Kente E-Commerce and Pattern Storage System

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***Abstract*— Ghana's iconic Kente textile, a vital export and cultural symbol, faces labor-intensive design and pattern challenges. Embracing modern technology, we introduce a software project to streamline native Kente pattern creation, storage, and sharing. This innovative approach has the potential to boost weavers' income while preserving and expanding Kente's rich heritage. Our paper outlines the software's design, development, and transformative implications for Ghana's Kente weaving industry.**

Keywords — Kente, Digital Pattern System, Textile Digitization

I. Introduction

Kente, the celebrated woven fabric of Ghana, represents a cherished cultural tradition among some ethnic groups in Ghana, and serves as one of the country's main exports to the rest of the world. Currently, the storage of some indigenous patterns has not been made mainstream. Again, the manual process of making the patterns that characterize this fabric takes an enormous amount of experience. With the ongoing evolution of technology, digital pattern systems have become increasingly prominent. There is a growing market for implementing these systems to automate the Kente pattern creation process, potentially increasing revenue for weavers. This project seeks to provide an avenue for the storage and trading of these patterns as well as integrate a mechanism for creating and customizing patterns that meet customer preferences. In undertaking the project, the Sustainable Development Goals 8 (Decent Work and Economic Growth) and 9 (Industry, Innovation, and Infrastructure) would be targeted.

II. Related Works

In this section, the paper will expound on existing papers in the digital pattern generation space and analyze some key points from these papers. This section also analyzes existing software systems and gleans from their strong points to assimilate them into the final proposed solution.

A. Virtual Store for Personalized Footwear Sales in the SME Sector

This paper discusses methodologies, software, and tools for creating an e-commerce web application that allows users to customize their footwear before orders are sent to a manufacturer. The web application, CustShoes, uses WordPress as a data manager for collecting user data and sending it to the website's SQL database. WooCommerce, an extension for WordPress, is mainly employed to enhance the web application's capabilities for online business. Fancy Product Designer is integrated into WooCommerce to work with SVG and PNG images for product customization. It allows users to design and customize various types of products, including using images of models or objects to apply prints, logos, and other graphics. It dynamically tailors product visuals by transforming the image into scalable vector graphics (SVG). [2]

Reviewing this paper provided insight into where the customization logic for the Kente E-Commerce system will rest. The customization system can be stored or centralized locally on the development server, but it can also be accessed through no-code methods. As mentioned earlier, the CustShoe website uses Fancy Product Designer, a plugin based on a trained AI model. Research has shown that Fancy Product Designer can also be downloaded as a library that will rest on the backend. The Kente E-commerce system can utilize this to place the final textile design on the graduation stoles. It can be used to edit the stole color, but it cannot be used to create or customize kente patterns.

Unlike most other websites, the CustShoe website does not limit users to a range of colors. Research has shown that other websites limit users' choices due to constraints such as dye availability or general product availability. In lieu of all of the above, the Kente E-commerce system seeks to offer a comprehensive customization process, making the color gradient selector used in CustShoes most appropriate for the Kente E-commerce website.

B. DigiBunai Fabric Creator

DigiBunai Fabric Creator is an open-source Computer-Aided Design (CAD) software built using the Java programming language, supplemented with libraries like OpenCV. It caters to the textile weaving industry by facilitating the creation of intricate textile designs and their seamless transfer to weavers as templates. [3] The software encompasses a wide array of templates for Indian clothing and provides users the flexibility to craft their motifs. [3] The software also simulates the fabric production process, allowing users to specify key parameters, such as texture and other fabric properties. [3]
DigiBunai Fabric Creator incorporates the following essential features:

- Customizable Color Base Weave Filling for artwork
- Yarn Density Customization to ensure correct motif appearance on fabric.

- Support for Multi-Loom Configurations to accommodate various weaving equipment.
- Graphical Corrections for refining motifs with filled weaves
- Flexibility in Yarn Color Sequencing for base fabrics.
- Color Customization for warp, weft, and extra wefts to enhance design aesthetics.
- Design Generation with extra warp or extra weft threads.
- Realistic 2D Fabric Rendering for visualization.
- Yarn Consumption Calculation tool for fabric production planning.

Although the proposed solution intends to support only color editing of existing Kente designs, insights derived from the source code of Digital Bunai indicate the feasibility of utilizing OpenCV as an image manipulation and editing tool to generate digital editable templates from existing Kente images.

Another significant observation is the discovery of AutoCAD as a potential solution for manual segmentation of images, offering an alternative method for creating digital templates of Kente fabrics. AutoCAD software provides drawing and editing tools for the manual tracing, drawing, and segmentation of different image components. [4] This process entails the creation of vector shapes and lines to represent various elements within the image. Different segments or elements can be efficiently organized by selecting and utilizing the grouping or layer management features in AutoCAD software. CAD software facilitates the easy modification of segmented parts, enabling adjustments to shapes, sizes, and positions as necessary. The composite image can subsequently be exported in a vector format, such as DWG or DXF [4].

C. Investigating The Development of Digital Patterns for Customized Apparel

Currently, the team aims to integrate AI-generated pattern-making capabilities. Existing research shows that this could be feasible. This paper explores the technologies of digital pattern development for customized apparel. The digital pattern-developing process has two paths. One path develops apparel according to traditional 2D pattern-making technology. These are based upon relationships among apparel topography, critical body scan measurements, and 2D flat pattern alteration heuristics. Another path develops patterns through flattening directly from individual 3D apparel models. According to [5], several companies have developed Made-to-measure (MTM) pattern systems using the existing method, which demands a high user experience.

However, Artificial Intelligence could prove helpful in bridging this gap. The authors mention two different approaches to the simulation of pattern masters' expertise using AI, namely artificial neural networks, and fuzzy logic. Building on these findings, the proposed solution seeks to explore the use of either of these AI techniques in the creation of novel patterns, inspired by existing ones. This could help bridge the experience gap seen in the pattern creation process.

D. Audaces

Audaces is a software solution tailored for the fashion and apparel industry. It is an intuitive software for constructing, modelling and grading sewing patterns. It enables fashion designers and pattern makers to craft, modify, and manage garment patterns digitally. Audaces Patterns can be used to develop high-precision dynamically and high-quality patterns, regardless of complexity, size or detail [6].

Audaces is a relatively big software comprised of many smaller products that altogether make the fashion designer's roles easier. One major product from Audaces is *Pattern*, which provides a simple and intuitive interface to create digital patterns faster than manually [6]. The interface especially has informed the project direction with regards to user experience of the final proposed solution.

E. SwatchNet: Small Components Aware Attention for Fashion Product Recoloring

The content is about a proposed method called SwatchNet, which is an image-to-image translation method for creating swatches by recoloring. The proposed method significantly outperforms all state-of-the-art methods for recoloring single-color and multi-color images. [7] The method uses four testing setups to show its superiority, which includes single-color product with background, multi-color product with background where the entire image is changed with one color, multi-color product with background where only one color out of many colors is changed, and product with human models. SwatchNet has also been shown to generalize well in cross-dataset scenarios and can recolor generic objects, rather than just fashion items.[7] The content includes visual examples, comparisons, and failure cases to showcase the performance of the proposed method.

According to the paper, SwatchNet significantly outperforms all state-of-the-art methods for recoloring single-color and multi-color images. The proposed method uses four testing setups to show the superiority of the method. These setups are:

1.Single-color product with background (T1)
2.Multi-color product with background where the entire image is changed with one color (many-color to one-color palette) (T2)
3.Multi-color product with background where only one color out of many colors is changed (T3)
4.Product with human models (T4)

In all three test setups, SwatchNet significantly outperforms all state-of-the-art methods. The closest performance from baselines in structural consistency is being given by BiCycleGAN, however, it does not possess control of one of multi-colors for recoloring. SwatchNet has also been shown to generalize well in cross-dataset scenarios and can recolor generic objects, rather than just fashion items.[7]

In this paper, the investigation delves into techniques for effectively working with designs characterized by multiple colors. The state-of-the-art method employed for ascertaining precision and applicability is introduced. SwatchNet introduces technologies that hold potential utility in the context of decomposing the colors within Kente patterns,

thereby enabling subsequent customization according to desired preferences.

III. Requirement Specifications

To generate a list of requirements that were reflective of the needs of the project, an interview with the main client was conducted.

Insights From Interview

After discussions with the project owner, it became evident that the customization of design patterns for Kente products, such as graduation stoles and other items, posed a significant challenge to the weavers. The plan is to offer trending design patterns and color options for clients to choose from, with the goal of mitigating the challenges faced by weavers in meeting clients' orders and preferences.

Furthermore, it has been observed that given the nationwide scope of the platform, the inclusion of diverse payment options such as electronic payments (debit and credit cards), Visa cards, PayPal, and internal payment methods like mobile money is imperative to ensure convenience for all clients within the payment system.

Another insight obtained was with regards to who received money from orders to be processed, It has become evident that the involvement of a third party, quite possibly the project owner, is essential. This third party will be responsible for receiving all payments and subsequently initiating the order for weavers to produce the design pattern based on the product description provided by client. For already designed available kente products, when the order is received, the third party will forward the order to the weavers, and the product will be delivered directly.

It has also been understood that new users of Kente might find it challenging to choose a particular design pattern. The plan is to have a "browse available product" page where all kinds of design patterns can be stored for clients and varieties of university graduation stoles to help select preferences. After realizing the idea of the system to serve nationwide, the intention is to make it function 24/7 to allow all clients to purchase and order products at any time at their convenience.

Key Decisions Made Based on Insights

After collecting extensive insights from related works and the interview, the team made some key decisions that would inform the requirements for the project. The project will take the form of a web application to ensure widespread accessibility across all devices. Again, the dynamic nature of the project and frequent need for input from the stakeholders meant that an agile approach would be required, informing the nature in which the requirements would be documented. Seeing how time serves as a constraint, the requirements obtained had to be prioritized based on the following key:

H – High Priority (To be implemented as soon as possible)

M – Medium Priority (To be implemented after High Priority Requirements)

Functional Requirements

Label	Requirement	Priority
US001	As a customer I want a feature to choose patterns for Kente fabric from a diverse range of available options because I want to have a personalized and unique design for their Kente fabric, reflecting my individual style and preferences.	H
US002	As a customer, I want a feature to customize my chosen pattern designs by interactively editing colors in the pattern because I seek the flexibility to tailor the Kente fabric to my specific color preferences and create a design that resonates with my personal taste.	H
US003	As a customer, I want a feature to interactively add custom text or embroidery to plain stoles, specifying the stole color, kente print, font, text size, and placements because I want a personalized touch on my Kente stole, allowing me to make it truly my own and commemorate special occasions or messages.	H
US004	As a customer, I want to be able to add items to a cart and review as needed because I want a more organized and flexible shopping experience.	H
US005	As a customer, I want a feature to select the desired yardage for Kente cloths, specifying the length and width I need because I require Kente fabric for various purposes and want the convenience of ordering the exact dimensions required for my projects.	M
US006	As a customer, I want a feature to choose the texture for Kente fabrics because I want the freedom to select the fabric that best suits my needs.	M
US007	As a customer, I want a feature to make payments using multiple methods, such as Mobile Money, PayPal, and Flutterwave, because I want the flexibility to use my preferred payment method.	M

Non-Functional Requirements

Label	Requirement	Priority
US001	As a customer, I want the purchasing platform to ensure secure payment transactions and protect user data because I value the security of my financial information and personal data.	H
US002	As a customer, I want the purchasing and customization platform to exhibit high performance, be responsive and have minimal downtime because I expect a seamless and efficient user experience.	H
US003	As an administrator, I want a platform that ensures reliable and timely payments to weavers and traders because I value fair and efficient business operations.	H
US004	As a customer, I want a platform that complies with relevant financial regulations because I seek transparency and compliance in businesses I engage with.	H
US005	As a customer, I want the user interface of the purchasing and customization platform to be intuitive and user-friendly because I appreciate a design that is easy to navigate.	M
US006	As an administrator, I want a platform that should be able to handle a growing number of users and products because I anticipate a platform's scalability to meet future high demand.	M
US007	As a customer, I want the platform to be compatible with various devices and browsers because I prefer the flexibility to access the platform from any device available to me.	M

IV. System Design

Diving into the intricacies of the project, it became imperative to produce some system diagrams to serve as a guideline for development and effectively convey the overall system architecture for the project.

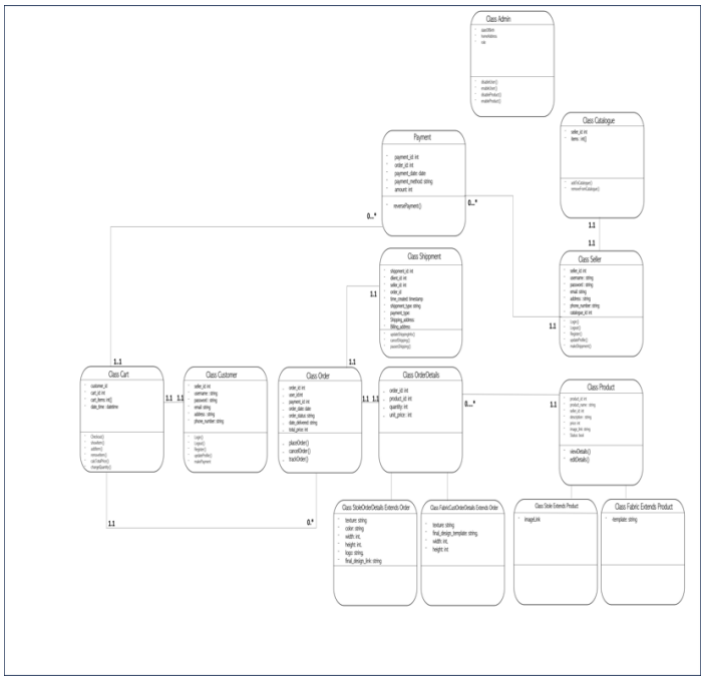

Fig 1. Class Diagram

This diagram provides a high-level overview of the different interacting components of the system, represented as classes. It helps model the numerical and dependency relationships that exist between customers, orders, products among other essential components.

System Diagram

Fig 2. System Diagram

This diagram provides an overarching detail of the various subsystems that will be composing the larger product, and all the activities that will be carried out under each subsystem.

Sequence Diagrams

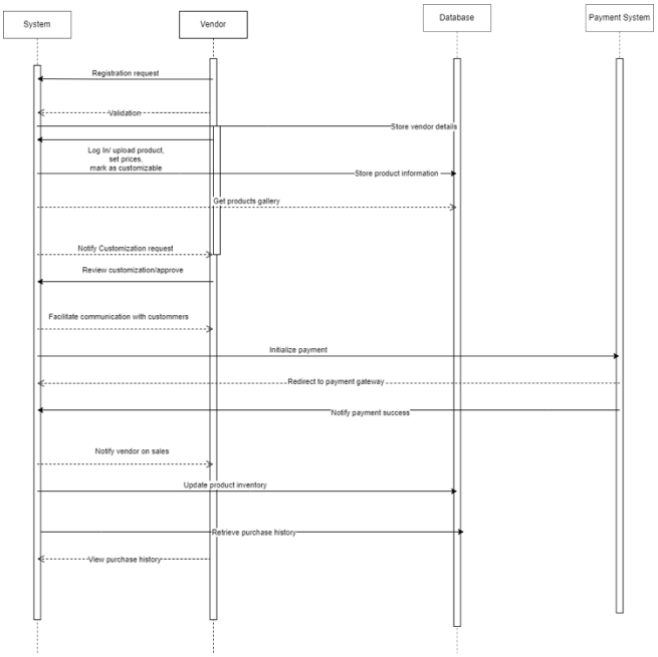

Fig 3. Vendor Sequence Diagram

This diagram shows the sequence of events of a vendor interacting with the product.

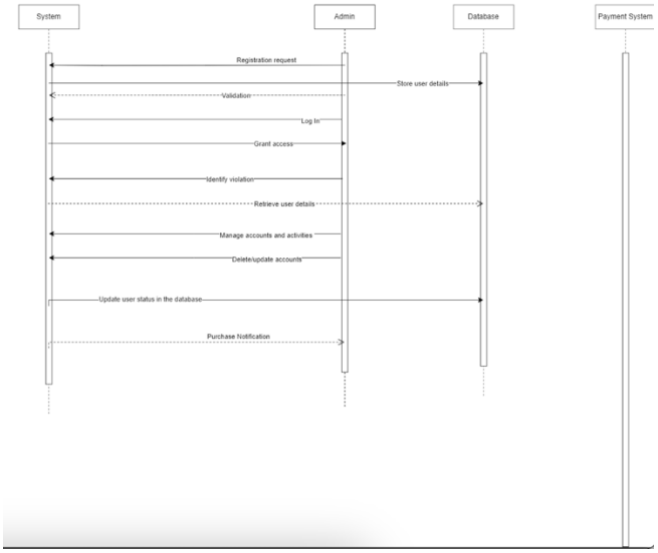

Fig 4. Administrator Sequence Diagram

This diagram shows the sequence of events of an administrator interacting with the product.

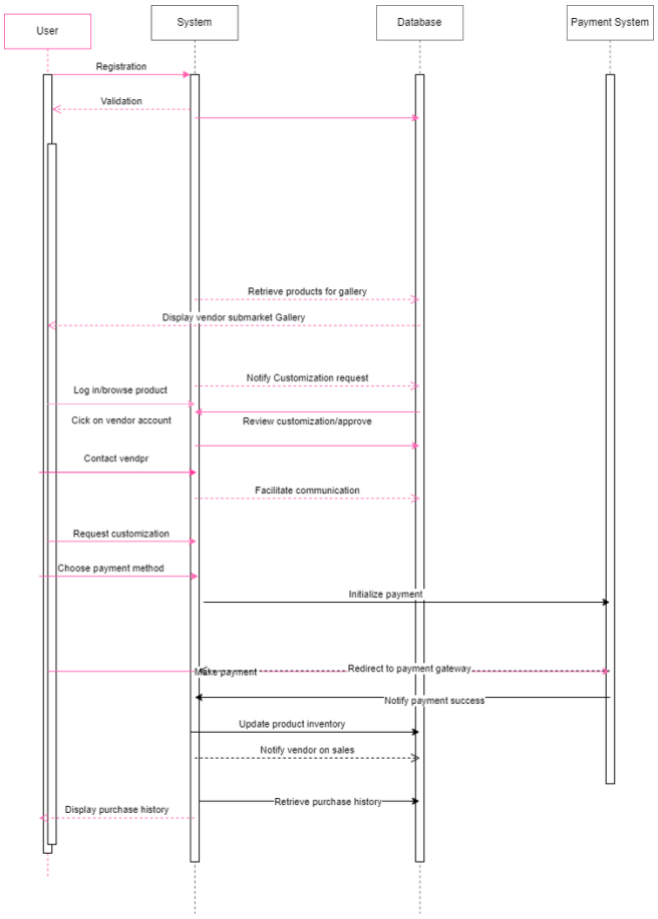

Fig 5. Customer Sequence Diagram

This diagram shows the sequence of events of a customer interacting with the product.

Use Case Diagrams

Fig 6. Online Marketplace Subsystem Use Case Diagram
This diagram shows the series of activities that the customer and vendor will undertake when interacting with the marketplace component of the product.

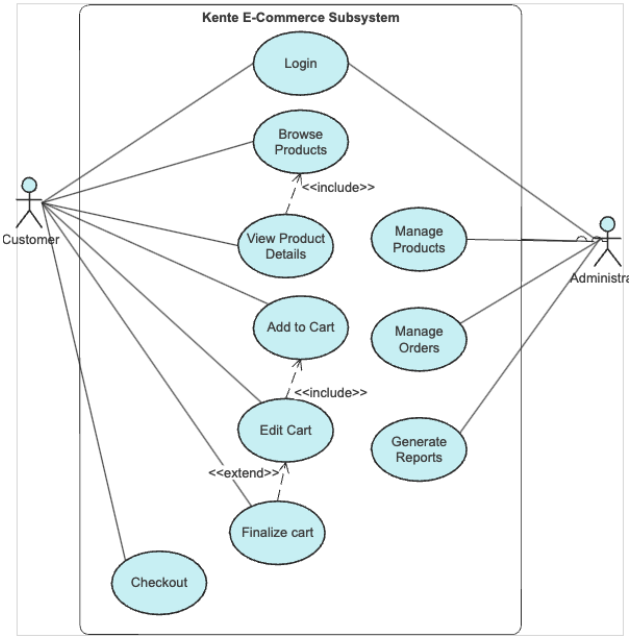

Fig 7. E-Commerce Subsystem Use Case Diagram

This diagram shows the series of activities that the customer and administrator will undertake when interacting with the e-commerce component of the product.

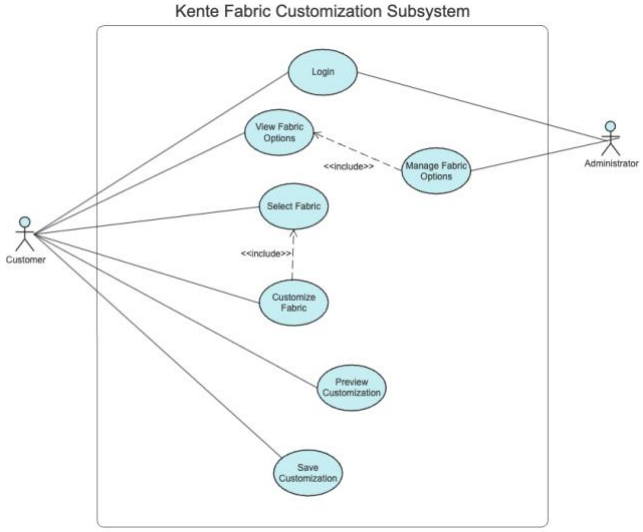

Fig 8. Customization Subsystem Use Case Diagram

This diagram shows the series of activities that the customer and the administrator will undertake when interacting with the customization component of the product.

Activity Diagrams

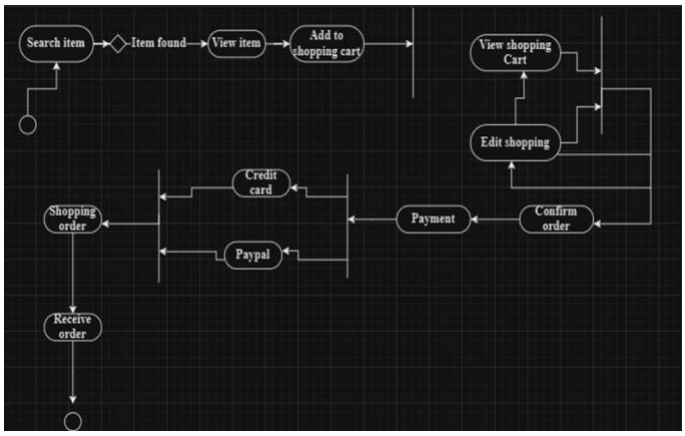

Fig 9. Customer Activity Diagram

This diagram produces a flow-chart activity diagram to illustrate the step-by-step activities that a customer purchasing a product on the system will undertake.

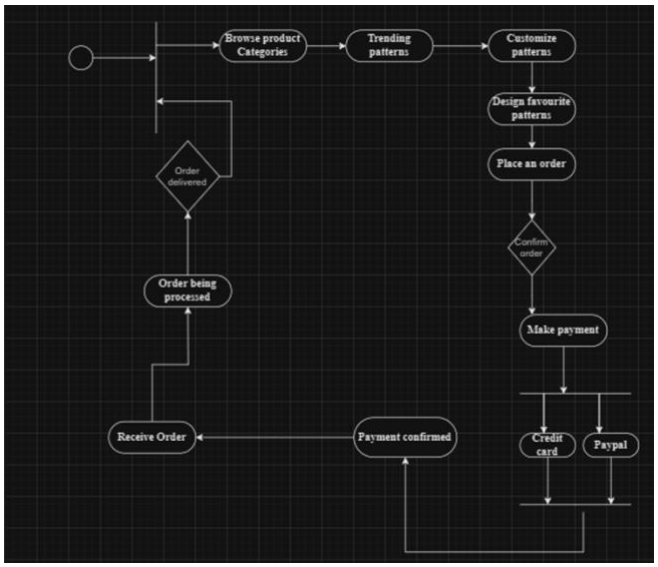

Fig 10. Customization Activity Diagram

This diagram produces a flow-chart activity diagram to illustrate the step-by-step activities that a customer customization a product on the system will undertake.

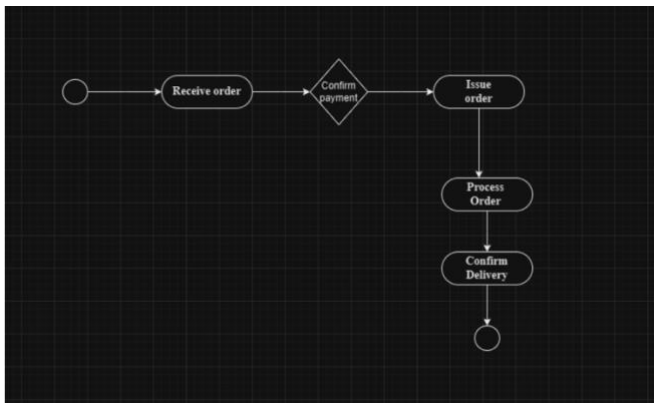

Fig 11. Order Processing Activity Diagram

This diagram produces a flow-chart activity diagram to illustrate the step-by-step activities that are undertaken from when an order is placed till it is confirmed for delivery.

System Architecture Diagram

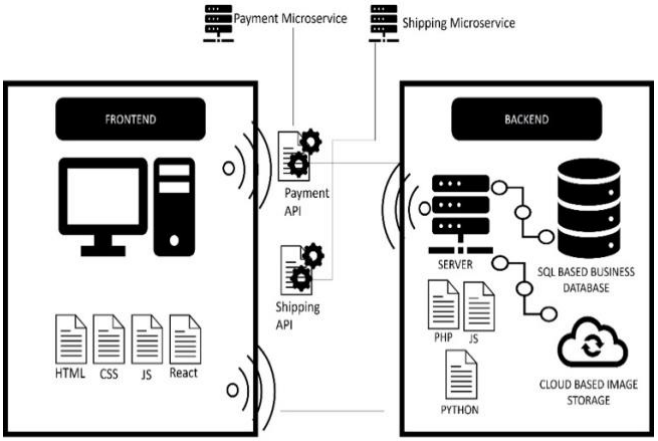

Fig 12. System Architecture Diagram

This diagram provides a description of the entire system make up and the various technologies that are utilized in composing each aspect of the entire system.

V. System Implementation

After extensive brainstorming and analysis, the tech stack that the team decided on was React for frontend, with Express and Node.js serving as the backend technologies and finally PostgreSQL for the database. Again, some machine learning algorithms like K-Means were utilized to aid with the customization aspect of the application.

Justification For Using React.js For Frontend

1. Component-Based Architecture. React.js follows a component-based architecture which is highly essential for this project since it allows for breaking the relatively complex user interface into smaller manageable components. Once modularity is achieved, it becomes easier to test the individual components of the application.
2. Reusability. Since the Kente E-commerce application would consist of many similar UI components like product cards, shopping cart items, and customization options, the nature of the React.js component allows for reusability of code with minor tweaks where necessary.
3. Virtual DOM. React uses a virtual DOM, which is a lightweight copy of the actual DOM. After updating the virtual DOM, React quickly updates the real DOM. This procedure reduces the amount of DOM manipulation, which enhances user experience and performance.

Justification For Using Express for Backend

Express is a popular Node.js web application framework for building server-side applications, particularly web applications and APIs. Its flexibility allows developers to create APIs quickly and easily, making it ideal for quick iterations. We used Express because it offers robust features for building APIs, such as routing, middleware, and error handling, making it easy to handle complex business logic and data management [8]. Considering the nature of the functionalities of the Kente project, Thus, the MarketPlace, which deals with a lot of data, Express.js, would be most suitable. Express's large and active developer community provides resources for learning and troubleshooting, ensuring support for both new and experienced developers. The well-documented framework nature of Express makes it easy to start even if you are new to Node.js. Using Express for the Kente project's backend can help build fast, efficient, and scalable web applications. Its flexibility and performant design allow it to handle large requests without slowing down or crashing, making it ideal for applications running high volumes of data.

Justification For Using PostgreSQL

SQL (Structured Query Language) tool for e-commerce businesses, including clothing e-commerce websites, due to its ability to manage and analyze vast amounts of data. It allows for the efficient retrieval, update, insertion, and deletion of data stored in relation databases, which are the backbone of many business operations. This includes everything from inventories and customer details to sales record.

Here are some reasons why SQL is beneficial for clothing e-commerce websites:

1. Customer Insights and Marketing: SQL can be used to analyse customer data, identify patterns and trends, and segment customers. This will allow “Woven” to have more personalized marketing campaigns, ensuring the right message reaches the right customer at the right time.
2. Customer Behavior Analysis: SQL can be used to analyze customer engagement, purchasing patterns, and product popularity. This can help Woven, understand their customers better and deliver more personalized experiences.
3. Scalability and Handling Traffic Spikes: MySQL, a popular SQL database, scales fluidly as needed and can handle spikes in traffic, which can be common while user try to customize, store and access their products along the way the seller.
4. Data Integrity: MySQL uses transactions to maintain data integrity. All SQL commands are treated as a single unit of work. If an operation succeeds, the transaction is committed to the database. However, if the operation fails, the entire transaction is rolled back. This prevents cluttering your database with records that may have partially been inserted or updated.

Justification For Using Machine Learning Models

The Problem of customizing images of Kente is a computer vision task, as computer vision is defined as “methods for acquiring, processing, analyzing and understanding digital images” [9]. To customize the colors on Kente or in any image, it was necessary to reduce the pixel color diversity of the image, creating a uniform and limited set of colors to represent the image. The process of homogenizing an image into pixel colors is known as image quantization.

K-means is a machine learning algorithm that is best for finding and creating clusters. The K-means clustering algorithm was applied to find all the similar colors. The K-means cluster analysis command is efficient primarily because it does not compute the distances between all pairs

of cases, like many other clustering algorithms; this makes the algorithm much faster. [10]

The Quantized function was then used to represent those clusters with a single color. The quantized image can then be used for proper editing since each clicked pixel belongs to a limited and specific cluster of colors.

Matplotlib was used to plot the quantized images since the images can now be represented as a simple matrix due to the quantization.

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