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BRIDGING THE GAP: INTEGRATING DEVSECOPS INTO AGILE SECURE SOFTWARE DEVELOPMENT LIFECYCLE (SDLC) FOR ENHANCED SOFTWARE SECURITY

Amit Goswami[1], Uday Kumar Manne[2], Hirenkumar Kamleshbhai Mistry[3], Chirag Mavani[4]

Software Developer, Source Infotech[1]

Database Engineer, Adobe Inc[2]

Sr. Linux Admin & Cloud Engineer, Zenosys LLC[3]

DevOps / Cybersecurity Engineer, DXC Technology[4]

Abstract: DevSecOps as a part of Agile Secure Software Development Life Cycle (SDLC) is increasingly significant in the development of secure contemporary applications. Modern business organizations implement Agile development methodologies to increase the speed and flexibility of development processes, but information security is addressed as an add-on or as an optional feature, and applications become easily exposed to various threats. DevSecOps implements security as a part of Development, Security and Operations where the objective is to include security measures in each stage of the SDLC to establish safety measures to minimize risks early. When integrated into the Agile SDLC as a system, DevSecOps can help improve the organization's culture focus on security from the initial stage and not solely during the process's completion. Using DevSecOps and Agile SDLC, this paper aims to provide a guide on how security can be made to run throughout the entire development cycle from the development feeling all the way to deployment, and maintenance. It provides detail overview on how security can be incorporated into the Agile approach, some of the techniques include, security testing, threat analysis and security checking in a continuous integration. Further, with the reference to developers, operation services, and security subsections mean that the security issue has to be a top priority for cross-functional cooperation. Over all the paper also avails strategies in dealing with contentious issues in integration including learning lessons from other organisations and that resistance to change is inevitable and the issue of security management at a large scale. Finally, this research establishes that expanding integration between DevSecOps and Agile SDLC can lead to dramatic organizational gains in software security while enabling the rapid speed of deliver that is vital for companies in the modern digital environment.

Keywords: DevSecOps, Agile, Secure Software Development Lifecycle, Security Integration, Continuous Monitoring

1. INTRODUCTION

Introduction

These days, when it comes to managing software types in the context of software development, the issue of security has risen to prominence with regularity because of the threats arising from cyber threats or data breaches. In the past, security requirements have been implemented toward the end of the software development life cycle hence highlighting the fact that fixing security was extremely expensive and also very time consuming. With the increasing popularity of Agile due to its focus on flexibility and fast delivery, incorporating security into this flexible system is a major issue. This paper aims to explain how the combination of DevSecOps in the context of Agile SDLC is a proper solution for connecting fast application development with a strong security system. The purpose is to show how it can be done to improve the software security without compromising the speed of Agile process. Figure 1 includes the 6 phases of the software development life cycle.

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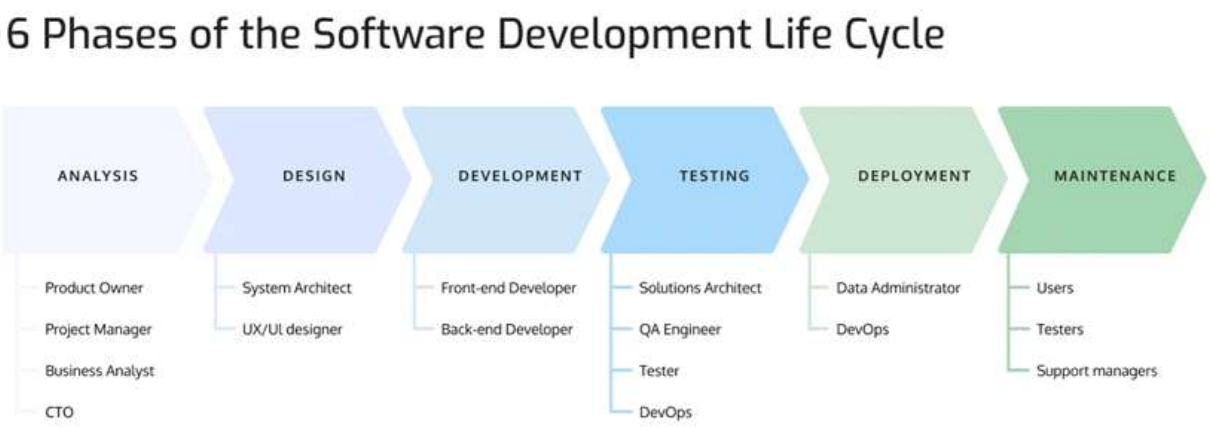

Figure 1. 6 Phases of the Software Development Life Cycle.

DevSecOps combines development, security and operations, the main focus being to incorporate security concerns into the SDLC process. It accepts the fact that development means security monitoring and testing in parallel to omit large amounts of work being done in the end when it is more expensive in terms of time and budget. Agree and DevSecOps work in harmony where it doesn't only increase the speed of app delivery but also integrate security measures at each step of the process. This paper examines the advantages, prospects, technical approaches and management frameworks in connection with the incorporation of DevSecOps into Agile SDLC, which provide guidance to organizations on how best to optimize their SDLC without having to sacrifice security. In figure 2, we have other phases of secure SDLC.

Figure 2. 7 Stages for Secure SDLC

1.1 The Importance of Security in Agile Development

Agile development maintains an extreme emphasis on getting software out 'frequent and often. However, this focus can be disadvantageous since it leads to bypassing or delaying some security steps which makes systems exposed to attacker's presence. The current traditional security procedures are normally applied as an added-on process at the later stages of the SDLC, which does not conform to the nature of agile projects. Security cannot be an afterthought and needs to be implemented right from when development is being conceived. Due to this realization, agile teams need to understand that security is a never-ending and a combined process. Coordinating an operational plan from the beginning insulates the vulnerability against the risks of the last-ditch security measures.

In addition, Agile teams are confronted with increased volatility of project requirements scope, features and time-lines. These rapid iterations usually mean little time is left for security testing and assessments — these gaps can easily be forgotten. Integrated security means they do not miss it altogether; instead, they include it within the Agile framework where they have to look for threats and roll them into the iterations. DevSecOps provides a strong approach to integrate security into the development process from the beginning of SDLC to assure that security is not an afterthought or

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innovation incorporated as the final stage with a negative impact on the development-crucial times. It is argued that agile security prescriptions have to be introduced with the intention of providing the most secure means of responding to threats and threats whilst at the same time, being as swift as possible in order to enable software development.

Finally, the security aspect of Agile is also about coordination between developers, security professionals and operations personnel. Normal implementations of agile activities occur in twits where functional organisations are formed, but security specialists are required to engage in all the activities for comprehensive security solutions. Security professionals can help to get information on potential risks, on how to avoid them, and help to integrate security automation tools into the process of continuous delivery. Through this synergy hence fostering this interdisciplinary collaboration, organizations can develop a security culture that goes through the development life cycle of the products.

1.2 DevSecOps: A Unified Approach to Security

DevSecOps is an enhancement of a more hybrid concept because it seeks to unify security with the development and operations arenas. DevSecOps is quite different from other models in that the focus on security is integrated throughout the application development life cycle. This change in attitude recognises that security cannot be done on the periphery yet incorporated into all stages of the software development life cycle. What DevSecOps does is that it turns security away from an impedance to soon speeds up development, opens up security to everyone involved in the proactive management of risks. DevSecOps frameworks are the essential principle applied by teams so that they track security threats and work with them in real-time rather than designing security after development is done.

Automation is the main emphasis of DevSecOps. DevSecOps allows for the integration of security testing, vulnerability scanning, and compliance checking into the development process and Executing these as and when problems are found by developers without disrupting the development life cycle. CI/CD processes are an inherent part of this approach as security check can merge with build and delivery pipelines. For this reason, the DevSecOps methodology does not only increase development speed and pace but also increases security by integrating securitization into each phase of the DevSecOps process. By incorporating all these models, the Security Operation Centre creates a proactive, rather than reactive Security Programme that will protect the organization against growing threats.

Further, DevSecOpspoints to the integration of the monitoring and feedback process. In this way, the security risks are assessed and the subsequent practices are modified as to reflect the constantly emerging new threats. This is especially important continuously as software can become vulnerable at any time during its usage phase. Further, DevSecOps practice promotes the involvement of those people in the development process who are responsible for security at each stage of the SDLC and security personnel who are to oversee security at the organizational level. This way it becomes more than just a sequence of tasks, which makes security an ongoing process for all stakeholders of the software development process.

1.3 Challenges in Integrating DevSecOps into Agile SDLC

Although DevSecOps integration into Agile SDLC is highly beneficial, there are some crucial difficulties that need to be solved to achieve it. One of the major challenges is the process of gaining organizational culture shared understanding about security as a responsibility of all teams. In traditional development models, security sits in a separate team to development meaning they are rarely in the same environment. When security has to be/wishes to be integrated into every phase of Agile processes, there is resistance from the Agile environments that emphasizes on collaboration and flexibility. Since developers from the development teams are used to working in a ‘high velocity’ environment, they will always deem security practices as disruptive activities, which slows them down hence a lot of conflict between the development teams and those promoting DevSecOps.

Another issue is the general issue within large projects of managing the level of security. In agile project development the code and infrastructure files are constantly changed and this results in the environment heterogeneity concerning with the security protocols. Testing and monitoring the security of applications in such dynamic environment calls for high end technology that is capable of coping with the fast pace of development. Besides that, it is critical for organizations to ensure that security tools and controls are integrated for Agile, hence there are no hindrances that slow down the draftees. The implementation of security and development BMI requires identifying suitable tools that address both objectives while avoiding creating SMPs.

1.4 Best Practices for Integrating DevSecOps into Agile SDLC

However, DevSecOps integration into Agile SDLC depends on specific techniques to ensure the incorporation of the best practices across the development life cycle. Among the core recommendations that were identified in the course of

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researching the subject is the inclusion of security engineers in the planning phase of a project. When security teams are involved early on, Agile teams are able to onboard security from the rest of the team, and this way, the teams will ensure that before any project is implemented, the security aspects are not discovered when it is too late. Security should not be an add-on or a secondary element but part of any of the phases of the project where S/He is to take an active role in every sprint and iteration phase. This means that a potential risk is early detected and its solutions are signed off by practicing security.

Another practice for integration of DevSecOps into Agile SDLC is an automation of security testing. SAST and DAST are the two types of automation security tools that can be embedded in the check continuously every build and deployment cycle. This does not overload the developers and the security team, that is frequently not familiar with programming languages, but allows them to devote their attention to other levels, while the security process is running in parallel and without interruption. Furthermore, the automation process allows teams to advance security, bring unified security actions towards all iterations, and do not hinder development.

1.5 Tools and Technologies for DevSecOps in Agile SDLC

Integration of DevSecOps to Agile SDLC is therefore enhanced by a number of tools and technologies that ensure security processes are optimized while not compromising on development initiatives. Security testing tools make up one of the most crucial categories of tools since they help to automate vulnerability identification of code. While SAAS provides a perspective of the written code independent of execution, SAAS based Analysis tools dynamically execute the code to find all plausible security violations. By including these tools in CI/CD pipeline the security testing becomes a part of the continuous process and helps in minimizing the inclusion of potential vulnerability.

Infrastructure as code (IaC) tools are the second essential tools that relate to the DevSecOps concept. Infrastructure as Code enables teams to apply the governance of code to environments allowing them to be managed, provisioned and rolled back like code. Terraform and Ansible are used to ensure consistency of the security configurations as the move from development to production or testing that could lead to misconfiguration of the security settings. The major concept is DevSecOps entails the automation of security infrastructure provisions; therefore, the security components are not only included in the application code but also in infrastructure.

2. REVIEW OF WORKS

In the recent decades, the most significant development area of focus that has received a lot of attention from various scholars is the marriage between Artificial Intelligence, DevOps and secure software development. These technologies have come together hand in hand with the need for advanced, efficient security measures hence software development and operational methodologies have advanced so much. Machine learning is being integrated across industries from cybersecurity to business intelligence and with the rise of connected devices like IoT the need for better paradigms cannot be overemphasized. In this context, studies have grown regarding how Agile, DevOps, AI, and other processes could be optimized, further incorporated, and developed to meet security needs for sustainable organizational functioning and impact.

2.1 DevOps and Security Integration

Due to paying much attention to effective collaboration between developers and operations teams especially in SIs and delivery, DevOps has trendy. The authors of the article Alenezi et al. (2019) state that there is a rising need to include security within the development and operations process called DevSecOps. This also solves the security problems that arise within the development phase and ensures security becomes a concern of the whole team. One issue can be traced to the fact that security usually takes a back seat in high velocity development environments, which creates room for exposed breaches. Alenezi et al. discussed that there should be an optimal practice to implement the following practices in traditional/improved and emerging methods, which include security assessment and testing that should be ongoing, vulnerability scanning, and the use of automated security technologies to prevent both external and internal threats. Ande and Khair (2019) also further talk about the importance of secure DevOps practices; the major discussion centered around the need to have secure software development particularly in the high-performance apps such as Artificial Intelligence and machine learning. They underscore the importance of inclusion of the concepts of security in the coding practices in DevOps . Incorporating security in the system development life cycle enables firms to increase system strength and decrease exposure to risks effectively combating emerging cyber threats.

2.2 AI in Software Development and Decision-Making

AI remains a powerful tool in numerous fields where it is applied to enterprising operations and enhance decision-making and system functionalities on software development. In Khair (2020), the author discusses the ways in which AI could influence decision-making within the management of human resources considering that it is quite effective

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tool enhancing organizational efficiency as well as integrity based on the limited number of decisions in large and detailed functions. With the AI integration, organizations can supply the system with large amounts of data to then navigate them more effectively and improve the overall correspondence between employees' requirements and corporation objectives of the enterprise. Analysis of AI in decision support systems points to the increasing use of AI in developing suitable and intelligent application environments to support the user.

Along the same line, Khair et al. (2020a) highlight the role of AI in connection to trade policies, by underlining how analysis with AI can be an effective tool for making valuable suggestions in terms of market integration. The authors particularly underline the importance of reciprocal symmetry in AI-based decision making, which means algorithms predicting decisions as well as learning from feedback and developing in response to shifting patterns. Reciprocal symmetry is one such concept when applied to AI augmented systems lends a more proactive flavour to the decision making processes which are critical for survival in today's capability oriented business landscapes. There is therefore a shift to intelligent, adaptive as well as users' oriented solutions when AI is incorporated into software development.

2.3 AI and Blockchain in Business Operations

Blockchain technology has is also being implemented in the business operations where is combined with AI to improve business decisions and data analytics. Dhameliya et al. (2020) do a study on consolidation of blockchain in the area of human resource analytics, where they explain how the integration of AI and Blockchain can dramatically transform the system of at the employee level. Through extended use of blockchain technology, the information concerning the employees can be recorded securely while AI can be used in carving out the performance analysis and determinant factors in the employee turnover, recruitment among others. Such integration also optimizes operational visibility and contributes to the proper strategic management of decision-making since it makes available current and accurate information.

Mullangi (2017) also expands on the application of AI and blockchain in financial performance to also demonstrate how the integration of AI endowed with predictive analytics and block chain as a distributed ledger can revolutionalize the business environment. The combination of these technologies brings about new methods through which businesses can increase data accuracy and security as well as minimize fraud and increase their customer confidence. Credibility and decentralization of blockchain when combined with the functionality of AI makes the tool suitable for the best business solutions that enhance the security of a digital environment.

2.4 Agile and Secure Software Development

New generation development paradigms that enables flexibility in the development process have been complemented with the use of security frameworks to address the emerging complexities within software systems Agile best practices have been incorporated by de Vicente et al. (2019) within the proposed S-SDLC framework, chiefly to cope with emergent requirements. Recommendation Their work found that placing security within Agile sprints develops more resistant systems because security issues are highlighted as iterations produce working software. This is particularly in line with what DevOps seeks to achieve as an organization's agility is coupled with security to realize secure application delivery.

Likewise, Russo et al. (2020) note that there is a requirement for secure DevOps practices while creating cyber-physical systems. Their works depict some of the issues related to the security during the development and deployment of embedded systems, which are highly integrated involving numerous network connections, and are, therefore, easily exposed to cyber-security threats. The adoption of Agile with security involves including security measures to counter the risks early enough and at each phase of development. Applying secure DevOps solutions enable organizations to develop strong systems that improve, constantly innovate and are secure from threats due to advancements in technology.

2.5 The Role of AI in Enhancing Cybersecurity

During recent years, the ways and opportunities to integrate AI in the context of improved cybersecurity have become one of the most discussed topics, considering introducing a variety of threats to organizations operating in the digital environment. Morales et al., (2018) highlight the need to integrate security into DevOps, especially in organizations functioning in environments where compliance and security are critical success factors. The authors explain their paper by stating that AI can be used to monitor the system for any strange pattern or for any particular opening that could be schematic to an attacker. The integration of machine learning in the cybersecurity architecture means that problematic cases can be recognized and resolved at a much faster rate that it would be achieved manually.

In addition, the same authors also pointed out the utilization of AI to mitigate the hardware-based threat models like the hardware trojans and side channel attacks which are pervasive threats to the embedded systems. This is because AI-

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based security features like Anomaly detection, and predictive analysis counteract threats before they may attempt to compromise the components and remains intact. This paper posits that incorporating AI into the cybersecurity models will make security foresee future threats and lead to an improved digital security environment. Hand in hand with the growth of the interest in cybersecurity, there is a possibility to improve the protection of the systems using AI approaches.

3. METHODOLOGY

For this study, the research method employed is qualitative in order to examine how traditional secure software development could be implemented within DevOps and the potential benefits for enhancing system security in real-time. This is to mean that the research methodology does not employ empirical data, but rather integrates review literature, case work, and theories. In this study, the best practices, challenges, and impact of security-focused DevOps implementation will be identified through evaluating recent academic articles, industry reports, and case studies.

The first process in the developed methodology would be the examination of literature on current state of DevOps, security integration, security with AI and Blockchain. In this review, attention will be paid to the studies conducted over the past few years, such as systematic literature reviews Alenezi et al. (2019), case studies Ande and Khair (2019), and Security pivot Software Development Model (SSD-Sec (Khair, 2018)) and solutions aimed at various industries. Published and scholarly articles retrieved from journals and conference materials will be used mostly.

The second of the methodology components will be the theme analysis of the DevOps security measures utilizing the qualitative assessment of case studies of different organizations. For instance, prior studies have shown that security is important across the software development life cycle (SDLC) (de Vicente et al., 2019; Russo et al., 2020) particularly in contexts where there are standard frameworks and guidelines (Morales et al., 2018). As a result of this study, this paper will also reveal major practices, issues, and approaches used by organizations to manage security threats in real-time systems. This approach will also involve ideas from literature based on papers that explain a specific industry in order to receive insights from those in the profession.

Lastly, this study will use a theoretical perspective with reciprocal symmetry concept and AI based analytics as proposed by Mullangi (2017) and Anumandla (2018) to understand the use of AI and other new technologies to improve security in DevOps settings. As a result of the information gathered from the literature review section of the study, the authors intend to synthesize the findings in order to create a consolidated plan for the application of these technologies in supporting security-centric DevOps and their integration within existing software development frameworks. This research utilizes a qualitative approach to formally evaluate the theory and practice and provide implementable recommendations for future study and practice.

4. RESULTS AND DISCUSSION

4.1 Integration of Security into DevOps Practices

The literature includes that extending security into DevOps, which is known as DevSecOps, is considered essential for improving software security. Studies suggest that security is considered as a critical issue throughout SDLC and organizations use automatic security tools, continuous monitoring, and do not allow insecure coding practices. Alenezi et al. (2019) also highlighted the importance of adopting secure code and incorporating security to development practice and use of vulnerability scans. Secondly, the incorporation of aspects of security testing and code analysis into integrated and delivery systems has enhanced system security immensely. According to Ande and Khair (2019), secure development is critical in high-performance applications, and the use of automated tools in the detection of vulnerabilities. Real-time development environment security scans detect the threats at early stages of development and thus security becomes part and parcel of the SDLC instead of being added as an extra wheel.

4.2 Role of AI and Automation in Enhancing Security

There are great expectations as to how artificial intelligence can support the application of security policies within DevOps to reduce the work of corresponding personnel by automating the execution of security procedures in specified zones, as well as how it can help identify threats and assess potential vulnerabilities. AI particularly the big data analytics has been used to detect patterns in the datasets in performing tasks that include; discovering security threats, intrusion and unusual activities within the system (Russo et al., 2020). A number of relevant papers focus on the observation that AI solutions can deliver real-time detection coupled with an extraordinary response tempo, thus improving the rate of the DevSecOps process. Also AI has also helped more in the future vulnerability projections based on past records in which help teams to prevent or act against such vulnerabilities before they occur.

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4.3 Adoption Challenges and Barriers to Security Integration

However, there are a number of issues that organizations have to consider when implementing security into DevOps. Some of the well-known issues include limited availability of people with expertise in both DevOps and security (Khair, 2018), resistance exhibited by development teams and integration problems related to the application of security tools in development processes. It is also common for many companies to also deal with the challenges of integrating security policies and especially given the highly charged short development cycles of DevSecOps (Morales et al., 2018). Among the challenges highlighted for consideration were; Thus, to overcome these challenges, several things required including; perpetual training, investment in security automation and culture of collaboration.

4.4 Impact of Emerging Technologies on Security Practices

For instance, the blockchain and machine learning have helped to improve the security in places that are used in DevOps. Out of all the emerging technologies, blockchain holds the most promise for increasing the level of data veracity and enabling the safe monitoring of software updates Alenezi et al. (2019). Likewise, DevSecOps tools have embedded machine learning designed to improve the accuracy in detecting risks and other vulnerabilities. The adoption of these technologies into DevOps work cycles improves on security through providing other layers of security and enhances real-time decision making.

4.5 Best Practices for Implementing Secure DevOps

The literature offers many recommendations on how to successfully apply DevSecOps in organizations. These are; the geographic inclusion of security measures to the software development lifecycle; use of test tools that address security issues; the use of secure coding standards; and proper involvement of development, operations and security departments Ande and Khair (2019). In addition, ownership of security at the individual level has been revealed as one of the foundational requirements for effective DevSecOps adoption. Malware defenses are strengthened in organisations that undertake these practices, while organisational development and integration of development life-cycle phases are optimised.

4.6 Discussion

In this regard, the research evidence shows that implementing security within the frameworks of the DevOps approach or adopting DevSecOps is an optimal solution to modern threats in conditions of accelerated developing. While many companies are already actively using new technologies such as AI, automation, and other emerging technologies, two main issues upskilling staff and adjusting team culture are still critical. Those organizations who are able to incorporate the security tools, automate the detection process, and that can invest on training their personnel can secure their software development processes against new forms of threats. But the issues concerning the change resistance and the integration of security into the shortening development cycles must be solved, and it will need strong planning and vigorous encouragement as well as constant engagement from all the concerned teams in the cycle.

5. CONCLUSION

Lastly, it can be stated that DevSecOps as the practice of integrating security into previously initiated DevOps practices provides a major improvement to software security as it makes security relevant and in-place at every phase of the SDLC. Techniques like automatic security instruments, real time surveillance and integration of radical technologies like Artificial Intelligence and machine learning enable detection of the security glitches and rectification in the system in a better and prior way. Thus, even facing numerous benefits of implementing DevSecOps practices, one can identify several threatening issues such as shortage of qualified personnel in this field, and resistance from development teams. These barriers indicate that security can be a challenge to be incorporated into DevOps but with the right investment in training and collaboration as well as embracing best practices organizations can actually overcome all these barriers.

The study also underscores that investment in DevSecOps can help improve security outcomes but that, the approach requires the right adoption. It was established that incorporating of security into the process means that risks are not seen as an add-on that can be addressed later but rather as an investment into development of reliable software products that can be protected from new threats. In the next practices, there is a need for organizations to advance on their DevSecOps practices, they should embrace technologies as well as really create a security conscience within the company for future security to prevail in development of software.

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