Carnegie Mellon University – NSE TalentSprint

Advanced Certificate Program in Software Architecture

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Capstone Project – Case Study

ModernMaven – StyleMart

Project Report

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Introduction

ModernMaven – StyleMart is a capstone project aimed at creating an e-commerce platform for ModernMaven, a renowned fashion brand. The project outlines the vision for ModernMaven, focusing on high-level requirements and constraints. The primary goal is to provide a seamless shopping experience for fashion-forward professionals worldwide, leveraging ModernMaven's reputation and the growing trend of online shopping. The platform aims to boost sales by 20% and generate $10 million in revenue within the first year.

Abstract

ModernMaven – StyleMart is an e-commerce platform designed to provide stylish wear for the modern users globally. The project aims to leverage ModernMaven's strong brand reputation to tap into the growing online shopping market, particularly targeting the upcoming holiday sales.

Key Aspects:

Objective: Create a visually appealing, user-friendly platform showcasing ModernMaven's latest collections, enhancing the shopping experience.

Functionality: Includes inventory management, search and filters, shopping cart, user accounts, multilingual support, secure payment, order management, and customer support.

System Goals: Focus on visual appeal, performance, scalability, mobile responsiveness, and secure transactions.

Constraints and Risks: Launch within six months, compatibility with various devices and browsers, adherence to regional regulations, and potential technical and market challenges.

Create an intuitive, responsive and user-friendly interface available to be used globally which works during peak traffic, accommodate growth in users & products. It must safeguard user's data and follow security & compliances.

Objective

The primary objective of StyleMart is to create a cutting-edge e-commerce platform that leverages ModernMaven's strong brand reputation to expand its market reach globally. This application aims to offer stylish workwear for modern professionals online and include the drop-shipping capabilities to enhance product variety and customer satisfaction.

Background

ModernMaven is a well-known fashion brand recognized for its aspirational designs and rave reviews at important fashion events. With a strong reputation in the industry, ModernMaven seeks to expand its market reach by leveraging the growing trend of online shopping and opportunities of upcoming holiday sales season. By launching StyleMart, ModernMaven aims to tap into the global market, catering to customers from different regions, languages, and cultures.

Business Goal

- **Expand Market Reach:** Leverage the growing trend of online shopping to reach a global customer base and increase sales revenue by 20% in the first year.

Business Constraints:

- **Launch Timeline**: Launch the e-commerce website within six months to capitalize on the holiday sales. Careful consideration between buy v/s build decision to meet the timeline
- **Global Presence**: Cater to customers from different regions, languages, and cultures.

Technical Constraints

- **Compatibility**: Website must be compatible with popular web browsers, devices, and operating systems.
- **Legal and Cultural Compliance**: Adhere to regional legal and cultural requirements, including data protection and e-commerce regulations.
- **Integration with Third party services (shipping, payment, seller, etc)**

Project Context

Overview

StyleMart is an online platform that connects fashion enthusiasts, designers, and shoppers. The system aims to provide a seamless shopping experience while ensuring security, scalability, and usability.

Stakeholders

1. **Users/Customers**: Fashion-conscious users who browse and purchase clothing, accessories, and beauty products.
2. **Administrators**: Responsible for managing the platform, handling disputes, and maintaining system health, maintaining inventory, provide customer support to the users.

3. **Designers and Sellers**: Individuals or brands who showcase their collections on StyleMart(Future scope Drop shipping capabilities)

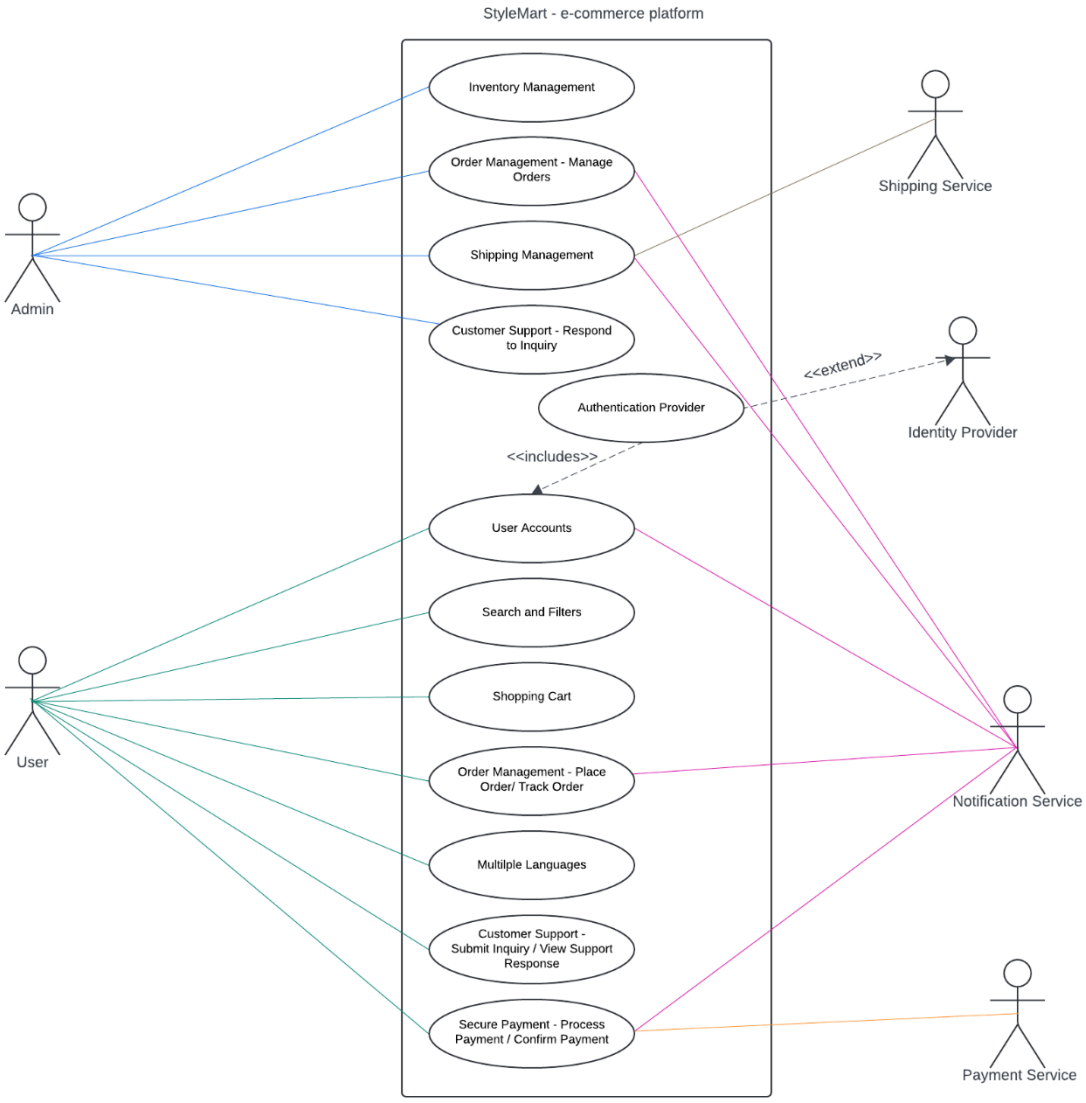
Requirements

Create an intuitive, responsive and user-friendly interface available to be used globally which works during peak traffic, accommodate growth in users & products. It must safeguard user's data and follow security & compliances.

Risks

1. **Data Breach**: Exposure of customer information.
2. **Downtime**: Loss of revenue during system outages.
3. **Poor Performance**: Frustrated users due to slow page loads.

Use Case Diagram:



Requirements

Functional Requirements

- **Inventory Management**: StyleMart shall offer a curated collection of fashionable workwear.
- **Search and Filters**: StyleMart shall provide functionality to efficiently search and filter various product options.

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- **Shopping Cart**: StyleMart shall be providing a customer a functionality to be able to add items to their shopping cart, review the cart, and proceed to checkout
- **User Accounts**: StyleMart shall allow customers to create accounts, manage personal information, track orders, and view purchase history
- **Multiple Languages**: The website must support English, French, and Spanish languages to cater to a global customer base.
- **Secure Payment**: StyleMart must implement secure payment gateways to ensure safe and reliable transactions.
- **Order Management**: ModernMaven should be able to manage and track orders efficiently, including shipping and delivery details
- **Customer Support**: StyleMart should offer customer support features, such as a help center, live chat, and email support, to address customer queries and concerns promptly.

Key Quality Attributes to be met by the system:

- **Usability**: Aesthetically pleasing design with intuitive navigation.
- **Performance**: Fast page loading times and minimal downtime.
- **Scalability**: Handle increasing customer traffic during peak periods.
- **Security**: Secure payment gateways and encryption protocols.
- A**vailability:** The system should be available for 99.99% of the time

Key Considerations: Trade-off between build v/s design decision

Summary in Favor of Building a Custom Solution for StyleMart –

Performance

A custom-built platform can be fine-tuned to meet the specific performance needs of StyleMart. This tailored approach can lead to better performance, especially under the unique traffic patterns and usage scenarios of the business. Scalability This can be designed from the ground up, ensuring the platform grows seamlessly with the business.

Modifiability

This provides the ability to customize every aspect of the platform. Pre-built solutions often come with limitations in terms of customization. With a custom build, you have full control over the architecture and features, allowing you to implement unique functionalities that align perfectly with the business needs. This flexibility can be crucial as the business evolves and new requirements emerge.

Cost Effectiveness

While the initial development costs for a custom solution can be high, they can be offset by long-term savings. Pre-built solutions typically involve ongoing licensing fees, and additional costs for customizations, integrations, and scaling. A custom-built platform, once developed, only incurs maintenance and infrastructure costs, which can be more predictable and manageable over time.

Future Limitations

Pre-built solutions can impose constraints that may hinder future growth and innovation. Custom building eliminates these limitations, providing a platform that can evolve with the business. You can avoid being locked into a vendor's roadmap and timeline, ensuring that any new features or changes can be implemented according to the business's priorities.

Further Customization

As the business grows, the need for further customization will inevitably arise. A custom-built platform allows for continuous development and enhancement, ensuring that the platform remains aligned with the business goals. Whether it's integrating new technologies, adding advanced features, or redesigning the user interface, a custom solution offers unmatched flexibility.

Specific Considerations

Search and Filters: Tailoring search algorithms and UI design to StyleMart's specific needs can significantly enhance user experience, offering personalized search results and advanced filtering options that match the product offerings.

Shopping Cart: Building a custom shopping cart allows for unique features that provide a seamless user experience, including advanced promotion handling, custom discount rules, and a highly optimized checkout process.

User Accounts: Implementing custom user account management can offer unique interactions and personalized experiences, differentiating the brand from competitors. Custom solutions can better handle specific requirements for user authentication, authorization, and profile management.

Order Management: Custom order management systems can be designed to perfectly align with the business processes, providing more efficient and effective handling of order tracking, returns, and inventory management.

Payment: Custom payment solutions offer flexibility in choosing and integrating with various payment providers, ensuring secure handling of payment information and compliance with relevant regulations while providing a tailored checkout experience.

Business Assumptions

- Target Market: The primary target market is young professionals who are fashion savvy
- Product Mix: Range of products offered will be clothing, accessories, footwear.
- Pricing Strategy: There will be discounted items, premium items and competitive pricing.
- Marketing and Sales Channels: Primary marketing and sales channels will be social media, email, search engine marketing).
- Customer Support: Email or live chat support for initial customer inquiries. Followed by phone support.

Technical Assumptions

- **Traffic Volume**: Estimated traffic volume under normal conditions is approximately 100k users per day. Estimated peak volume is around 1 million users per day, and transaction

volume will be approximately 3500 transactions per minute. This will determine the required infrastructure capacity and performance optimization strategies.

- **Data Volume**:
  - Product catalog: Several terabytes for images and videos, with relatively small text data.
  - Customer data: Hundreds of gigabytes for customer profiles and interactions.
  - Order and transaction data: Tens of gigabytes per month, growing over time.
- **Integration**: Authentication provider, Identification provider, Payment service provider and notification service providers need to be integrated into the system.
- **Security Requirements**: PCI DSS and GDPR regulations need to be complied with.
- **Scalability**: User base is expected to increase by 2%-5% annually.

Operational Assumptions

Area	Tools
Development Methodology	Agile
Front-end Development	React, Angular and CSS
Back-end development	Python, Node.js, Django, Express JS
Database	PostgreSQL, Cassandra, DynamoDB
Payment Gateway	Paypal, CyberSource
Shipping and Fulfilment	FedEx
Hosting Services	AWS Cloud
Analytics	Google Analytics
Social Media Management	Facebook, Instagram
Customer Support	Zendesk
Logging & Monitoring	Dynatrace, AWS CloudWatch
	Splunk
	log4js, Loguru, Logging

Quality Attributes

Identified ASRs

1. Availability

When a system or any component (e.g., hardware failure or software crash) having critical features fail under normal operating conditions or peak load, the system or its component switches to a backup component or recovers from the failure within 1 minute resulting into 99.99% availability for those features.

Stimulus	A system or its components dealing with critical features
Source of stimuli	Failure

Environment	Under normal operating conditions or peak load
Artifacts stimulated	Affected system or components
Response	The system switches to a backup component or recovers from a failure
Response Measure	Overall availability of the system should be 99.99% and recover from failure within 1 minute

2. **Security**

- Implementation of secure payment systems to protect user data.
- Protection against potential cyberattacks and data breaches.
- Compliance with data protection laws and e-commerce regulations.

When a potential attack, malicious login attempts, fraudulent transactions or any threat happens in the system the intrusion detection system should be able to monitor, detect and prevent threats, safeguard user data according to legal compliance with its strong security effectiveness such as regular policy review, update to the process with compliance alignments, industry standard encryption protocols, log and prevent any unauthorized access or fraud transaction. The time to repair attack should be minimal with no damage to PII, PCI related data.

Stimulus	When a potential attack, malicious login attempts, fraudulent transactions or any threat happens
Source of stimuli	Security threats
Environment	During normal operations
Artifacts stimulated	Intrusion detection system
Response	Detect, prevent threats and safeguard user's data
Response Measure	Regular policy review, compliance alignment, industry standard encryption protocols, log and prevent unauthorized access or fraud transaction

3. **Usability**

- The website should have a visually pleasing and user-friendly interface that reflects the brand.
- The platform should work seamlessly across different devices, including mobile phones and tablets.
- Support for multiple languages (English, French, Spanish) to cater to a global audience.

When a website is used by different users globally across different devices, it should have a visually appealing and user-friendly interface which can support multiple languages such as English, French, Spanish.

Stimulus	A website used by different users across different devices
Source of stimuli	Global users and different devices
Environment	Under normal operating conditions
Artifacts stimulated	The visual interface of the system

Response	Multiple language & different device support
Response Measure	User friendly interface across multiple devices & language

4. **Performance**

- The website must load quickly to enhance user experience.
- Efficient search algorithms and indexing to ensure users can quickly find products.
- High availability is crucial, especially during peak periods like holiday sales.

When a user browses the catalog and search for the product or place an order in the system under normal operation conditions, the website response time should be less than 1 second for each activity. Retrieved product should be updated in real time based on available inventory.

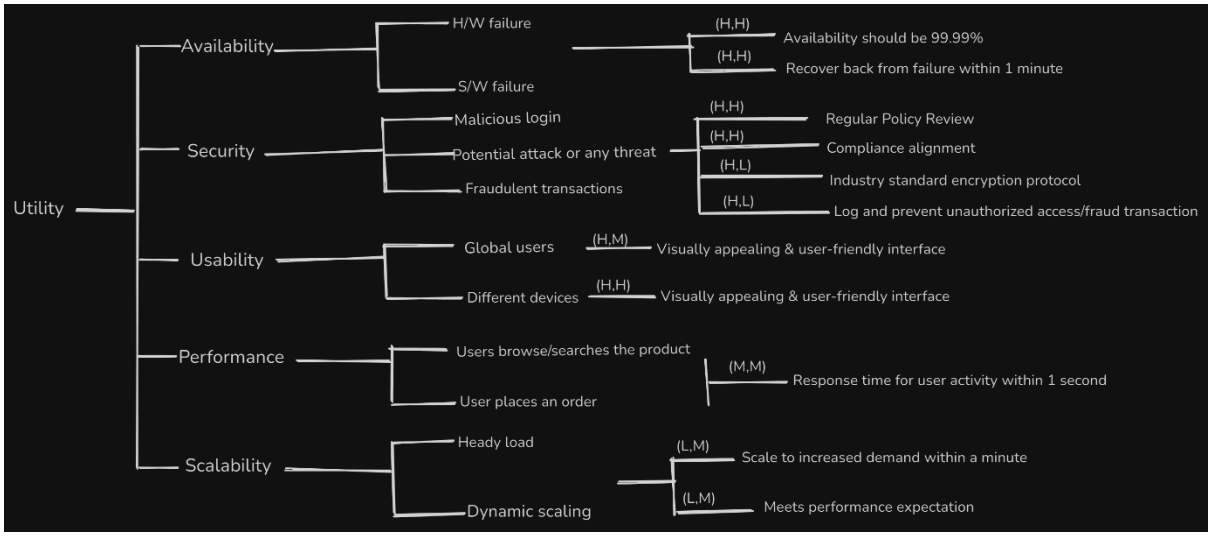
Stimulus	When a user searches the product, or places an order
Source of stimuli	User who browses the catalogue or search the product or place an order
Environment	Under normal operating conditions
Artifacts stimulated	The product databases, UI, order or product services
Response	System displaying the relevant product or responding to user activity
Response Measure	Ensure response time within 1 second

5. **Scalability**

- The system should support scaling up for high traffic, especially during peak seasons.
- It must support many concurrent users without degradation in performance.

A sudden surge in user requests as shoppers visit the website during a major sale event such as black Friday, the system component should be able to scale dynamically within a minute without performance degradation under heavy load.

Stimulus	A sudden surge in user requests as shoppers visit the website during a major sale event
Source of stimuli	Increased user activity
Environment	Under heavy load
Artifacts stimulated	System components
Response	Scale dynamically without performance degradation
Response Measure	Adapts to increased demand within a minute



Prioritization:

1. Scalability vs Availability

Critical for Business Growth: As StyleMart aims to cater to a global customer base, the system must handle increasing traffic and user demands, especially during peak times like holiday sales.

Future-Proofing: Ensuring scalability from the outset will allow for smooth expansion and the addition of new features, such as drop-shipping partnerships.

Trade-Offs:

Performance: Achieving scalability might require a more distributed system architecture, potentially complicating the optimization for low-latency and high-speed transactions.

Cost: Scalable infrastructure, such as cloud services with auto-scaling features, can lead to higher operational costs.

Scalability is essential for supporting the platform's growth and handling peak loads, especially during critical sales periods like the holidays. It directly impacts the platform's ability to serve a global customer base effectively.

2. Security

Customer Trust: Security is paramount for protecting sensitive customer data, such as payment information and personal details. This is crucial for building and maintaining customer trust.

Legal Compliance: Compliance with data protection regulations, such as GDPR, is mandatory and can have significant legal and financial repercussions if not adequately addressed.

Trade-Offs:

Usability: Enhanced security measures, like two-factor authentication, may add complexity to the user experience, potentially deterring customers.

Performance: Security protocols, like encryption and secure payment gateways, can add overhead and potentially impact system performance.

Security is critical for protecting customer data and ensuring legal compliance, which are non-negotiable aspects of operating an e-commerce platform. It is crucial for maintaining customer trust and avoiding legal repercussions.

3. Performance vs Usability Vs Scalability

User Experience: Fast page loading times and responsive interactions are crucial for a positive user experience, which directly impacts conversion rates and customer retention.

Competitive Advantage: In a highly competitive market, superior performance can differentiate StyleMart from other e-commerce platforms.

Trade-Offs:

Complexity: Achieving high performance may require complex caching strategies, optimized database queries, and efficient coding practices.

Scalability and Cost: Balancing performance with scalability can be challenging, as optimizing for one may impact the other. Additionally, investing in high-performance infrastructure can be costly.

Usability:

Performance directly affects the user experience and can significantly influence customer satisfaction and conversion rates. In the competitive fashion e-commerce market, performance can be a key differentiator.

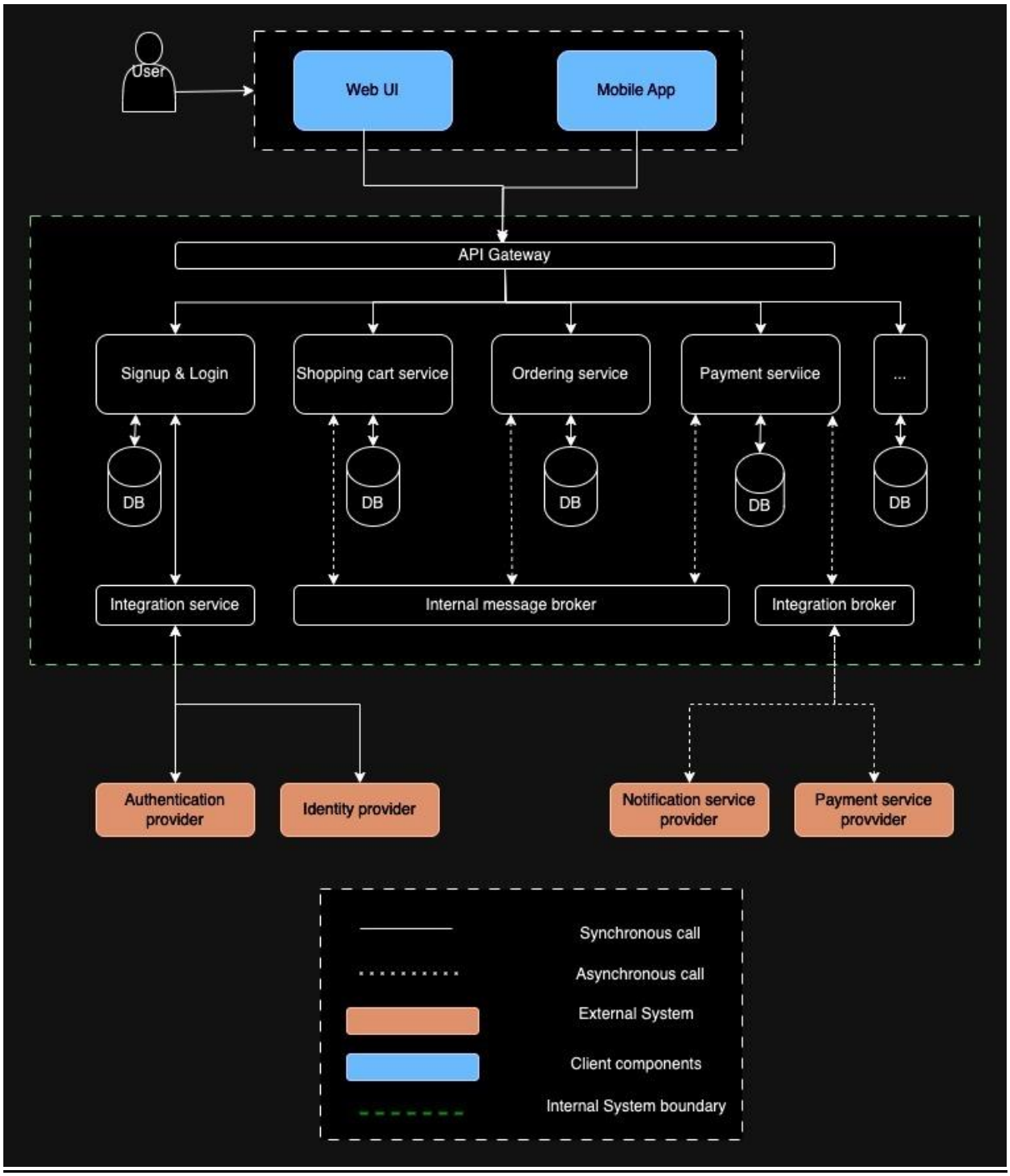
Architecture Styles

Call-Return - Microservices Architecture Style

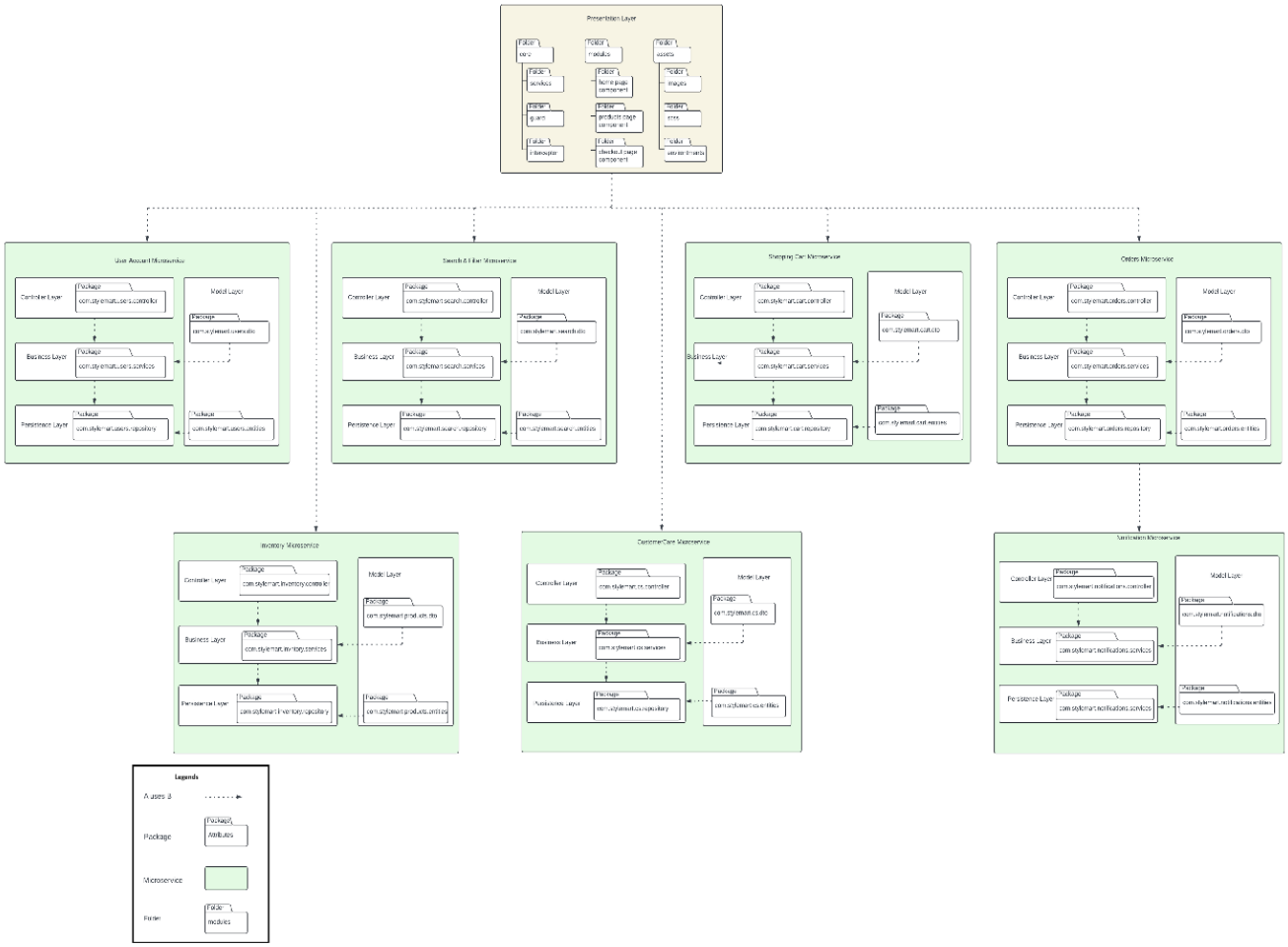
Event-based - publish-subscribe

Architecture Diagrams

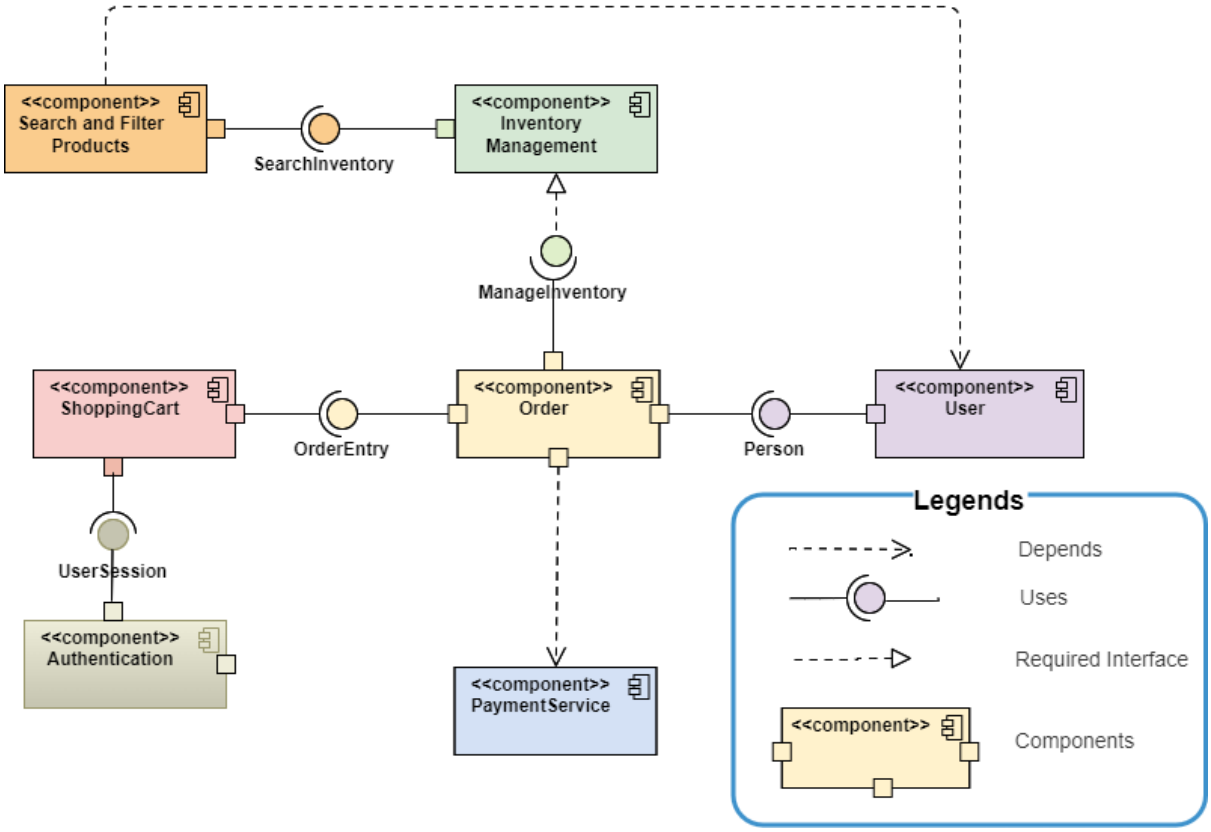
High-Level View



Module View



C & C View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Uses
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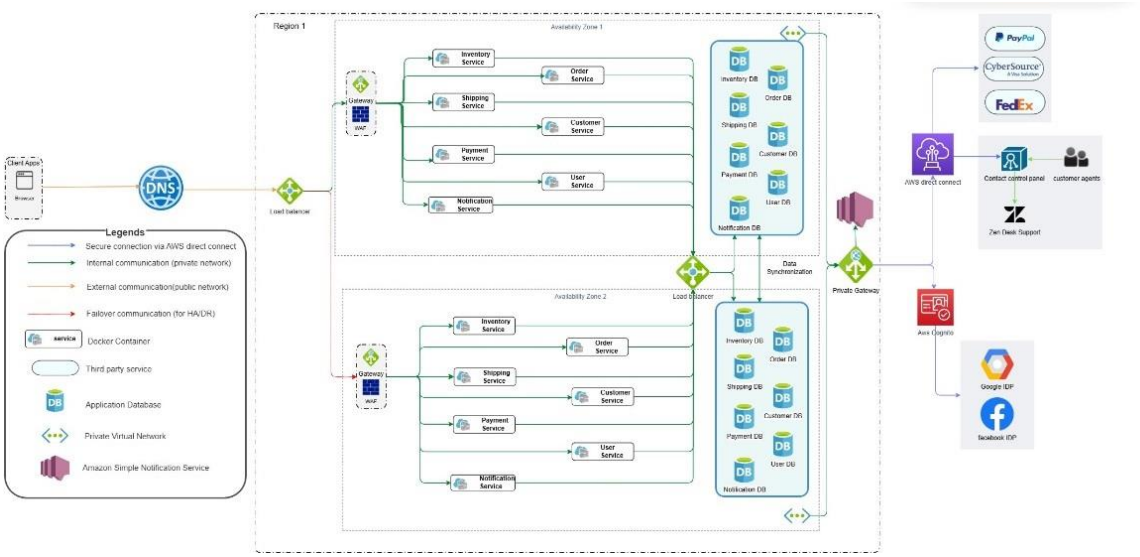
Components

Deployment View



Architecture Decision Records

1. Adoption of Microservices Architecture

Context

The need for a scalable, modular and flexible system to support a global e-commerce platform.

Options Considered

Monolithic Architecture: Simple to implement initially but lacks the flexibility and scalability needed for global e-commerce.
Microservices Architecture: Provides modularity, scalability, and flexibility, allowing for independent deployment and scaling of different services.
Serverless Architecture: Offers automatic scaling but might not offer the control and flexibility required for complex business logic and integrations.

Decision

The architecture for StyleMart will follow a microservices approach.

Rationale

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Microservices allow the system to be divided into smaller, manageable services that can be independently deployed and scaled. This architecture supports scalability, maintainability, and agility.

Implications

Pros: Each service can be developed, deployed, and scaled independently. It supports continuous delivery and integration.

Cons: Increased complexity in managing inter-service communication and data consistency. Requires a robust deployment strategy and orchestration

Consequences:

Enhanced ability to scale the platform based on traffic and regional demand. Increased development complexity, requiring experienced DevOps and architectural oversight.

2. Decision: Cloud-based Infrastructure

Context:

The need to support high traffic during peak periods and ensure availability globally.

Options Considered:

On-Premises Infrastructure: Offers control but requires significant upfront investment and ongoing maintenance.

Cloud Infrastructure: Provides scalability, flexibility, and cost-efficiency, with global reach and managed services for security and compliance.

Hybrid Approach: Combines both on-premises and cloud but adds complexity in management and integration.

Decision:

There are numerous cloud infrastructure providers in the market that have proven to be reliable and efficient. However, AWS not only offers a comprehensive set of services to cater to our needs, but it also has an extensive customer base and a track record of successful deployments. AWS also provides a broad range of support and training resources to ensure that our team can work effectively with the platform.

Furthermore, AWS has an extensive global presence with data centers located in various regions around the world. This ensures that our data is secure and our applications and services will be highly available. AWS also has a robust security framework that is critical for our business.

Lastly, AWS provides a pay-as-you-go model which offers us the flexibility to scale our infrastructure based on demand. This means that we will only be charged for what we use, which allows us to optimize our costs and invest in other areas of the business.

Based on the evaluations performed and the advantages offered by AWS, it has been decided that AWS will be adopted for our cloud infrastructure needs.

Scalability: Easily scales resources up or down based on demand.

Global Reach: Cloud providers offer data centers around the world, ensuring low latency and high availability.
Cost Efficiency: Pay-as-you-go model reduces upfront costs and aligns with business growth.
Security: Cloud providers offer advanced security features and compliance certifications that are crucial for handling sensitive customer data.
Rationale:
Cloud infrastructure provides the flexibility to scale resources on demand, ensuring performance during high traffic events such as holiday sales.

Implications:
Pros: Auto-scaling, global availability, disaster recovery, and managed services.
Cons: Higher operational costs, potential vendor lock-in, and security management complexity.
Consequences:
The adoption of AWS may require training for our teams to ensure that they are familiar with the platform and can effectively utilize it. There may also be some initial costs to move our current infrastructure to the AWS platform.

Further, ability to handle traffic surges efficiently with an operational focus on managing cloud costs and security.
Ownership: The responsibility for ensuring the effective utilization of AWS and the management of associated risks will fall within the remit of the cloud infrastructure team. Any issues that arise must be addressed by this team.

Review: The decision to adopt AWS will be reviewed on an annual basis to ensure that it continues to meet our needs and that the benefits of the platform are being fully realized.

Future Steps

1. Phase 2 Expansion:

Mobile App Development
Objective: Extend the platform's reach with a native mobile app for iOS and Android.
Plan: Develop a mobile app that mirrors the web platform's functionality, with additional mobile-specific features (e.g., push notifications, mobile payment options).
Impact: Enhanced user experience on mobile devices, increased customer loyalty, and higher sales.
Timeline: 12-18 months post-launch.

AI-Driven Personalization
Objective: Integrate AI-driven recommendation engines to personalize the shopping experience for users based on their browsing and purchasing history.

Plan: Implement machine learning models to analyze user behavior and provide tailored product suggestions.
Impact: Increased user engagement, higher conversion rates, and customer retention.
Timeline: 6-12 months post-launch.

2. Phase 3: International Expansion and Localization

Objective: Expand to additional regions (Asia, South America) with localized content and currency support.
Plan: Implement additional language support, regional payment gateways, and compliance with local regulations.
Impact: Broader market reach, higher sales in new regions, and brand growth.
Timeline: 18-24 months post-launch.

4. Continuous Improvement: Performance Optimization

Objective: Regularly optimize the platform for speed, responsiveness, and resource efficiency.
Plan: Conduct periodic performance audits, optimize code and database queries, and implement caching strategies.
Impact: Improved user experience, lower bounce rates, and reduced infrastructure costs.
Timeline: Ongoing, with major reviews every 6 months.

5. Customer Feedback Loop: Continuous Feature Development

Objective: Incorporate customer feedback to continuously improve and expand the platform's features.
Plan: Set up a feedback loop through surveys, user testing, and analytics to identify pain points and opportunities for new features.
Impact: Higher customer satisfaction, loyalty, and platform growth.

Timeline: Ongoing, with quarterly reviews.

References and Tools

1. **Books and Articles:**
    a. Software Architecture in Practice" by Len Bass, Paul Clements, Rick Kazman.
    b. Documenting Software Architectures View and Beyond second edition by Paul Clements, Felix Bachmann, Len Bass, David Garlan, James Ivers
    c. Designing Data-Intensive Applications by Martin Kleppmann.
    d. Fundamentals of Software Architecture by Mark Richards & Neal Ford

e. Architecting Software Intensive Systems by Anthony J. Lattanze

2. **Documentation and Guidelines:**
    a. PCI DSS (Payment Card Industry Data Security Standard) documentation for payment processing security requirements.
    b. OWASP (Open Web Application Security Project) guidelines for web application security best practices.
    c. ISO standards related to e-commerce, data protection, and internationalization.
3. **Case Studies and Whitepapers:**
    a. Case studies from companies known for successful e-commerce platforms (e.g., Amazon, Shopify) regarding scalability and performance optimization.
    b. Whitepapers from cloud service providers (e.g., AWS, Azure) on best practices for deploying scalable applications.
4. **Tools:**
    a. Draw.io, LucidChart, Excalidraw, Visual Paradigm as diagramming tool
    b. Gliffy – an extension in confluence as a diagramming tool
    c. Confluence, JIRA, Github

Other Applicable Information [Optional]

[Any other information that you might want to highlight]