Secure Development Lifecycle

Secure Development Lifecycle

❌ Identifying errors in late lifecycle phases makes them more expensive to fix or mitigate. [^1]

❌ Having an unpublished or informal Secure Development Lifecycle will not be successful. [^2]

✔️ Security must be embedded into all stages of the Software Development Lifecycle to be effective. [^2]

✔️ A close connection with the right expert and management drive from the beginning are both mandatory. [^3]

Spaghetti Analogy

Sprinkling security on insecurely written software is equivalent to sprinkling salt on spaghetti 🍝 after cooking them in unsalted water 🚰.

Estimates of Relative Cost Factors of Correcting Errors

Introduction of Error	Requirements / Design	Coding / Unit Test	Integration / System Test	Early Access / Beta Test	Post-Release
Requirements / Design	x1	x5	x10	x15	x30
Coding / Unit Test		x1	x10	x20	x30
Integration / System Test			x1	x10	x20

NIST: The Economic Impacts of Inadequate Infrastructure for Software Testing, 2002

Example: Microsoft SDL

Phase	Practice
Training	Core Security Training
Requirements	Establish Security Requirements, Create Quality Gates/Bug Bars, Perform Security and Privacy Risk Assessments
Design	Establish Design Requirements, Perform Attack Surface Analysis/Reduction, Use Threat Modelling
Implementation	Use Approved Tools, Deprecate Unsafe Functions, Perform Static Analysis

Phase	Practice
[Verification](#)	Perform Dynamic Analysis, Perform Fuzz Testing, Conduct Attack Surface Review
[Release](#)	Create an Incident Response Plan, Conduct Final Security Review, Certify Release and Archive
[Response](#)	Execute Incident Response Plan

Security Requirements

Derive Security Requirements from Business Functionality

- Gather and review functional requirements
- For each functional requirement derive relevant security requirements
  - Lead stakeholders through explicitly noting security expectations
    - e.g. data security, access control, transaction integrity, criticality of business function, separation of duties, uptime etc.
  - Follow the same principles for writing good requirements in general
    - i.e. they should be specific, measurable, and reasonable

Security and Compliance Guidance for Requirements

- Determine industry best-practices that project teams should treat as requirements
  - e.g. publicly available guidelines, internal or external guidelines/standards/policies, or established compliance requirements
- Do not attempt to bring in too many best-practice requirements into each development iteration
- Slowly add best-practices over successive development cycles

Protection Requirements ("Schutzbedarf" 🇩🇪) Calculator

- Provides an idea of the expected effort for security topics
- Serves as a starting point for detailed requirements analysis
- Formalizes the "gut-feeling" of business and IT stakeholders
- Covers all **CIA** triad aspects in a high-level fashion
  - **C**onfidentiality: Information classification, Compliance requirements
  - **I**ntegrity: Authentication mechanism, Compliance requirements
  - **A**vailability: Business criticality, Exposure to threats

Requirements Score Table

Aspect	(=5)	(=2)	(=1)	(=0)
Business criticality	Mission Critical	Business Critical	Business Operational	Administrative Service
Information classification	Secret	Confidential	Internal	Public
Compliance requirements	Legal	Industry	Customer	None
Exposure to threats	Internet-facing		Internal Web	Desktop / Batch
Authentication mechanism		(+/-0) None	(-1) Proprietary	(-2) Centralized

Protection Requirements Rating Evaluation

$$TotalScore = Max(0, (BusinessCriticality \\ +InformationClassification + ComplianceRequirement) \\ +ExposureToThreats + AuthenticationMechansim))$$

Total Score	PR Group
10 - 20	🔴 High
5 - 9	🔶/ 🔸 Medium
0 - 4	💚 Low

Exercise 9.1

1. Calculate the Total Score and Rating for the applications of fictive *Juice Shop Inc.* (Fill any gaps with reasonable assumptions)

2. Repeat for at least one additional system from your own company

Aspect / Application	Website	VCS	Webshop	B2B API
Business criticality	🔶	🔸		🔴
Information classification	💚		🔶	🔶
Compliance requirements	💚	💚	🔶	
Exposure to threats				
Authentication mechanism		💙	🔷	🔷

Secure Design Principles

Secure Design Principles

Minimize Attack Surface Area	Don't trust Services
Establish Secure Defaults	Separation of Duties
Principle of Least Privilege	Avoid Security by Obscurity
Principle of Defense in Depth	Keep Security simple
Fail securely	Fix Security Issues correctly

Minimize Attack Surface Area

- **Every feature** that is added to an application **adds a certain amount of risk** to the overall application
- The aim for secure development is to **reduce** the overall risk by reducing **the attack surface area**

Establish Secure Defaults

- The **"out-of-box"** experience for the user **should be secure**
- It should be up to the user to reduce their security - if they are allowed

Principle of Least Privilege

- Accounts have the **least amount of privilege required** to perform their business processes
- This encompasses user rights and resource permissions, e.g.
    - CPU limits
    - memory
    - network
    - file system

Principle of Defense in Depth

- Where one control would be reasonable, **more controls that approach risks in different fashions** are better
- In-depth-controls can make severe vulnerabilities extraordinarily difficult to exploit

Fail securely

- Whenever a transaction fails or code execution throws an exception it should **always "fail closed"** and never "fail open"

Don't trust Services

- Third party partners more than likely have differing security policies and posture
- Implicit **trust of externally run systems is not warranted**
- All external systems should be treated in a similar fashion

Separation of Duties

- Separation of duties is a key **fraud control**
- **Administrators should not also be users** of an application they are responsible for

Avoid Security by Obscurity

- Security through obscurity is a weak security control, and nearly always fails when it is the only control
- The **security** of key systems **should not be reliant upon keeping details hidden**

Keep Security simple

- **Attack surface and simplicity go hand in hand**
- Prefer straightforward and simple code over complex and over-engineered approaches
- Avoid the use of double negatives and complex architectures when a simpler approach would be faster and simpler

Fix Security Issues correctly

- Once a security issue has been identified, it is important to develop a test for it, and to **understand the root cause** of the issue
- It is likely that the security issue is widespread amongst all code bases, so **developing the right fix without introducing regressions** is essential

Secure Coding Guidelines

❌ Secure Coding Guidelines

> - Overlooked by developers
> - "Static and not helpful"
> - 100+ pages that can be language specific
> - *Can* be successful if collaborative/Wiki format and regularly updated [^4]

ℹ️ *Secure Coding Guidelines are often mandated by contracts, compliance requirements or as a certification precondition.*

✓ Secure Coding Checklist

> Checklists are good. Big secure coding books are bad. In know this, I wrote one. Didn't help. [*Jim Manico @ dotSecurity 2017*, ^5]
>
> - Simple 1-2 page document
> - All checklist items must be relevant
> - Brief document must be backed up with deeper resources and code samples [^5]

✓ OWASP Cheat Sheet Series

OWASP Cheat Sheets [edit | edit source]

V · T · E	Cheat Sheets [Collapse]
Developer / Builder	3rd Party Javascript Management · Access Control · AJAX Security Cheat Sheet · Authentication (ES) · Bean Validation Cheat Sheet · Choosing and Using Security Questions · Clickjacking Defense · Credential Stuffing Prevention Cheat Sheet · Cross-Site Request Forgery (CSRF) Prevention · Cryptographic Storage · C-Based Toolchain Hardening · Deserialization · DOM based XSS Prevention · Forgot Password · HTML5 Security · HTTP Strict Transport Security · Injection Prevention Cheat Sheet · Injection Prevention Cheat Sheet in Java · JSON Web Token (JWT) Cheat Sheet for Java · Input Validation · Insecure Direct Object Reference Prevention · JAAS · Key Management · LDAP Injection Prevention · Logging · Mass Assignment Cheat Sheet · .NET Security · OS Command Injection Defense Cheat Sheet · OWASP Top Ten · Password Storage · Pinning · Query Parameterization · REST Security · Ruby on Rails · Session Management · SAML Security · SQL Injection Prevention · Transaction Authorization · Transport Layer Protection · Unvalidated Redirects and Forwards · User Privacy Protection · Web Service Security · XSS (Cross Site Scripting) Prevention · XML External Entity (XXE) Prevention Cheat Sheet
Assessment / Breaker	Attack Surface Analysis · REST Assessment · Web Application Security Testing · XML Security Cheat Sheet · XSS Filter Evasion
Mobile	Android Testing · IOS Developer · Mobile Jailbreaking
OpSec / Defender	Virtual Patching · Vulnerability Disclosure
Draft and Beta	Application Security Architecture · Business Logic Security · Content Security Policy · Denial of Service Cheat Sheet · Grails Secure Code Review · IOS Application Security Testing · PHP Security · Regular Expression Security Cheatsheet · Secure Coding · Secure SDLC · Threat Modeling
	All Pages In This Category

Security Testing

Static Application Security Testing (SAST)

> Static application security testing (SAST) is a set of technologies designed to analyze application source code, byte code and binaries for coding and design conditions that are indicative of security vulnerabilities. SAST solutions analyze an application from the "inside out" in a nonrunning state. [^6]

💪 Strengths of SAST

- Scales well - can be run on lots of software, and can be run repeatedly (as with nightly builds or continuous integration)
- Useful for things that such tools can automatically find with high confidence, such as buffer overflows, SQL Injection Flaws, and so forth
- Output is good for developers - highlights the precise source files, line numbers, and even subsections of lines that are affected

Weaknesses of SAST

- Many types of security vulnerabilities are very difficult to find automatically (e.g. authentication problems, access control issues, insecure use of cryptography, etc.)
- Cover only a relatively small percentage of application security flaws
- High numbers of false positives
- Cannot find configuration issues not represented in the code
- Difficult to *prove* that an identified security issue is an actual vulnerability

Open Source SAST Tools (Examples)

Tool	Supported Language
SonarQube	20+ languages
FindSecBugs plugin for SpotBugs	Java, Android, Groovy, Scala
Bandit	Python
Brakeman	Ruby on Rails

Dynamic Application Security Testing (DAST)

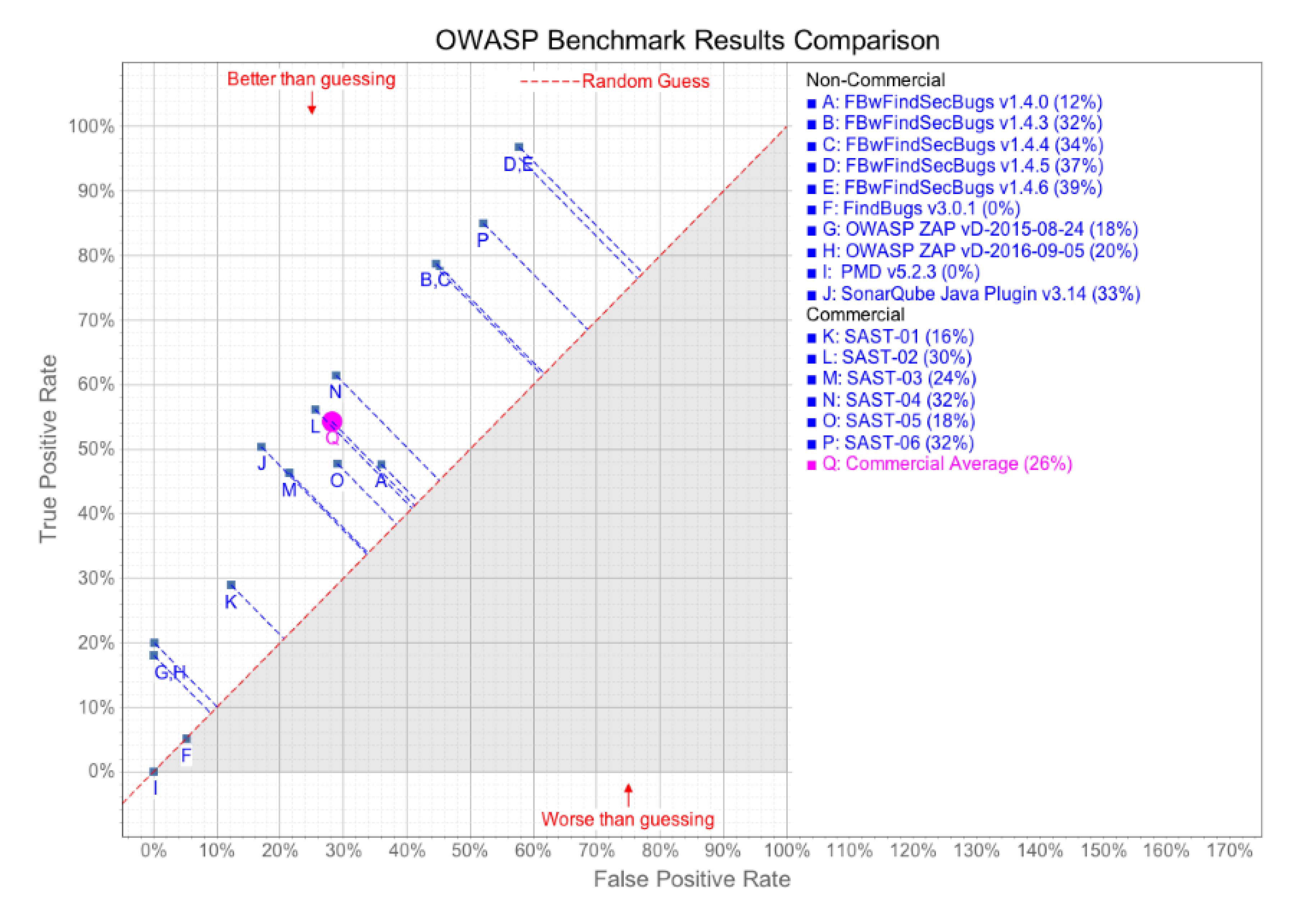
> Dynamic application security testing (DAST) technologies are designed to detect conditions indicative of a security vulnerability in an application in its running state. Most DAST solutions test only the exposed HTTP and HTML interfaces of Web-enabled applications; however, some solutions are designed specifically for non-Web protocol and data malformation (for example, remote procedure call, Session Initiation Protocol [SIP] and so on). [^7]

Open Source DAST Tools (Examples)

	Tool	Proxy	Scanner
	Zed Attack Proxy	✓	✓
	w3af	✗	✓
	Wapiti	✗	✓
	Nikto	✗	✓
	Arachni	✗	✓

OWASP Benchmark

> “ The OWASP Benchmark for Security Automation (OWASP Benchmark) is a free and open test suite designed to evaluate the speed, coverage, and accuracy of automated software vulnerability detection tools and services (henceforth simply referred to as 'tools'). [...] There are four possible test outcomes in the Benchmark:
>
> 1. Tool correctly identifies a real vulnerability (True Positive)
> 2. Tool fails to identify a real vulnerability (False Negative)
> 3. Tool correctly ignores a false alarm (True Negative)
> 4. Tool fails to ignore a false alarm (False Positive) ”



OWASP Benchmark Results Comparison
Better than guessing
Random Guess
Worse than guessing
True Positive Rate
False Positive Rate
Non-Commercial
A: FBwFindSecBugs v1.4.0 (12%)
B: FBwFindSecBugs v1.4.3 (32%)
C: FBwFindSecBugs v1.4.4 (34%)
D: FBwFindSecBugs v1.4.5 (37%)
E: FBwFindSecBugs v1.4.6 (39%)
F: FindBugs v3.0.1 (0%)
G: OWASP ZAP vD-2015-08-24 (18%)
H: OWASP ZAP vD-2016-09-05 (20%)
I: PMD v5.2.3 (0%)
J: SonarQube Java Plugin v3.14 (33%)
Commercial
K: SAST-01 (16%)
L: SAST-02 (30%)
M: SAST-03 (24%)
N: SAST-04 (32%)
O: SAST-05 (18%)
P: SAST-06 (32%)
Q: Commercial Average (26%)

Security Logging & Monitoring

Insufficient Logging & Monitoring

- Exploitation of **insufficient logging and monitoring is the bedrock of nearly every major incident**
- **Attackers** rely on the lack of monitoring and timely response to **achieve their goals without being detected**
  - Most successful attacks start with vulnerability probing
  - Allowing such probes to continue can raise the likelihood of successful exploit to nearly 100%

Examples of Insufficiencies

- Auditable events, such as logins, failed logins, and high-value transactions are not logged
- Warnings and errors generate no, inadequate, or unclear log messages
- Logs of applications and APIs are not monitored for suspicious activity
- Logs are only stored locally
- Appropriate alerting thresholds and response escalation processes are not in place or effective

Risk Rating

Insufficient Logging & Monitoring

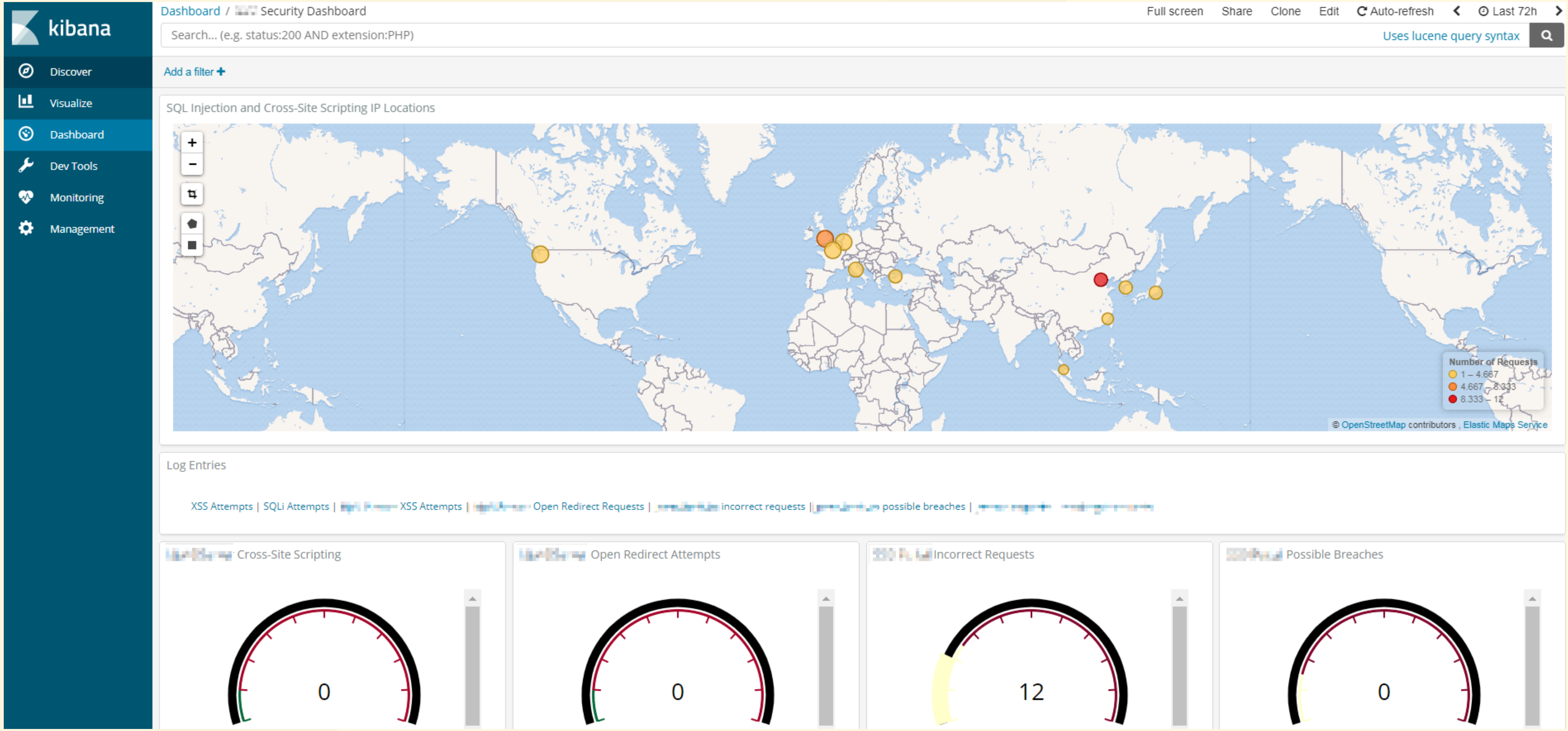
Exploitability	Prevalence	Detecability	Impact	Risk
Average	Widespread	Difficult	Moderate	[A10](#)
(**2**	+ **3**	+ **1**) / 3	* **2**	= **4.0**

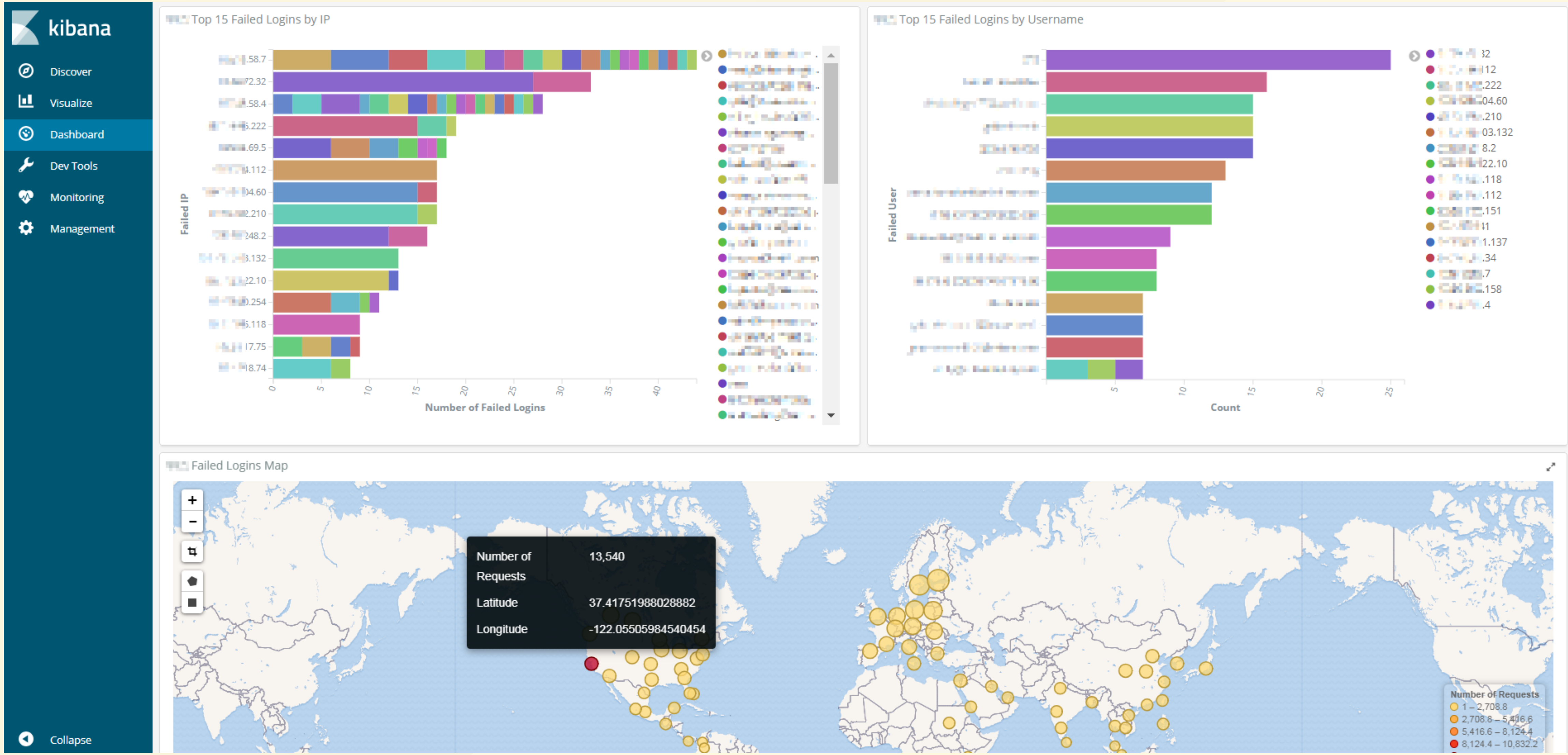
Prevention

- Ensure all login, access control failures, and server-side input validation **failures can be**
  - **logged with sufficient user context** to identify suspicious or malicious accounts
  - **held for sufficient time** to allow delayed forensic analysis
- Ensure that logs are generated in a format that can be easily consumed by a **centralized log management solution**
  - e.g. Elastic Stack (Kibana, Elasticsearch, Logstash & Beats)

* Ensure **high-value transactions have an audit trail** with integrity controls to prevent tampering or deletion
  * e.g. append-only database tables or similar
* Establish effective monitoring and alerting such that **suspicious activities are detected** and responded to **in a timely fashion**
* Establish or adopt an incident response and recovery plan

Example Kibana Security Dashboard



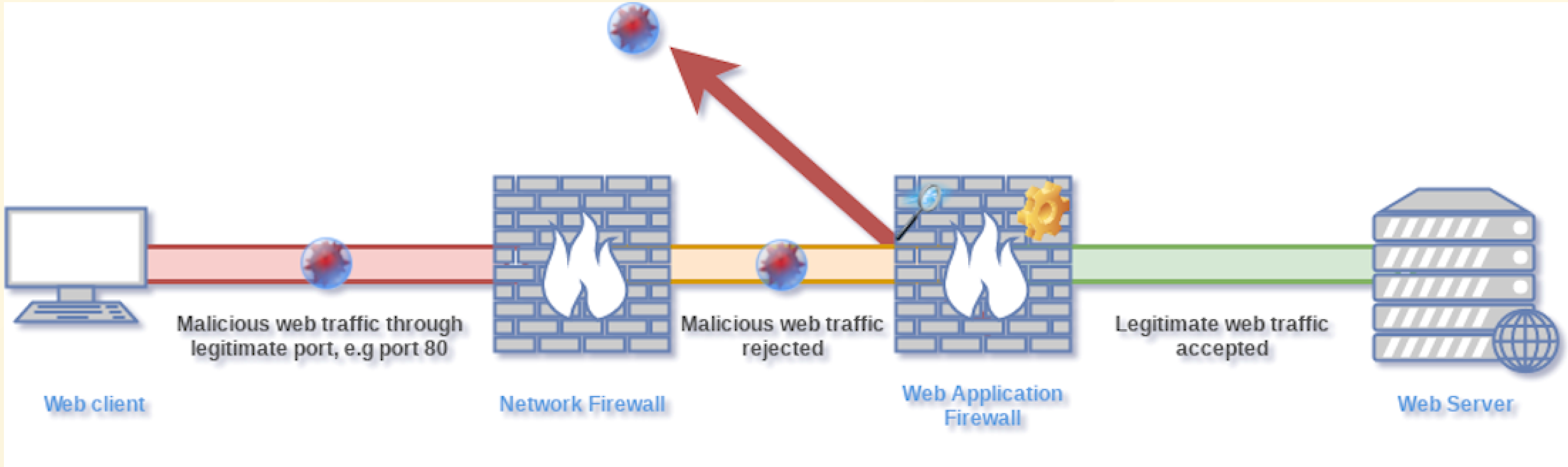

kibana
Discover
Visualize
Dashboard
Dev Tools
Monitoring
Management
Collapse
Top 15 Failed Logins by IP
Failed IP
Number of Failed Logins
Top 15 Failed Logins by Username
Failed User
Count
Failed Logins Map
Number of Requests 13,540
Latitude 37.41751988028882
Longitude -122.05505984540454
Number of Requests
1 – 2,708.8
2,708.8 – 5,416.6
5,416.6 – 8,124.4
8,124.4 – 10,832.2

Web Application Firewall (WAF)

Web Application Firewall

> A web application firewall (WAF) is an application firewall for HTTP applications. It applies a set of rules to an HTTP conversation. Generally, these rules cover common attacks such as cross-site scripting (XSS) and SQL injection.
>
> While proxies generally protect clients, WAFs protect servers. A WAF is deployed to protect a specific web application or set of web applications. A WAF can be considered a reverse proxy.
>
> WAFs may come in the form of an appliance, server plugin, or filter, and may be customized to an application. The effort to perform this customization can be significant and needs to be maintained as the application is modified. [^8]

WAF Deployment in the Network



💡 *An application should be able to protect itself! Use a WAF only as a secondary defense mechanism to achieve [Defense in Depth](#)! For legacy systems (with no feasible way to patch directly) a WAF can be the main protection mechanism.*

Risk in the use of WAFs

- "Yet-another-proxy" (increased complexity of the IT infrastructure)
- Organisational tasks
- Training the WAF on each new release of the web application
- Testing
- False positives (which may have a significant business impact)
- More complex troubleshooting
- WAFs also have/generate errors
- Responsibility for system-wide error situations
- Cost-effectiveness

WAF Modes

- **Blocking Mode**: Normal operational mode where the WAF blocks requests it identified as malicious.
- **Monitoring Mode**: The WAF logs alerts but does not block the corresponding requests.
- **Learning Mode**: The WAF learns from good traffic (e.g. by whitelisted IPs) what the normal use cases and input are.

💡 *Learning Mode might lead to false positives on new application releases when the WAF did not learn any traffic for new functionality.*

OWASP ModSecurity Core Rule Set

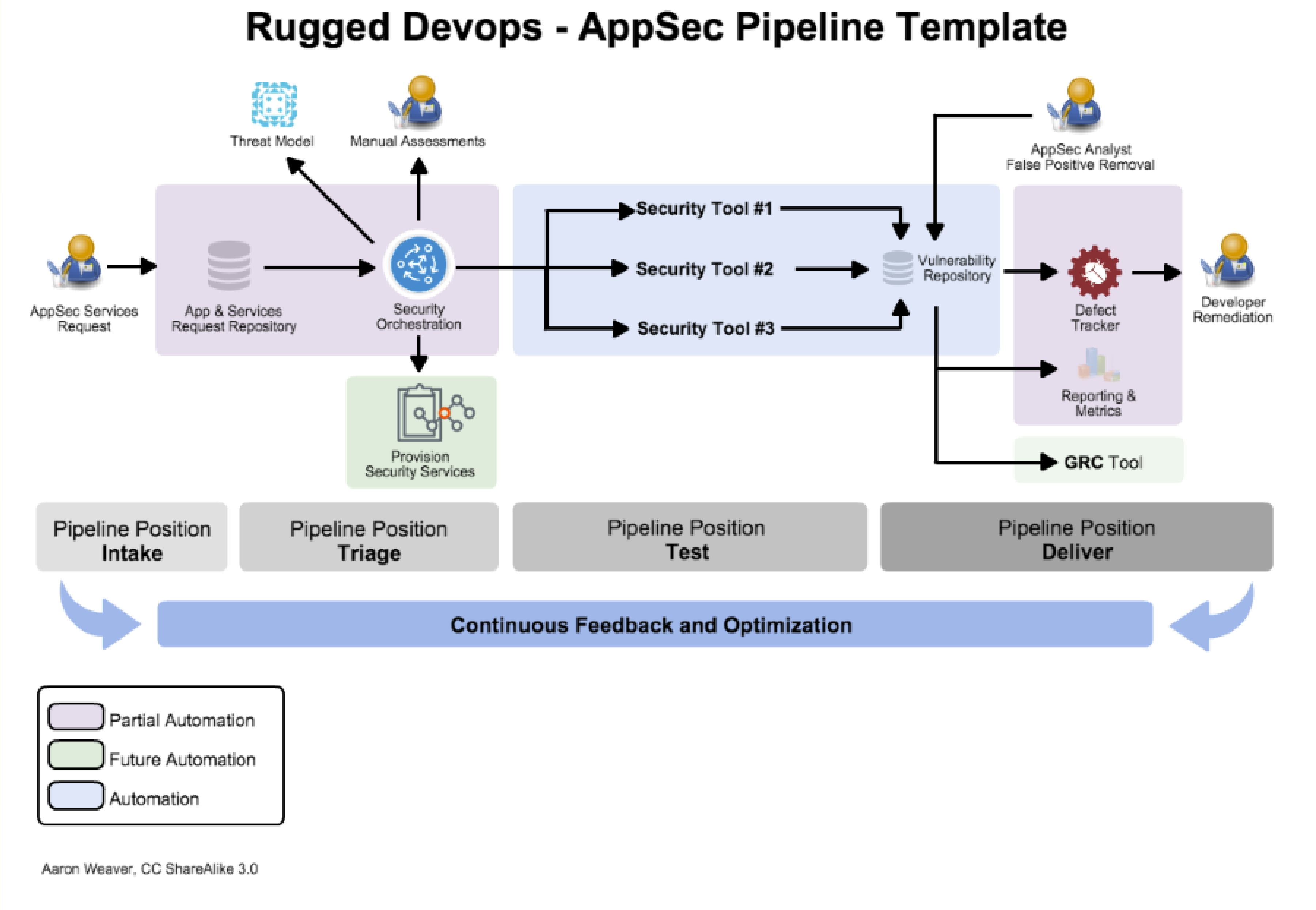
> “ The OWASP ModSecurity Core Rule Set (CRS) is a set of generic attack detection rules for use with ModSecurity or compatible web application firewalls. The CRS aims to protect web applications from a wide range of attacks, including the OWASP Top Ten, with a minimum of false alerts. ”

AppSec Pipeline

AppSec Pipeline

* Applies **principles of DevOps and Lean** to application security
* Designed for **iterative improvement** and has the ability to **grow in functionality organically** over time
* Provides a **consistent process** for the application security team and the constituency (devs, QA, product & senior managers)
* Throughout the process flow each activity has well-defined states
* **Relies heavily on automation** for repeatable tasks

ℹ️ *Start with the area of greatest pain and work on a reusable path for all the AppSec activities that follow.*


Rugged Devops - AppSec Pipeline Template
Threat Model
Manual Assessments
AppSec Analyst
False Positive Removal
AppSec Services
Request
App & Services
Request Repository
Security
Orchestration
Security Tool #1
Security Tool #2
Security Tool #3
Vulnerability
Repository
Defect
Tracker
Developer
Remediation
Reporting &
Metrics
Provision
Security Services
GRC Tool
Pipeline Position
Intake
Pipeline Position
Triage
Pipeline Position
Test
Pipeline Position
Deliver
Continuous Feedback and Optimization
Partial Automation
Future Automation
Automation
Aaron Weaver, CC ShareAlike 3.0

Exercise 9.1 (🏠)

1. Find out if your university uses a Web Application Firewall
2. Find out which product/vendor is being used
3. Find out the number of web applications in your university
   - in total
   - accessible from public Internet (i.e. without VPN)
   - protected by a WAF
4. Repeat steps 1-3 for the company you work at (if applicable)