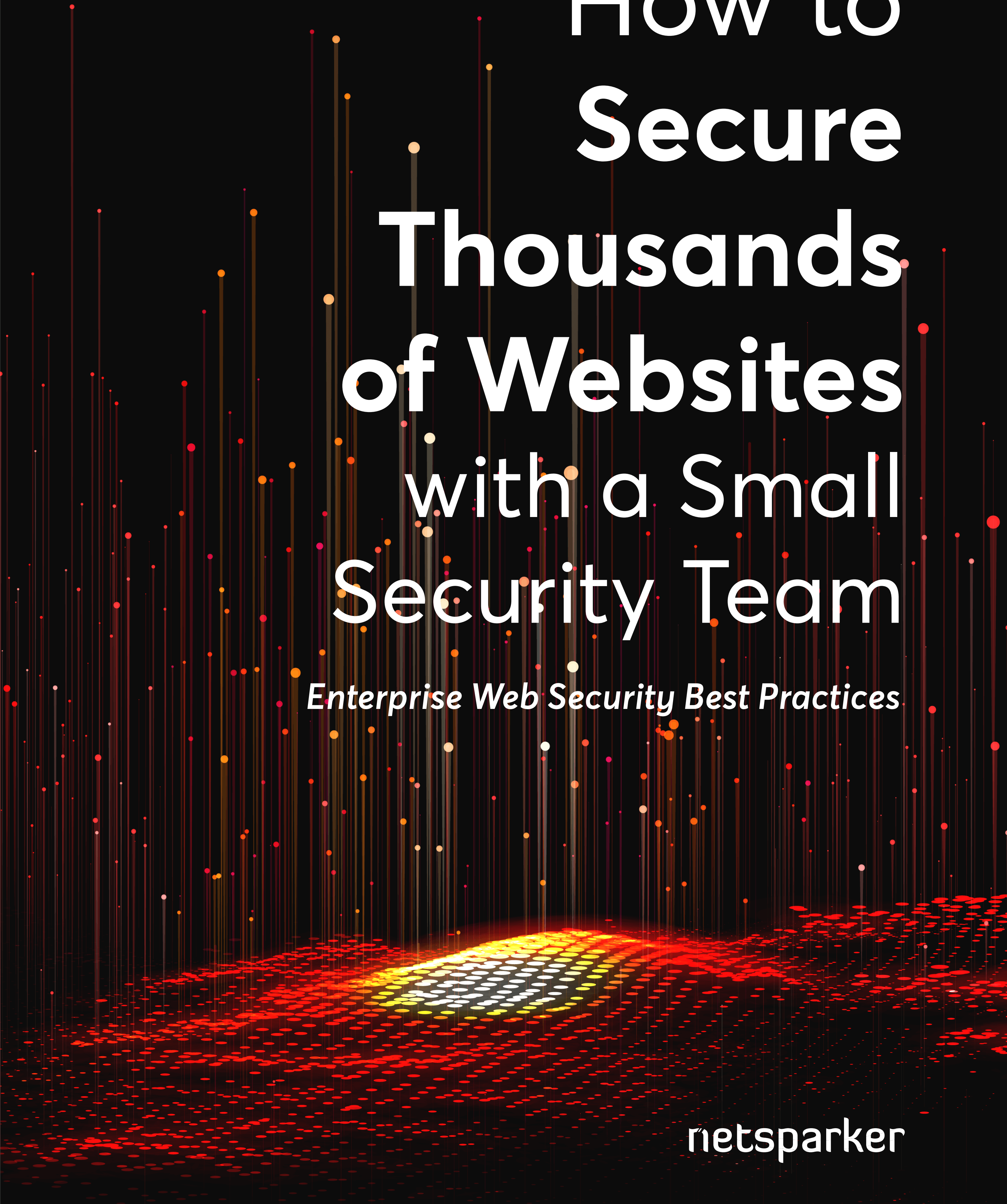
WHITEPAPER

How to **Secure Thousands of Websites** with a Small Security Team

Enterprise Web Security Best Practices



netsparker

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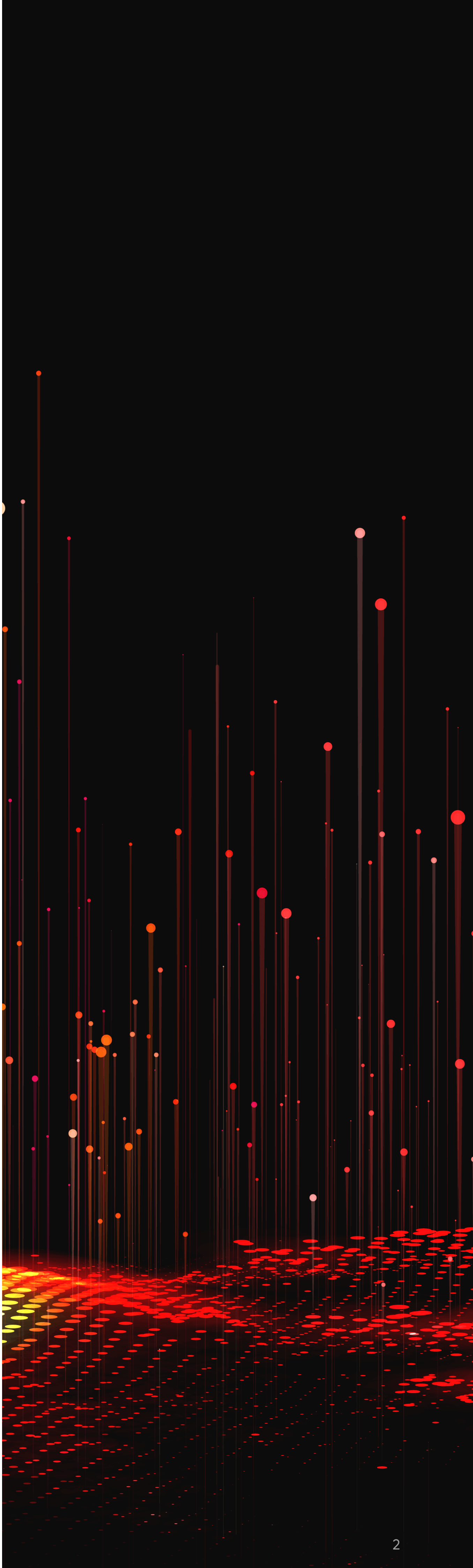


Executive Summary

This whitepaper examines how integration and automation of enterprise web security may be used to combat the growing cybersecurity talent shortage, which is expected to grow to 3.5 million job openings in 2021. We focus on four key factors that may be addressed using such an approach: awareness, responsibility, protection, and validation.

Technologies that are now available in selected web security solutions enable enterprises to automate many processes that were traditionally manual:

- Web assets may be automatically identified and inventoried using crawler technology pioneered by search engines.
- Vulnerabilities may be automatically proven using safe exploits to greatly reduce the number of false positives, thus reducing time and resource costs, as well as greatly improving scalability.
- Proven vulnerabilities may be automatically assessed on the basis of both technical and organizational factors.
- Assessed vulnerabilities may be efficiently managed using integration with tools that are already used to manage tasks and issues during software development.
- Web security processes may be implemented at the earliest possible stage of software development using integration with DevOps solutions, thus greatly reducing the cost and improving the ease of remediation.

The whitepaper explains the details of these methods and technologies, as well as shows the benefits that they bring.

Introduction: Challenging the Cybersecurity Talent Gap

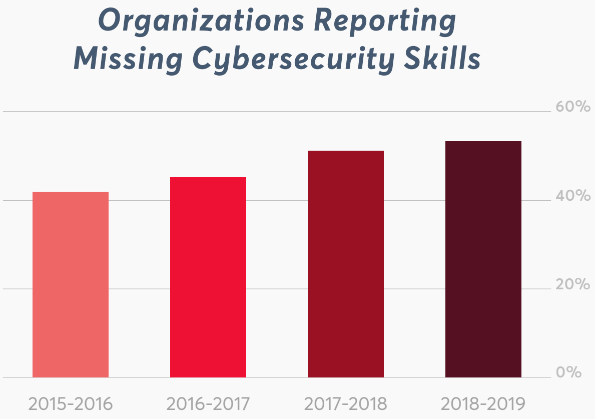
The cybersecurity talent gap is being addressed in two primary ways. The first way focuses on increasing available resources. Universities are promoting more cybersecurity programs for IT students. Businesses are trying to find incentives to convince independent security professionals to work for them full-time. Governments are encouraging more young professionals, especially women who are underrepresented in the industry.

The second way to address the cybersecurity talent gap is by lowering the resource requirements. Enterprises shift the responsibility for cybersecurity from dedicated teams onto other roles – not only administrators or developers but non-technical roles as well. Scientists seek ways to use innovative technologies such as artificial intelligence to fill in for unavailable humans.

However, currently, the most efficient way is simply to eliminate the need for resources through **automation** coupled with **integration**. Large organizations need innovative and comprehensive solutions that are built specifically for them and help reduce the cybersecurity talent gap. Unlike AI security or new university graduates, these solutions are already available.

The cybersecurity talent gap is not going anywhere. Quite the opposite, it's getting worse with time. The larger the organization, the more issues it poses because the more resources are needed. This calls for immediate solutions.

The number of organizations that report missing cybersecurity skills grows annually.



Based on annual surveys performed by ESG

Awareness, Responsibility, Protection, and Validation

The basis for a successful cybersecurity strategy is educating the organization about potential dangers and how to avoid them. However, even the best training won't suffice if employees don't feel responsible for security. And even the best efforts in promoting awareness and responsibility fail unless there is a way to validate the efficiency of those efforts and support them with automated tools for validation and protection.

Comparison of security approaches for two major cybersecurity threats

Threat	Primary Cause	Awareness	Responsibility	Protection	Validation
Phishing and malware (including ransomware	Users are careless and have excessive trust in the received information	How do I recognize phishing and malware?	I am responsible for reporting and potential consequences	Antivirus/ antispam tools (partial protection only)	Simulated attacks – fake phishing
Web vulnerabilities	Developers are careless and have excessive trust in users	How do I avoid introducing vulnerabilities?	I am responsible for avoiding vulnerabilities and potential consequences	Web application firewalls (partial protection only)	Simulated attacks – vulnerability scanning and penetration testing

For example, in the case of phishing, organizations should first teach users how to recognize such attacks. Then, they should make sure that every user realizes their responsibility to avoid and report phishing attempts. Finally, organizations should carry out exercises to test how well users can react to a fake phishing attempt. Additionally, organizations should use automated systems such as antispam and antivirus tools, which have the ability to spot and neutralize the majority of phishing attacks.

The same rules apply to web attacks which, next to phishing, are the other most prominent cause of security breaches. Everyone involved in developing web resources must be aware of potential vulnerabilities and feel responsible for eliminating them. There are limited protection methods such as web application firewalls, but they do not get to the root of the problem.

In the case of web assets, selective validation is not enough. Every web asset in the company can and should be verified thoroughly. Such verification, if done manually, would be impossible due to the sheer number of such assets and potential vulnerabilities. That is why in the case of web security, the only efficient solution is to rely as much as possible on automation and integration.

Asset Identification

To protect your assets, you must first know them. In the case of websites and web applications, asset identification and inventory cannot be limited to primary production websites. They are only the tip of the iceberg. The following additional web assets must also be included:

Temporary Web Assets

Assets created for one-time marketing campaigns, demo assets for customers, etc. Such assets are the most elusive and they can easily escape identification because they are often perceived as low-risk.

Pre-production Web Assets

Staging assets, UAT (User Acceptance Testing) assets, OAT (Operational Acceptance Testing) assets, QA (Quality Assurance) assets, even development assets. Organizations may perceive these assets as low-risk but vulnerabilities in such assets ultimately end up in high-risk ones (production), too.

Third-party Web Assets

Assets maintained by third parties that are still associated with the organization (for example, use a subdomain of the organization's top-level domain). These assets are very difficult to include in organizational processes but if exploited, they may cause major harm to company reputation.

Importance of Asset Identification

Many enterprises follow renowned cybersecurity frameworks to build and manage their security practices. One such framework is developed by the National Institute of Standards and Technology (NIST) – the Framework for Improving Critical Infrastructure Cybersecurity Version 1.1.

The key part of this NIST framework – Framework Core – is a set of activities that are aimed to achieve specific cybersecurity outcomes. The highest level of the Framework Core is the set of Framework Functions with Subcategories. The first Function is Identify, its first Category (ID.AM) is Asset Management, and the second Subcategory focuses on building an inventory of software platforms and applications within the application (ID.AM-2). This, of course, includes all web applications and websites.

The structure of the NIST framework highlights the importance of asset identification. However, the framework, being a general set of guidelines, does not include specific processes, techniques, or mechanisms used to achieve the goal. Therefore, organizations need to figure out the most efficient way to achieve the highest level of identification.

Traditional Approach: Manual Asset Identification

To identify as many assets as possible (preferably all of them), organizations first and foremost need to build a data source. This must be a central database with information on all identified assets. If this information is scattered across teams, departments, or offices, it cannot be used efficiently.

The data source is not only important for awareness, but it must also serve as the origin of information for tools that follow up on security. Of course, in a large organization, such a data source may need to be continuously fed with information from secondary data sources.

The existence of the central data source is not enough to ensure that assets are identified. The bigger issue is making sure that the data source is not only initially filled but regularly updated. In a large organization, this may mean even several updates a day – if you maintain thousands of websites, new ones may even appear daily.

The traditional approach to maintaining such a data source is via organizational processes. Such processes require that all personnel that is involved in developing and maintaining websites, especially those formally responsible, keep the data source updated. However, if this is a manual process, it is prone to human error. And even one error might mean that a completely unprotected website slips past the process. An attacker needs just one such website to wreak havoc on company assets and reputation.

Additionally, such manual processes often fail if they include external entities. If third parties are involved in asset development or maintenance, they are frequently either unaware of reporting procedures or don't pay enough attention to them.

The identification process for websites may be partially streamlined using custom-built scripts, specialized inventory software, or manual scanning using tools such as network scanners. All these must also support the format of the data source, which makes the process even more difficult to orchestrate.

Modern Approach: Automated Asset Identification

The most efficient way to ensure the highest possible level of identification is through the use of software that is designed specifically to build an inventory of web assets and that is tightly integrated with a vulnerability scanning solution (preferably, an integral part of such a solution). Such software has huge advantages:

- It provides a single central data source for all web assets. It also provides import mechanisms for secondary data sources. All in all, this guarantees that all the information is available in one authoritative location.
- It has mechanisms to automatically discover all the web assets. Such mechanisms include both name-based discovery (for example, Internet scans, public certificate repositories, relying on open-source intelligence) and location-based discovery (for example, network scanning). These mechanisms automate the identification of all types of assets mentioned above: production, pre-production, temporary, and third-party assets.
- Data may also be entered manually for any assets that are impossible to identify automatically. Therefore, it may be included in manual processes thus providing complete coverage.

If such a solution is integrated with tools for vulnerability scanning, vulnerability assessment, and vulnerability management, it means that the identification process works in unison with further stages.

Vulnerability Assessment Automation

In a large organization, there are too many errors and vulnerabilities discovered on a regular basis to be able to fix them all immediately. Therefore, the order of fixing is a matter of priorities. And with a large number of assets, those priorities may be quite complex. There are multiple aspects that the organization must consider when deciding on which vulnerabilities to focus first:

The Severity of the Vulnerability

Some vulnerabilities pose little threat, while some may allow the attacker to take over the whole system or give them access to an entire database full of sensitive data.

The Criticality of the Asset

An asset with simple marketing information obviously has a lower priority than a mission-critical web application that stores sensitive data.

The Scope of Access

For example, an external web application is more apt to be attacked than an internal system. And a vulnerability that requires the attacker to be authenticated is less critical than one that can be exploited by an anonymous visitor.

The Potential for Escalation

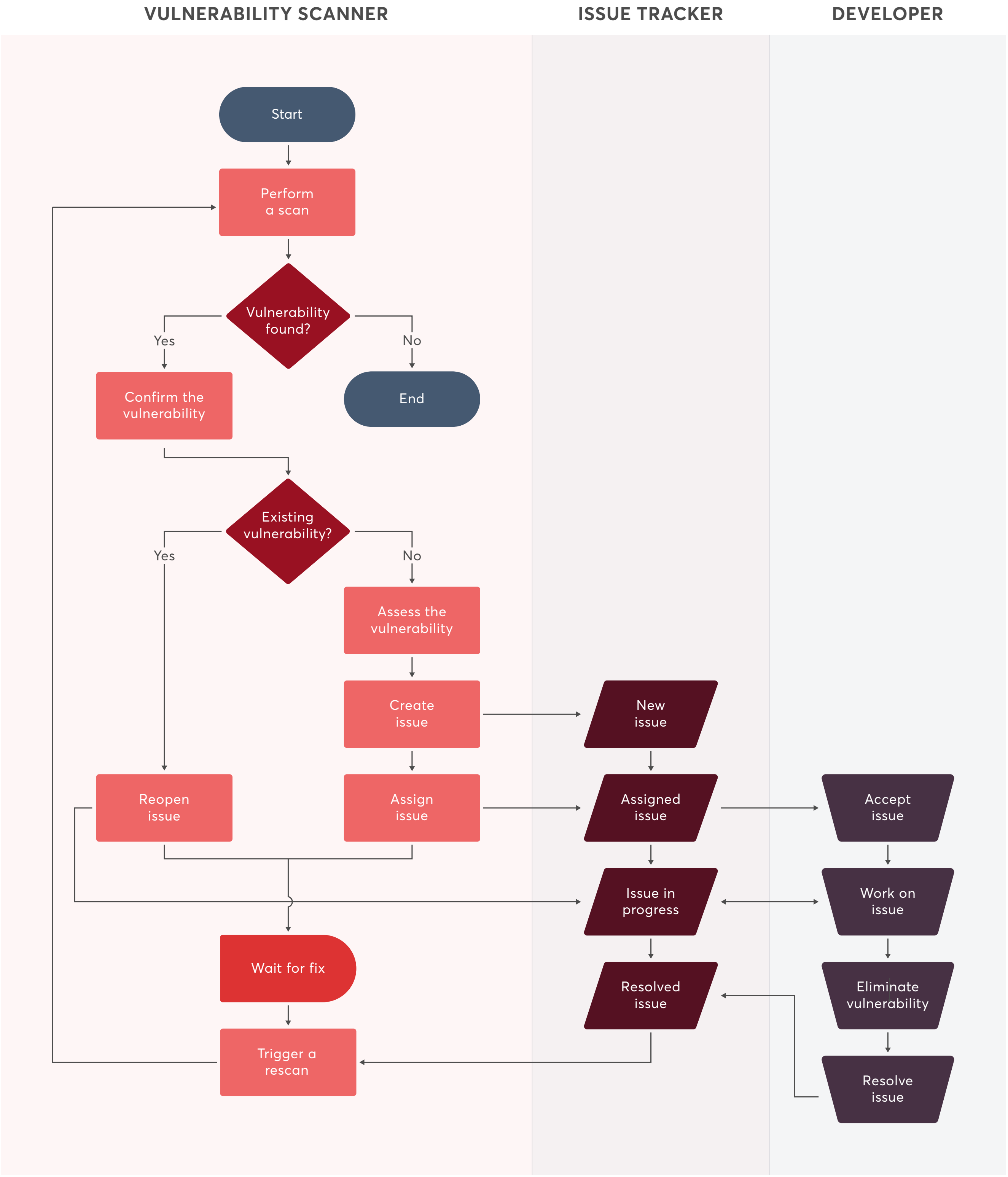
A vulnerability in a system that is not interconnected with other systems is less critical than a vulnerability in a system from which an attacker may escalate to other assets.

Manually assessing vulnerabilities in thousands of web assets is impractical. Therefore, a large organization must have a way to automate the process by assigning weights to each factor and by applying these weights to each vulnerability right after it is identified.

Obviously, even if this process is automated, it must also be centralized and closely coupled with the identification process. Each identified asset must be scanned for vulnerabilities and then those that are found must be automatically assessed. It is possible with a multitude of interconnected tools but it works much better if all the functionality is part of a single integrated solution.

Vulnerability Management Automation

Finding vulnerabilities is just the beginning of a complex process. For a large organization, manually managing thousands of such processes is impossible. Again, the only efficient solution is automation.



The vulnerability management process involves the following basic stages:

- It begins with finding the vulnerability and confirming that it's not a false alarm.
- The vulnerability must then be assessed based on multiple factors.
- It must then be treated as an issue and assigned to a person or a team who are responsible for managing it.
- The issue must then be monitored for state changes resulting from other processes and manual input.
- When the issue is marked as resolved, the vulnerability must be retested. This must not be optional.
- Only when the vulnerability scanner confirms that the vulnerability is no longer present can the issue be closed. If not, it must be kept open.
- Even when the issue is marked as resolved, it must not be forgotten. If the scanner finds the same vulnerability in the same application in the future, the new find must be linked to the previous issue. This saves a lot of resources on identifying the cause and helps to resolve the reoccuring problem much quicker.

Some parts of the above process may be automated but some will remain manual. A large organization will want to automate as much as possible and therefore the only steps that should remain manual are those associated with fixing the vulnerability. In an agile environment, the product/service owner or team leader will have to oversee the issue management process, for example, manually allocate the vulnerability to a sprint and reassign it to a particular developer.

The vulnerability management process requires that the software solution is adapted to the needs of development teams. Development teams already heavily rely on issue management solutions, both for adding new functionality and fixing bugs. Vulnerabilities should be treated exactly the same way that bugs are treated (those discovered by automated and manual testing). It would be highly inefficient if developers were forced to use different issue management systems for different types of issues.

Therefore, the key to successful vulnerability management is tight integration with major issue management systems. The vulnerability management system must be able to create and manage issues in issue management systems and must be able to react to issue changes. If so, the process is transparent to all parties involved and highly efficient.

Automation in Web Security

A lot of processes in web security can be automated with the right tools. Only few processes need to be handled manually:

- Automatic and continuous identification of all web assets
- Automatic and comprehensive vulnerability scanning for all identified web assets
- Automatic vulnerability confirmation (proving) to eliminate all false positives
- Automatic vulnerability assessment based on multiple factors
- Automatic creation of issues for development teams
- Automatic assignment of issues to relevant teams
- Manual sprint management by product/service owners or team leaders
- Manual code repair by developers to eliminate the vulnerability
- Automatic vulnerability retesting
- Automatic issue management: closing, reassigning, reopening
- Automatic vulnerability archival
- Automatic linking of reoccurring vulnerabilities with original issues

Automatically Proving Vulnerabilities

One of the key aspects of introducing automation to vulnerability assessment and management is having trust in the automatic tool. The vulnerability management process consumes a lot of resources. If the vulnerability is ultimately found to be invalid (a false positive), the resources are wasted.

When a developer attempts to fix a false positive, they usually need much more time than for a real vulnerability. First, they have to try to replicate the vulnerability. If they are unable to do so after several attempts, they have to authoritatively decide that there is no vulnerability and take responsibility for this decision. This may also involve additional resources, for example, a dedicated penetration test to confirm the diagnosis. Therefore, resources consumed by a false positive are substantially greater than in the case of real vulnerability.

In smaller organizations with few assets and few vulnerabilities, the false positive rate is often not a major problem because the total number of false positives is relatively small.

However, in a large organization with thousands of assets, even a seemingly negligible positive rate may mean several false alarms appearing in every sprint. This, in turn, causes the security and development teams to lose trust in the vulnerability scanner. It can cause issues to be treated less seriously or it may ultimately lead the organization to stop vulnerability scanning altogether due to the associated cost.

Therefore, an enterprise-class vulnerability scanning solution should ideally have a zero positive rate. In theory, this seems impossible but it depends on the way that the vulnerability scanner is built. If a scanner performs its diagnosis on the basis of signatures or simple patterns, you can never reach zero false positives. The only viable approach is for every vulnerability to be actually exploited. If the scanner sends a payload and, for example, gains access to unauthorized data (such as the /etc/passwd file in Linux/UNIX), the vulnerability is one hundred percent certain. And this means that no time and effort is ever wasted by developers or security researchers to try to prove that such a vulnerability exists.

Real Issue VS **False Positive**

Real Issue

- The vulnerability scanner detects an issue
- The developer fixes the issue
- The vulnerability scanner confirms the issue as fixed
- The problem is **solved**

False Positive

- The vulnerability scanner detects an issue
- The developer tries to find the issue and fails
- The developer challenges the vulnerability scanner
- The security team might get involved in a discussion
- The vulnerability scanner still detects the issue
- The security team trusts the vulnerability scanner less
- The problem is **not solved** and a lot of **time is wasted**

Earliest Possible Detection

All organizations, independent of their size, should try to identify vulnerabilities as early as possible. There is only one case, when a vulnerability may be allowed to be discovered on a production system: if it is in a third-party product or library and it was newly discovered in the current version of that product or library that is already in production. In all other cases, the organization should strive to find vulnerabilities ideally immediately after they are introduced.

Whenever a fragment of code is added or changed, it is consecutively introduced into the application on various systems. It is impractical for every developer to install and run a vulnerability scanner on their own machine after every code change and compilation. It would also be impossible to enforce. However, in agile environments, changes are committed by the developer to the repository and the CI/CD system immediately builds the application to test if it can be compiled correctly. The CI/CD system then performs a series of automated tests. This is the perfect spot to include a vulnerability scan as well.

There are many advantages to finding vulnerabilities at such an early stage. First of all, if a vulnerability is found at any later stage, it must go back to the developer and the build process must be repeated. Therefore, it consumes unnecessary resources and delays the release. In the worst possible case, if a vulnerability is found on a production system, it may even require the release to be reverted and delay the re-release by several days or weeks (depending on the deployment procedures and resource availability).

The additional advantage of early discovery is that the code is fresh in the mind of the developer. If a developer worked on a piece of code, committed it to the repository, and then receives a notification about a particular vulnerability within a very short time, they still remember the code that they wrote and have no doubt about where the vulnerability could have been introduced. On the other hand, if a vulnerability is found on a production system, the code might have been originally committed even weeks before, which means that even the original developer doesn't know what code changes caused it.

To achieve top efficiency, an enterprise-class vulnerability scanning/assessment/management solution must be integrated with CI/CD systems. The more configurable the integration, the better. DevSecOps should be able to define thresholds for warnings and failures. The scanner should also be able to perform incremental scans. If only a small code piece was added to one module of an application, scanning the whole application from scratch consumes unnecessary resources and takes a lot of time. In enterprise environments, applications may even require several builds a day, so every minute saved on scanning is very valuable.

Example of late scanning vs. early scanning

Late Scanning		Early Scanning	
1. Application deployed on the local machine	DAY 1	1. Application deployed on the local machine	DAY 1
2. Application deployed in the CI/CD system	DAY 1	2. Application deployed in the CI/CD system	DAY 1
3. Application deployed in the QA environment	DAY 2	3. Vulnerability scan performed and issues found	DAY 1
4. Application deployed in the staging/OAT/UAT environments	DAY 5	4. Repeat steps 1-3	DAY 2
5. Application deployed in the production environment	DAY 14	5. Safe application deployed in the QA environment	DAY 3
6. Vulnerability scan performed and issues found	DAY 15	6. Safe application deployed in the staging/OAT/UAT environments	DAY 6
7. Repeat steps 1-6	DAY 30	7. Safe application deployed in the production environment	DAY 15
8. Safe application deployed in the production environment	DAY 31		
Total Delay: **15 Days**		Total Delay: **1 Day**	

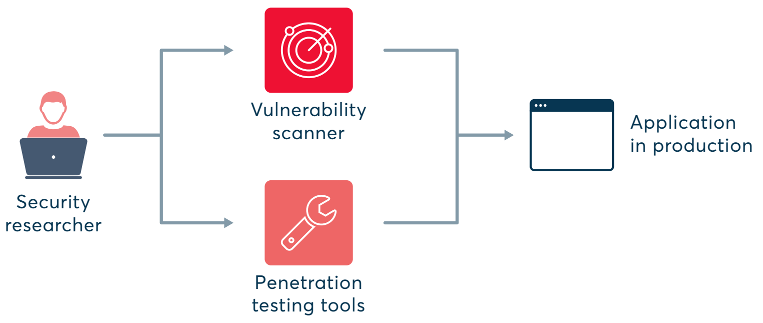
Conclusion: Efficiency, Not Perfection

Some organizations may have a misconception that automatic web security solutions are supposed to find every possible vulnerability. This is not true and it will never be true. While automated tools have a very high success rate, they won't be able to replace security researchers and independent whitehat hackers. However, they are excellent at replacing mundane and repetitive tasks that are a waste of time for professionals.

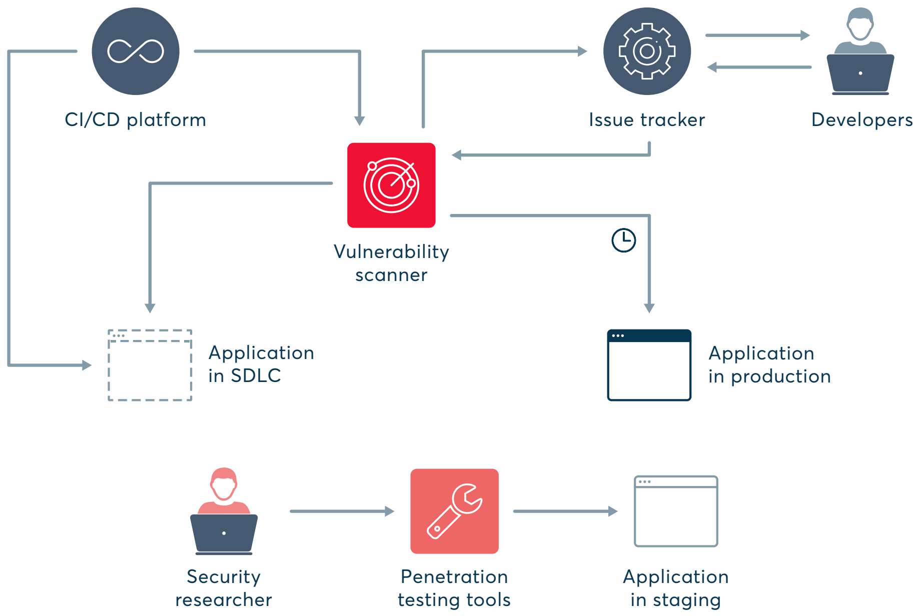
This was not the initial role of web vulnerability scanners. At first, they were built as tools that would help security researchers with their manual work, and many of them are still meant for that role. On the other hand, modern web security solutions encompass tasks in the whole organization, which would otherwise be performed by different roles including product/service owners and team leaders, developers, and operations.

Leading-edge comprehensive web security solutions aim to eliminate the simple tasks and support decision-making (for example, by pre-assessing and pre-assigning vulnerabilities). The ultimate goal is for the valuable cybersecurity talent not to be wasted on something that can be done by a machine. With the support of such solutions, you can easily keep the web assets secure with a small team, even in a very large organization.

Legacy Vulnerability Scanner



Modern Vulnerability Scanner



About Netsparker Enterprise

Netsparker Enterprise is a comprehensive automated web security solution that includes web vulnerability scanning, vulnerability assessment, and vulnerability management. Its strongest points are scanning precision, unique asset discovery technology, and integration with leading issue management and CI/CD solutions.

The Netsparker scanner can identify vulnerabilities in all types of modern and custom web applications, regardless of the architectures or platforms that they are based on. Upon identifying a vulnerability, the scanner generates a proof-of-concept exploit that confirms it is not a false positive, thus greatly improving scalability.

Netsparker Enterprise is designed to meet the needs of enterprises that require a security solution, which fits into a complex environment and may require customization. Netsparker is also available in other variations, depending on customer requirements. Netsparker Standard is designed for SMBs and Netsparker Team for large organizations. Netsparker can be implemented as desktop software, managed service, or an on-premise solution.

About Netsparker Ltd

Netsparker Ltd was founded in 2009. The company develops a comprehensive and dead-accurate web application security solution. The proprietary **Proof-Based Scanning™ Technology** helped Netsparker achieve early success and the company is now recognized as a leading player in the web application security industry.

Netsparker is trusted and used by world-renowned organizations from all industry verticals such as **Samsung**, **NASA**, **Microsoft**, **ING**, and **Ernst & Young**.

For more information or a free trial,
please contact us: contact@netsparker.com.

netsparker

Cannon Place,
78 Cannon Street, London,
United Kingdom, EC4N 6AF

Tel (US): **+1 415 877 4450**
Tel (Rest of the World): **+44 (0)20 3588 3840**
Fax: **+44 (0)20 3588 3846**

contact@netsparker.com
www.netsparker.com