Development Team Project: Design Document

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Contents

1 Introduction

This design document outlines the development of a secure management application for an online retailer. The application provides a Command-Line Interface (CLI) for authorised users to perform Create, Read, Update, and Delete (CRUD) operations. Security and compliance with the General Data Protection Regulation (GDPR) (GDPR, N.D.) and the Payment Card Industry Data Security Standard (PCI DSS) (PCI Security Standards Council, 2024) are key priorities.

The business model chosen is a B2B eShop for beauty products, targeting individual hair stylists working at salons. Customers must specify their associated companies during registration for platform access. The system uses role-based access control (RBAC) for admins, clerks, and customers.

2 Retail Domain

Consumer trust is critical for retail websites, (D'Adamo et al., 2021), and this application prioritises cybersecurity, privacy, and compliance to meet industry expectations (Appendix 1).

3 System Requirements and Assumptions

3.1 System Requirements

The application meets the following functional and non-functional requirements, supported by user stories (Appendix 2).

- Enabling user authentication and authorisation with RBAC.
- REST Application Programming Interface (API) integration.
- CRUD operations.
- Security capability toggle via CLI.
- Logging and monitoring of interactions.
- Input validation to prevent vulnerabilities.
- Inventory stored in JSON file format.
- Protect Personal data using encryption.
- CLI-based access.

3.2 Assumptions

- Third-party libraries will be used for development.
- Compatible with on-premise infrastructure.
- Not hosted on a live web server.
- Focus on security features, not complete eShop functionality.

4 Design Decisions and Approaches

4.1 Methodology

The Scrum Solo methodology (Pagotto et al., 2016; Brito et al., 2020) is used, dividing the project into iterative sprints for incremental development. SOLID design principles (Singh & Hassan, 2015) and PEP-8 style guide for Python ensure high code quality.

4.2 Software Design

The Model-View-Controller (MVC) pattern separates concerns, enabling rapid prototyping and customisability (Pop & Altar, 2014). The Strategy pattern is used for user validation, ensuring appropriate strategies for authentication and authorisation based on the user (Hays et al. (2000), as cited in Uzunov, 2012; Blancarte, 2021). The two design patterns go hand-in-hand as the controller decides what to send to the view, depending on the strategy applied (Sellares, n.d.).

4.3 Data Structures

Key data structures include:

Data structure	Field	Justification
Array	orderItems	Efficient retrieval using unique IDs.
	inventoryItems	
	orderHistory	

Tree	categoryTree	Efficient searching by brand, category and subCategory fields (Lin, 2023).
Dictionary	Address	Address fields will be stored as key-value pairs for easy storage and retrieval (Ada, n.d.).

Table 1: Data Structures

4.4 API

The application incorporates a REST API to validate user input during registration. It integrates with an internal repository of company IDs for legitimate user verification (Moore. et al, 2023).

`Flask` is used for the REST API to create a microservice without requiring additional decisions, such as data storage (Martinez & Krebs, 2022).

5 Security Concerns and Mitigations

Key security challenges and mitigations are summarised below:

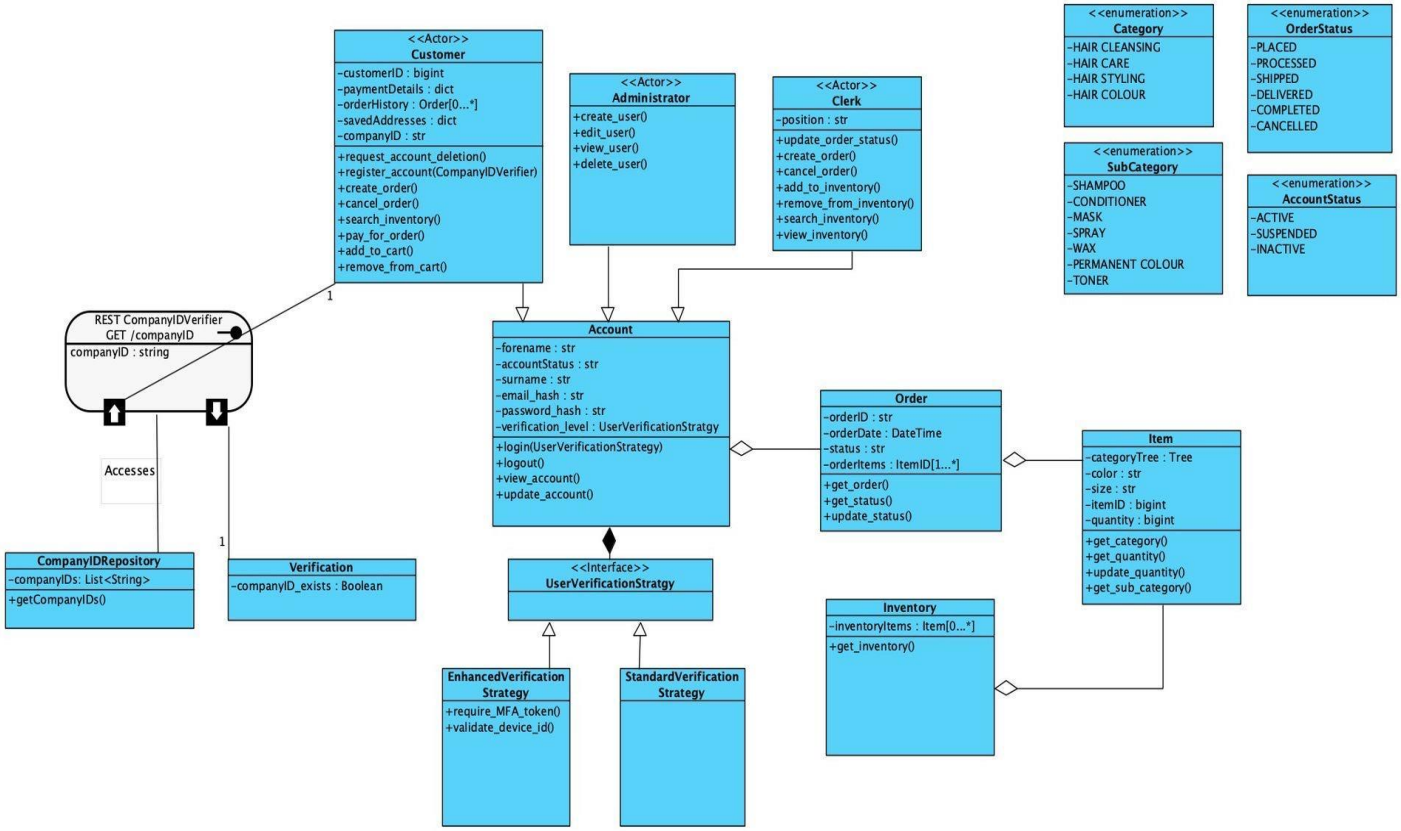
Attack Vector	**OWASP Top 10 2021** (Appendix 3)	**Challenge and Threat**	**Mitigation**	**OWASP Proactive Controls 2024** (Appendix 4)	**STRIDE Threat** (Appendix 5)
Brute Force Attacks	● A04 ● A07 ● A09	Credential stuffing and password spraying to gain unauthorised access.	● Multi-Factor Authentication (MFA) ● Account lockout after 3 attempts ● Monitoring ● Logging	● C4 ● C7 ● C9	● Spoofing (S) ● Repudiation (R) ● Elevation of Privilege (E)

Denial of Service (DoS) Attacks	● A04 ● A09 ● A10	Flooding attacks cause downtime or resource exhaustion.	● Monitoring ● Logging ● Rate-limiting	● C4 ● C9 ● C10	● Denial of Service (D)
Insecure APIs and Injection Attacks	● A03 ● A04	Weak APIs expose systems to unauthorised access and malicious payloads.	● API securing with OAuth ● Token-based API authentication ● Input validation ● Permission limiting	● C3 ● C4	● S ● Tampering (T) ● Information Disclosure (I)
Weak Authentication Mechanisms	● A07	Poor authentication enables unauthorised access.	● Strong password requirement ● MFA ● Secure session management ● Sensitive data encryption ● RBAC	● C7	● S ● R ● E

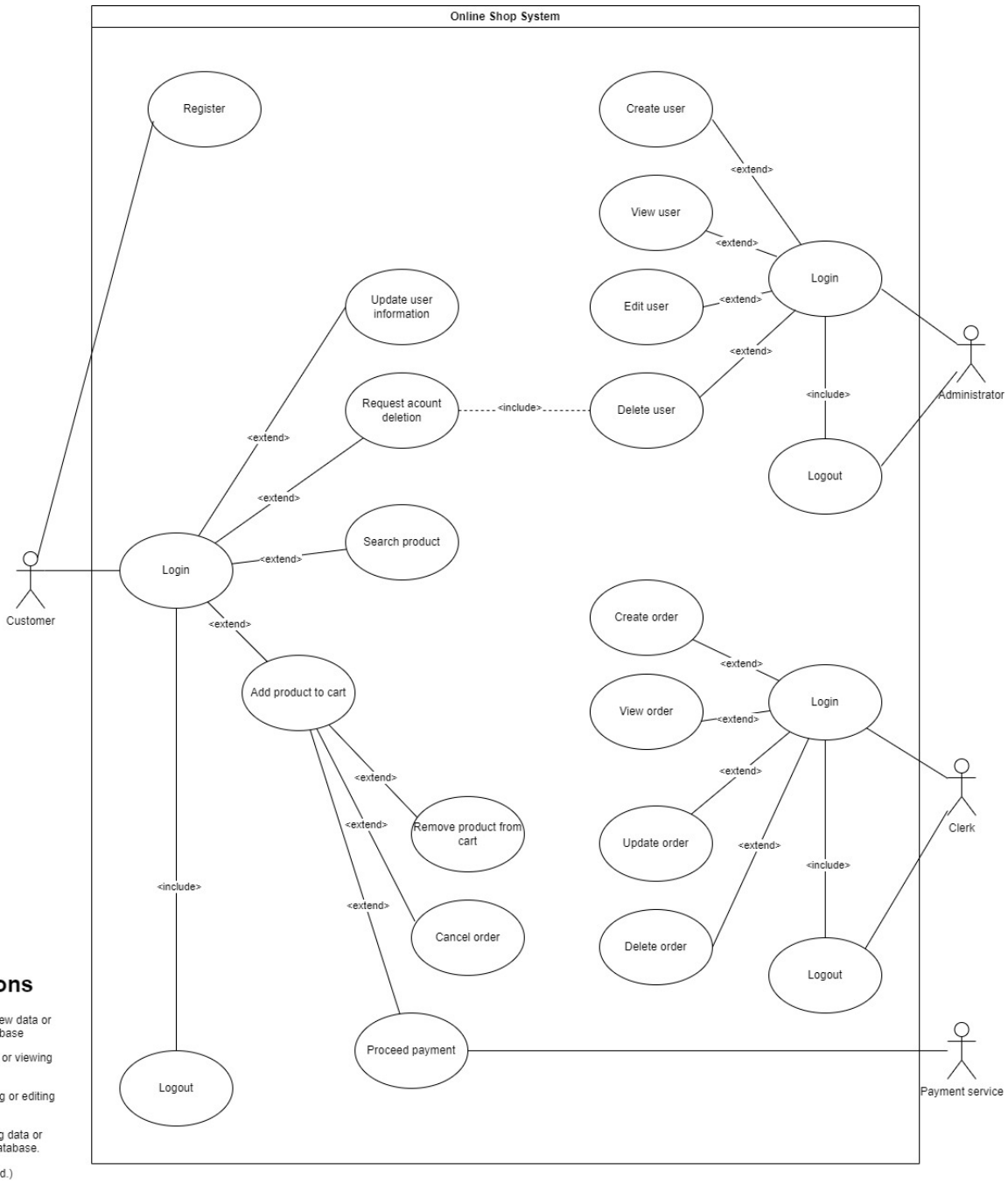
Table 2: Key attack vectors and proposed mitigations, in alignment with OWASP Top Ten and STRIDE.

6 UML Designs

6.1 Class Diagram



6.2 Use Case Diagram



CRUD Operations

Create: Adding new data or records to a database

Read: Retrieving or viewing existing data.

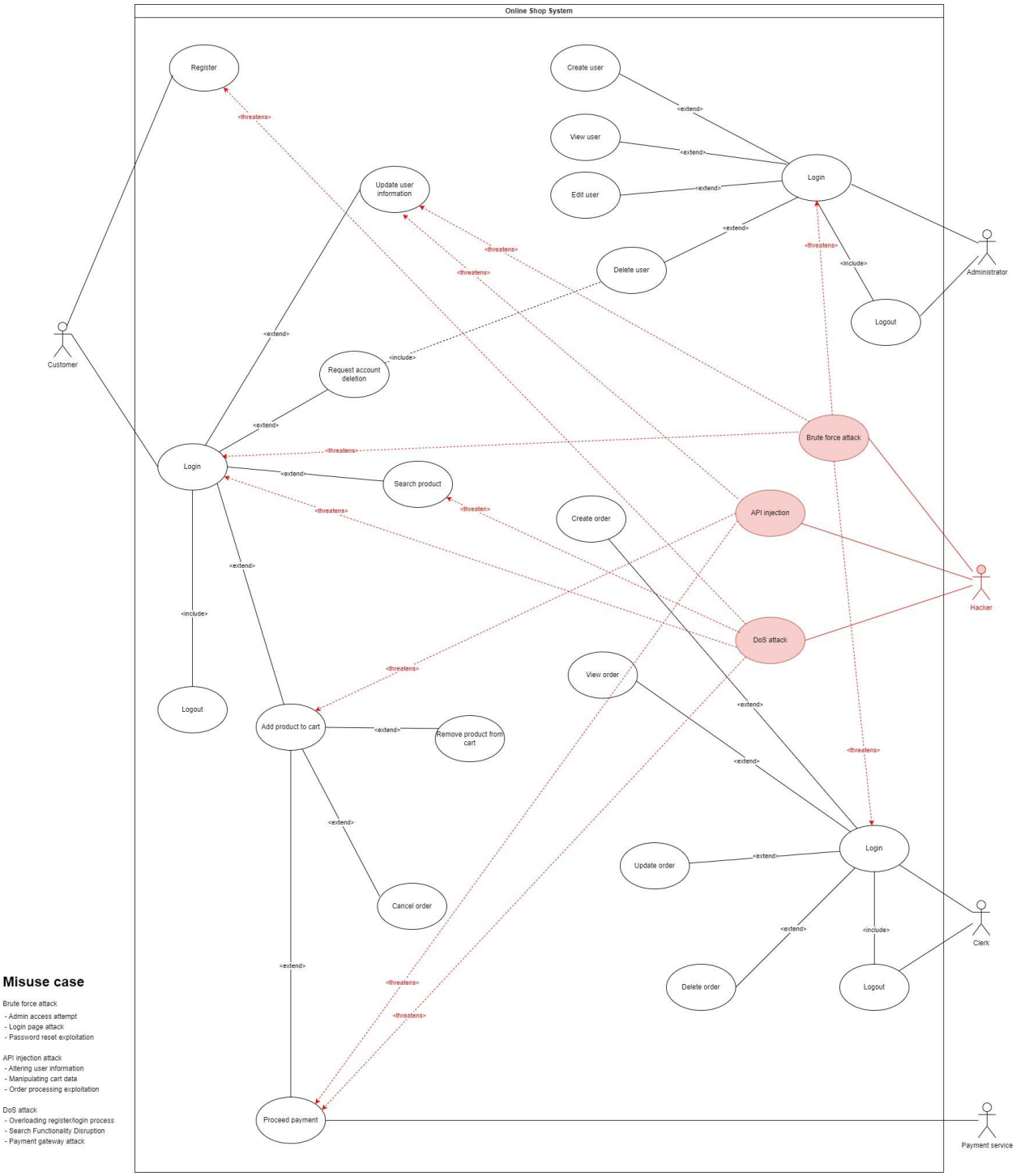
Update: Modifying or editing existing data.

Delete: Removing data or records from a database.

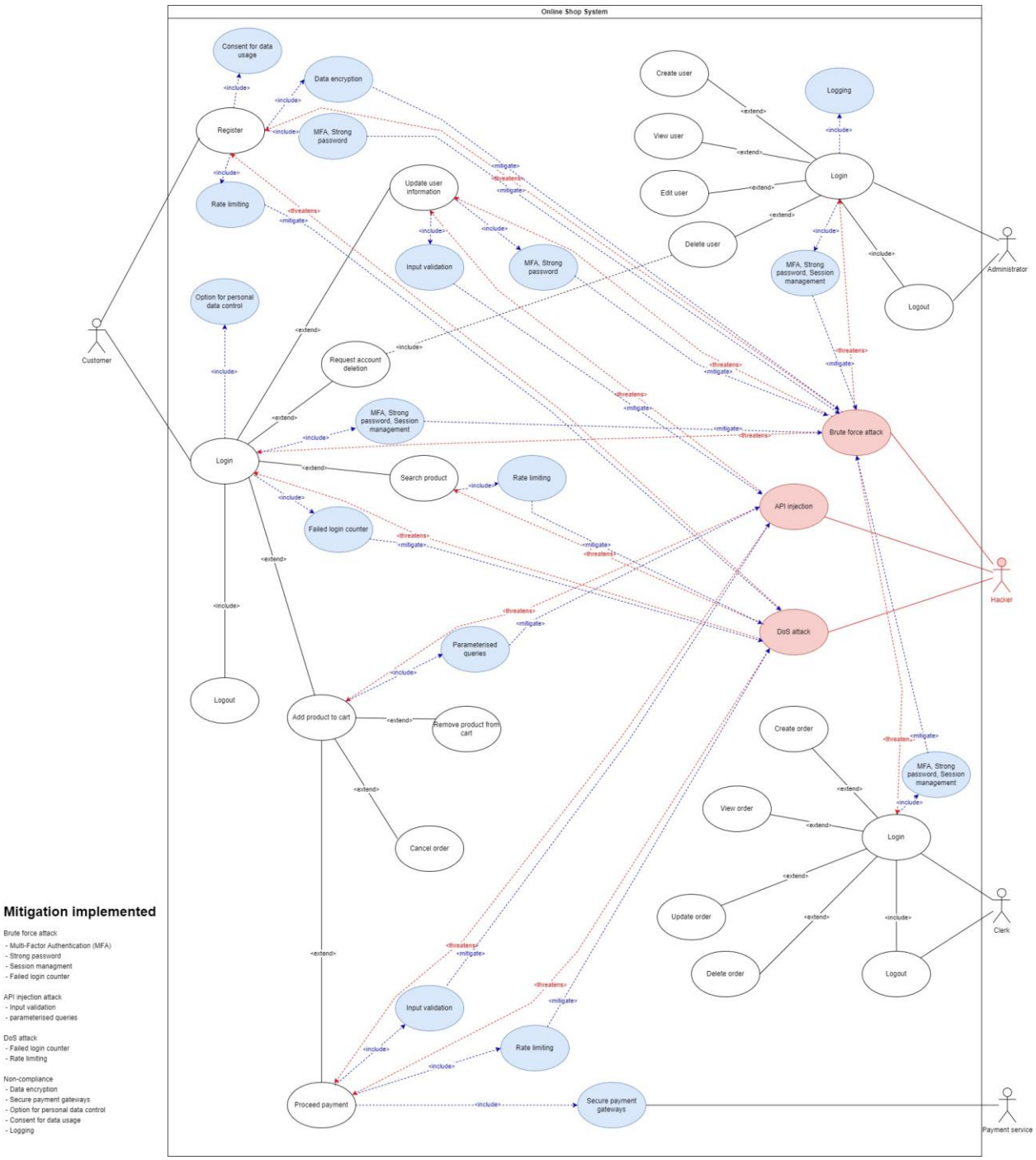
(Codecademy, n.d.)

6.3 Misuse Case Diagram

6.3.1 Misuse Case (Pauli & Xu, 2005)



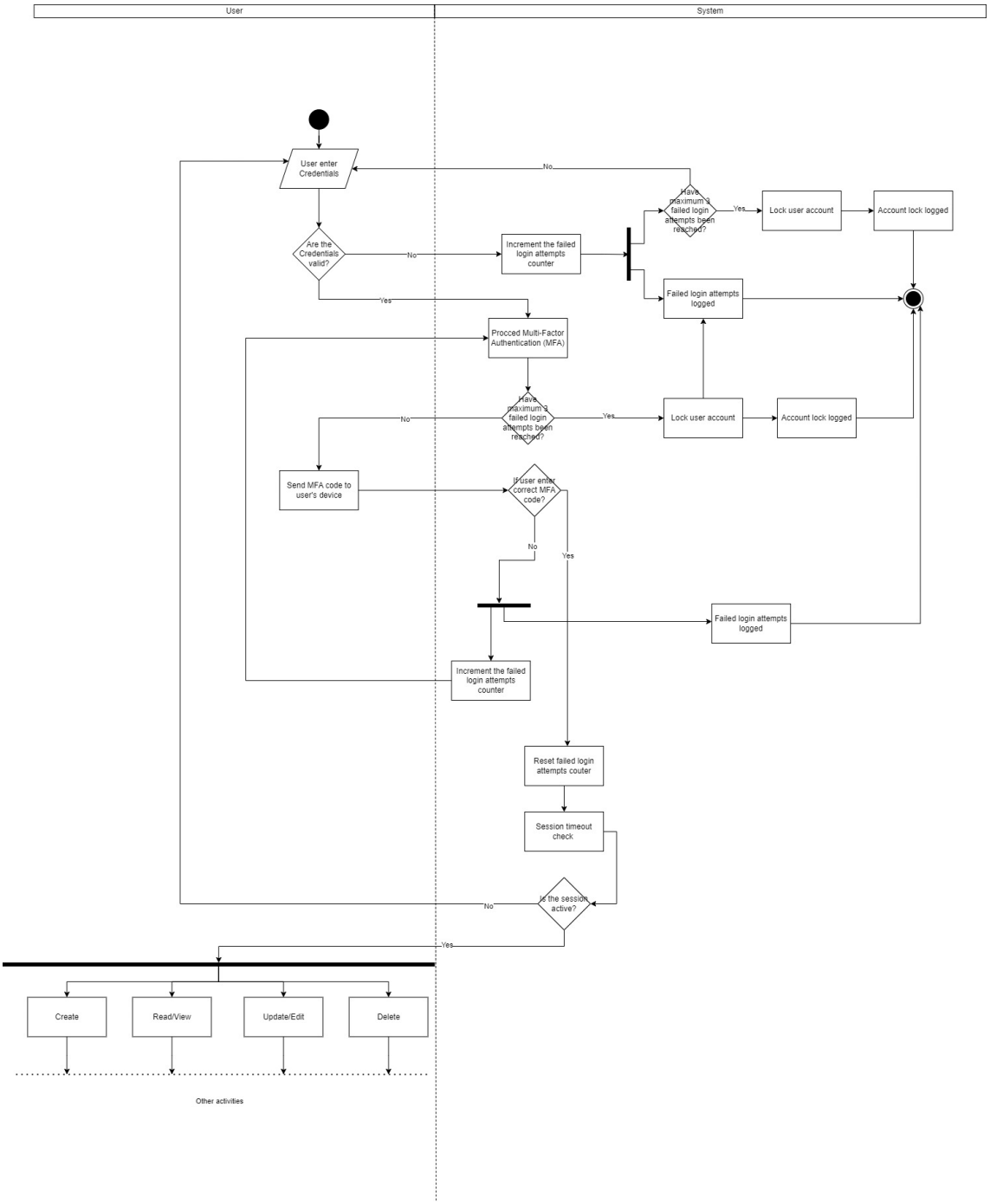
6.3.2 Misuse Case with Mitigation



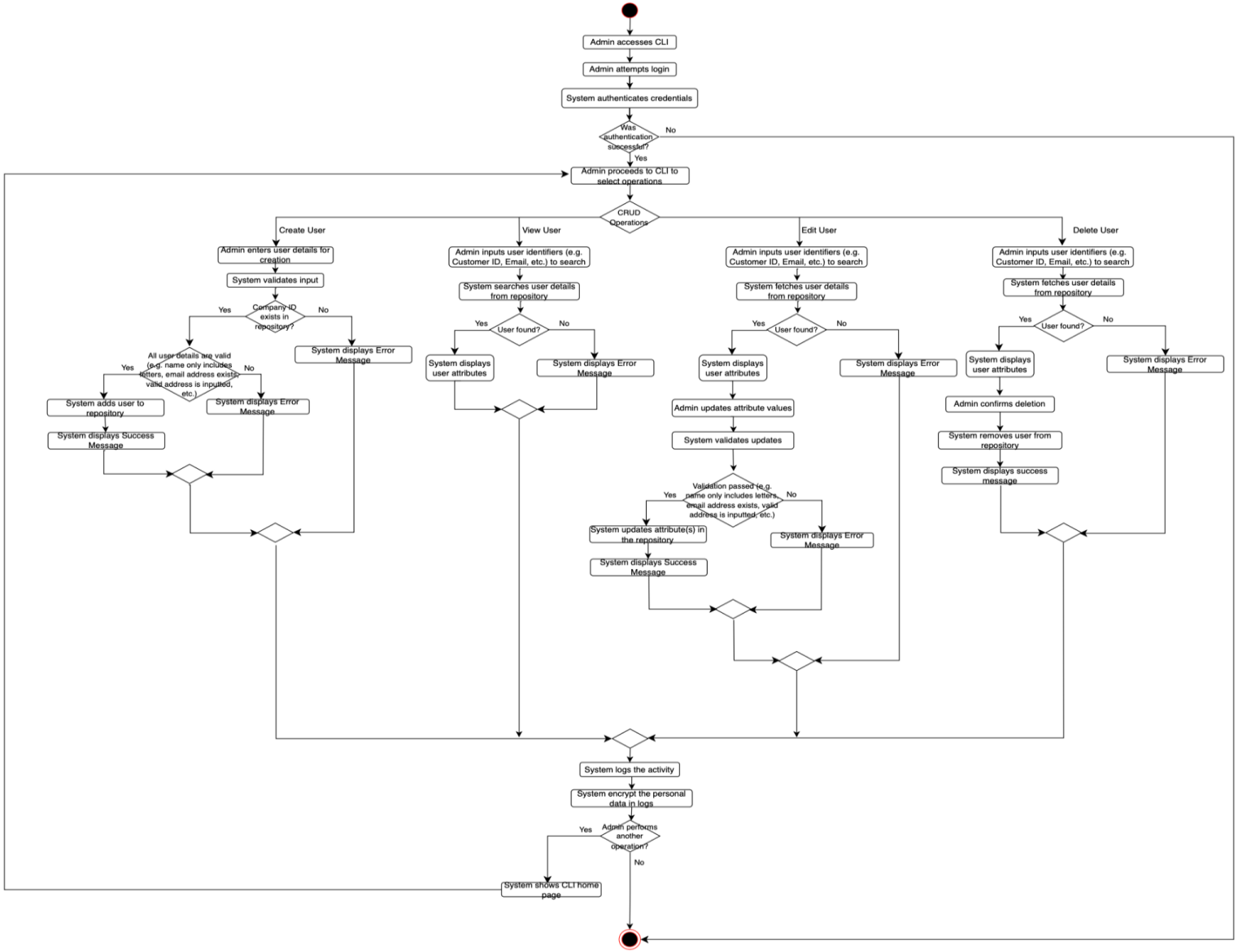
6.4 Activity Diagram

Separate diagrams for login and CRUD operations.

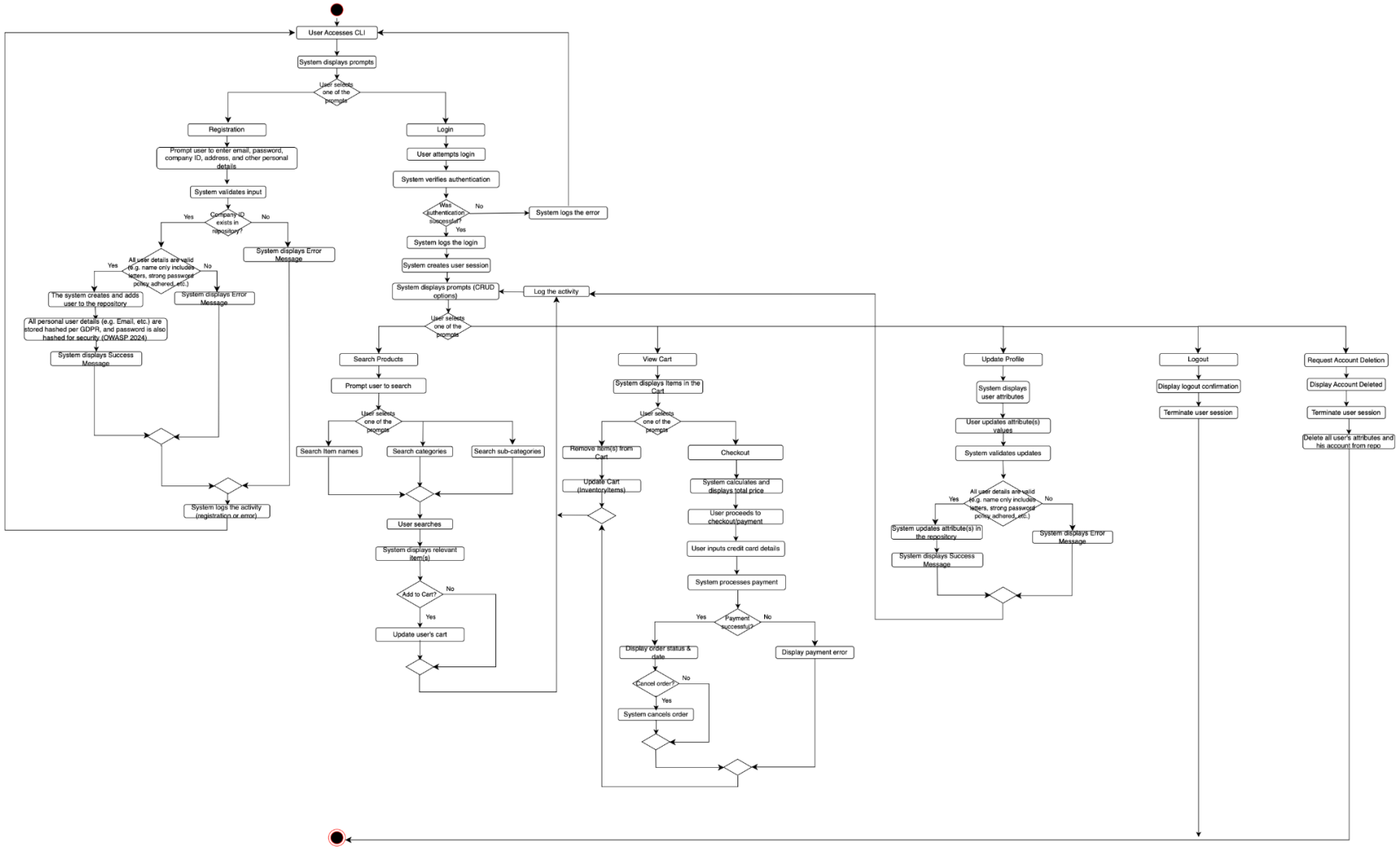
6.4.1 User login activities



6.4.2 Administration user CRUD activities



6.4.3 Customer user activities



7 Tools and Libraries

Category	Tools and Libraries
Development and Version Control	Python 3; Git and GitHub
Security	`bcrypt` (password hashing to prevent brute-force attacks) (OWASP, 2024a). `cryptography` (encryption key management for sensitive data with secure key storage and retrieval) (PCI Security Standards Council, 2024; Reitz & Schlusser, 2016). `hashlib` (data integrity through secure hashing) (OWASP, 2024a). `pyJWT` (API protection) (OWASP, 2024a).
API Handling and Validation	`requests` (simplifies HTTP requests for integration with APIs) (Madden, 2020). `oauthlib` (framework for authorising API requests). `Flask` (library for creating microframework REST API) (Pallets, 2010).
Input Validation	`regex` (build tailored input validation rules for multiple use cases)
Logging and Monitoring	logging (tracking events and detecting issues with system actions) (Madden, 2020).

Table 3: Tools and Libraries

8 Testing Strategy

The following will be used to test the software application:

Test Category	Test	Methods & Libraries	Justification
White-Box / Functional Testing	Unit Testing	`Pytest` library	Fixtures enhance customisability and user-friendly syntax (Barbosa & Hora, 2022).
	Integration Testing		
Black-Box Testing	Non-Destructive Penetration Testing	Brute Force Attacks (Password Spraying (Ranjan, n.d.), Credential Stuffing)	Identifies weaknesses in authentication; password spraying is increasingly successful (Vugdelija et al., 2021)
	Destructive Penetration Testing	DoS attack; Buffer Overflow Attack	DoS attacks test system resilience by breaking availability, violating GDPR requirements (Bienkowski, 2018).

Table 4: Testing strategy

The following source code analysis tools for static application security testing (SAST) will aid secure code development:

Linter	Tool	Justification
Security Linter	`Bandit`	Identifies hard-coded passwords and vulnerabilities (Sonar, n.d.).
Type Checking	`Pyre`	Enhances linter performance and code maintainability (Bailey, 2019).
General Linter	`Ruff`	Integrates capabilities of `Flake8`, `mccabe`, `isort` and `pydocstyle`.

Table 5: SAST

9 Compliance and Privacy

This application limits personal data collection to essential information under Article 6(1)(f) (GDPR, 2024a), ensures GDPR compliance for user rights and data handling (Appendix 6), and adheres to PCI DSS standards for secure payment data handling and transmission (Appendix 7).

10 Appendices

- **Appendix 1: Domain requirements table**

Requirement Area	Requirement	Justification
Cybersecurity and Privacy	Data Protection	Safeguards consumer information from unauthorised entry ensures GDPR adherence and builds customer confidence (D'Adamo et al., 2021).
	Secure Payment Systems	Safe transaction processing enhances buyer trust and minimises fraudulent activities, which are key concerns in e-commerce (D'Adamo et al., 2021).
	User Authentication	Two-factor verification provides a crucial security barrier that decreases the likelihood of unauthorised account access (D'Adamo et al., 2021).
	Regular Security Audits	Consistent security checks actively detect weaknesses, uphold protection, and reduce data breach risk (D'Adamo et al., 2021).
	Incident Response Plan	A breach response strategy enables swift action during security incidents, minimising potential

		harm to reputation and consumer faith (D'Adamo et al., 2021).
User Experience and Trust	Accessible and Reliable Customer Support	Precise item details help to avoid misinformation, enhance consumer trust, and lower return frequencies (D'Adamo et al., 2021).
	Secure and Convenient Checkout	An intuitive protected checkout process decreases cart abandonment and boosts conversion rates (D'Adamo et al. 2021).
Operational and Technical	Scalability	Facilitates expansion by ensuring that the system can manage traffic surges during high-volume periods (D'Adamo et al., 2021).
	Cross-Device Compatibility	A uniform user experience is delivered across platforms, which is crucial to the increasing prevalence of mobile shopping (D'Adamo et al., 2021).
	Inventory and Order Management	Live-stock monitoring ensures order precision, minimises errors, and enhances customer satisfaction (D'Adamo et al., 2021).
	Analytics and Personalization	Data analysis enables personalised experiences, boosting engagement and the probability of repeat purchases (D'Adamo et al., 2021).
Compliance and Legal	Adherence to Consumer Rights	Adherence to consumer protection regulations builds trust and shields companies from legal consequences (D'Adamo et al., 2021).
	Cross-Border Sales Compliance	Guarantees comply with international tax and customs regulations that are crucial for global expansion and scaling (D'Adamo et al. 2021).
	Transparency in Data Usage	Open communication about data usage strengthens consumer trust, aligns with privacy laws, and addresses consumer data concerns (D'Adamo et al., 2021).

○ Appendix 2: User stories

Customer user

- As a user, I want to decide my own username and password, so that I can personalise my login credentials.
- As a user, I want to know the password rules so that I can create a strong password to secure my account.
- As a user, I want to reset my password, so that I can login again if I forgot my password.
- As a user, I want to see an error message if I input wrong credentials, so that I know when my login attempt has failed.
- As a user, I want to view my personal data, so that I know if my account records are corrected.
- As a user, I want to update my personal data if it is incorrect, so that I can ensure the accuracy of my account information.
- As a user, I want to request the deletion of my account and all personal data if I no longer need it, so that I can ensure it will not be kept by the e-shop anymore.
- As a user, I want to view product categories and details to make informed purchasing decisions.
- As a user, I want to search for products with keywords, so that I don't need to browse the entire item list.
- As a user, I want to proceed with a secure checkout to complete my purchase.

Administrator / Clerk

- As an administrator, I want to create, view, update, or delete user for user management.
- As an administrator, I want to access system logs to monitor activities and identify any security issues.
- As an administrator, I want to require new users to use strong passwords to enhance security.
- As an administrator, I want to limit user login attempts to prevent brute force attacks.
- As a clerk, I want to add, update, or remove products from the inventory to manage the product catalogue effectively.

Hacker

- As a hacker, I want to exploit input fields to perform SQL injection attacks to gain unauthorised access to the database.
- As a hacker, I want to deploy a Denial of Service (DoS) attack to disrupt the availability of the online retailer's services.
- As a hacker, I want to intercept data transmissions to steal sensitive customer information.

○ Appendix 3: OWASP Top 10 2021

OWASP Top 10 Web Application Security Risks (OWASP, 2021)	
A01:2021 – Broken Access Control	Limit unauthorised access by enforcing role-based controls, least privilege, and deny-by-default policies on all endpoints.
A02:2021 – Cryptographic Failures	Secure sensitive data with strong encryption (e.g., AES-256), key management, and enforce HTTPS to prevent exposure.
A03:2021 – Injection	Prevent SQL, NoSQL, and command injections with parameterized queries, input validation, and avoiding concatenated queries.
A04:2021 – Insecure Design	Use secure design principles, threat modelling, and architectural reviews to prevent vulnerabilities in initial development.
A05:2021 – Security Misconfiguration	Review configurations, disable unused features, secure cloud storage, and update software to prevent exposure from misconfigurations.

A06:2021 – Vulnerable and Outdated Components	Update components, avoid deprecated libraries, and use dependency management tools to protect against known vulnerabilities.
A07:2021 – Identification and Authentication Failures	Strengthen authentication with MFA, strong password policies, and secure session management to prevent unauthorised access.
A08:2021 – Software and Data Integrity Failures	Use code signing, secure CI/CD pipelines, and validate dependencies to ensure software and data integrity.
A09:2021 – Security Logging and Monitoring Failures	Implement logging, real-time monitoring, and alerting to detect and respond to security incidents effectively.
A10:2021 – Server-Side Request Forgery (SSRF)	Prevent SSRF by validating URLs, restricting HTTP requests, and applying strict network access controls.

- **Appendix 4: OWASP Top 10 2024 Proactive Controls**

OWASP Top 10 2024 proactive controls (OWASP, 2024b)	
C1: Implement Access Control	Inadequate access controls allow unauthorised access. Use **RBAC** or attribute-based access control (**ABAC)**, enforce least privilege, and review permissions to restrict access.
C2: Use Cryptography to Protect Data	Weak cryptography exposes data. Secure sensitive data using **AES** encryption, proper key management, and enforce HTTPS for data in transit.
C3: Validate all Input & Handle Exceptions	Unvalidated inputs allow injection attacks. Apply **OWASP Input Validation** guidelines, sanitise data, and handle exceptions for secure data processing.
C4: Address Security from the Start	Early-stage security prevents vulnerabilities. Use **Secure Software Development Lifecycle (S-SDLC)** principles, perform threat modelling, and apply secure design.
C5: Secure By Default Configurations	Default settings increase risk. Change defaults, disable unnecessary features, and follow **OWASP Security Configuration** guidelines to strengthen defences.

C6: Keep your Components Secure	Outdated components introduce vulnerabilities. Regularly update dependencies, use **OWASP Dependency-Check**, and monitor for known security issues.
C7: Secure Digital Identities	Weak authentication risks account security. Implement **MFA**, enforce strong passwords, and secure sessions using **OAuth 2.0** or **OpenID Connect**.
C8: Leverage Browser Security Features	Prevent browser-based attacks using **CSP** and **HSTS** headers, secure cookies, and enable client-side security policies.
C9: Implement Security Logging and Monitoring	Lack of logging impedes response. Log security events, monitor in real-time, and establish alerts to detect suspicious activity early.
C10: Stop Server-Side Request Forgery	SSRF allows unauthorised server requests. Validate URLs, enforce network access controls, and limit outbound requests per **OWASP SSRF Prevention** guidelines.

- **Appendix 5: STRIDE Model**

STRIDE Model	**Threats**	**Mitigations**
Spoofing	Impersonation of customers, admins, APIs, or payment systems.	Use multi-factor authentication (MFA), strong password policies, and token-based API authentication
Tampering	Modifying product data, payments, or client-side scripts.	Enforce input validation, use cryptographic hashes, and apply Content Security Policies (CSP)
Repudiation	Denial of actions like orders or changes by users or employees.	Secure, tamper-proof logging with timestamps and digital signatures.
Information Disclosure	Leaking customer data, API keys, or sensitive backend info.	Enforce HTTPS, encrypt sensitive data, and implement least-privilege access.

Denial of Service (DoS)	DDoS attacks, API abuse, resource exhaustion.	Deploy WAFs, rate-limiting, and scalable architectures.
Elevation of Privilege	Gaining admin-level access or exploiting weak role configurations.	Apply RBAC, enforce least-privilege principles, and regularly patch systems.

- **Appendix 6: Correspond GDPR Compliance**

GDPR Standards (GDPR, N.D.)	
Art. 5: Principles relating to processing of personal data	Only collect personal data that is necessary for legitimate business interest for e-commerce (e.g. name, address, payment information) and ensure the data is processed lawfully and transparently.
Art. 7: Conditions for consent	Allow customers to give, withdraw or refuse consent for data collection.
Chapter 3 - Rights of the data subject (Art. 12-14)	Ensure information disclosure on privacy policy, data collection, storage and processing purposes.
Chapter 3 - Rights of the data subject (Art. 15-22)	Provide mechanisms for users to access, update, and request deletion on their personal data. Customers retain the right to request account deletion under the “Right to erasure” (also known as "right to be forgotten") provision (GDPR, 2024b).

- **Appendix 7: Correspond PCI DSS Compliance**

PCI DSS Requirements (PCI Security Standards Council, 2024)	
Requirement 3 (v4.0.1): Protect Stored Account Data	Ensure cardholder data is securely stored by minimising data storage, encrypting the stored Primary Account Number (PAN), and implementing access controls.
Requirement 4 (v4.0.1): Protect Cardholder Data with Strong Cryptography During	Ensure the safeguarding of cardholder data by encrypting data in transit, avoiding the sending of cardholder data via email or other end-user messaging, and enhancing payment page security.

Transmission Over Open, Public Networks	

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