

“A Comprehensive Study for Green Computing-Based DevOps Process in Agile Delivery Model”

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Abstract–

This paper deals with the review for existing work done in green computing & DevOps process. The paper may help in a bigger landscape of entire software development process models to analyze and implement green computing processes. Green computing inspires people to create software or infrastructure which is planet friendly and emit very less carbon compare to existing technology. These days DevOps is the very common process adopted within software development life cycle to produce the automated infrastructure, to automate the code promotion from non-production to production environments. Agile delivery model helps to deliver the expected client deliverables in terms of smaller release cycle to production so rather than waiting for entire product to get ready and reviewed late in stage the smaller chunks of feature gets verified early and deployed to production following all quality checks and process controls in place. This paper reviews the existing literatures available online to find the scope for the green computing-based DevOps process in the software development life cycle.

Keywords: DevOps, Green Computing, Agile Delivery, Green Agile, Green DevOps

1. Introduction

1.1 Green Computing

From the past decade, a lot of focus has been made over energy efficiency of tools/software practices to achieve the green computing objectives. We also have read a lot about the Data centers which are moving to zero emissions. Mostly by their zero emission they do not mean that they don't emit any pollution to the climate by their software, data centers, technological inventions but by zero emission they mean that they are investing the equal amount of green energy within their business use or giving to the society as a charity work. But it is found that the replacement for existing process followed within software development life cycle are less explored. For example, when we try to find the literatures on implementation of green computing-based DevOps process in Agile delivery model, we could not find much literature. This brings a need of research to be done in these areas. We pick Green computing-based DevOps for our research because this is one of the most common process adopted within all Agile based delivery models. More & more organizations are following DevOps automation to release their codes faster to production, to continuously monitor their infrastructures and doing other repetitive tasks. The ever-growing progression in computing and data innovation proven by the emerging of super computers and tremendous information centers over the different geographic locations had been reported as a contributor of natural contamination, debasement and climate carbon. The characteristic desire of corporates to always have the

competitive edge over peers could be a major factor that clearly obscures the considering of world's corporate executives in regard of the looming perils that will emerge from the unbound expansion of full-scale ICT framework organizations[1]. In recent years, people have noticed the potential growth of green agile research. A large number of publications also clarified the need of DevOps integration with agile methodology. which prompted us to conduct systematic reviews to do analysis to find any risk factors in this process. The outcome could be the unique, and it will help develop a green computing-based DevOps process in agile maturity model [2].

There is less carbon footprint when cloud native applications are used. But we need to identify which all tools can be adopted in keeping the carbon footprint zero or as much minimum possible in Agile Delivery Model for Green computing-based DevOps.

1.2 DevOps

Traditionally in a software development life cycle, there were different team handling the automation in software releases, infrastructure setups, monitoring, capturing metrics etc. With the availability of containerization, creating software release automation, infrastructure as service, software as service etc. many teams were dissolved into one. This one team which now takes care of auto scaling of infrastructure, defining the automation code for continuous monitoring, continuous testing, continuous integration, continuous deployment etc. is now called as DevOps Team. They are a single team involving infrastructure engineers, cloud engineers, automation engineers. Among the software designing exercises, program testing may be a pivotal one which devours more than 50% of add up to taken a toll and time required within the advancement handle. As quality is the critically important for effective conveyance of the program, total testing is always absolutely necessary[3]. Chaos Monkey is an automated schedule job that runs persistently in all the expected Netflix situations, which creates random unavailability of services by arbitrarily shutting the server availability. In this way, whereas composing code, Netflix engineers are continually working in an environment of questionable administrations and startling blackouts. This chaos gives engineers realistic unpredictable failures to test their program in unfavorable conditions, it gives them motivation to build fault-tolerant frameworks. That is the DevOps at its finest: changing the advancement handle along with utilizing mechanization to plan a framework where unpredictable failure conditions favor creating fault tolerant computer program quality. In reaction to making computer program in this sort of environment, Netflix engineers will plan their frameworks to be secluded, testable, and highly resilient against back-end service outages from the start[4].

There is a deployment strategy as Green Deployment which is widely used in release deployments. That feature is generally referred to a unique deployment strategy which keeps two identical production environments. Only one environment of them serves traffic. When deployment happens to one environment then slowly the user traffic is moved from older version to newer version of application to reduce the downtime & risk. This strategy is a deployment strategy and must not be confused with Green computing-based DevOps. DevOps process brings the Agile attitude in the software development project. DevOps include writing the infrastructure as code, Automation for continuous integration, automation for continuous deployment &/or for continuous delivery &/or for continuous testing &/or for continuous monitoring. Agile and DevOps have given the speed and accuracy to deliver the software applications. Particularly, though the Agile focus more one time bound and iterative changes for features of software, the DevOps focus is on automation of required resources to deliver the software features which were developed in Agile iteration, to the Live application. Agile and DevOps techniques deliver the common objective of business contracts for faster and automated software release.[5].

1.3 Agile Delivery Model

In Agile Delivery model, the software project is divided to different Agile Teams. Each of the team then plan the time bound framework to deliver the specific features for planned release of software. It becomes an iterative process until the entire software gets completed in terms of to be delivered with all features. The agile group primarily has three parts: product owner, master and development team. Within the common circumstance, the advancement group individuals require capable for the advancement and test. And in arrange to create their unused highlights or alter portion sends to the client as before long as conceivable, they require an uncommon operations team. In this case, for solving these questions, numerous companies consider adopting DevOps to undertake to move forward the circumstance. DevOps is an improvement approach outlined to bridge the gap between advancement and operations. One good thing about DevOps is the quickened release cycle. With convenient criticism from the end users, program engineers convey items that will be more fulfilling and indeed surprising [6].

The whole software delivery is broken into smaller features and they are delivered iteratively. Each time a release is deployed the build is supposed to deliver the features through planned release by release; the final build will have all the features required by the customer. The Agile planning brings the people from business, operations Team, and Technology team to collaborate very well to identify the potential business requirement, their development planning and release schedule to meet the commonly established goals. To achieve those common goals on time, process has to be streamlined for the development team which include specifically, continuous integration (CI), nonstop delivery (CDE) and continuous deployment (CD), all upheld by cited open-source and restrictive arrangements[7]. Business organizations and ICT firms consider green computing as a fundamentally portion of their in general trade procedures. From the trade and client viewpoint, the most concern is all about advancement of computer program with no effect on climatic change and feasible advancement [8].

2. Objective

The centralized purpose of myreview is to find out how Green computing principles can help in the formulating a sustainable DevOps process in Software development life cycle that very well fits with Agile Delivery model. Which can be accomplished by taking the following small objectives.

- Find minimum common DevOps process which is followed in software development life cycle.
- How Green computing principles can be adopted in the DevOps process to use as a common development process.
- How cloud resources can help in reduction of carbon emission for DevOps in Agile Delivery model.
- How DevOps itself can be self-sufficient to reduce the carbon emission

3. Literature review

After review of different literatures available online in the Green Computing, Agile methodology and DevOps there is a big need for the identification/implementation/ of new framework to achieve all those three clubbed together.

1. The ever-growing advances in computers and data generation have been confirmed by the emergence of large data centers and large information centers around the world have been reported as potential sources of pollution and a major impact on climate change. The competitive corporations could be a major factor that hides openly the perceptions of the world's top executives regarding future risks to emerging ICT organizations. Information Communication Technology (ICT) is playing as a crucial factor in increase of carbon emission. [7]

2. In recent years, people have noticed the potential growth of green agile research. Their agile delivery methods focus more on the immediate delivery of software according to current customer needs without considering its long duration impact on individuals and society. In certain continents, agile maturity may not have attended a maturity level that can better reduce risks as well as can contribute to the development of green computing software development[25].
3. Among the software development activity, the software program testing is also a factor that takes half of the time in overall software development and deliverables. As quality is that the foremost vital model for effective conveyance of the program, total testing is always required to attain it. the various studies conducted amid the past few a protracted time elaborated not because it was the problems of comprehensive testing however furthermore the problems connected with vitality utilization and also the by and huge impact on the surroundings thanks to devoted instrumentation and different framework assets used for testing. In typical take a look at surroundings, the standard administration and testing exercises square measure performed utilizing the devoted natural set-up. This successively alarmingly increments the carbon outflow to the environment [17].
4. Netflix drastically changed their engineering prepare by presenting an apparatus called Chaos Monkey, the primary tools of this chaos monkey series tools was called as Netflix Simian Armed force. Chaos Monkey is a script which gets executed persistently in all Netflix situations, resulting in a chaos to functionality by arbitrarily closing down server occurrences. In this way, whereas composing code, Netflix engineers are continually working in an environment of questionable administrations and startling blackouts. This chaos not as it were giving engineers the special use cases to test their program in startling disappointment conditions, but motivates them to build reliable & fault-tolerant frameworks to form their business as usual work as designers less disappointing. This form the basis offinestDevOps: changing the advancement handle and utilizing mechanization to set up a framework where the behavioral financial matters favors creating an alluring level of computer program quality. In reaction to making computer program in this sort of environment, engineers would be able to build their frameworks to be secluded, testable, and highly resilient against back-end service outages from the start. [3]
5. Agile and DevOps are creating more efficient software delivery plans to deliver the best business objectives. Particularly, the Agile methodology helps to meet the client business objectives by the timely way and with less imperfection rate. These discoveries demonstrate that, the Agile and DevOps strategies have a big say on scope administration, quality administration and efforts which impacts the venture administration process. It is additionally apparent from the survey of writing that, Agile and DevOps techniques have effect on the common obligation, mechanization and input which organizes group structure.[4]
6. The agile group primarily has three parts: product owner, master and development team. Within the common circumstance, the advancement group individuals require capable for the advancement and test. And in arrange to create their unused highlights or alter portion sends to the client as before long as conceivable, they require an uncommon operations team. In this case, for solving these questions, numerous companies consider adopting DevOps to undertake to move forward the circumstance. DevOps is an improvement approach outlined to bridge the gap between advancement and operations. One good thing about DevOps is the quickened release cycle. With convenient criticism from the end users, program engineers convey items that will be

more fulfilling and indeed surprising. Despite DevOps is exceptionally cheerful for dispensing with the hole between improvement and operations.[24]

7. The ever-evolving technology industry presented a big open-source and exclusive solutions to keep the business expectations, IT operations, and software developers all in sync to each other towards the commonly established goals. In turn, as a result of working and collaborating together the unused practices have risen, specifically Continuous integration, Continuous delivery, Continuous deployment i.e. The CI, CD,CDE all upheld by cited open-source and restrictive arrangements. This investigate speaks to an introductory step towards planning and creating strategies for robotized conveyance of assets in a programmable environment, by doing showcase investigate and analyzing related articles to confirm and summarize the current status of CI/CD/CDE [26]
8. Sustainable development is the thought that human society must live and meet their needs without doing compromise with the planet and environment so that future generation can also get all privileges of living in a healthy planet. The Sustainable Advancement Objectives are an all-inclusive call to action to conclusion destitution, secure the planet and make strides the lives and prospects of everybody, all over. Business organizations and ICT firms consider green computing as a fundamentally portion of their in general trade procedures. From the trade and client viewpoint, the most concern is all about advancement of computer program with no effect on climatic change and feasible advancement.[2]
9. The DevOps practice is very basic process oriented and there are specific rules upon which the software organizations can evaluate and make strides towards the DevOps exercises. Consequently, there's an ought to create a planned process for DevOps with a point to help the professionals for execution of DevOps process in computer program firms. The DevOps model which was created was a model derived from the existing process and development and delivery methods in computer program building space, for illustration, computer program prepares advancement preparation demonstrate (SPIRM) and computer program outsourcing merchant status demonstrate (SOVRM).[8]
10. GreenData Innovation and Green Computing methods are basically a source for the sustainable environment with computing and similar innovations such as Database, Mixed media, Communication Technology and so on. Software products, their software processes and systems are exceptionally much vital for their profitable part in our common life and commerce exercises to reduce the carbon emission per se. Software products their process generate a lot of carbon outflow towards the environment. Ever increasing the need of cloud technology, the extensive increases in internet reach, online presence of population are primarily mindful for such aspects against environment.
11. The phenomenal increase in globalization has resulted in large IT infrastructures, software, live streaming, clouds infrastructure. All the increases in those factors is also resulting the huge carbon emission increase. Green Computing” methods advocates the efficient energy utilization and mindful usage of computing resources, software or hardware processes in all factors which are causing the carbon emission increase due to IT or computing process.[20]
12. ICT (Data and Communication Advances) is capable of around 2% around the world greenhouse gas outflows which is comparable of that transmitted by the aircraft industry. Agreeing to the reports, the Interval Board on Climate Alter (IPCC), CO2 outflows due to ICT

are expanding broadly and is dynamically increasing. All things considered, ICT, in permitting to unravel complex issues in other divisions, can significantly and effortlessly take an interest to decrease critical parcel of the remaining 98% of worldwide CO2 emanations. The utilize of computer program suggests equipment operations which are physically mindful of vitality utilization. Thus, computer program is in a roundabout way included within the energy consumption. Thus, we have to be decrease program vitality utilization whereas keeping up the same functionalities for the computer program in arrange to construct economical and green computer program[6].

13. Green computing is the ponder and hone of ecologically feasible computing. Green Computing hones involve creating, mechanizing, utilizing and arranging of computers capably with irrelevant effect on the climate. Green computing can too be named as Go-Green practice that helps reducing the carbon impression. Green computing encourages us to a secure, secure and sound environment for the mankind. [9]

4. CONCLUSION

In conclusion, this review paper has delved into the intersection of Green Computing and DevOps, highlighting their significant impact on modern IT operations and sustainability efforts. The synthesis of these two domains offers a promising avenue for optimizing resource utilization, minimizing environmental footprints, and enhancing software development practices. Several key takeaways emerge from this comprehensive exploration:

1. **Sustainable Synergy:** The integration of Green Computing principles into the DevOps lifecycle can lead to a synergy that fosters sustainable software development and deployment. By conscientiously managing energy consumption, hardware utilization, and software efficiency, organizations can achieve a harmonious balance between technological innovation and environmental responsibility.
2. **Efficiency Amplification:** DevOps methodologies, with their emphasis on automation, continuous integration, and iterative development, are inherently aligned with the goals of Green Computing. This alignment enables efficient resource allocation, reduced waste, and quicker identification of energy-intensive code segments, ultimately contributing to more eco-friendly software ecosystems.
3. **Collaborative Culture:** A successful adoption of Green DevOps necessitates a cultural shift within organizations. Cross-functional collaboration between development, operations, and environmental stakeholders becomes imperative. Teams should be empowered to implement sustainable practices, such as optimizing cloud usage, adopting containerization, and leveraging energy-efficient hardware.
4. **Metric-Driven Insights:** Effective Green DevOps implementation hinges on comprehensive monitoring and measurement of key performance indicators (KPIs). Utilizing metrics such as energy consumption, server utilization, deployment frequency, and mean time to recovery (MTTR) empowers organizations to make informed decisions and continuously improve both environmental and operational outcomes.
5. **Challenges and Future Prospects:** While Green DevOps holds great promise, challenges remain in terms of technical complexity, tool integration, and change management. Future research can

delve deeper into refining best practices, developing standardized metrics, and designing eco-friendly toolchains that seamlessly integrate into DevOps workflows.

The synthesis of Green Computing and DevOps presents an innovative approach to not only improving software development and delivery but also addressing pressing environmental concerns. By fostering a culture of collaboration, embracing efficiency-driven practices, and leveraging advanced monitoring techniques, organizations can embark on a path towards sustainable technological advancement. As the digital landscape evolves, embracing the principles of Green DevOps could lead to a future where technology and ecology coexist harmoniously, benefitting both industry and the planet. Therefore, there is a pressing need to find out if green computing principles and with available related resources can design a sustainable DevOps framework.

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