get to deploy, scale the containers and also have to ensure that they are highly available (Ashfin, 2021). Thirdly, new sophisticated solutions emphasize DevOps and continuous delivery, contributing to cultural changes and promoting fast and safe applications delivery. Nevertheless, the question remains on how organizations can overcome various hurdles such as security threats, resistance to change, and governance factors that are still a hindrance to the implementation of cloud native architectures.

Best Practices of Cloud Native Application Development

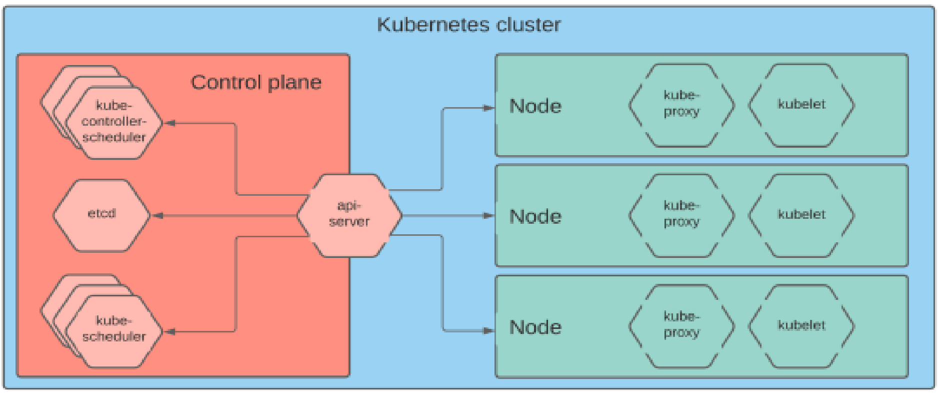


Figure 2: Kubernetes cluster infrastructure

(Source: Kertész, *et al* 2021)

According to Kertész, *et al* 2021, Kubernetes is used frequently as an application container orchestration software because of its contribution to automate container management and increase scalability, load balancing, and supply dynamic scalability in cloud circumstances. The second is the declarative model, which means that the operator defines the state in which the system is to be and Kubernetes is continuously trying to reach that state. As this approach ensures idempotence, p Van Waes and Mahesh Jagannath 2007 several servers can be configured at once and version control is made easier. As represented from the previous surveys, the Kubernetes has gained much popularity improvement; Its usage has witnessed growth after Kubernetes created a 1.0 version in 2015. As a 2020 survey of JetBrains showed, 40% of infrastructure developers involve Kubernetes, and, according to a Stack Overflow 2020 survey, 12.9% of employed working developers work with it. Kubernetes is especially appreciated for flexibility and its open-source code that allows for development of specific solutions and implementation of automation of development cycles (Chelliah and Surianarayanan, 2021). This is due to the fact that it has proven to be quite useful in the management of the cloud applications and structures mainly built in the cloud.

Logging design patterns for cloud-native applications

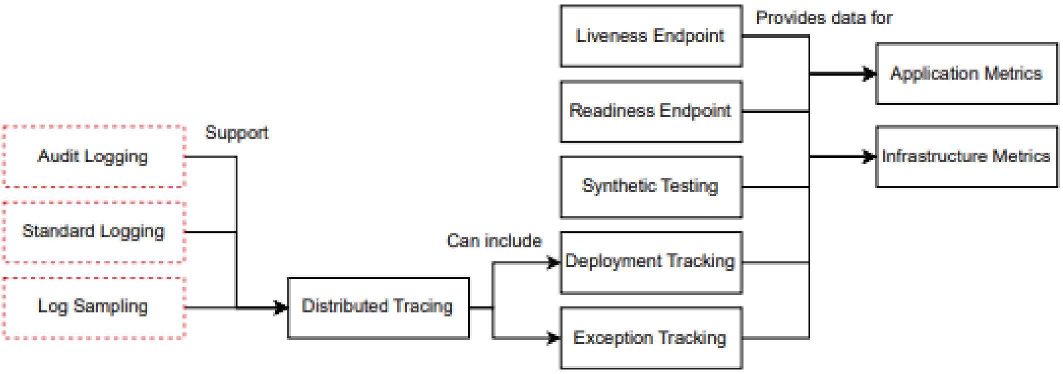


Figure 3: Monitoring design pattern

(Source: Albuquerque and Correia, 2024)

According to Albuquerque and Correia, 2024, Logging holds a very important place in maintaining and supporting cloud-native applications, especially when it comes to monitoring and troubleshooting the system and making it more observable. So, while using numerous services which are located in different clouds, immediate problem resolution becomes critical, and structured logs help achieve this goal. In this paper, three logging design patterns specific to the cloud-native applications include Standard Logging, Audit Logging, and Log Sampling. Standard Logging also suggests that the logging format of a service should be unified to ease its decipherment by bots and people. Audit Logging is therefore the process of documenting important user interactions and system alterations with the aim of meeting compliance requirements and after incident analysis. Log Sampling tackles the issue of using large amounts of log data by focusing and restricting the storage of logs, hence more efficient without using a lot of resources (Oyeniran et al., 2024). The authors of this paper derived these patterns from an analysis of current literature and drawing on current industry standards or best practices while developing this framework for cloud-native logging.

Methods

Research Approach

The research method utilized in this study is the mixed research method that aims to adopt both qualitative and quantitative research methods. The first research question was meant to capture the best practices and the issues related to the creation of applications built from the cloud up. To capture all the necessary information, the study looked into the research papers, market reports, and case studies from organizations that have employed the CN projects. Moreover, inspired by the authors of similar studies, interviews were also conducted with the end-users, namely cloud architects and DevOps (Team, 2024). A literature review process was also conducted for this paper with a view of identifying the leading trends, technologies and frameworks in cloud-native development in order to get both theoretical and empirical perspective of the results.

Cloud-Native Architecture Models

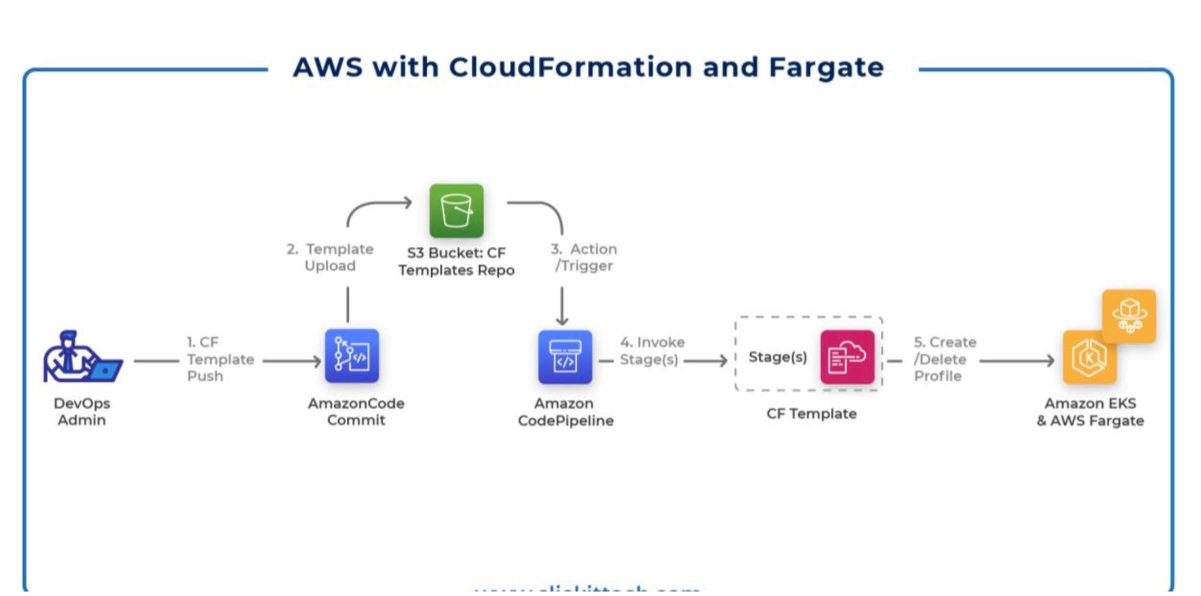


Figure 4: Cloud Native Architecture

(Source: https://images.clickittech.com)

Looking at cloud-native application design, there were two main architectural models taken into consideration; the microservices, and the monolithic architectures. This particular concept is the most foundational structure of cloud-native apps, where the app's services are deployable, scalable and manageable. This paper also assesses the advantages that relate to flexibility, modularity, and capacity to work independently at an enhanced level by specific segments. On the other hand, monolithic architecture applications are assessed in order to illustrate their issues in aspects such as flexibility, integration, and upgrade to cloud contexts. The comparison of these models will help point out why organizations are moving to the cultures of cloud-native and starting to use microservices, containers, and tools like Kubernetes.

Data Collection

Data for this study was obtained from case outreaches with organizations that employ cloud native solutions and from the opinions of adhoc professionals in the same field. Thus, these sources helped to determine the particular difficulties that are faced when using cloud-native approaches and the solutions that are implemented in practice (Indrasiri and Suhothayan, 2021). Moreover, two online surveys were administered to IT professionals and practitioners specifically regarding experiences and perception of best practices and challenges in CNAs. This was achieved to guarantee that both quantitative and qualitative were collected and incorporated in the study hence offer a detailed understanding of cloud-native applications practices and challenges.

Result

Overview of Findings

Cloud-Native Applications
Delivering the best results for your business
Better Customer Experiences
Enhanced Business Continuity
Improved Collaboration
Reduced Development Cost
Streamline IT Infrastructure

Figure 5: Cloud Native Application

(Source: https://www.altexsoft.com)

It also gave substantial information regarding the rate at which different organizations are adopting cloud-native applications. Some of the findings also point to some improvements that come with the cloud native principles adoption which include scalability, time to market and efficiency. Formerly, microservices architecture has become the way to achieve success in enhancing the modularity of applications and its deployment. Specifically, application containers combining Docker and further orchestrations with tools such as Kubernetes, have become popular for the automation of deploying, scaling and managing of CNF applications. It helps ensure that the application remains as similar as possible from the development environment to the testing environment and the production environment hence reducing the amount of time that is taken to deploy the application.

Best Practices Identified

Several best practices were revealed that define cloud-native applications, and that are critical for the effective adoption of such methodologies. The first of these is the microservices architecture to achieve quicker update and scalability of specific components. Finally, the practice of the CI/CD pipeline process was also identified as important as it made the release process faster and more reliable (Alonso et al., 2023). Another important practice is the management of cloud infrastructure utilizing Infrastructure as Code tools like Terraform and AWS CloudFormation, as it decreases the number of possible mistakes during infrastructure configuration. Prometheus and Grafana for monitoring and observability over the cloud-native applications' health and performance were cited as valuable aspects as well.

Challenges Identified

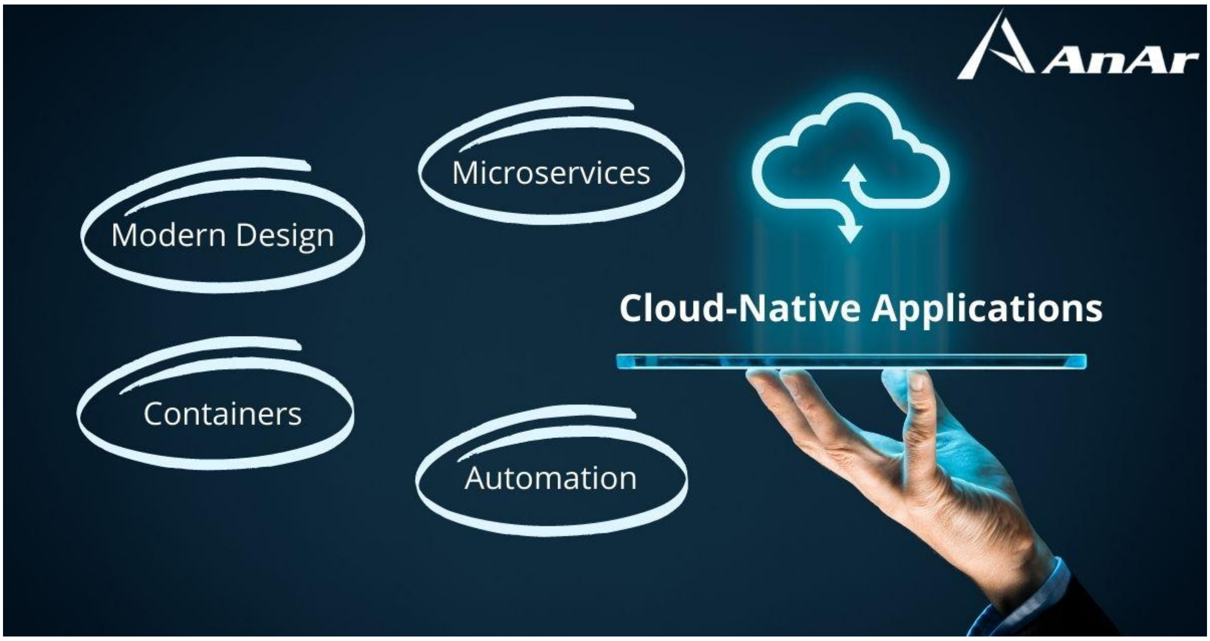


Figure 6: Cloud Native challenges

(Source: https://anarsolutions.com)

However, the study concluded that the organisations have the following challenges when using cloud-native practices. Some issues have arisen and one of them is security considering containerization where misconfigurations of the services are somewhat a risk. Another main disadvantage is that managing ms architectures becomes difficult when many are in deployment, and this could be seen in challenges faced in monitoring, logging, and the debugging of distributed systems. Additionally, cloud-native implementations and information technologies are not easy to understand and require extensive training due to the scarcity of professionals who have extensive experience in this area, thus blocking the effective implementation of these practices by organizations (Telang, 2022). Another one of the issues that appeared critical for using cloud computing include cost management, particularly for massive scale projects.

Discussion

The outcomes of this report are aimed at establishing the importance of cloud-native applications to enhance organizational structures with scalability, flexibility, and enhanced speed in introducing innovations. Microservices has become a standard that goes hand in hand with containerization and orchestration solutions when it comes to the deliverance of application. The practices of DevOps, CI/CD pipelines and Infrastructure as Code have been useful in automating the processes and making them efficient and viable for organizations to embrace cloud-native practices. Issues of security, especially the matters as related to the containers, need constant surveillance, as well as the proper configuration control (Gil, Corujo et al., 2021). Juggling such a vast number of microservices as the number of containers skyrocket means knowing how best to monitor, diagnose issues, and coordinate them on a large scale. Further, there are skilled professionals' scarcity and high cost of implementation as key issues that the organization faces to fully embrace the cloud-native strategies. However, the potential benefits of cloud native architecture realize the value of embracing this technology in an emerging digital environment as a key player to give business a competitive advantage.

Future Directions

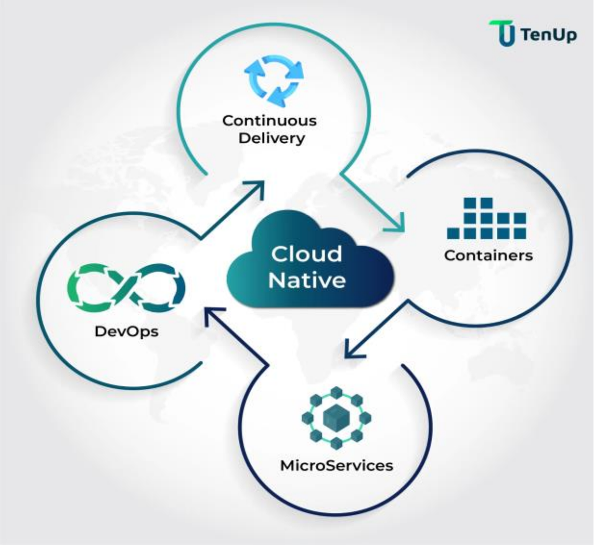


Figure 7: Cloud Native challenges

(Source: https://www.tenupsoft.com)

The future of cloud-native applications is dubious for further evolving in terms of automation, security, and deploying infrastructure. Looking at the future and further advancement of the technologies in AI and ML, it is expected that with advancement of these two technologies, they are expected to significantly assist in automation of deployment and scaling of resources as well as monitoring of cloud-native application systems with even more intelligent ways. The increased use of serverless and edge computing will go further in enhancing performance that will be characterized by low latency and the best processing speeds (Oyeniran et al., 2024). However, there will be new tools and histories to adopt and develop for managing compounds and interconnections of hybrid and multi-cloud cloud-native structures for higher flexibility and reliability.

Conclusion

Cloud native is a relatively new trend in managing applications that provides certain advantages such as flexibility, scalability, and shorter time to market. This paper seeks to address these challenges in greater detail so as to realize how they can be managed through proper practices and strategic planning. Microservices, with containerization, and CI/CD pipeline have become a center for the application of cloud-native architectures in the digital era. Having seen the principle indicated above, it can be safely assumed that as technology keeps on developing, so does cloud-native architectures, allowing businesses to remain relevant in their respective markets. Hence, the better the organizations capable of implementing cloud-native principles and techniques, the more prepared them will be for the future.

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