



Threagile

Agile Threat Modeling

Threat Model Report

SAPL.io

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mb

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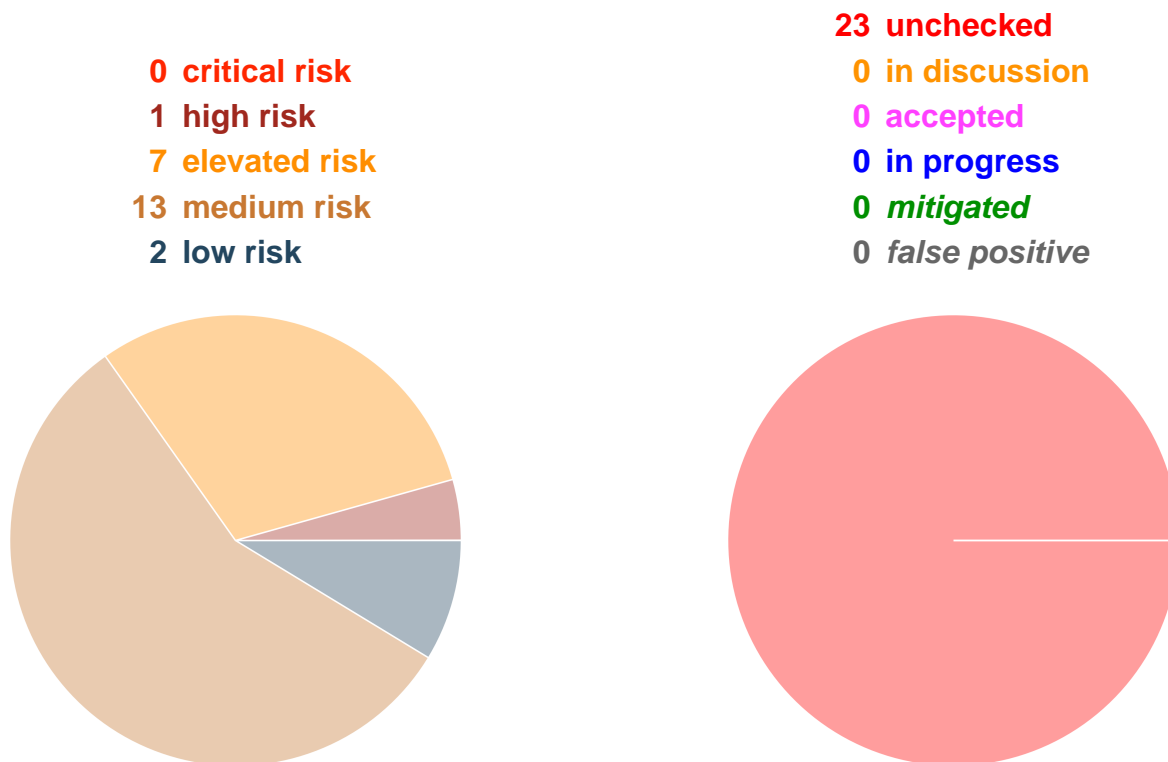
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Management Summary

Threagile toolkit was used to model the architecture of "SAPL.io" and derive risks by analyzing the components and data flows. The risks identified during this analysis are shown in the following chapters. Identified risks during threat modeling do not necessarily mean that the vulnerability associated with this risk actually exists: it is more to be seen as a list of potential risks and threats, which should be individually reviewed and reduced by removing false positives. For the remaining risks it should be checked in the design and implementation of "SAPL.io" whether the mitigation advices have been applied or not.

Each risk finding references a chapter of the OWASP ASVS (Application Security Verification Standard) audit checklist. The OWASP ASVS checklist should be considered as an inspiration by architects and developers to further harden the application in a Defense-in-Depth approach. Additionally, for each risk finding a link towards a matching OWASP Cheat Sheet or similar with technical details about how to implement a mitigation is given.

In total **23 initial risks** in **16 categories** have been identified during the threat modeling process:



Simple flexible and dynamic attribute based access-control (ABAC). The reactive open source engine to bring ABAC to you applications supporting streams of attributes for efficient interactive real-time access control.

Impact Analysis of 23 Initial Risks in 16 Categories

The most prevalent impacts of the **23 initial risks** (distributed over **16 risk categories**) are (taking the severity ratings into account and using the highest for each category):

Risk finding paragraphs are clickable and link to the corresponding chapter.

High: Path-Traversal: 1 Initial Risk - Exploitation likelihood is *Very Likely* with *High* impact.

If this risk is unmitigated, attackers might be able to read sensitive files (configuration data, key/credential files, deployment files, business data files, etc.) from the filesystem of affected components.

Elevated: Cross-Site Request Forgery (CSRF): 1 Initial Risk - Exploitation likelihood is *Very Likely* with *Medium* impact.

If this risk remains unmitigated, attackers might be able to trick logged-in victim users into unwanted actions within the web application by visiting an attacker controlled web site.

Elevated: Cross-Site Scripting (XSS): 1 Initial Risk - Exploitation likelihood is *Likely* with *High* impact.

If this risk remains unmitigated, attackers might be able to access individual victim sessions and steal or modify user data.

Elevated: Missing Hardening: 3 Initial Risks - Exploitation likelihood is *Likely* with *Medium* impact.

If this risk remains unmitigated, attackers might be able to easier attack high-value targets.

Elevated: Server-Side Request Forgery (SSRF): 1 Initial Risk - Exploitation likelihood is *Likely* with *Medium* impact.

If this risk is unmitigated, attackers might be able to access sensitive services or files of network-reachable components by modifying outgoing calls of affected components.

Elevated: Unencrypted Communication: 1 Initial Risk - Exploitation likelihood is *Likely* with *High* impact.

If this risk is unmitigated, network attackers might be able to eavesdrop on unencrypted sensitive data sent between components.

Medium: DoS-risky Access Across Trust-Boundary: 3 Initial Risks - Exploitation likelihood is *Unlikely* with *Medium* impact.

If this risk remains unmitigated, attackers might be able to disturb the availability of important parts of the system.

Medium: Missing Build Infrastructure: 1 Initial Risk - Exploitation likelihood is *Unlikely* with *Medium* impact.

If this risk is unmitigated, attackers might be able to exploit risks unseen in this threat model due to critical build infrastructure components missing in the model.

Medium: Missing Identity Propagation: 1 Initial Risk - Exploitation likelihood is *Unlikely* with *Medium* impact.

If this risk is unmitigated, attackers might be able to access or modify foreign data after a successful compromise of a component within the system due to missing resource-based authorization checks.

Medium: Missing Identity Store: 1 Initial Risk - Exploitation likelihood is *Unlikely* with *Medium* impact.

If this risk is unmitigated, attackers might be able to exploit risks unseen in this threat model in the identity provider/store that is currently missing in the model.

Medium: Missing Two-Factor Authentication (2FA): 1 Initial Risk - Exploitation likelihood is *Unlikely* with *Medium* impact.

If this risk is unmitigated, attackers might be able to access or modify highly sensitive data without strong authentication.

Medium: Missing Vault (Secret Storage): 1 Initial Risk - Exploitation likelihood is *Unlikely* with *Medium* impact.

If this risk is unmitigated, attackers might be able to easier steal config secrets (like credentials, private keys, client certificates, etc.) once a vulnerability to access files is present and exploited.

Medium: Missing Web Application Firewall (WAF): 2 Initial Risks - Exploitation likelihood is *Unlikely* with *Medium* impact.

If this risk is unmitigated, attackers might be able to apply standard attack pattern tests at great speed without any filtering.

Medium: Unencrypted Technical Assets: 2 Initial Risks - Exploitation likelihood is *Unlikely* with *High* impact.

If this risk is unmitigated, attackers might be able to access unencrypted data when successfully compromising sensitive components.

Medium: Unnecessary Data Transfer: 2 Initial Risks - Exploitation likelihood is *Unlikely* with *Medium* impact.

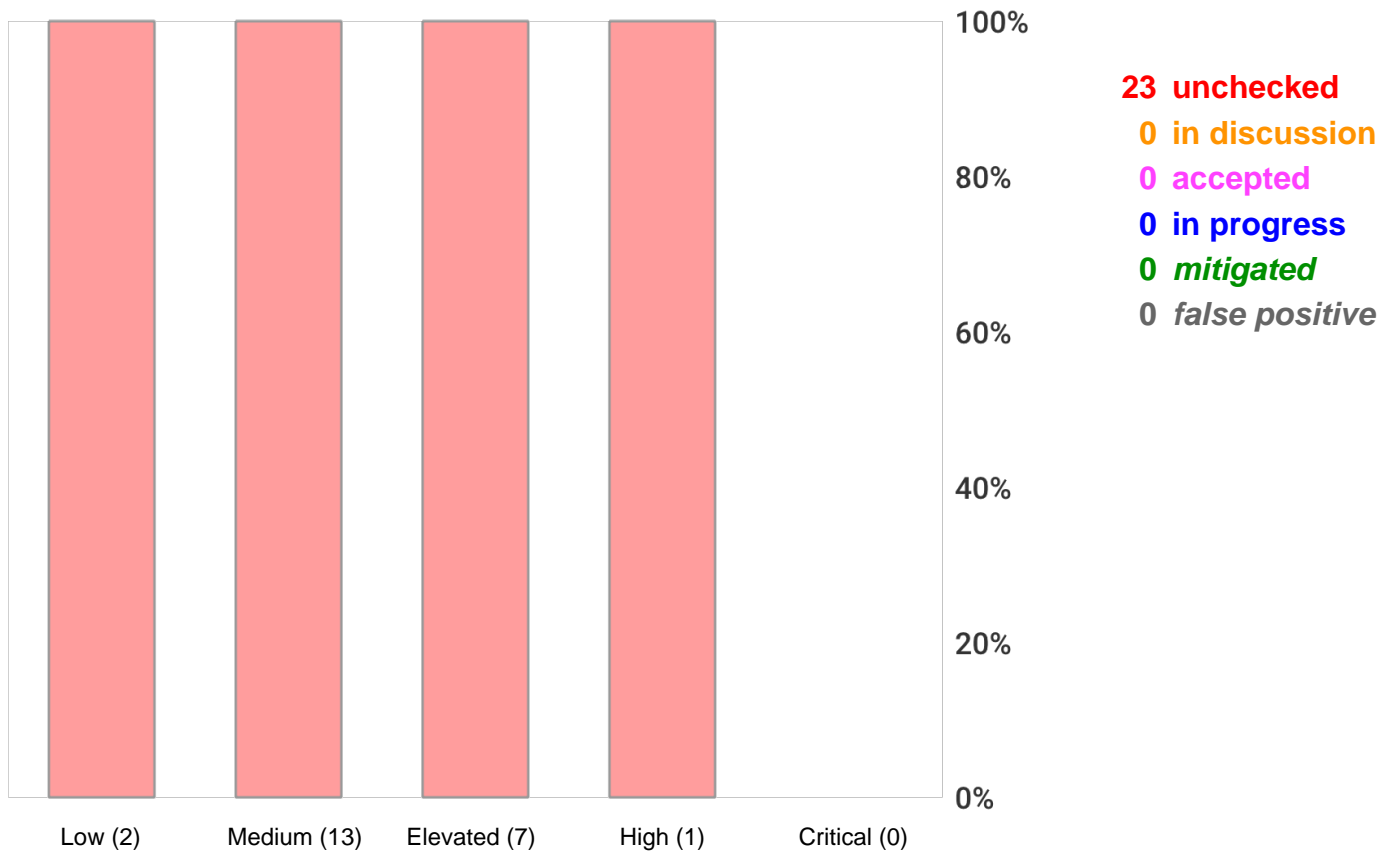
If this risk is unmitigated, attackers might be able to target unnecessarily transferred data.

Low: Wrong Communication Link Content: 1 Initial Risk - Exploitation likelihood is *Unlikely* with *Low* impact.

If this potential model error is not fixed, some risks might not be visible.

Risk Mitigation

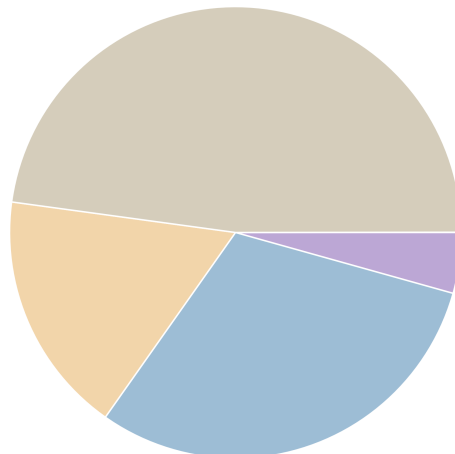
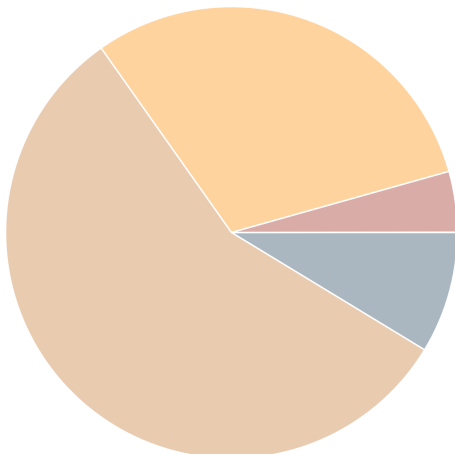
The following chart gives a high-level overview of the risk tracking status (including mitigated risks):



After removal of risks with status *mitigated* and *false positive* the following 23 remain unmitigated:

0 unmitigated critical risk
1 unmitigated high risk
7 unmitigated elevated risk
13 unmitigated medium risk
2 unmitigated low risk

1 business side related
7 architecture related
4 development related
11 operations related



Impact Analysis of 23 Remaining Risks in 16 Categories

The most prevalent impacts of the **23 remaining risks** (distributed over **16 risk categories**) are (taking the severity ratings into account and using the highest for each category):

Risk finding paragraphs are clickable and link to the corresponding chapter.

High: Path-Traversal: 1 Remaining Risk - Exploitation likelihood is *Very Likely* with *High* impact.
If this risk is unmitigated, attackers might be able to read sensitive files (configuration data, key/credential files, deployment files, business data files, etc.) from the filesystem of affected components.

Elevated: Cross-Site Request Forgery (CSRF): 1 Remaining Risk - Exploitation likelihood is *Very Likely* with *Medium* impact.
If this risk remains unmitigated, attackers might be able to trick logged-in victim users into unwanted actions within the web application by visiting an attacker controlled web site.

Elevated: Cross-Site Scripting (XSS): 1 Remaining Risk - Exploitation likelihood is *Likely* with *High* impact.
If this risk remains unmitigated, attackers might be able to access individual victim sessions and steal or modify user data.

Elevated: Missing Hardening: 3 Remaining Risks - Exploitation likelihood is *Likely* with *Medium* impact.
If this risk remains unmitigated, attackers might be able to easier attack high-value targets.

Elevated: Server-Side Request Forgery (SSRF): 1 Remaining Risk - Exploitation likelihood is *Likely* with *Medium* impact.
If this risk is unmitigated, attackers might be able to access sensitive services or files of network-reachable components by modifying outgoing calls of affected components.

Elevated: Unencrypted Communication: 1 Remaining Risk - Exploitation likelihood is *Likely* with *High* impact.
If this risk is unmitigated, network attackers might be able to eavesdrop on unencrypted sensitive data sent between components.

Medium: DoS-risky Access Across Trust-Boundary: 3 Remaining Risks - Exploitation likelihood is *Unlikely* with *Medium* impact.
If this risk remains unmitigated, attackers might be able to disturb the availability of important parts of the system.

Medium: Missing Build Infrastructure: 1 Remaining Risk - Exploitation likelihood is *Unlikely* with *Medium* impact.
If this risk is unmitigated, attackers might be able to exploit risks unseen in this threat model due to critical build infrastructure components missing in the model.

Medium: Missing Identity Propagation: 1 Remaining Risk - Exploitation likelihood is *Unlikely* with *Medium* impact.

If this risk is unmitigated, attackers might be able to access or modify foreign data after a successful compromise of a component within the system due to missing resource-based authorization checks.

Medium: Missing Identity Store: 1 Remaining Risk - Exploitation likelihood is *Unlikely* with *Medium* impact.

If this risk is unmitigated, attackers might be able to exploit risks unseen in this threat model in the identity provider/store that is currently missing in the model.

Medium: Missing Two-Factor Authentication (2FA): 1 Remaining Risk - Exploitation likelihood is *Unlikely* with *Medium* impact.

If this risk is unmitigated, attackers might be able to access or modify highly sensitive data without strong authentication.

Medium: Missing Vault (Secret Storage): 1 Remaining Risk - Exploitation likelihood is *Unlikely* with *Medium* impact.

If this risk is unmitigated, attackers might be able to easier steal config secrets (like credentials, private keys, client certificates, etc.) once a vulnerability to access files is present and exploited.

Medium: Missing Web Application Firewall (WAF): 2 Remaining Risks - Exploitation likelihood is *Unlikely* with *Medium* impact.

If this risk is unmitigated, attackers might be able to apply standard attack pattern tests at great speed without any filtering.

Medium: Unencrypted Technical Assets: 2 Remaining Risks - Exploitation likelihood is *Unlikely* with *High* impact.

If this risk is unmitigated, attackers might be able to access unencrypted data when successfully compromising sensitive components.

Medium: Unnecessary Data Transfer: 2 Remaining Risks - Exploitation likelihood is *Unlikely* with *Medium* impact.

If this risk is unmitigated, attackers might be able to target unnecessarily transferred data.

Low: Wrong Communication Link Content: 1 Remaining Risk - Exploitation likelihood is *Unlikely* with *Low* impact.

If this potential model error is not fixed, some risks might not be visible.

Application Overview

Business Criticality

The overall business criticality of "SAPL.io" was rated as:

(archive | operational | important | critical | **MISSION-CRITICAL**)

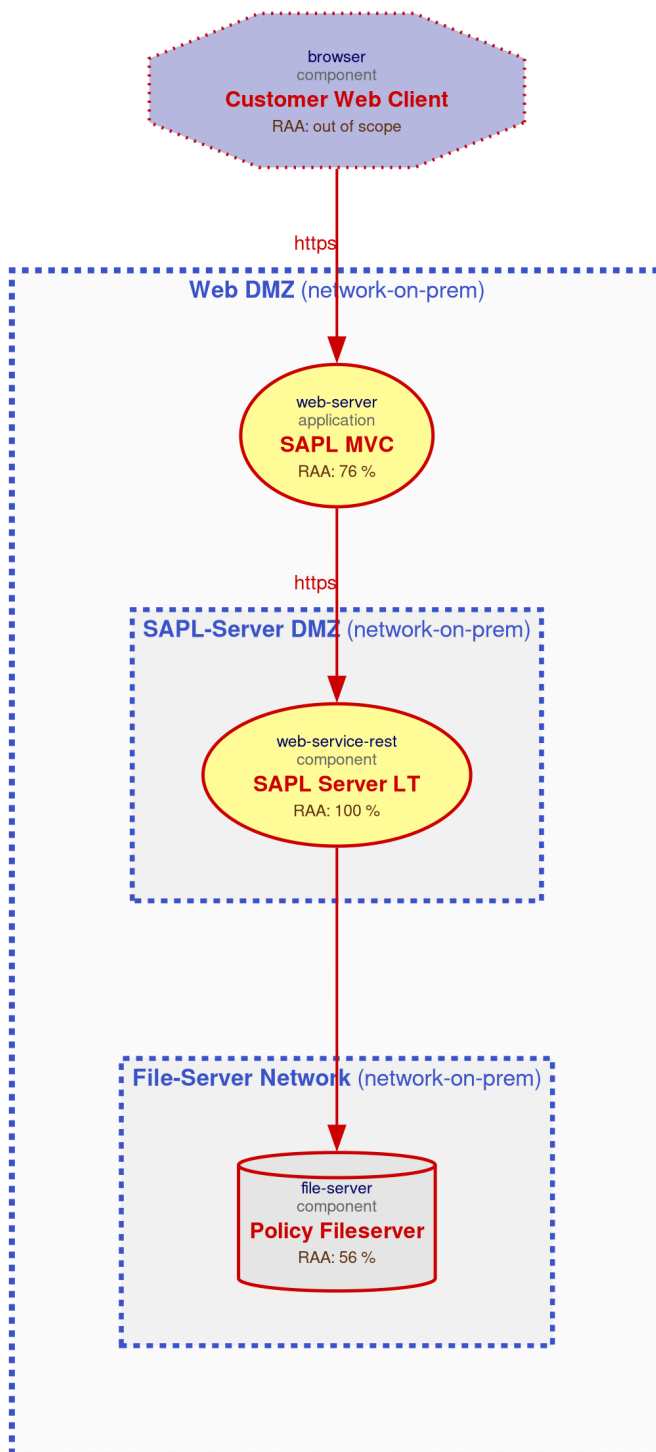
Business Overview

SAPL, or the Streaming Attribute Policy Language, is an open-source implementation of the Attribute-based access control (ABAC) paradigm. SAPL comes with an expressive policy language, policy engine, authorization servers, and framework integrations. SAPL extends the basic ABAC paradigm by following a publish-subscribe pattern instead of the traditional request-response pattern used in most ABAC implementations. So more precisely, SAPL implements Attribute stream-based access control (ASBAC).

Technical Overview

Data-Flow Diagram

The following diagram was generated by Threagile based on the model input and gives a high-level overview of the data-flow between technical assets. The RAA value is the calculated *Relative Attacker Attractiveness* in percent. For a full high-resolution version of this diagram please refer to the PNG image file alongside this report.



Security Requirements

This chapter lists the custom security requirements which have been defined for the modeled target.

This list is not complete and regulatory or law relevant security requirements have to be taken into account as well. Also custom individual security requirements might exist for the project.

Abuse Cases

This chapter lists the custom abuse cases which have been defined for the modeled target.

This list is not complete and regulatory or law relevant abuse cases have to be taken into account as well. Also custom individual abuse cases might exist for the project.

Tag Listing

This chapter lists what tags are used by which elements.

sapl-jwt

SAPL Server LT

sapl-spring-pdp-embedded

SAPL Server LT

sapl-webflux-endpoint

SAPL Server LT

spring-boot

SAPL MVC, SAPL Server LT

spring-security

SAPL Server LT

windows-server

Policy Fileserver

STRIDE Classification of Identified Risks

This chapter clusters and classifies the risks by STRIDE categories: In total **23 potential risks** have been identified during the threat modeling process of which **2 in the Spoofing** category, **7 in the Tampering** category, **0 in the Repudiation** category, **7 in the Information Disclosure** category, **3 in the Denial of Service** category, and **4 in the Elevation of Privilege** category.

Risk finding paragraphs are clickable and link to the corresponding chapter.

Spoofing

Elevated: **Cross-Site Request Forgery (CSRF)**: 1 / 1 Risk - Exploitation likelihood is *Very Likely* with *Medium* impact.

When a web application is accessed via web protocols Cross-Site Request Forgery (CSRF) risks might arise.

Medium: **Missing Identity Store**: 1 / 1 Risk - Exploitation likelihood is *Unlikely* with *Medium* impact.

The modeled architecture does not contain an identity store, which might be the risk of a model missing critical assets (and thus not seeing their risks).

Tampering

Elevated: **Cross-Site Scripting (XSS)**: 1 / 1 Risk - Exploitation likelihood is *Likely* with *High* impact.

For each web application Cross-Site Scripting (XSS) risks might arise. In terms of the overall risk level take other applications running on the same domain into account as well.

Elevated: **Missing Hardening**: 3 / 3 Risks - Exploitation likelihood is *Likely* with *Medium* impact.

Technical assets with a Relative Attacker Attractiveness (RAA) value of 55 % or higher should be explicitly hardened taking best practices and vendor hardening guides into account.

Medium: **Missing Build Infrastructure**: 1 / 1 Risk - Exploitation likelihood is *Unlikely* with *Medium* impact.

The modeled architecture does not contain a build infrastructure (devops-client, sourcecode-repo, build-pipeline, etc.), which might be the risk of a model missing critical assets (and thus not seeing their risks). If the architecture contains custom-developed parts, the pipeline where code gets developed and built needs to be part of the model.

Medium: **Missing Web Application Firewall (WAF)**: 2 / 2 Risks - Exploitation likelihood is *Unlikely* with *Medium* impact.

To have a first line of filtering defense, security architectures with web-services or web-applications should include a WAF in front of them. Even though a WAF is not a replacement for security (all components must be secure even without a WAF) it adds another layer of defense to the overall system by delaying some attacks and having easier attack alerting through it.

Repudiation

n/a

Information Disclosure

High: Path-Traversal: 1 / 1 Risk - Exploitation likelihood is *Very Likely* with *High* impact.

When a filesystem is accessed Path-Traversal or Local-File-Inclusion (LFI) risks might arise. The risk rating depends on the sensitivity of the technical asset itself and of the data assets processed or stored.

Elevated: Server-Side Request Forgery (SSRF): 1 / 1 Risk - Exploitation likelihood is *Likely* with *Medium* impact.

When a server system (i.e. not a client) is accessing other server systems via typical web protocols Server-Side Request Forgery (SSRF) or Local-File-Inclusion (LFI) or Remote-File-Inclusion (RFI) risks might arise.

Elevated: Unencrypted Communication: 1 / 1 Risk - Exploitation likelihood is *Likely* with *High* impact.

Due to the confidentiality and/or integrity rating of the data assets transferred over the communication link this connection must be encrypted.

Medium: Missing Vault (Secret Storage): 1 / 1 Risk - Exploitation likelihood is *Unlikely* with *Medium* impact.

In order to avoid the risk of secret leakage via config files (when attacked through vulnerabilities being able to read files like Path-Traversal and others), it is best practice to use a separate hardened process with proper authentication, authorization, and audit logging to access config secrets (like credentials, private keys, client certificates, etc.). This component is usually some kind of Vault.

Medium: Unencrypted Technical Assets: 2 / 2 Risks - Exploitation likelihood is *Unlikely* with *High* impact.

Due to the confidentiality rating of the technical asset itself and/or the processed data assets this technical asset must be encrypted. The risk rating depends on the sensitivity technical asset itself and of the data assets stored.

Low: Wrong Communication Link Content: 1 / 1 Risk - Exploitation likelihood is *Unlikely* with *Low* impact.

When a communication link is defined as readonly, but does not receive any data asset, or when it is defined as not readonly, but does not send any data asset, it is likely to be a model failure.

Denial of Service

Medium: **DoS-risky Access Across Trust-Boundary**: 3 / 3 Risks - Exploitation likelihood is *Unlikely* with *Medium* impact.

Assets accessed across trust boundaries with critical or mission-critical availability rating are more prone to Denial-of-Service (DoS) risks.

Elevation of Privilege

Medium: **Missing Identity Propagation**: 1 / 1 Risk - Exploitation likelihood is *Unlikely* with *Medium* impact.

Technical assets (especially multi-tenant systems), which usually process data for endusers should authorize every request based on the identity of the enduser when the data flow is authenticated (i.e. non-public). For DevOps usages at least a technical-user authorization is required.

Medium: **Missing Two-Factor Authentication (2FA)**: 1 / 1 Risk - Exploitation likelihood is *Unlikely* with *Medium* impact.

Technical assets (especially multi-tenant systems) should authenticate incoming requests with two-factor (2FA) authentication when the asset processes or stores highly sensitive data (in terms of confidentiality, integrity, and availability) and is accessed by humans.

Medium: **Unnecessary Data Transfer**: 2 / 2 Risks - Exploitation likelihood is *Unlikely* with *Medium* impact.

When a technical asset sends or receives data assets, which it neither processes or stores this is an indicator for unnecessarily transferred data (or for an incomplete model). When the unnecessarily transferred data assets are sensitive, this poses an unnecessary risk of an increased attack surface.

Assignment by Function

This chapter clusters and assigns the risks by functions which are most likely able to check and mitigate them: In total **23 potential risks** have been identified during the threat modeling process of which **1 should be checked by Business Side**, **7 should be checked by Architecture**, **4 should be checked by Development**, and **11 should be checked by Operations**.

Risk finding paragraphs are clickable and link to the corresponding chapter.

Business Side

Medium: **Missing Two-Factor Authentication (2FA)**: 1 / 1 Risk - Exploitation likelihood is *Unlikely* with *Medium* impact.

Apply an authentication method to the technical asset protecting highly sensitive data via two-factor authentication for human users.

Architecture

Medium: **Missing Build Infrastructure**: 1 / 1 Risk - Exploitation likelihood is *Unlikely* with *Medium* impact.

Include the build infrastructure in the model.

Medium: **Missing Identity Propagation**: 1 / 1 Risk - Exploitation likelihood is *Unlikely* with *Medium* impact.

When processing requests for endusers if possible authorize in the backend against the propagated identity of the enduser. This can be achieved in passing JWTs or similar tokens and checking them in the backend services. For DevOps usages apply at least a technical-user authorization.

Medium: **Missing Identity Store**: 1 / 1 Risk - Exploitation likelihood is *Unlikely* with *Medium* impact.

Include an identity store in the model if the application has a login.

Medium: **Missing Vault (Secret Storage)**: 1 / 1 Risk - Exploitation likelihood is *Unlikely* with *Medium* impact.

Consider using a Vault (Secret Storage) to securely store and access config secrets (like credentials, private keys, client certificates, etc.).

Medium: **Unnecessary Data Transfer**: 2 / 2 Risks - Exploitation likelihood is *Unlikely* with *Medium* impact.

Try to avoid sending or receiving sensitive data assets which are not required (i.e. neither processed or stored) by the involved technical asset.

Low: **Wrong Communication Link Content**: 1 / 1 Risk - Exploitation likelihood is *Unlikely* with *Low* impact.

Try to model the correct readonly flag and/or data sent/received of communication links. Also try to use communication link types matching the target technology/machine types.

Development

High: Path-Traversal: 1 / 1 Risk - Exploitation likelihood is *Very Likely* with *High* impact.

Before accessing the file cross-check that it resides in the expected folder and is of the expected type and filename/suffix. Try to use a mapping if possible instead of directly accessing by a filename which is (partly or fully) provided by the caller. When a third-party product is used instead of custom developed software, check if the product applies the proper mitigation and ensure a reasonable patch-level.

Elevated: Cross-Site Request Forgery (CSRF): 1 / 1 Risk - Exploitation likelihood is *Very Likely* with *Medium* impact.

Try to use anti-CSRF tokens or the double-submit patterns (at least for logged-in requests). When your authentication scheme depends on cookies (like session or token cookies), consider marking them with the same-site flag. When a third-party product is used instead of custom developed software, check if the product applies the proper mitigation and ensure a reasonable patch-level.

Elevated: Cross-Site Scripting (XSS): 1 / 1 Risk - Exploitation likelihood is *Likely* with *High* impact.

Try to encode all values sent back to the browser and also handle DOM-manipulations in a safe way to avoid DOM-based XSS. When a third-party product is used instead of custom developed software, check if the product applies the proper mitigation and ensure a reasonable patch-level.

Elevated: Server-Side Request Forgery (SSRF): 1 / 1 Risk - Exploitation likelihood is *Likely* with *Medium* impact.

Try to avoid constructing the outgoing target URL with caller controllable values. Alternatively use a mapping (whitelist) when accessing outgoing URLs instead of creating them including caller controllable values. When a third-party product is used instead of custom developed software, check if the product applies the proper mitigation and ensure a reasonable patch-level.

Operations

Elevated: Missing Hardening: 3 / 3 Risks - Exploitation likelihood is *Likely* with *Medium* impact.

Try to apply all hardening best practices (like CIS benchmarks, OWASP recommendations, vendor recommendations, DevSec Hardening Framework, DBSAT for Oracle databases, and others).

Elevated: Unencrypted Communication: 1 / 1 Risk - Exploitation likelihood is *Likely* with *High* impact.

Apply transport layer encryption to the communication link.

Medium: DoS-risky Access Across Trust-Boundary: 3 / 3 Risks - Exploitation likelihood is *Unlikely* with *Medium* impact.

Apply anti-DoS techniques like throttling and/or per-client load blocking with quotas. Also for maintenance access routes consider applying a VPN instead of public reachable interfaces. Generally applying redundancy on the targeted technical asset reduces the risk of DoS.

Medium: **Missing Web Application Firewall (WAF): 2 / 2 Risks** - Exploitation likelihood is *Unlikely* with *Medium* impact.

Consider placing a Web Application Firewall (WAF) in front of the web-services and/or web-applications. For cloud environments many cloud providers offer pre-configured WAFs. Even reverse proxies can be enhanced by a WAF component via ModSecurity plugins.

Medium: **Unencrypted Technical Assets: 2 / 2 Risks** - Exploitation likelihood is *Unlikely* with *High* impact.

Apply encryption to the technical asset.

RAA Analysis

For each technical asset the "**Relative Attacker Attractiveness**" (RAA) value was calculated in percent. The higher the RAA, the more interesting it is for an attacker to compromise the asset. The calculation algorithm takes the sensitivity ratings and quantities of stored and processed data into account as well as the communication links of the technical asset. Neighbouring assets to high-value RAA targets might receive an increase in their RAA value when they have a communication link towards that target ("Pivoting-Factor").

The following lists all technical assets sorted by their RAA value from highest (most attacker attractive) to lowest. This list can be used to prioritize on efforts relevant for the most attacker-attractive technical assets:

Technical asset paragraphs are clickable and link to the corresponding chapter.

SAPL Server LT: RAA 100%

SAPL Server LT

SAPL MVC: RAA 76%

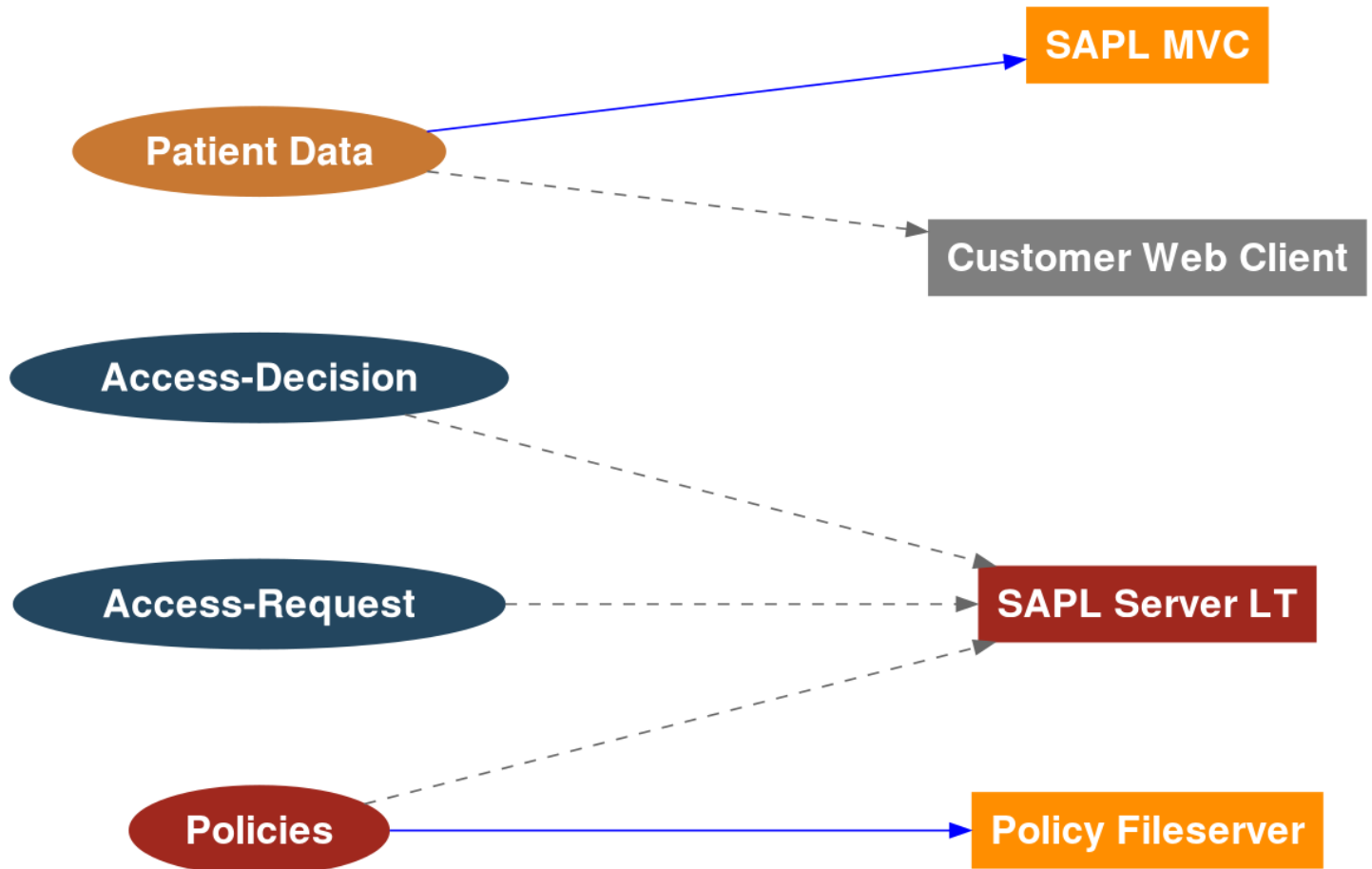
Spring-Boot MVC Webserver

Policy Fileserver: RAA 56%

NTFS-Filesystem to store policies

Data Mapping

The following diagram was generated by Threagile based on the model input and gives a high-level distribution of data assets across technical assets. The color matches the identified data breach probability and risk level (see the "Data Breach Probabilities" chapter for more details). A solid line stands for *data is stored by the asset* and a dashed one means *data is processed by the asset*. For a full high-resolution version of this diagram please refer to the PNG image file alongside this report.



Out-of-Scope Assets: 1 Asset

This chapter lists all technical assets that have been defined as out-of-scope. Each one should be checked in the model whether it should better be included in the overall risk analysis:

Technical asset paragraphs are clickable and link to the corresponding chapter.

Customer Web Client: out-of-scope

Owned and managed by enduser customer

Potential Model Failures: 6 / 6 Risks

This chapter lists potential model failures where not all relevant assets have been modeled or the model might itself contain inconsistencies. Each potential model failure should be checked in the model against the architecture design:

Risk finding paragraphs are clickable and link to the corresponding chapter.

Medium: Missing Build Infrastructure: 1 / 1 Risk - Exploitation likelihood is *Unlikely* with *Medium* impact.

The modeled architecture does not contain a build infrastructure (devops-client, sourcecode-repo, build-pipeline, etc.), which might be the risk of a model missing critical assets (and thus not seeing their risks). If the architecture contains custom-developed parts, the pipeline where code gets developed and built needs to be part of the model.

Medium: Missing Identity Store: 1 / 1 Risk - Exploitation likelihood is *Unlikely* with *Medium* impact.

The modeled architecture does not contain an identity store, which might be the risk of a model missing critical assets (and thus not seeing their risks).

Medium: Missing Vault (Secret Storage): 1 / 1 Risk - Exploitation likelihood is *Unlikely* with *Medium* impact.

In order to avoid the risk of secret leakage via config files (when attacked through vulnerabilities being able to read files like Path-Traversal and others), it is best practice to use a separate hardened process with proper authentication, authorization, and audit logging to access config secrets (like credentials, private keys, client certificates, etc.). This component is usually some kind of Vault.

Medium: Unnecessary Data Transfer: 2 / 2 Risks - Exploitation likelihood is *Unlikely* with *Medium* impact.

When a technical asset sends or receives data assets, which it neither processes or stores this is an indicator for unnecessarily transferred data (or for an incomplete model). When the unnecessarily transferred data assets are sensitive, this poses an unnecessary risk of an increased attack surface.

Low: Wrong Communication Link Content: 1 / 1 Risk - Exploitation likelihood is *Unlikely* with *Low* impact.

When a communication link is defined as readonly, but does not receive any data asset, or when it is defined as not readonly, but does not send any data asset, it is likely to be a model failure.

Questions: 0 / 0 Questions

This chapter lists custom questions that arose during the threat modeling process.

No custom questions arose during the threat modeling process.

Identified Risks by Vulnerability Category

In total **23 potential risks** have been identified during the threat modeling process of which **0 are rated as critical, 1 as high, 7 as elevated, 13 as medium, and 2 as low.**

These risks are distributed across **16 vulnerability categories**. The following sub-chapters of this section describe each identified risk category.

Path-Traversal: 1 / 1 Risk

Description (Information Disclosure): [CWE 22](#)

When a filesystem is accessed Path-Traversal or Local-File-Inclusion (LFI) risks might arise. The risk rating depends on the sensitivity of the technical asset itself and of the data assets processed or stored.

Impact

If this risk is unmitigated, attackers might be able to read sensitive files (configuration data, key/credential files, deployment files, business data files, etc.) from the filesystem of affected components.

Detection Logic

Filesystems accessed by in-scope callers.

Risk Rating

The risk rating depends on the sensitivity of the data stored inside the technical asset.

False Positives

File accesses by filenames not consisting of parts controllable by the caller can be considered as false positives after individual review.

Mitigation (Development): Path-Traversal Prevention

Before accessing the file cross-check that it resides in the expected folder and is of the expected type and filename/suffix. Try to use a mapping if possible instead of directly accessing by a filename which is (partly or fully) provided by the caller. When a third-party product is used instead of custom developed software, check if the product applies the proper mitigation and ensure a reasonable patch-level.

ASVS Chapter: [V12 - File and Resources Verification Requirements](#)

Cheat Sheet: [Input Validation Cheat Sheet](#)

Check

Are recommendations from the linked cheat sheet and referenced ASVS chapter applied?

Risk Findings

The risk **Path-Traversal** was found **1 time** in the analyzed architecture to be potentially possible. Each spot should be checked individually by reviewing the implementation whether all controls have been applied properly in order to mitigate each risk.

Risk finding paragraphs are clickable and link to the corresponding chapter.

High Risk Severity

Path-Traversal risk at **SAPL Server LT** against filesystem **Policy Fileserver** via **Policy Filesystem Access**: Exploitation likelihood is *Very Likely* with *High* impact.

[path-traversal@sapl-server-lt@policy-fileserver@sapl-server-lt>policy-filesystem-access](#)

Unchecked

Cross-Site Request Forgery (CSRF): 1 / 1 Risk

Description (Spoofing): [CWE 352](#)

When a web application is accessed via web protocols Cross-Site Request Forgery (CSRF) risks might arise.

Impact

If this risk remains unmitigated, attackers might be able to trick logged-in victim users into unwanted actions within the web application by visiting an attacker controlled web site.

Detection Logic

In-scope web applications accessed via typical web access protocols.

Risk Rating

The risk rating depends on the integrity rating of the data sent across the communication link.

False Positives

Web applications passing the authentication state via custom headers instead of cookies can eventually be false positives. Also when the web application is not accessed via a browser-like component (i.e not by a human user initiating the request that gets passed through all components until it reaches the web application) this can be considered a false positive.

Mitigation (Development): CSRF Prevention

Try to use anti-CSRF tokens or the double-submit patterns (at least for logged-in requests). When your authentication scheme depends on cookies (like session or token cookies), consider marking them with the same-site flag. When a third-party product is used instead of custom developed software, check if the product applies the proper mitigation and ensure a reasonable patch-level.

ASVS Chapter: [V4 - Access Control Verification Requirements](#)

Cheat Sheet: [Cross-Site Request Forgery Prevention Cheat Sheet](#)

Check

Are recommendations from the linked cheat sheet and referenced ASVS chapter applied?

Risk Findings

The risk **Cross-Site Request Forgery (CSRF)** was found **1 time** in the analyzed architecture to be potentially possible. Each spot should be checked individually by reviewing the implementation whether all controls have been applied properly in order to mitigate each risk.

Risk finding paragraphs are clickable and link to the corresponding chapter.

Elevated Risk Severity

Cross-Site Request Forgery (CSRF) risk at SAPL MVC via Customer Traffic from Customer Web Client: Exploitation likelihood is *Very Likely* with *Medium* impact.

[cross-site-request-forgery@sapl-mvc@customer-client>customer-traffic](#)

Unchecked

Cross-Site Scripting (XSS): 1 / 1 Risk

Description (Tampering): [CWE 79](#)

For each web application Cross-Site Scripting (XSS) risks might arise. In terms of the overall risk level take other applications running on the same domain into account as well.

Impact

If this risk remains unmitigated, attackers might be able to access individual victim sessions and steal or modify user data.

Detection Logic

In-scope web applications.

Risk Rating

The risk rating depends on the sensitivity of the data processed or stored in the web application.

False Positives

When the technical asset is not accessed via a browser-like component (i.e not by a human user initiating the request that gets passed through all components until it reaches the web application) this can be considered a false positive.

Mitigation (Development): XSS Prevention

Try to encode all values sent back to the browser and also handle DOM-manipulations in a safe way to avoid DOM-based XSS. When a third-party product is used instead of custom developed software, check if the product applies the proper mitigation and ensure a reasonable patch-level.

ASVS Chapter: [V5 - Validation, Sanitization and Encoding Verification Requirements](#)

Cheat Sheet: [Cross Site Scripting Prevention Cheat Sheet](#)

Check

Are recommendations from the linked cheat sheet and referenced ASVS chapter applied?

Risk Findings

The risk **Cross-Site Scripting (XSS)** was found **1 time** in the analyzed architecture to be potentially possible. Each spot should be checked individually by reviewing the implementation whether all controls have been applied properly in order to mitigate each risk.

Risk finding paragraphs are clickable and link to the corresponding chapter.

Elevated Risk Severity

Cross-Site Scripting (XSS) risk at **SAPL MVC**: Exploitation likelihood is *Likely* with *High* impact.

[cross-site-scripting@sapl-mvc](#)

Unchecked

Missing Hardening: 3 / 3 Risks

Description (Tampering): [CWE 16](#)

Technical assets with a Relative Attacker Attractiveness (RAA) value of 55 % or higher should be explicitly hardened taking best practices and vendor hardening guides into account.

Impact

If this risk remains unmitigated, attackers might be able to easier attack high-value targets.

Detection Logic

In-scope technical assets with RAA values of 55 % or higher. Generally for high-value targets like datastores, application servers, identity providers and ERP systems this limit is reduced to 40 %

Risk Rating

The risk rating depends on the sensitivity of the data processed or stored in the technical asset.

False Positives

Usually no false positives.

Mitigation (Operations): System Hardening

Try to apply all hardening best practices (like CIS benchmarks, OWASP recommendations, vendor recommendations, DevSec Hardening Framework, DBSAT for Oracle databases, and others).

ASVS Chapter: [V14 - Configuration Verification Requirements](#)

Cheat Sheet: [Attack Surface Analysis Cheat Sheet](#)

Check

Are recommendations from the linked cheat sheet and referenced ASVS chapter applied?

Risk Findings

The risk **Missing Hardening** was found **3 times** in the analyzed architecture to be potentially possible. Each spot should be checked individually by reviewing the implementation whether all controls have been applied properly in order to mitigate each risk.

Risk finding paragraphs are clickable and link to the corresponding chapter.

Elevated Risk Severity

Missing Hardening risk at **Policy Fileserver**: Exploitation likelihood is *Likely* with *Medium* impact.

[missing-hardening@policy-fileserver](#)

Unchecked

Missing Hardening risk at **SAPL MVC**: Exploitation likelihood is *Likely* with *Medium* impact.

[missing-hardening@sapl-mvc](#)

Unchecked

Missing Hardening risk at **SAPL Server LT**: Exploitation likelihood is *Likely* with *Medium* impact.

[missing-hardening@sapl-server-lt](#)

Unchecked

Server-Side Request Forgery (SSRF): 1 / 1 Risk

Description (Information Disclosure): [CWE 918](#)

When a server system (i.e. not a client) is accessing other server systems via typical web protocols Server-Side Request Forgery (SSRF) or Local-File-Inclusion (LFI) or Remote-File-Inclusion (RFI) risks might arise.

Impact

If this risk is unmitigated, attackers might be able to access sensitive services or files of network-reachable components by modifying outgoing calls of affected components.

Detection Logic

In-scope non-client systems accessing (using outgoing communication links) targets with either HTTP or HTTPS protocol.

Risk Rating

The risk rating (low or medium) depends on the sensitivity of the data assets receivable via web protocols from targets within the same network trust-boundary as well on the sensitivity of the data assets receivable via web protocols from the target asset itself. Also for cloud-based environments the exploitation impact is at least medium, as cloud backend services can be attacked via SSRF.

False Positives

Servers not sending outgoing web requests can be considered as false positives after review.

Mitigation (Development): SSRF Prevention

Try to avoid constructing the outgoing target URL with caller controllable values. Alternatively use a mapping (whitelist) when accessing outgoing URLs instead of creating them including caller controllable values. When a third-party product is used instead of custom developed software, check if the product applies the proper mitigation and ensure a reasonable patch-level.

ASVS Chapter: [V12 - File and Resources Verification Requirements](#)

Cheat Sheet: [Server Side Request Forgery Prevention Cheat Sheet](#)

Check

Are recommendations from the linked cheat sheet and referenced ASVS chapter applied?

Risk Findings

The risk **Server-Side Request Forgery (SSRF)** was found **1 time** in the analyzed architecture to be potentially possible. Each spot should be checked individually by reviewing the implementation whether all controls have been applied properly in order to mitigate each risk.

Risk finding paragraphs are clickable and link to the corresponding chapter.

Elevated Risk Severity

Server-Side Request Forgery (SSRF) risk at **SAPL MVC** server-side web-requesting the target **SAPL Server LT** via **SAPL Server LT Traffic**: Exploitation likelihood is *Likely* with *Medium* impact.

server-side-request-forgery@sapl-mvc@sapl-server-lt@sapl-mvc>sapl-server-lt-traffic

Unchecked

Unencrypted Communication: 1 / 1 Risk

Description (Information Disclosure): [CWE 319](#)

Due to the confidentiality and/or integrity rating of the data assets transferred over the communication link this connection must be encrypted.

Impact

If this risk is unmitigated, network attackers might be able to to eavesdrop on unencrypted sensitive data sent between components.

Detection Logic

Unencrypted technical communication links of in-scope technical assets (excluding monitoring traffic as well as local-file-access and in-process-library-call) transferring sensitive data.

Risk Rating

Depending on the confidentiality rating of the transferred data-assets either medium or high risk.

False Positives

When all sensitive data sent over the communication link is already fully encrypted on document or data level. Also intra-container/pod communication can be considered false positive when container orchestration platform handles encryption.

Mitigation (Operations): Encryption of Communication Links

Apply transport layer encryption to the communication link.

ASVS Chapter: [V9 - Communication Verification Requirements](#)

Cheat Sheet: [Transport Layer Protection Cheat Sheet](#)

Check

Are recommendations from the linked cheat sheet and referenced ASVS chapter applied?

Risk Findings

The risk **Unencrypted Communication** was found **1 time** in the analyzed architecture to be potentially possible. Each spot should be checked individually by reviewing the implementation whether all controls have been applied properly in order to mitigate each risk.

Risk finding paragraphs are clickable and link to the corresponding chapter.

Elevated Risk Severity

Unencrypted Communication named **Policy Filesystem Access** between **SAPL Server LT** and **Policy Fileserver** transferring authentication data (like credentials, token, session-id, etc.): Exploitation likelihood is *Likely* with *High* impact.

[unencrypted-communication@sapl-server-lt>policy-filesystem-access@sapl-server-lt@policy-fileserver](#)

Unchecked

DoS-risky Access Across Trust-Boundary: 3 / 3 Risks

Description (Denial of Service): [CWE 400](#)

Assets accessed across trust boundaries with critical or mission-critical availability rating are more prone to Denial-of-Service (DoS) risks.

Impact

If this risk remains unmitigated, attackers might be able to disturb the availability of important parts of the system.

Detection Logic

In-scope technical assets (excluding load-balancer) with availability rating of critical or higher which have incoming data-flows across a network trust-boundary (excluding devops usage).

Risk Rating

Matching technical assets with availability rating of critical or higher are at low risk. When the availability rating is mission-critical and neither a VPN nor IP filter for the incoming data-flow nor redundancy for the asset is applied, the risk-rating is considered medium.

False Positives

When the accessed target operations are not time- or resource-consuming.

Mitigation (Operations): Anti-DoS Measures

Apply anti-DoS techniques like throttling and/or per-client load blocking with quotas. Also for maintenance access routes consider applying a VPN instead of public reachable interfaces. Generally applying redundancy on the targeted technical asset reduces the risk of DoS.

ASVS Chapter: [V1 - Architecture, Design and Threat Modeling Requirements](#)

Cheat Sheet: [Denial of Service Cheat Sheet](#)

Check

Are recommendations from the linked cheat sheet and referenced ASVS chapter applied?

Risk Findings

The risk **DoS-risky Access Across Trust-Boundary** was found **3 times** in the analyzed architecture to be potentially possible. Each spot should be checked individually by reviewing the implementation whether all controls have been applied properly in order to mitigate each risk.

Risk finding paragraphs are clickable and link to the corresponding chapter.

Medium Risk Severity

Denial-of-Service risky access of **Policy Fileserver** by **SAPL Server LT** via **Policy Filesystem Access**: Exploitation likelihood is *Unlikely* with *Medium* impact.

[dos-risky-access-across-trust-boundary@policy-fileserver@sapl-server-lt@sapl-server-lt>policy-filesystem-access](#)

Unchecked

Denial-of-Service risky access of **SAPL Server LT** by **SAPL MVC** via **SAPL Server LT Traffic**: Exploitation likelihood is *Unlikely* with *Medium* impact.

[dos-risky-access-across-trust-boundary@sapl-server-lt@sapl-mvc@sapl-mvc>sapl-server-lt-traffic](#)

Unchecked

Low Risk Severity

Denial-of-Service risky access of **SAPL MVC** by **Customer Web Client** via **Customer Traffic**: Exploitation likelihood is *Unlikely* with *Low* impact.

[dos-risky-access-across-trust-boundary@sapl-mvc@customer-client@customer-client>customer-traffic](#)

Unchecked

Missing Build Infrastructure: 1 / 1 Risk

Description (Tampering): [CWE 1127](#)

The modeled architecture does not contain a build infrastructure (devops-client, sourcecode-repo, build-pipeline, etc.), which might be the risk of a model missing critical assets (and thus not seeing their risks). If the architecture contains custom-developed parts, the pipeline where code gets developed and built needs to be part of the model.

Impact

If this risk is unmitigated, attackers might be able to exploit risks unseen in this threat model due to critical build infrastructure components missing in the model.

Detection Logic

Models with in-scope custom-developed parts missing in-scope development (code creation) and build infrastructure components (devops-client, sourcecode-repo, build-pipeline, etc.).

Risk Rating

The risk rating depends on the highest sensitivity of the in-scope assets running custom-developed parts.

False Positives

Models not having any custom-developed parts can be considered as false positives after individual review.

Mitigation (Architecture): Build Pipeline Hardening

Include the build infrastructure in the model.

ASVS Chapter: [V1 - Architecture, Design and Threat Modeling Requirements](#)

Cheat Sheet: [Attack Surface Analysis Cheat Sheet](#)

Check

Are recommendations from the linked cheat sheet and referenced ASVS chapter applied?

Risk Findings

The risk **Missing Build Infrastructure** was found **1 time** in the analyzed architecture to be potentially possible. Each spot should be checked individually by reviewing the implementation whether all controls have been applied properly in order to mitigate each risk.

Risk finding paragraphs are clickable and link to the corresponding chapter.

Medium Risk Severity

Missing Build Infrastructure in the threat model (referencing asset **SAPL Server LT** as an example): Exploitation likelihood is *Unlikely* with *Medium* impact.

[missing-build-infrastructure@sapl-server-lt](#)

Unchecked

Missing Identity Propagation: 1 / 1 Risk

Description (Elevation of Privilege): [CWE 284](#)

Technical assets (especially multi-tenant systems), which usually process data for endusers should authorize every request based on the identity of the enduser when the data flow is authenticated (i.e. non-public). For DevOps usages at least a technical-user authorization is required.

Impact

If this risk is unmitigated, attackers might be able to access or modify foreign data after a successful compromise of a component within the system due to missing resource-based authorization checks.

Detection Logic

In-scope service-like technical assets which usually process data based on enduser requests, if authenticated (i.e. non-public), should authorize incoming requests based on the propagated enduser identity when their rating is sensitive. This is especially the case for all multi-tenant assets (there even less-sensitive rated ones). DevOps usages are exempted from this risk.

Risk Rating

The risk rating (medium or high) depends on the confidentiality, integrity, and availability rating of the technical asset.

False Positives

Technical assets which do not process requests regarding functionality or data linked to end-users (customers) can be considered as false positives after individual review.

Mitigation (Architecture): Identity Propagation and Resource-based Authorization

When processing requests for endusers if possible authorize in the backend against the propagated identity of the enduser. This can be achieved in passing JWTs or similar tokens and checking them in the backend services. For DevOps usages apply at least a technical-user authorization.

ASVS Chapter: [V4 - Access Control Verification Requirements](#)

Cheat Sheet: [Access Control Cheat Sheet](#)

Check

Are recommendations from the linked cheat sheet and referenced ASVS chapter applied?

Risk Findings

The risk **Missing Identity Propagation** was found **1 time** in the analyzed architecture to be potentially possible. Each spot should be checked individually by reviewing the implementation whether all controls have been applied properly in order to mitigate each risk.

Risk finding paragraphs are clickable and link to the corresponding chapter.

Medium Risk Severity

Missing Enduser Identity Propagation over communication link **SAPL Server LT Traffic** from **SAPL MVC** to **SAPL Server LT**: Exploitation likelihood is *Unlikely* with *Medium* impact.

[missing-identity-propagation@sapl-mvc>sapl-server-lt-traffic@sapl-mvc@sapl-server-lt](#)

Unchecked

Missing Identity Store: 1 / 1 Risk

Description (Spoofing): [CWE 287](#)

The modeled architecture does not contain an identity store, which might be the risk of a model missing critical assets (and thus not seeing their risks).

Impact

If this risk is unmitigated, attackers might be able to exploit risks unseen in this threat model in the identity provider/store that is currently missing in the model.

Detection Logic

Models with authenticated data-flows authorized via enduser-identity missing an in-scope identity store.

Risk Rating

The risk rating depends on the sensitivity of the enduser-identity authorized technical assets and their data assets processed and stored.

False Positives

Models only offering data/services without any real authentication need can be considered as false positives after individual review.

Mitigation (Architecture): Identity Store

Include an identity store in the model if the application has a login.

ASVS Chapter: [V2 - Authentication Verification Requirements](#)

Cheat Sheet: [Authentication Cheat Sheet](#)

Check

Are recommendations from the linked cheat sheet and referenced ASVS chapter applied?

Risk Findings

The risk **Missing Identity Store** was found **1 time** in the analyzed architecture to be potentially possible. Each spot should be checked individually by reviewing the implementation whether all controls have been applied properly in order to mitigate each risk.

Risk finding paragraphs are clickable and link to the corresponding chapter.

Medium Risk Severity

Missing Identity Store in the threat model (referencing asset **SAPL MVC** as an example):
Exploitation likelihood is *Unlikely* with *Medium* impact.

[missing-identity-store@sapl-mvc](#)

Unchecked

Missing Two-Factor Authentication (2FA): 1 / 1 Risk

Description (Elevation of Privilege): [CWE 308](#)

Technical assets (especially multi-tenant systems) should authenticate incoming requests with two-factor (2FA) authentication when the asset processes or stores highly sensitive data (in terms of confidentiality, integrity, and availability) and is accessed by humans.

Impact

If this risk is unmitigated, attackers might be able to access or modify highly sensitive data without strong authentication.

Detection Logic

In-scope technical assets (except load-balancer, reverse-proxy, waf, ids, and ips) should authenticate incoming requests via two-factor authentication (2FA) when the asset processes or stores highly sensitive data (in terms of confidentiality, integrity, and availability) and is accessed by a client used by a human user.

Risk Rating

medium

False Positives

Technical assets which do not process requests regarding functionality or data linked to end-users (customers) can be considered as false positives after individual review.

Mitigation (Business Side): Authentication with Second Factor (2FA)

Apply an authentication method to the technical asset protecting highly sensitive data via two-factor authentication for human users.

ASVS Chapter: [V2 - Authentication Verification Requirements](#)

Cheat Sheet: [Multifactor Authentication Cheat Sheet](#)

Check

Are recommendations from the linked cheat sheet and referenced ASVS chapter applied?

Risk Findings

The risk **Missing Two-Factor Authentication (2FA)** was found **1 time** in the analyzed architecture to be potentially possible. Each spot should be checked individually by reviewing the implementation whether all controls have been applied properly in order to mitigate each risk.

Risk finding paragraphs are clickable and link to the corresponding chapter.

Medium Risk Severity

Missing Two-Factor Authentication covering communication link **Customer Traffic** from **Customer Web Client** to **SAPL MVC**: Exploitation likelihood is *Unlikely* with *Medium* impact.

[missing-authentication-second-factor@customer-client>customer-traffic@customer-client@sapl-mvc](#)

Unchecked

Missing Vault (Secret Storage): 1 / 1 Risk

Description (Information Disclosure): [CWE 522](#)

In order to avoid the risk of secret leakage via config files (when attacked through vulnerabilities being able to read files like Path-Traversal and others), it is best practice to use a separate hardened process with proper authentication, authorization, and audit logging to access config secrets (like credentials, private keys, client certificates, etc.). This component is usually some kind of Vault.

Impact

If this risk is unmitigated, attackers might be able to easier steal config secrets (like credentials, private keys, client certificates, etc.) once a vulnerability to access files is present and exploited.

Detection Logic

Models without a Vault (Secret Storage).

Risk Rating

The risk rating depends on the sensitivity of the technical asset itself and of the data assets processed and stored.

False Positives

Models where no technical assets have any kind of sensitive config data to protect can be considered as false positives after individual review.

Mitigation (Architecture): Vault (Secret Storage)

Consider using a Vault (Secret Storage) to securely store and access config secrets (like credentials, private keys, client certificates, etc.).

ASVS Chapter: [V6 - Stored Cryptography Verification Requirements](#)

Cheat Sheet: [Cryptographic Storage Cheat Sheet](#)

Check

Is a Vault (Secret Storage) in place?

Risk Findings

The risk **Missing Vault (Secret Storage)** was found **1 time** in the analyzed architecture to be potentially possible. Each spot should be checked individually by reviewing the implementation whether all controls have been applied properly in order to mitigate each risk.

Risk finding paragraphs are clickable and link to the corresponding chapter.

Medium Risk Severity

Missing Vault (Secret Storage) in the threat model (referencing asset **Policy Fileserver** as an example): Exploitation likelihood is *Unlikely* with *Medium* impact.

[missing-vault@policy-fileserver](#)

Unchecked

Missing Web Application Firewall (WAF): 2 / 2 Risks

Description (Tampering): [CWE 1008](#)

To have a first line of filtering defense, security architectures with web-services or web-applications should include a WAF in front of them. Even though a WAF is not a replacement for security (all components must be secure even without a WAF) it adds another layer of defense to the overall system by delaying some attacks and having easier attack alerting through it.

Impact

If this risk is unmitigated, attackers might be able to apply standard attack pattern tests at great speed without any filtering.

Detection Logic

In-scope web-services and/or web-applications accessed across a network trust boundary not having a Web Application Firewall (WAF) in front of them.

Risk Rating

The risk rating depends on the sensitivity of the technical asset itself and of the data assets processed and stored.

False Positives

Targets only accessible via WAFs or reverse proxies containing a WAF component (like ModSecurity) can be considered as false positives after individual review.

Mitigation (Operations): Web Application Firewall (WAF)

Consider placing a Web Application Firewall (WAF) in front of the web-services and/or web-applications. For cloud environments many cloud providers offer pre-configured WAFs. Even reverse proxies can be enhanced by a WAF component via ModSecurity plugins.

ASVS Chapter: [V1 - Architecture, Design and Threat Modeling Requirements](#)

Cheat Sheet: [Virtual Patching Cheat Sheet](#)

Check

Is a Web Application Firewall (WAF) in place?

Risk Findings

The risk **Missing Web Application Firewall (WAF)** was found **2 times** in the analyzed architecture to be potentially possible. Each spot should be checked individually by reviewing the implementation whether all controls have been applied properly in order to mitigate each risk.

Risk finding paragraphs are clickable and link to the corresponding chapter.

Medium Risk Severity

Missing Web Application Firewall (WAF) risk at **SAPL MVC**: Exploitation likelihood is *Unlikely* with *Medium* impact.

[missing-waf@sapl-mvc](#)

Unchecked

Missing Web Application Firewall (WAF) risk at **SAPL Server LT**: Exploitation likelihood is *Unlikely* with *Medium* impact.

[missing-waf@sapl-server-lt](#)

Unchecked

Unencrypted Technical Assets: 2 / 2 Risks

Description (Information Disclosure): [CWE 311](#)

Due to the confidentiality rating of the technical asset itself and/or the processed data assets this technical asset must be encrypted. The risk rating depends on the sensitivity technical asset itself and of the data assets stored.

Impact

If this risk is unmitigated, attackers might be able to access unencrypted data when successfully compromising sensitive components.

Detection Logic

In-scope unencrypted technical assets (excluding reverse-proxy, load-balancer, waf, ids, ips and embedded components like library) storing data assets rated at least as confidential or critical. For technical assets storing data assets rated as strictly-confidential or mission-critical the encryption must be of type data-with-enduser-individual-key.

Risk Rating

Depending on the confidentiality rating of the stored data-assets either medium or high risk.

False Positives

When all sensitive data stored within the asset is already fully encrypted on document or data level.

Mitigation (Operations): Encryption of Technical Asset

Apply encryption to the technical asset.

ASVS Chapter: [V6 - Stored Cryptography Verification Requirements](#)

Cheat Sheet: [Cryptographic Storage Cheat Sheet](#)

Check

Are recommendations from the linked cheat sheet and referenced ASVS chapter applied?

Risk Findings

The risk **Unencrypted Technical Assets** was found **2 times** in the analyzed architecture to be potentially possible. Each spot should be checked individually by reviewing the implementation whether all controls have been applied properly in order to mitigate each risk.

Risk finding paragraphs are clickable and link to the corresponding chapter.

Medium Risk Severity

Unencrypted Technical Asset named **Policy Fileserver** missing enduser-individual encryption with data-with-enduser-individual-key: Exploitation likelihood is *Unlikely* with *High* impact.

[unencrypted-asset@policy-fileserver](#)

Unchecked

Unencrypted Technical Asset named **SAPL MVC**: Exploitation likelihood is *Unlikely* with *High* impact.

[unencrypted-asset@sapl-mvc](#)

Unchecked

Unnecessary Data Transfer: 2 / 2 Risks

Description (Elevation of Privilege): [CWE 1008](#)

When a technical asset sends or receives data assets, which it neither processes or stores this is an indicator for unnecessarily transferred data (or for an incomplete model). When the unnecessarily transferred data assets are sensitive, this poses an unnecessary risk of an increased attack surface.

Impact

If this risk is unmitigated, attackers might be able to target unnecessarily transferred data.

Detection Logic

In-scope technical assets sending or receiving sensitive data assets which are neither processed nor stored by the technical asset are flagged with this risk. The risk rating (low or medium) depends on the confidentiality, integrity, and availability rating of the technical asset. Monitoring data is exempted from this risk.

Risk Rating

The risk assessment is depending on the confidentiality and integrity rating of the transferred data asset either low or medium.

False Positives

Technical assets missing the model entries of either processing or storing the mentioned data assets can be considered as false positives (incomplete models) after individual review. These should then be addressed by completing the model so that all necessary data assets are processed and/or stored by the technical asset involved.

Mitigation (Architecture): Attack Surface Reduction

Try to avoid sending or receiving sensitive data assets which are not required (i.e. neither processed or stored) by the involved technical asset.

ASVS Chapter: [V1 - Architecture, Design and Threat Modeling Requirements](#)

Cheat Sheet: [Attack Surface Analysis Cheat Sheet](#)

Check

Are recommendations from the linked cheat sheet and referenced ASVS chapter applied?

Risk Findings

The risk **Unnecessary Data Transfer** was found **2 times** in the analyzed architecture to be potentially possible. Each spot should be checked individually by reviewing the implementation whether all controls have been applied properly in order to mitigate each risk.

Risk finding paragraphs are clickable and link to the corresponding chapter.

Medium Risk Severity

Unnecessary Data Transfer of Access-Decision data at **SAPL MVC** from/to **SAPL Server**

LT: Exploitation likelihood is *Unlikely* with *Medium* impact.

[unnecessary-data-transfer@access-decision@sapl-mvc@sapl-server-it](#)

Unchecked

Unnecessary Data Transfer of Access-Request data at **SAPL MVC** from/to **SAPL Server**

LT: Exploitation likelihood is *Unlikely* with *Medium* impact.

[unnecessary-data-transfer@access-request@sapl-mvc@sapl-server-it](#)

Unchecked

Wrong Communication Link Content: 1 / 1 Risk

Description (Information Disclosure): [CWE 1008](#)

When a communication link is defined as readonly, but does not receive any data asset, or when it is defined as not readonly, but does not send any data asset, it is likely to be a model failure.

Impact

If this potential model error is not fixed, some risks might not be visible.

Detection Logic

Communication links with inconsistent data assets being sent/received not matching their readonly flag or otherwise inconsistent protocols not matching the target technology type.

Risk Rating

low

False Positives

Usually no false positives as this looks like an incomplete model.

Mitigation (Architecture): Model Consistency

Try to model the correct readonly flag and/or data sent/received of communication links. Also try to use communication link types matching the target technology/machine types.

ASVS Chapter: [V1 - Architecture, Design and Threat Modeling Requirements](#)

Cheat Sheet: [Threat Modeling Cheat Sheet](#)

Check

Are recommendations from the linked cheat sheet and referenced ASVS chapter applied?

Risk Findings

The risk **Wrong Communication Link Content** was found **1 time** in the analyzed architecture to be potentially possible. Each spot should be checked individually by reviewing the implementation whether all controls have been applied properly in order to mitigate each risk.

Risk finding paragraphs are clickable and link to the corresponding chapter.

Low Risk Severity

Wrong Communication Link Content (data assets sent/received not matching the communication link's readonly flag) at **SAPL Server LT** regarding communication link **Policy Filesystem Access**: Exploitation likelihood is *Unlikely* with *Low* impact.

wrong-communication-link-content@sapl-server-lt@sapl-server-lt>policy-filesystem-access

Unchecked

Identified Risks by Technical Asset

In total **23 potential risks** have been identified during the threat modeling process of which **0 are rated as critical, 1 as high, 7 as elevated, 13 as medium, and 2 as low.**

These risks are distributed across **3 in-scope technical assets**. The following sub-chapters of this section describe each identified risk grouped by technical asset. The RAA value of a technical asset is the calculated "Relative Attacker Attractiveness" value in percent.

SAPL Server LT: 8 / 8 Risks

Description

SAPL Server LT

Identified Risks of Asset

Risk finding paragraphs are clickable and link to the corresponding chapter.

High Risk Severity

Path-Traversal risk at **SAPL Server LT** against filesystem **Policy Fileserver** via **Policy Filesystem Access**: Exploitation likelihood is *Very Likely* with *High* impact.

[path-traversal@sapl-server-lt@policy-fileserver@sapl-server-lt>policy-filesystem-access](#)

Unchecked

Elevated Risk Severity

Unencrypted Communication named **Policy Filesystem Access** between **SAPL Server LT** and **Policy Fileserver** transferring authentication data (like credentials, token, session-id, etc.): Exploitation likelihood is *Likely* with *High* impact.

[unencrypted-communication@sapl-server-lt>policy-filesystem-access@sapl-server-lt@policy-fileserver](#)

Unchecked

Missing Hardening risk at **SAPL Server LT**: Exploitation likelihood is *Likely* with *Medium* impact.

[missing-hardening@sapl-server-lt](#)

Unchecked

Medium Risk Severity

Denial-of-Service risky access of **SAPL Server LT** by **SAPL MVC** via **SAPL Server LT Traffic**: Exploitation likelihood is *Unlikely* with *Medium* impact.

[dos-risky-access-across-trust-boundary@sapl-server-lt@sapl-mvc@sapl-mvc>sapl-server-lt-traffic](#)

Unchecked

Missing Build Infrastructure in the threat model (referencing asset **SAPL Server LT** as an example): Exploitation likelihood is *Unlikely* with *Medium* impact.

[missing-build-infrastructure@sapl-server-lt](#)

Unchecked

Missing Enduser Identity Propagation over communication link **SAPL Server LT Traffic** from **SAPL MVC** to **SAPL Server LT**: Exploitation likelihood is *Unlikely* with *Medium* impact.

missing-identity-propagation@sapl-mvc>sapl-server-lt-traffic@sapl-mvc@sapl-server-lt

Unchecked

Missing Web Application Firewall (WAF) risk at **SAPL Server LT**: Exploitation likelihood is *Unlikely* with *Medium* impact.

missing-waf@sapl-server-lt

Unchecked

Low Risk Severity

Wrong Communication Link Content (data assets sent/received not matching the communication link's readonly flag) at **SAPL Server LT** regarding communication link **Policy Filesystem Access**: Exploitation likelihood is *Unlikely* with *Low* impact.

wrong-communication-link-content@sapl-server-lt@sapl-server-lt>policy-filesystem-access

Unchecked

Asset Information

ID:	sapl-server-lt
Type:	process
Usage:	business
RAA:	100 %
Size:	component
Technology:	web-service-rest
Tags:	sapl-jwt, sapl-spring-pdp-embedded, sapl-webflux-endpoint, spring-boot, spring-security
Internet:	false
Machine:	virtual
Encryption:	data-with-asymmetric-shared-key
Multi-Tenant:	false
Redundant:	false
Custom-Developed:	true
Client by Human:	false
Data Processed:	Access-Decision, Access-Request, Policies
Data Stored:	none
Formats Accepted:	JSON

Asset Rating

Owner:	https://github.com/heutelbeck	
Confidentiality:	strictly-confidential	(rated 5 in scale of 5)
Integrity:	mission-critical	(rated 5 in scale of 5)
Availability:	mission-critical	(rated 5 in scale of 5)
CIA-Justification:	Central component for authorization	

Outgoing Communication Links: 1

Target technical asset names are clickable and link to the corresponding chapter.

Policy Filesystem Access (outgoing)

[Link to the file system](#)

Target:	Policy Fileserver
Protocol:	smb
Encrypted:	false
Authentication:	credentials
Authorization:	technical-user
Read-Only:	false
Usage:	business
Tags:	none
VPN:	false
IP-Filtered:	false
Data Sent:	none
Data Received:	Policies

Incoming Communication Links: 1

Source technical asset names are clickable and link to the corresponding chapter.

SAPL Server LT Traffic (incoming)

[Link to the SAPL Server LT](#)

Source:	SAPL MVC
Protocol:	https
Encrypted:	true
Authentication:	credentials
Authorization:	technical-user
Read-Only:	false

Usage: business
Tags: none
VPN: false
IP-Filtered: false
Data Received: Access-Request
Data Sent: Access-Decision

Policy Fileserver: 4 / 4 Risks

Description

NTFS-Filesystem to store policies

Identified Risks of Asset

Risk finding paragraphs are clickable and link to the corresponding chapter.

Elevated Risk Severity

Missing Hardening risk at **Policy Fileserver**: Exploitation likelihood is *Likely* with *Medium* impact.

[missing-hardening@policy-fileserver](#)

Unchecked

Medium Risk Severity

Unencrypted Technical Asset named **Policy Fileserver** missing enduser-individual encryption with data-with-enduser-individual-key: Exploitation likelihood is *Unlikely* with *High* impact.

[unencrypted-asset@policy-fileserver](#)

Unchecked

Denial-of-Service risky access of **Policy Fileserver** by **SAPL Server LT** via **Policy Filesystem Access**: Exploitation likelihood is *Unlikely* with *Medium* impact.

[dos-risky-access-across-trust-boundary@policy-fileserver@sapl-server-lt@sapl-server-lt>policy-filesystem-access](#)

Unchecked

Missing Vault (Secret Storage) in the threat model (referencing asset **Policy Fileserver** as an example): Exploitation likelihood is *Unlikely* with *Medium* impact.

[missing-vault@policy-fileserver](#)

Unchecked

Asset Information

ID:	policy-fileserver
Type:	datastore
Usage:	business
RAA:	56 %
Size:	component
Technology:	file-server
Tags:	windows-server

Internet:	false
Machine:	virtual
Encryption:	none
Multi-Tenant:	false
Redundant:	false
Custom-Developed:	false
Client by Human:	false
Data Processed:	none
Data Stored:	Policies
Formats Accepted:	File

Asset Rating

Owner:	
Confidentiality:	strictly-confidential (rated 5 in scale of 5)
Integrity:	mission-critical (rated 5 in scale of 5)
Availability:	mission-critical (rated 5 in scale of 5)
CIA-Justification:	Policy-files are crucial for safe operation

Incoming Communication Links: 1

Source technical asset names are clickable and link to the corresponding chapter.

Policy Filesystem Access (incoming)

Link to the file system

Source:	SAPL Server LT
Protocol:	smb
Encrypted:	false
Authentication:	credentials
Authorization:	technical-user
Read-Only:	false
Usage:	business
Tags:	none
VPN:	false
IP-Filtered:	false
Data Received:	none
Data Sent:	Policies

SAPL MVC: 11 / 11 Risks

Description

Spring-Boot MVC Webserver

Identified Risks of Asset

Risk finding paragraphs are clickable and link to the corresponding chapter.

Elevated Risk Severity

Cross-Site Scripting (XSS) risk at **SAPL MVC**: Exploitation likelihood is *Likely* with *High* impact.

`cross-site-scripting@sapl-mvc`

Unchecked

Cross-Site Request Forgery (CSRF) risk at **SAPL MVC** via **Customer Traffic** from **Customer Web Client**: Exploitation likelihood is *Very Likely* with *Medium* impact.

`cross-site-request-forgery@sapl-mvc@customer-client>customer-traffic`

Unchecked

Missing Hardening risk at **SAPL MVC**: Exploitation likelihood is *Likely* with *Medium* impact.

`missing-hardening@sapl-mvc`

Unchecked

Server-Side Request Forgery (SSRF) risk at **SAPL MVC** server-side web-requesting the target **SAPL Server LT** via **SAPL Server LT Traffic**: Exploitation likelihood is *Likely* with *Medium* impact.

`server-side-request-forgery@sapl-mvc@sapl-server-lt@sapl-mvc>sapl-server-lt-traffic`

Unchecked

Medium Risk Severity

Unencrypted Technical Asset named **SAPL MVC**: Exploitation likelihood is *Unlikely* with *High* impact.

`unencrypted-asset@sapl-mvc`

Unchecked

Missing Identity Store in the threat model (referencing asset **SAPL MVC** as an example): Exploitation likelihood is *Unlikely* with *Medium* impact.

`missing-identity-store@sapl-mvc`

Unchecked

Missing Two-Factor Authentication covering communication link **Customer Traffic** from **Customer Web Client** to **SAPL MVC**: Exploitation likelihood is *Unlikely* with *Medium* impact.

missing-authentication-second-factor@customer-client>customer-traffic@customer-client@sapl-mvc

Unchecked

Missing Web Application Firewall (WAF) risk at **SAPL MVC**: Exploitation likelihood is *Unlikely* with *Medium* impact.

missing-waf@sapl-mvc

Unchecked

Unnecessary Data Transfer of Access-Decision data at **SAPL MVC** from/to **SAPL Server** **LT**: Exploitation likelihood is *Unlikely* with *Medium* impact.

unnecessary-data-transfer@access-decision@sapl-mvc@sapl-server-lt

Unchecked

Unnecessary Data Transfer of Access-Request data at **SAPL MVC** from/to **SAPL Server** **LT**: Exploitation likelihood is *Unlikely* with *Medium* impact.

unnecessary-data-transfer@access-request@sapl-mvc@sapl-server-lt

Unchecked

Low Risk Severity

Denial-of-Service risky access of **SAPL MVC** by **Customer Web Client** via **Customer Traffic** : Exploitation likelihood is *Unlikely* with *Low* impact.

dos-risky-access-across-trust-boundary@sapl-mvc@customer-client@customer-client>customer-traffic

Unchecked

Asset Information

ID:	sapl-mvc
Type:	process
Usage:	business
RAA:	76 %
Size:	application
Technology:	web-server
Tags:	spring-boot
Internet:	false
Machine:	virtual
Encryption:	none
Multi-Tenant:	false
Redundant:	false
Custom-Developed:	true
Client by Human:	false
Data Processed:	Patient Data

Data Stored: Patient Data
Formats Accepted: JSON

Asset Rating

Owner:
Confidentiality: internal (rated 2 in scale of 5)
Integrity: critical (rated 4 in scale of 5)
Availability: critical (rated 4 in scale of 5)
CIA-Justification: The correct configuration and reachability of the web server is mandatory for all usages of the portal.

Outgoing Communication Links: 1

Target technical asset names are clickable and link to the corresponding chapter.

SAPL Server LT Traffic (outgoing)

Link to the SAPL Server LT

Target:	SAPL Server LT
Protocol:	https
Encrypted:	true
Authentication:	credentials
Authorization:	technical-user
Read-Only:	false
Usage:	business
Tags:	none
VPN:	false
IP-Filtered:	false
Data Sent:	Access-Request
Data Received:	Access-Decision

Incoming Communication Links: 1

Source technical asset names are clickable and link to the corresponding chapter.

Customer Traffic (incoming)

Link to the mvc-app

Source:	Customer Web Client
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Protocol:	https
Encrypted:	true
Authentication:	credentials
Authorization:	enduser-identity-propagation
Read-Only:	false
Usage:	business
Tags:	none
VPN:	false
IP-Filtered:	false
Data Received:	Patient Data
Data Sent:	Patient Data

Customer Web Client: out-of-scope

Description

Customer Web Client

Identified Risks of Asset

Asset was defined as out-of-scope.

Asset Information

ID:	customer-client
Type:	external-entity
Usage:	business
RAA:	out-of-scope
Size:	component
Technology:	browser
Tags:	none
Internet:	false
Machine:	physical
Encryption:	none
Multi-Tenant:	false
Redundant:	false
Custom-Developed:	false
Client by Human:	true
Data Processed:	Patient Data
Data Stored:	none
Formats Accepted:	none of the special data formats accepted

Asset Rating

Owner:	Customer	
Confidentiality:	internal	(rated 2 in scale of 5)
Integrity:	operational	(rated 2 in scale of 5)
Availability:	operational	(rated 2 in scale of 5)
CIA-Justification:	The client used by the customer to access the system.	

Asset Out-of-Scope Justification

Owned and managed by enduser customer

Outgoing Communication Links: 1

Target technical asset names are clickable and link to the corresponding chapter.

Customer Traffic (outgoing)

Link to the mvc-app

Target:	SAPL MVC
Protocol:	https
Encrypted:	true
Authentication:	credentials
Authorization:	enduser-identity-propagation
Read-Only:	false
Usage:	business
Tags:	none
VPN:	false
IP-Filtered:	false
Data Sent:	Patient Data
Data Received:	Patient Data

Identified Data Breach Probabilities by Data Asset

In total **23 potential risks** have been identified during the threat modeling process of which **0 are rated as critical, 1 as high, 7 as elevated, 13 as medium, and 2 as low.**

These risks are distributed across **4 data assets**. The following sub-chapters of this section describe the derived data breach probabilities grouped by data asset.

Technical asset names and risk IDs are clickable and link to the corresponding chapter.

Policies: 7 / 7 Risks

Policies for authorization decisions

ID:	policies	
Usage:	business	
Quantity:	few	
Tags:	none	
Origin:	business	
Owner:		
Confidentiality:	strictly-confidential	(rated 5 in scale of 5)
Integrity:	mission-critical	(rated 5 in scale of 5)
Availability:	mission-critical	(rated 5 in scale of 5)
CIA-Justification:	Very important and highly sensitive data	
Processed by:	SAPL Server LT	
Stored by:	Policy Fileserver	
Sent via:	none	
Received via:	Policy Filesystem Access	
Data Breach:	probable	
Data Breach Risks:	This data asset has data breach potential because of 7 remaining risks:	

Probable: [path-traversal@sapl-server-lt@policy-fileserver@sapl-server-lt>policy-filesystem-access](#)

Possible: [unencrypted-communication@sapl-server-lt>policy-filesystem-access@sapl-server-lt@policy-fileserver](#)

Improbable: [missing-identity-propagation@sapl-mvc>sapl-server-lt-traffic@sapl-mvc@sapl-server-lt](#)

Improbable: [missing-hardening@policy-fileserver](#)

Improbable: [missing-hardening@sapl-server-lt](#)

Improbable: [missing-waf@sapl-server-lt](#)

Improbable: [unencrypted-asset@policy-fileserver](#)

Patient Data: 9 / 9 Risks

Patient Data stored on hard drive

ID: patient-data
Usage: business
Quantity: many
Tags: none
Origin: Patient
Owner:
Confidentiality: strictly-confidential (rated 5 in scale of 5)
Integrity: mission-critical (rated 5 in scale of 5)
Availability: operational (rated 2 in scale of 5)
CIA-Justification: Very sensitive data
Processed by: Customer Web Client, SAPL MVC
Stored by: SAPL MVC
Sent via: Customer Traffic
Received via: Customer Traffic
Data Breach: **possible**

Data Breach Risks: This data asset has data breach potential because of 9 remaining risks:

Possible: cross-site-scripting@sapl-mvc

Possible: missing-authentication-second-factor@customer-client>customer-traffic@customer-client@sapl-mvc

Possible: server-side-request-forgery@sapl-mvc@sapl-server-It@sapl-mvc>sapl-server-It-traffic

Improbable: cross-site-request-forgery@sapl-mvc@customer-client>customer-traffic

Improbable: missing-hardening@sapl-mvc

Improbable: missing-waf@sapl-mvc

Improbable: unencrypted-asset@sapl-mvc

Improbable: unnecessary-data-transfer@access-decision@sapl-mvc@sapl-server-It

Improbable: unnecessary-data-transfer@access-request@sapl-mvc@sapl-server-It

Access-Decision: 3 / 3 Risks

response by PDP to PEP

ID:	access-decision	
Usage:	business	
Quantity:	very-many	
Tags:	none	
Origin:	PDP	
Owner:		
Confidentiality:	strictly-confidential	(rated 5 in scale of 5)
Integrity:	mission-critical	(rated 5 in scale of 5)
Availability:	mission-critical	(rated 5 in scale of 5)
CIA-Justification:	Very important and highly sensitive data	
Processed by:	SAPL Server LT	
Stored by:	none	
Sent via:	none	
Received via:	SAPL Server LT Traffic	
Data Breach:	improbable	
Data Breach Risks:	This data asset has data breach potential because of 3 remaining risks:	
	Improbable: missing-identity-propagation@sapl-mvc>sapl-server-lt-traffic@sapl-mvc@sapl-server-lt	
	Improbable: missing-hardening@sapl-server-lt	
	Improbable: missing-waf@sapl-server-lt	

Access-Request: 3 / 3 Risks

request by PEP to PDP

ID:	access-request
Usage:	business
Quantity:	very-many
Tags:	none
Origin:	PEP
Owner:	
Confidentiality:	strictly-confidential (rated 5 in scale of 5)
Integrity:	mission-critical (rated 5 in scale of 5)
Availability:	mission-critical (rated 5 in scale of 5)
CIA-Justification:	Very important and highly sensitive data
Processed by:	SAPL Server LT
Stored by:	none
Sent via:	SAPL Server LT Traffic
Received via:	none
Data Breach:	improbable
Data Breach Risks:	This data asset has data breach potential because of 3 remaining risks: Improbable: missing-identity-propagation@sapl-mvc>sapl-server-lt-traffic@sapl-mvc@sapl-server-lt Improbable: missing-hardening@sapl-server-lt Improbable: missing-waf@sapl-server-lt

Trust Boundaries

In total **3 trust boundaries** have been modeled during the threat modeling process.

File-Server Network

File-Server Network

ID: file-server-network
Type: [network-on-prem](#)
Tags: none
Assets inside: Policy Fileserver
Boundaries nested: none

SAPL-Server DMZ

Authz-DMZ

ID: sapl-server-dmz
Type: [network-on-prem](#)
Tags: none
Assets inside: SAPL Server LT
Boundaries nested: none

Web DMZ

MVC-DMZ

ID: web-dmz
Type: [network-on-prem](#)
Tags: none
Assets inside: SAPL MVC
Boundaries nested: File-Server Network, SAPL-Server DMZ

Shared Runtimes

In total **0 shared runtime** has been modeled during the threat modeling process.

Risk Rules Checked by Threagile

Threagile Version: 1.0.0

Threagile Build Timestamp: 20231104141112

Threagile Execution Timestamp: 20231114045704

Model Filename: /github/workspace/threagile.yaml

Model Hash (SHA256): 54b82b68d52134a27f3c7eec82b8297d9ea973073bbf1b34bab2e4e2a63c895a

Threagile (see <https://threagile.io> for more details) is an open-source toolkit for agile threat modeling, created by Christian Schneider (<https://christian-schneider.net>): It allows to model an architecture with its assets in an agile fashion as a YAML file directly inside the IDE. Upon execution of the Threagile toolkit all standard risk rules (as well as individual custom rules if present) are checked against the architecture model. At the time the Threagile toolkit was executed on the model input file the following risk rules were checked:

Accidental Secret Leak

accidental-secret-leak

STRIDE: Information Disclosure

Description: Sourcecode repositories (including their histories) as well as artifact registries can accidentally contain secrets like checked-in or packaged-in passwords, API tokens, certificates, crypto keys, etc.

Detection: In-scope sourcecode repositories and artifact registries.

Rating: The risk rating depends on the sensitivity of the technical asset itself and of the data assets processed and stored.

Code Backdooring

code-backdooring

STRIDE: Tampering

Description: For each build-pipeline component Code Backdooring risks might arise where attackers compromise the build-pipeline in order to let backdoored artifacts be shipped into production. Aside from direct code backdooring this includes backdooring of dependencies and even of more lower-level build infrastructure, like backdooring compilers (similar to what the XcodeGhost malware did) or dependencies.

Detection: In-scope development relevant technical assets which are either accessed by out-of-scope unmanaged developer clients and/or are directly accessed by any kind of internet-located (non-VPN) component or are themselves directly located on the internet.

Rating: The risk rating depends on the confidentiality and integrity rating of the code being handled and deployed as well as the placement/calling of this technical asset on/from the internet.

Container Base Image Backdooring

container-baseimage-backdooring

STRIDE: Tampering

Description: When a technical asset is built using container technologies, Base Image Backdooring risks might arise where base images and other layers used contain vulnerable components or backdoors.

Detection: In-scope technical assets running as containers.

Rating: The risk rating depends on the sensitivity of the technical asset itself and of the data assets.

Container Platform Escape

container-platform-escape

STRIDE: Elevation of Privilege

Description: Container platforms are especially interesting targets for attackers as they host big parts of a containerized runtime infrastructure. When not configured and operated with security best practices in mind, attackers might exploit a vulnerability inside an container and escape towards the platform as highly privileged users. These scenarios might give attackers capabilities to attack every other container as owning the container platform (via container escape attacks) equals to owning every container.

Detection: In-scope container platforms.

Rating: The risk rating depends on the sensitivity of the technical asset itself and of the data assets processed and stored.

Cross-Site Request Forgery (CSRF)

cross-site-request-forgery

STRIDE: Spoofing

Description: When a web application is accessed via web protocols Cross-Site Request Forgery (CSRF) risks might arise.

Detection: In-scope web applications accessed via typical web access protocols.

Rating: The risk rating depends on the integrity rating of the data sent across the communication link.

Cross-Site Scripting (XSS)

cross-site-scripting

STRIDE: Tampering

Description: For each web application Cross-Site Scripting (XSS) risks might arise. In terms of the overall risk level take other applications running on the same domain into account as well.

Detection: In-scope web applications.

Rating: The risk rating depends on the sensitivity of the data processed or stored in the web application.

DoS-risky Access Across Trust-Boundary

dos-risky-access-across-trust-boundary

STRIDE: Denial of Service

Description: Assets accessed across trust boundaries with critical or mission-critical availability rating are more prone to Denial-of-Service (DoS) risks.

Detection: In-scope technical assets (excluding load-balancer) with availability rating of critical or higher which have incoming data-flows across a network trust-boundary (excluding devops usage).

Rating: Matching technical assets with availability rating of critical or higher are at low risk. When the availability rating is mission-critical and neither a VPN nor IP filter for the incoming data-flow nor redundancy for the asset is applied, the risk-rating is considered medium.

Incomplete Model**incomplete-model**

STRIDE: Information Disclosure

Description: When the threat model contains unknown technologies or transfers data over unknown protocols, this is an indicator for an incomplete model.

Detection: All technical assets and communication links with technology type or protocol type specified as unknown.

Rating: low

LDAP-Injection**ldap-injection**

STRIDE: Tampering

Description: When an LDAP server is accessed LDAP-Injection risks might arise. The risk rating depends on the sensitivity of the LDAP server itself and of the data assets processed or stored.

Detection: In-scope clients accessing LDAP servers via typical LDAP access protocols.

Rating: The risk rating depends on the sensitivity of the LDAP server itself and of the data assets processed or stored.

Missing Authentication**missing-authentication**

STRIDE: Elevation of Privilege

Description: Technical assets (especially multi-tenant systems) should authenticate incoming requests when the asset processes or stores sensitive data.

Detection: In-scope technical assets (except load-balancer, reverse-proxy, service-registry, waf, ids, and ips and in-process calls) should authenticate incoming requests when the asset processes or stores sensitive data. This is especially the case for all multi-tenant assets (there even non-sensitive ones).

Rating: The risk rating (medium or high) depends on the sensitivity of the data sent across

the communication link. Monitoring callers are exempted from this risk.

Missing Two-Factor Authentication (2FA)

missing-authentication-second-factor

STRIDE: Elevation of Privilege

Description: Technical assets (especially multi-tenant systems) should authenticate incoming requests with two-factor (2FA) authentication when the asset processes or stores highly sensitive data (in terms of confidentiality, integrity, and availability) and is accessed by humans.

Detection: In-scope technical assets (except load-balancer, reverse-proxy, waf, ids, and ips) should authenticate incoming requests via two-factor authentication (2FA) when the asset processes or stores highly sensitive data (in terms of confidentiality, integrity, and availability) and is accessed by a client used by a human user.

Rating: medium

Missing Build Infrastructure

missing-build-infrastructure

STRIDE: Tampering

Description: The modeled architecture does not contain a build infrastructure (devops-client, sourcecode-repo, build-pipeline, etc.), which might be the risk of a model missing critical assets (and thus not seeing their risks). If the architecture contains custom-developed parts, the pipeline where code gets developed and built needs to be part of the model.

Detection: Models with in-scope custom-developed parts missing in-scope development (code creation) and build infrastructure components (devops-client, sourcecode-repo, build-pipeline, etc.).

Rating: The risk rating depends on the highest sensitivity of the in-scope assets running custom-developed parts.

Missing Cloud Hardening

missing-cloud-hardening

STRIDE: Tampering

Description: Cloud components should be hardened according to the cloud vendor best practices. This affects their configuration, auditing, and further areas.

Detection: In-scope cloud components (either residing in cloud trust boundaries or more specifically tagged with cloud provider types).

Rating: The risk rating depends on the sensitivity of the technical asset itself and of the data assets processed and stored.

Missing File Validation

missing-file-validation

STRIDE: Spoofing

- Description:** When a technical asset accepts files, these input files should be strictly validated about filename and type.
- Detection:** In-scope technical assets with custom-developed code accepting file data formats.
- Rating:** The risk rating depends on the sensitivity of the technical asset itself and of the data assets processed and stored.

Missing Hardening

missing-hardening

- STRIDE:** Tampering
- Description:** Technical assets with a Relative Attacker Attractiveness (RAA) value of 55 % or higher should be explicitly hardened taking best practices and vendor hardening guides into account.
- Detection:** In-scope technical assets with RAA values of 55 % or higher. Generally for high-value targets like datastores, application servers, identity providers and ERP systems this limit is reduced to 40 %
- Rating:** The risk rating depends on the sensitivity of the data processed or stored in the technical asset.

Missing Identity Propagation

missing-identity-propagation

- STRIDE:** Elevation of Privilege
- Description:** Technical assets (especially multi-tenant systems), which usually process data for endusers should authorize every request based on the identity of the enduser when the data flow is authenticated (i.e. non-public). For DevOps usages at least a technical-user authorization is required.
- Detection:** In-scope service-like technical assets which usually process data based on enduser requests, if authenticated (i.e. non-public), should authorize incoming requests based on the propagated enduser identity when their rating is sensitive. This is especially the case for all multi-tenant assets (there even less-sensitive rated ones). DevOps usages are exempted from this risk.
- Rating:** The risk rating (medium or high) depends on the confidentiality, integrity, and availability rating of the technical asset.

Missing Identity Provider Isolation

missing-identity-provider-isolation

- STRIDE:** Elevation of Privilege
- Description:** Highly sensitive identity provider assets and their identity datastores should be isolated from other assets by their own network segmentation trust-boundary (execution-environment boundaries do not count as network isolation).
- Detection:** In-scope identity provider assets and their identity datastores when surrounded by other (not identity-related) assets (without a network trust-boundary in-between).

This risk is especially prevalent when other non-identity related assets are within the same execution environment (i.e. same database or same application server).

Rating: Default is high impact. The impact is increased to very-high when the asset missing the trust-boundary protection is rated as strictly-confidential or mission-critical.

Missing Identity Store

missing-identity-store

STRIDE: Spoofing

Description: The modeled architecture does not contain an identity store, which might be the risk of a model missing critical assets (and thus not seeing their risks).

Detection: Models with authenticated data-flows authorized via enduser-identity missing an in-scope identity store.

Rating: The risk rating depends on the sensitivity of the enduser-identity authorized technical assets and their data assets processed and stored.

Missing Network Segmentation

missing-network-segmentation

STRIDE: Elevation of Privilege

Description: Highly sensitive assets and/or datastores residing in the same network segment than other lower sensitive assets (like webserver or content management systems etc.) should be better protected by a network segmentation trust-boundary.

Detection: In-scope technical assets with high sensitivity and RAA values as well as datastores when surrounded by assets (without a network trust-boundary in-between) which are of type client-system, web-server, web-application, cms, web-service-rest, web-service-soap, build-pipeline, sourcecode-repository, monitoring, or similar and there is no direct connection between these (hence no requirement to be so close to each other).

Rating: Default is low risk. The risk is increased to medium when the asset missing the trust-boundary protection is rated as strictly-confidential or mission-critical.

Missing Vault (Secret Storage)

missing-vault

STRIDE: Information Disclosure

Description: In order to avoid the risk of secret leakage via config files (when attacked through vulnerabilities being able to read files like Path-Traversal and others), it is best practice to use a separate hardened process with proper authentication, authorization, and audit logging to access config secrets (like credentials, private keys, client certificates, etc.). This component is usually some kind of Vault.

Detection: Models without a Vault (Secret Storage).

Rating: The risk rating depends on the sensitivity of the technical asset itself and of the data assets processed and stored.

Missing Vault Isolation

missing-vault-isolation

STRIDE: Elevation of Privilege

Description: Highly sensitive vault assets and their datastores should be isolated from other assets by their own network segmentation trust-boundary (execution-environment boundaries do not count as network isolation).

Detection: In-scope vault assets when surrounded by other (not vault-related) assets (without a network trust-boundary in-between). This risk is especially prevalent when other non-vault related assets are within the same execution environment (i.e. same database or same application server).

Rating: Default is medium impact. The impact is increased to high when the asset missing the trust-boundary protection is rated as strictly-confidential or mission-critical.

Missing Web Application Firewall (WAF)

missing-waf

STRIDE: Tampering

Description: To have a first line of filtering defense, security architectures with web-services or web-applications should include a WAF in front of them. Even though a WAF is not a replacement for security (all components must be secure even without a WAF) it adds another layer of defense to the overall system by delaying some attacks and having easier attack alerting through it.

Detection: In-scope web-services and/or web-applications accessed across a network trust boundary not having a Web Application Firewall (WAF) in front of them.

Rating: The risk rating depends on the sensitivity of the technical asset itself and of the data assets processed and stored.

Mixed Targets on Shared Runtime

mixed-targets-on-shared-runtime

STRIDE: Elevation of Privilege

Description: Different attacker targets (like frontend and backend/datastore components) should not be running on the same shared (underlying) runtime.

Detection: Shared runtime running technical assets of different trust-boundaries is at risk. Also mixing backend/datastore with frontend components on the same shared runtime is considered a risk.

Rating: The risk rating (low or medium) depends on the confidentiality, integrity, and availability rating of the technical asset running on the shared runtime.

Path-Traversal

path-traversal

STRIDE: Information Disclosure

Description: When a filesystem is accessed Path-Traversal or Local-File-Inclusion (LFI) risks might arise. The risk rating depends on the sensitivity of the technical asset itself

and of the data assets processed or stored.

Detection: Filesystems accessed by in-scope callers.

Rating: The risk rating depends on the sensitivity of the data stored inside the technical asset.

Push instead of Pull Deployment

push-instead-of-pull-deployment

STRIDE: Tampering

Description: When comparing push-based vs. pull-based deployments from a security perspective, pull-based deployments improve the overall security of the deployment targets. Every exposed interface of a production system to accept a deployment increases the attack surface of the production system, thus a pull-based approach exposes less attack surface relevant interfaces.

Detection: Models with build pipeline components accessing in-scope targets of deployment (in a non-readonly way) which are not build-related components themselves.

Rating: The risk rating depends on the highest sensitivity of the deployment targets running custom-developed parts.

Search-Query Injection

search-query-injection

STRIDE: Tampering

Description: When a search engine server is accessed Search-Query Injection risks might arise.

Detection: In-scope clients accessing search engine servers via typical search access protocols.

Rating: The risk rating depends on the sensitivity of the search engine server itself and of the data assets processed or stored.

Server-Side Request Forgery (SSRF)

server-side-request-forgery

STRIDE: Information Disclosure

Description: When a server system (i.e. not a client) is accessing other server systems via typical web protocols Server-Side Request Forgery (SSRF) or Local-File-Inclusion (LFI) or Remote-File-Inclusion (RFI) risks might arise.

Detection: In-scope non-client systems accessing (using outgoing communication links) targets with either HTTP or HTTPS protocol.

Rating: The risk rating (low or medium) depends on the sensitivity of the data assets receivable via web protocols from targets within the same network trust-boundary as well on the sensitivity of the data assets receivable via web protocols from the target asset itself. Also for cloud-based environments the exploitation impact is at least medium, as cloud backend services can be attacked via SSRF.

Service Registry Poisoning

service-registry-poisoning**STRIDE:** Spoofing**Description:** When a service registry used for discovery of trusted service endpoints Service Registry Poisoning risks might arise.**Detection:** In-scope service registries.**Rating:** The risk rating depends on the sensitivity of the technical assets accessing the service registry as well as the data assets processed or stored.**SQL/NoSQL-Injection****sql-nosql-injection****STRIDE:** Tampering**Description:** When a database is accessed via database access protocols SQL/NoSQL-Injection risks might arise. The risk rating depends on the sensitivity technical asset itself and of the data assets processed or stored.**Detection:** Database accessed via typical database access protocols by in-scope clients.**Rating:** The risk rating depends on the sensitivity of the data stored inside the database.**Unchecked Deployment****unchecked-deployment****STRIDE:** Tampering**Description:** For each build-pipeline component Unchecked Deployment risks might arise when the build-pipeline does not include established DevSecOps best-practices. DevSecOps best-practices scan as part of CI/CD pipelines for vulnerabilities in source- or byte-code, dependencies, container layers, and dynamically against running test systems. There are several open-source and commercial tools existing in the categories DAST, SAST, and IAST.**Detection:** All development-relevant technical assets.**Rating:** The risk rating depends on the highest rating of the technical assets and data assets processed by deployment-receiving targets.**Unencrypted Technical Assets****unencrypted-asset****STRIDE:** Information Disclosure**Description:** Due to the confidentiality rating of the technical asset itself and/or the processed data assets this technical asset must be encrypted. The risk rating depends on the sensitivity technical asset itself and of the data assets stored.**Detection:** In-scope unencrypted technical assets (excluding reverse-proxy, load-balancer, waf, ids, ips and embedded components like library) storing data assets rated at least as confidential or critical. For technical assets storing data assets rated as strictly-confidential or mission-critical the encryption must be of type data-with-enduser-individual-key.

Rating: Depending on the confidentiality rating of the stored data-assets either medium or high risk.

Unencrypted Communication

unencrypted-communication

STRIDE: Information Disclosure

Description: Due to the confidentiality and/or integrity rating of the data assets transferred over the communication link this connection must be encrypted.

Detection: Unencrypted technical communication links of in-scope technical assets (excluding monitoring traffic as well as local-file-access and in-process-library-call) transferring sensitive data.

Rating: Depending on the confidentiality rating of the transferred data-assets either medium or high risk.

Unguarded Access From Internet

unguarded-access-from-internet

STRIDE: Elevation of Privilege

Description: Internet-exposed assets must be guarded by a protecting service, application, or reverse-proxy.

Detection: In-scope technical assets (excluding load-balancer) with confidentiality rating of confidential (or higher) or with integrity rating of critical (or higher) when accessed directly from the internet. All web-server, web-application, reverse-proxy, waf, and gateway assets are exempted from this risk when they do not consist of custom developed code and the data-flow only consists of HTTP or FTP protocols. Access from monitoring systems as well as VPN-protected connections are exempted.

Rating: The matching technical assets are at low risk. When either the confidentiality rating is strictly-confidential or the integrity rating is mission-critical, the risk-rating is considered medium. For assets with RAA values higher than 40 % the risk-rating increases.

Unguarded Direct Datastore Access

unguarded-direct-datastore-access

STRIDE: Elevation of Privilege

Description: Datastores accessed across trust boundaries must be guarded by some protecting service or application.

Detection: In-scope technical assets of type datastore (except identity-store-ldap when accessed from identity-provider and file-server when accessed via file transfer protocols) with confidentiality rating of confidential (or higher) or with integrity rating of critical (or higher) which have incoming data-flows from assets outside across a network trust-boundary. DevOps config and deployment access is excluded from this risk.

Rating: The matching technical assets are at low risk. When either the confidentiality rating is strictly-confidential or the integrity rating is mission-critical, the risk-rating is considered medium. For assets with RAA values higher than 40 % the risk-rating increases.

Unnecessary Communication Link

unnecessary-communication-link

STRIDE: Elevation of Privilege

Description: When a technical communication link does not send or receive any data assets, this is an indicator for an unnecessary communication link (or for an incomplete model).

Detection: In-scope technical assets' technical communication links not sending or receiving any data assets.

Rating: low

Unnecessary Data Asset

unnecessary-data-asset

STRIDE: Elevation of Privilege

Description: When a data asset is not processed or stored by any data assets and also not transferred by any communication links, this is an indicator for an unnecessary data asset (or for an incomplete model).

Detection: Modelled data assets not processed or stored by any data assets and also not transferred by any communication links.

Rating: low

Unnecessary Data Transfer

unnecessary-data-transfer

STRIDE: Elevation of Privilege

Description: When a technical asset sends or receives data assets, which it neither processes or stores this is an indicator for unnecessarily transferred data (or for an incomplete model). When the unnecessarily transferred data assets are sensitive, this poses an unnecessary risk of an increased attack surface.

Detection: In-scope technical assets sending or receiving sensitive data assets which are neither processed nor stored by the technical asset are flagged with this risk. The risk rating (low or medium) depends on the confidentiality, integrity, and availability rating of the technical asset. Monitoring data is exempted from this risk.

Rating: The risk assessment is depending on the confidentiality and integrity rating of the transferred data asset either low or medium.

Unnecessary Technical Asset

unnecessary-technical-asset

STRIDE: Elevation of Privilege

Description: When a technical asset does not process or store any data assets, this is an

indicator for an unnecessary technical asset (or for an incomplete model). This is also the case if the asset has no communication links (either outgoing or incoming).

Detection: Technical assets not processing or storing any data assets.

Rating: low

Untrusted Deserialization

untrusted-deserialization

STRIDE: Tampering

Description: When a technical asset accepts data in a specific serialized form (like Java or .NET serialization), Untrusted Deserialization risks might arise.

Detection: In-scope technical assets accepting serialization data formats (including EJB and RMI protocols).

Rating: The risk rating depends on the sensitivity of the technical asset itself and of the data assets processed and stored.

Wrong Communication Link Content

wrong-communication-link-content

STRIDE: Information Disclosure

Description: When a communication link is defined as readonly, but does not receive any data asset, or when it is defined as not readonly, but does not send any data asset, it is likely to be a model failure.

Detection: Communication links with inconsistent data assets being sent/received not matching their readonly flag or otherwise inconsistent protocols not matching the target technology type.

Rating: low

Wrong Trust Boundary Content

wrong-trust-boundary-content

STRIDE: Elevation of Privilege

Description: When a trust boundary of type network-policy-namespace-isolation contains non-container assets it is likely to be a model failure.

Detection: Trust boundaries which should only contain containers, but have different assets inside.

Rating: low

XML External Entity (XXE)

xml-external-entity

STRIDE: Information Disclosure

Description: When a technical asset accepts data in XML format, XML External Entity (XXE) risks might arise.

Detection: In-scope technical assets accepting XML data formats.

Rating: The risk rating depends on the sensitivity of the technical asset itself and of the data

assets processed and stored. Also for cloud-based environments the exploitation impact is at least medium, as cloud backend services can be attacked via SSRF (and XXE vulnerabilities are often also SSRF vulnerabilities).

Disclaimer

mb conducted this threat analysis using the open-source Threagile toolkit on the applications and systems that were modeled as of this report's date. Information security threats are continually changing, with new vulnerabilities discovered on a daily basis, and no application can ever be 100% secure no matter how much threat modeling is conducted. It is recommended to execute threat modeling and also penetration testing on a regular basis (for example yearly) to ensure a high ongoing level of security and constantly check for new attack vectors.

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In this particular project, a timebox approach was used to define the analysis effort. This means that the author allotted a prearranged amount of time to identify and document threats. Because of this, there is no guarantee that all possible threats and risks are discovered. Furthermore, the analysis applies to a snapshot of the current state of the modeled architecture (based on the architecture information provided by the customer) at the examination time.

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