Application Name	Mojaloop Portals
Application Version	1.0
Description	A review of the portal’s application using the STRIDE threat model
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Executive Summary

The Portals application will serve as the landing page for Mojaloop clients to interact with the backend Mojaloop deployment for the following key purposes:

1. Portlet sandboxing
2. Single click configurations
3. Certificate exchange via CM backend
4. Reporting and Searching
5. Workflows
6. User access control e.t.c

The Portals frontend will provide access to the following back end services:

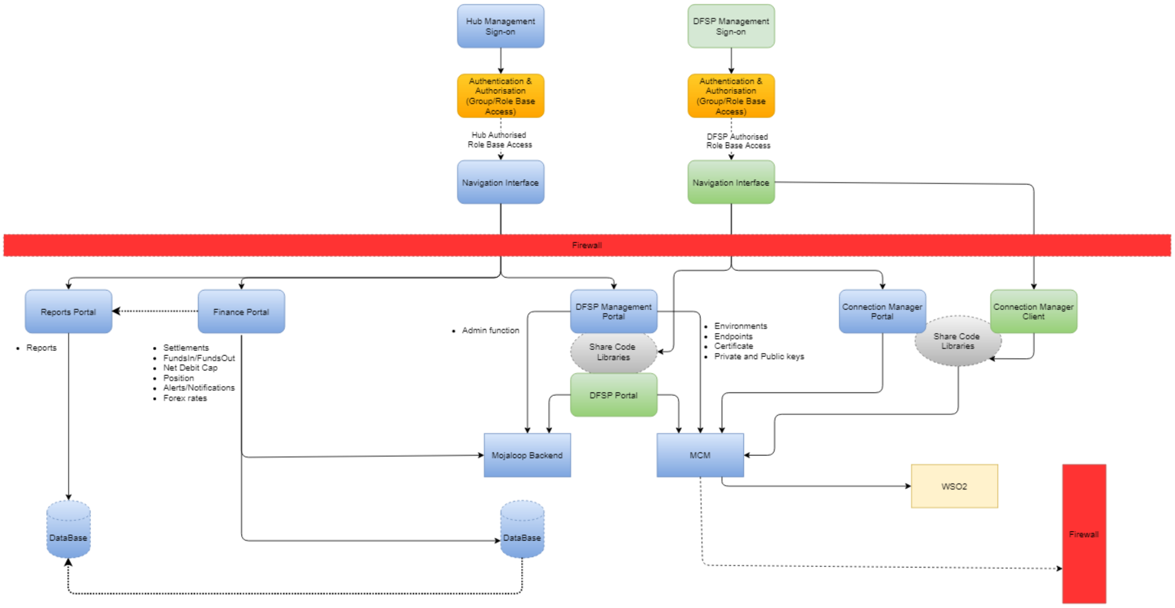
1. Reports portal
2. Finance portal
3. DFSP Management portal
4. Connection manager

Risk and objective

The portals application acts as single pane gateway to critical services in Mojaloop backend, on this note it is classified as a **high risk** application requiring robust controls around its deployment, management and operations.

The purpose of this report was to review the Portals proposed design and review inherent controls, making recommendations on any additional controls to be implemented.

Portals proposed design



Security Requirements summary

The following are high level requirements for implementation within the portals application. These are high level recommendations based on OWASP Top 20 controls for web applications as well as PCI-DSS guidelines for PII data protection.

1. Web application firewall / reverse proxy - This will act as a filter to protect portals application from web application attacks and depending on capabilities offer intrusion detection.
2. Data Protection controls
    a. Restrict access to sensitive data
    b. Encrypt data at rest and in motion
3. Identity and Access management - using a proper identity management solution, Portals can enforce strong authentication and authorization procedures including:
    a. User access management and workflows with least privilege controls
    b. API authentication and authorization
    c. Multi Factor Authentication with configurable policies
    d. Session management and control
4. Input validation within Portals as well as back end APIs
    a. Secure database communication and queries
5. Secure communication
    a. Use SSL/TLS for all communication
    b. Secure PKI artifact exchange
    c. Secure cookies, headers
6. Logging controls as prescribed by secure logging standard:
    a. Authentication and authorization calls
    b. Privilege changes
    c. Administrative actions
    d. Access to sensitive data
    e. Sanitise error messages

External Dependencies

External dependencies are items external to the code of the application that may pose a threat to the application. These items are typically still within the control of the organization, but possibly not within the control of the development team.

Dependency / Components	Description
Web Server	Details of selected web server
Operating System	Details of OS to be used
Database	Details of back end database used
UI Framework	Details of selected framework to be used to code application
Application Server	Will the application have a web server and application server?
Application Server	Application server to sit in DMZ behind a firewall
API Calls	API calls to back end applications via HTTPS
SSL encryption	DFSP users access portal via HTTPS url
Report SQL Queries	Optimised queries to be used for reporting and updates
SSL Certificate	Certificate for use in portals procured from a valid CA provider
Database tuning	Backend database to be tuned to optimise query responses, avoid timeouts and validate all inputs before execution
IAM server	We currently assume its using WSO2 to manage identities for users and APIs communicating with the portals.

Threats and Countermeasures

Threat	**Stride Mapping**	**Countermeasure**
Compromised credentials	Spoofing	Strong authentication controls ● IP binding ● IP Whitelisting ● MFA ● SSL authentication
Privilege escalation - Users	Elevation of privilege	Access controls ● RBAC within portal ● Audit logs
Privilege escalation - Devices and Services	Elevation of privilege	Access controls ● MTLS authentication for servers ● Least privilege server access for hub admins ● Audit logs
Privilege escalation - APIs	Elevation of privilege	Access controls ● API Authentication and authorisation ● API gateway baseline configs ● Audit logs
Insecure configuration	Information disclosure	Baseline setup and configuration for: ● Firewalls ● API gateway ● Servers ● Database ● Web Server ● Application Server ● SQL Optimisation ● Audit logging
Insecure communication - exposed sensitive data	Information disclosure	Encryption and data access controls
Exposed services are prone to intrusion attacks on public IPs	Spoofing Information disclosure Denial of service	Baseline setup and configuration for: ● Firewalls ● Intrusion detection rules ● Audit logging
Application availability	Denial of service	Configurations to ensure uptime

		- High availability
Data exfiltration	Information Disclosure	Authentication and intrusion detection controls - Database access controls - API authentication and authorisation - Query optimisation - Input validation
Zero day vulnerabilities	All	Baseline setup and configuration for: - Firewalls - API gateway - Servers - Database - Web Server - Application Server - SQL Optimisation - Audit logging - Patch Management - Change Management

Components and Entry Points

Entry points define the interfaces through which potential attackers can interact with the application or supply it with data. In order for a potential attacker to attack an application, entry points must exist. Entry points in an application can be layered, for example each web page in a web application may contain multiple entry points.

Name	**Description**	**Trust Level**

HTTPS Port	The Portals application will only be accessible via TLS. All pages within the Portals application are layered on this entry point.	(14) Valid API DFSP token (15) Valid MTLS authenticated user (16) Valid DFSP IP (Whitelisted)
Portal landing page	The splash page for the Portals application is the entry point for all users.	(14) Valid API DFSP token (15) Valid MTLS authenticated user (16) Valid DFSP IP (Whitelisted)
Portal login page	Login page for all users	(2) User with Valid Login Credentials (4) Hub User (5) Database Server Administrator (7) Web Server User Process (8) Database Read User (9) Database Read/Write User (16) Whitelisted IP
Navigation page	Page allowing users to navigate various features of portals application	(2) User with Valid Login Credentials (4) Hub User (5) Database Server Administrator (7) Web Server User Process (8) Database Read User (9) Database Read/Write User
APi Endpoint	API endpoint that will receive requests from Portal for processing	(2) User with Valid Login Credentials (4) Hub User (5) Database Server Administrator (7) Web Server User Process (8) Database Read User (9) Database Read/Write User

Assets/ Components

Name	**Description**	**Trust Level**
Portal Users	Portal users at Hub and DFSP.	(2) User with Valid Login Credentials (4) Hub User (5) Database Server Administrator (7) Web Server User Process (8) Database Read User (9) Database Read/Write User
Hub User login	Portal user within the hub	(2) User with Valid Login Credentials (4) Hub User (5) Database Server Administrator (7) Web Server User Process (8) Database Read User (9) Database Read/Write User
DFSP User login	Portal user within the valid DFSP	(2) User with Valid Login Credentials (4) Hub user (5) Database Server Administrator (7) Web Server User Process (8) Database Read User (9) Database Read/Write User
Customer data	Any customer data sent to and / or from the portal	(2) User with Valid Login Credentials (4) Hub user (5) Database Server Administrator (7) Web Server User Process (8) Database Read User (9) Database Read/Write User
Hub User data	Details about a portal hub user profile	(2) User with Valid Login Credentials (4) Hub User (5) Database Server Administrator (7) Web Server User Process (8) Database Read User (9) Database Read/Write User
DFSP user data	Details about a DFSP user profile	(2) User with Valid Login Credentials (4) Hub user

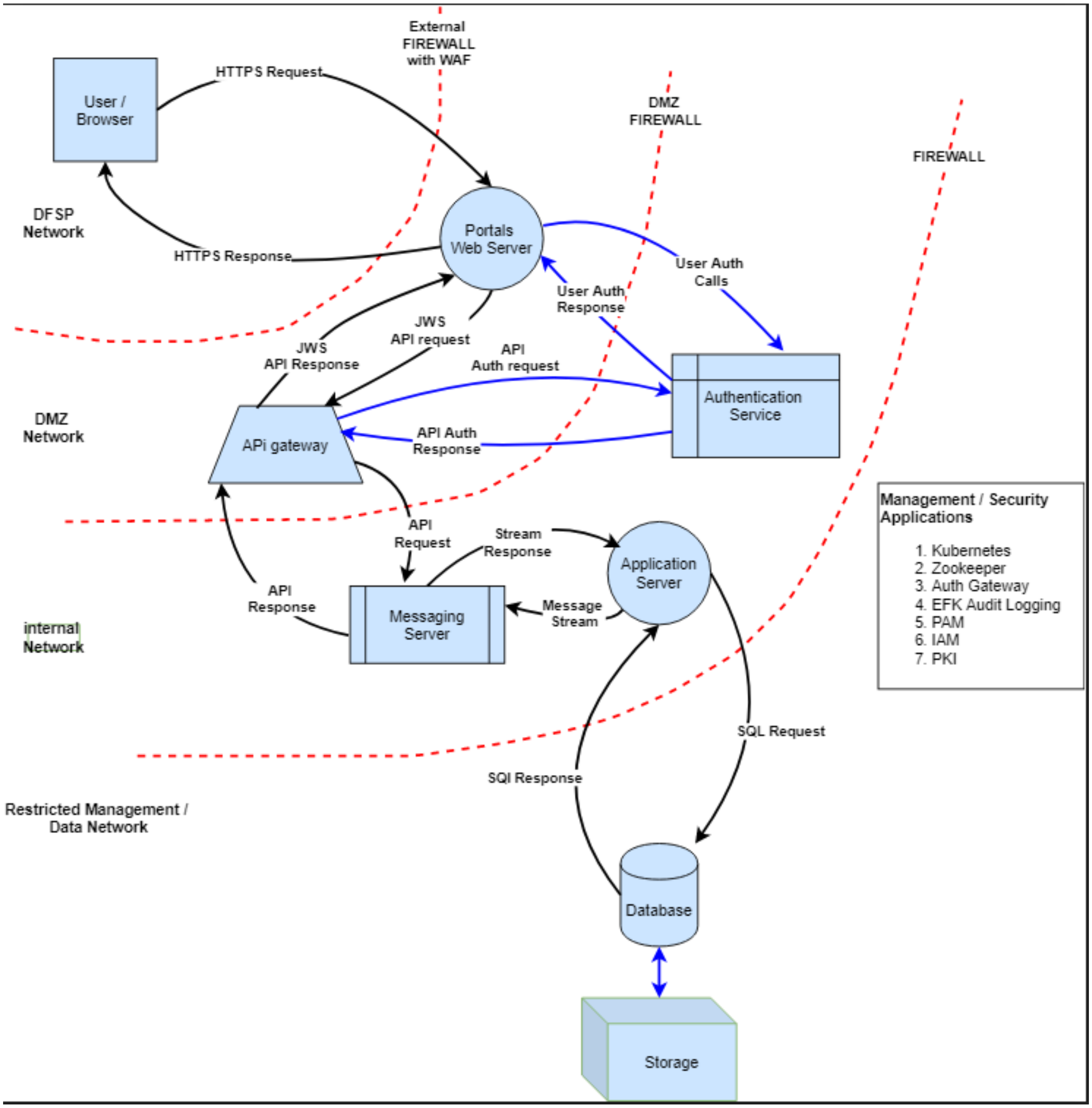
		(5) Database Server Administrator (7) Web Server User Process (8) Database Read User (9) Database Read/Write User
DFSP data	Details about a DFSP entity profile	(2) User with Valid Login Credentials (4) Hub user (5) Database Server Administrator (7) Web Server User Process (8) Database Read User (9) Database Read/Write User
Web Server code execution	Permissions to execute code in web server	(7) Web Server User Process (8) Database Read User (9) Database Read/Write User
Database read execution	Permissions to execute code in web server	(7) Web Server User Process (8) Database Read User (9) Database Read User
Database Read/Write execution	Permissions to execute SQL code in database server	(7) Web Server User Process (8) Database Read User (9) Database Read/Write User
API calls	Permission to execute API calls on exposed endpoint	(14) Valid API DFSP Token (15) Valid MTLS authenticated user
User session	Data on user session	(2) User with Valid Login Credentials (4) Hub user (5) Database Server Administrator (7) Web Server User Process (8) Database Read User (9) Database Read/Write User
Create Users	Ability to create users - DFSP	(2) User with Valid Login Credentials (4) Hub user (5) Database Server Administrator (7) Web Server User Process (8) Database Read User (9) Database Read/Write User
Create users - hub	Ability to create users - hub	(2) User with Valid Login Credentials

		(4) Hub user (5) Database Server Administrator (7) Web Server User Process (8) Database Read User (9) Database Read/Write User
Access audit data - DFSP	Access to view audit log data	(2) User with Valid Login Credentials (4) Hub user (5) Database Server Administrator (7) Web Server User Process (8) Database Read User (9) Database Read/Write User
Access audit data - Hub	Access to view audit log data	(2) User with Valid Login Credentials (4) Hub user (5) Database Server Administrator (7) Web Server User Process (8) Database Read User (9) Database Read/Write User
Search DFSP information	Access to DFSP search functionality	(2) User with Valid Login Credentials (4) Hub user (5) Database Server Administrator (7) Web Server User Process (8) Database Read User (9) Database Read/Write User
Print report data	Access to DFSp print report	(2) User with Valid Login Credentials (4) Hub user (5) Database Server Administrator (7) Web Server User Process (8) Database Read User (9) Database Read/Write User
Endpoint URL / IP / Hostname	Access to published services	(16) Valid DFSP IP

Trust Levels

ID	Name	Description
1	Anonymous Hub user	Unauthenticated user to the portal from within hub
2	Anonymous DFSP user	Unauthenticated user to the portal from within DFSP network
3	Valid hub user	User with valid credentials within hub
4	Valid DFSP user	User with valid credentials within DFSP
5	Hub Officers	User with valid credentials within hub
6	Hub IT administrator - web application	User with valid credentials within hub to manage Infrastructure and applications
7	Hub IT Administrator - application server	User with valid credentials within hub to manage applications
8	Hub IT administrator - database	User with valid credentials within hub to manage the database server
9	Hub IT administrator - API gateway	User with valid credentials within hub to manage Infrastructure - APi gateway
10	Hub IT administrator - WSO2	User with valid credentials within hub to manage Infrastructure - WSO2
11	Web server process user	Web server process
12	Database user read only	Read only DB user
13	Database user read / write	Read/Write DB user
14	Valid API DFSP token	User with valid API token to push API calls to hub
15	Valid MTLS authenticated user	Authenticated DFSP using valid SSL certificates
16	Valid DFSP IP (Whitelisted)	Whitelisted DFSP IP

Data Flow Diagram



STRIDE Threat descriptions

Type	Examples	Security Controls
Spoofing (S)	Threat action aimed to illegally access and use another user's credentials, such as username and password.	Strong authentication
Tampering (T)	Threat action aimed to maliciously change/modify persistent data, such as persistent data in a database, and the alteration of data in transit between two computers over an open network, such as the Internet.	Integrity
Repudiation (R)	Threat action aimed to perform illegal operations in a system that lacks the ability to trace the prohibited operations.	Non repudiation
Information disclosure (I)	Threat action to read a file that one was not granted access to, or to read data in transit.	Confidentiality
Denial of service (D)	Threat aimed to deny access to valid users, such as by making a web server temporarily unavailable or unusable.	Resilience and business continuity
Elevation of privilege (E)	Threat aimed to gain privileged access to resources for gaining unauthorized access to information or to compromise a system.	Authorisation

STRIDE in applications and networks

The following table summarises how key application components are affected by threats as viewed from a STRIDE perspective:

Component	S	T	R	I	D	E
External Entity	X		X			
Process	X	X	X	X	X	X
Data Flow		X		X	X	
Data Store		X	X	X	X	X

Threats and Countermeasures

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Privilege escalation - APIs	Elevation of privilege	Access controls ● API Authentication and authorisation ● API gateway baseline configs ● Audit logs

Insecure configuration	Information disclosure	Baseline setup and configuration for: ● Firewalls ● API gateway ● Servers ● Database ● Web Server ● Application Server ● SQL Optimisation ● Audit logging
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Application availability	Denial of service	Configurations to ensure uptime ● High availability
Data exfiltration	Information Disclosure	Authentication and intrusion detection controls ● Database access controls ● API authentication and authorisation ● Query optimisation ● Input validation
Zero day vulnerabilities	All	Baseline setup and configuration for: ● Firewalls ● API gateway ● Servers ● Database ● Web Server ● Application Server ● SQL Optimisation ● Audit logging ● Patch Management ● Change Management

Best Practice Standard mapping - OWASP (2017 release)

OWASP Application Risk	Description	STRIDE mapping	Control / Feature
A1:2017- Injection	Injection flaws, such as SQL, NoSQL, OS, and LDAP injection, occur when untrusted data is sent to an interpreter as part of a command or query. The attacker's hostile data can trick the interpreter into executing unintended commands or accessing data without proper authorization.	Spoofing Elevation of privilege	Strong authentication controls ● Input validation ● Query optimisation ● IP binding ● IP Whitelisting ● MFA ● SSL authentication ● RBAC within portal ● Firewall ● WAF filtering
A2:2017-Broken Authentication	Application functions related to authentication and session management are often implemented incorrectly, allowing attackers to compromise passwords, keys, or session tokens, or to exploit other implementation flaws to assume other users' identities temporarily or permanently.	Spoofing Elevation of privilege	Strong authentication controls ● IP binding ● IP Whitelisting ● MFA ● SSL authentication ● RBAC within portal ● API token authorisation
A3:2017- Sensitive Data Exposure	Attackers may steal or modify such weakly protected data to conduct credit card fraud, identity theft, or other crimes.	Information disclosure	Authentication and intrusion detection controls ● Database access controls ● API authentication and authorisation ● Query optimisation

			- Input validation
A4:2017-XML External Entities (XXE)	External entities can be used to disclose internal files using the file URI handler, internal file shares, internal port scanning, remote code execution, and denial of service attacks.	Information disclosure Denial of service	Data input validation controls - API authentication and authorisation - Query optimisation - Input validation - WAF filtering
A5:2017-Broken Access Control	Attackers can exploit these flaws to access unauthorized functionality and/or data, such as access other users' accounts, view sensitive files, modify other users' data, change access rights, etc.	Privilege escalation Information disclosure	Data input validation controls - RBAC controls - Audit logs
A6:2017-Security Misconfiguration	Security misconfiguration is the most commonly seen issue. This is commonly a result of insecure default configurations, incomplete or ad hoc configurations, open cloud storage, misconfigured HTTP headers, and verbose error messages containing sensitive information.	All	SecOps processes. Baseline setup and configuration for: - Firewalls - API gateway - Servers - Database - Web Server - Application Server - SQL Optimisation - Audit logging - Patch Management
A7:2017-Cross-Site Scripting (XSS)	XSS flaws occur whenever an application includes untrusted data in a new web page without proper validation or escaping, or updates an existing web page	Spoofing Repudiation	

	with user-supplied data using a browser API that can create HTML or JavaScript. XSS allows attackers to execute scripts in the victim’s browser which can hijack user sessions, deface web sites, or redirect the user to malicious sites		
A8:2017-Insecure Deserialization	Insecure deserialization often leads to remote code execution. Even if deserialization flaws do not result in remote code execution, they can be used to perform attacks, including replay attacks, injection attacks, and privilege escalation attacks.	Spoofing Elevation of Privilege	
A9:2017-Using Components with Known Vulnerabilities	Components, such as libraries, frameworks, and other software modules, run with the same privileges as the application. If a vulnerable component is exploited, such an attack can facilitate serious data loss or server takeover. Applications and APIs using components with known vulnerabilities may undermine application defenses and enable various	Information Disclosure Elevation of Privilege	

	attacks and impacts.		
A10:2017- Insufficient Logging & Monitoring	Insufficient logging and monitoring, coupled with missing or ineffective integration with incident response, allows attackers to further attack systems, maintain persistence, pivot to more systems, and tamper, extract, or destroy data. Most breach studies show time to detect a breach is over 200 days, typically detected by external parties rather than internal processes or monitoring	Elevation of privilege	

Attacker Stories / Abuse Cases

Story	Description	Stride
As an attacker I want to access the published portals using a spoofed IP address	Attempt to spoof a valid whitelisted IP	Spoofing
As an attacker I want to use malicious SQL code to manipulate the portal backend database so it reveals information.	Attempt SQL injection	Information disclosure Privilege escalation
As an attacker I want to attempt to load invalid URLs or force error input so I can get information on backend services based on error response	Attempted error generation for information disclosure	Information Disclosure Denial of service
As an attacker I want to attempt to launch an XSS injection attack targeting users in order to access accounts, activate Trojans or modify page content.	Attempted user redirection, injection of malicious code and exposing fake pages to users to harvest information	Information Disclosure Spoofing
As an attacker I want to inject malicious files into the portals application via exposed service endpoints	Malicious file uploads	Privilege escalation
As an attacker I want to attempt to perform tasks outside what my user is authorised to perform	Attempt to escalate privileges and perform illegal tasks not configured for my user	Privilege escalation Spoofing
As an attacker I want to attempt to log in multiple times using a valid user with invalid credentials so I test if the Portals application has robust authentication mechanism	Attempt to brute force attack the Portals application using numerous invalid logins. Check how application will respond. This also applies to API tokens	Spoofing Privilege escalation
As an attacker I want to attempt to log in to the Portals application and exposed supporting services / infrastructure using default credentials	Testing use of default credentials in exposed applications / infrastructure	Privilege escalation
As an attacker I want to attempt to	Testing data protection	Information Disclosure

eavesdrop traffic to and from Portals server using a man in the middle attack	in motion using encryption.	
As an attacker I want to attempt to enumerate and take advantage of weak / old cryptographic algorithms in use by the portals to break encryption and steal data	Enumerate encryption algorithms used and attempt to breach data encryption	Information disclosure
As an attacker, I want to exploit vulnerable areas of the application where the user or system can upload XML to extract data, execute a remote request from the server, scan internal systems, perform a denial-of-service attack, as well as execute other attacks.	Scan application components for vulnerabilities that are exploitable and attempt to breach system	Information Disclosure Privilege escalation
As an attacker, I want to bypass access control checks by modifying the URL, internal application state, or the HTML page, or simply using a custom API attack tool.	URL breach, session management controls bypass.	Information Disclosure Privilege escalation
As an attacker, I want to leverage metadata manipulation, such as replaying or tampering with a JSON Web Token (JWT) access control token or a cookie or hidden field manipulated to elevate privileges or abusing JWT invalidation.	Input validation breach as well as access controls integrity testing	Information Disclosure Privilege escalation
As an attacker, I force browsing to authenticated pages as an unauthenticated user or to privileged pages as a standard user.	Session validation and access control testing	Privilege escalation
As an attacker, I want to access APIs with missing access controls for POST, PUT and DELETE.	API access control testing	Privilege escalation
As an attacker, I find areas where the user agent (e.g. app) does not verify if the received server certificate is valid and perform attacks where I get unauthorized access to data.	Test user agent and server certificate validation	Information Disclosure
As an attacker, I want to find and exploit missing appropriate security hardening configurations on any part	Test patch management and zero day vulnerabilities	Information Disclosure Privilege escalation

of the application stack, or improperly configured permissions on cloud services.		
As an attacker, I want to find unnecessary features which are enabled or installed (e.g. unnecessary ports, services, pages, accounts, or privileges) and attack or exploit the weakness.	Identify unnecessary services and applications that are exposed and attempt to exploit them.	Information Disclosure Privilege escalation
As an attacker, I want to use default accounts and their passwords to access systems, interfaces, or perform actions on components which I should not be able to.	Test for default settings and configurations	Information Disclosure Privilege Escalation
As an attacker, I want to find areas of the application where error handling reveals stack traces or other overly informative error messages I can use for further exploitation.	Test error handling messages and information disclosure	Information Disclosure
As an attacker, I find security settings in the application servers, application frameworks (e.g. Struts, Spring, ASP.NET), libraries, databases, etc. not set to secure values.	Test insecure deployedcomponents and libraries	Information Disclosure
As an attacker, I find the server does not send security headers or directives or they are not set to secure values.	Test security of server headers	Information Disclosure
As an attacker, I attack an organization and the logs, monitoring systems, and teams do not see or respond to my attacks.	Test adequacy of logging and monitoring of security events	Information Disclosure