Development of an Application for Enhanced Management Control in Garment Manufacturing

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Abstract **– Garment manufacturers face significant challenges in managing the complex processes involved in planning, production and quality control. This work aims to identify and mitigate the key causes that hinder management's ability to address persistent shipment delays faced by a leading Bangladeshi garment manufacturer. Through root cause analysis, the lack of process data visibility emerged as the most significant issue. The management could not access timely and accurate information and the situation was further exacerbated by the use of a legacy ERP system that lacks suitable visualization tools.**

Key issues were confirmed through stakeholder interviews using thematic coding, which helped shape the solution. A web application is designed and developed to work with the legacy ERP system using a user-centered approach, incorporating feedback from stakeholders and end-users. The application integrates data from various sources, provides real-time visibility into processes and enables data-driven decision-making.

The application was developed using suitable frontend and backend platforms, with a focus on scalability, security, and maintainability. The final product was validated through user testing and feedback to ensure that it meets the stakeholders' needs.

Keywords**—Bangladesh Apparel industry shipment delays, ERP system, data visibility, application, dashboard**

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1. Introduction

Fashion products are created to reflect the fleeting trends of the moment, making them marketable for only brief periods—sometimes just weeks or months. Retailers on the frontlines of the fashion market face significant challenges in selecting the right products in appropriate quantities to satisfy customer preferences for the upcoming season. One approach to tackling this issue is to delay purchasing decisions until the last possible moment to gain a clearer understanding of market trends and ensure the right products are delivered to meet rapidly changing consumer demand [1]. To accommodate this strategy, retailers often shift the pressure onto upstream partners—such as garment manufacturers and fabric suppliers—who must adopt greater flexibility to keep up with often unrealistic timelines.

When garment manufacturers agree to a delivery date with a retailer, it is contractually binding. If shipment arrives outside of the agreed delivery date, it forces retailer to adjust their schedule, which can disrupt day-to-day operations and require resource reassignments. Delivery delays may result in unsold stocks and lost sales opportunities for the retailer. As a result, deliveries beyond the deadline often entails chargebacks for the vendor or garment manufacturer [2].

Apparel manufacturing companies need flexible production systems that can respond quickly to orders and handle both small and large volumes [1]. Manufacturers are under pressure to optimize production methods and business models to meet the needs of retailers who are increasingly focused on fast fashion [3]. Suppliers who fail to meet these demands risk losing their business [1][4].

These challenges are reflected in the operations of one of the largest private sector conglomerates (henceforth referred to as BCD group) in Bangladesh, where this study was conducted. Established over 50 years ago, the organization has diversified operations and investments across a wide range of industries, including textiles, pharmaceuticals, personal protective equipment (PPE), ceramics, real estate, construction, financial services, and energy among many others. BCD group is one of South Asia's largest vertically integrated textile and garment manufacturers and caters to the domestic market as well as many of the leading fast fashion retailers internationally.

A preliminary study at BCD group of shipment data of three-month period shows that approximately 15% of shipments were delayed, affecting nearly half a million garments. These delays were not limited to any particular manufacturing unit of BCD group or any specific buyer. This appeared to be a common phenomenon across all factories for most retail buyers. Although shipment delays stem from multiple factors, the core issue was the BCD management's inability to identify and resolve them due to limited process visibility and lack of decision-support tools.

Studies on Bangladesh's textile and apparel sector highlight similar challenges, including poor communication, limited supply chain visibility, and long lead times [5]. Recent research highlights the importance of improving visibility by using digital tools. Some studies show how Management Information Systems (MIS) and predictive analytics are helping apparel companies reduce risks and forecast demand better [6][7]. Others emphasize that ERP and Industry 4.0 tools can improve decision-making, shorten lead times, and reduce shipment delays [2] [8]. There is also evidence that poor reporting and inconsistent data from ERP systems can slow down decisions and contribute to delays in shipments [7]. To overcome this, organizations need to either upgrade their ERP systems or add new tools that can meet growing needs [9].

The primary objective of this study is to address issues related to poor process visibility and support data-driven decision-making to reduce the shipment delays observed within the organization. A structured methodological approach is adopted, combining root cause analysis and stakeholder interviews to uncover actionable insights and design a practical, scalable solution to integrate with the legacy ERP system used by BCD group.

2. LITERATURE REVIEW

2.1. Delivery Delay Challenges in the Ready-Made Garment (RMG) Sector

The RMG industry often operates under stringent delivery schedules set by fast fashion retailers, where delays result in financial penalties, order cancellations, and strained buyer relationships [1][2][10]. One study tried to quantify the economic value of on-time delivery, showing that delays, regardless of root cause can significantly affects long-term buyer relationships and financial outcomes while reducing buyer trust, and supplier competitiveness [10]. Even small delays can result in significant cost penalties, lost orders, and buyer dissatisfaction that are common risks in the RMG sector [2] [10].

Bangladesh's ready-made garment (RMG) sector, while being a vital contributor to its economy, faces similar challenges particularly in the context of rising demands for flexibility and responsiveness driven by fast fashion. Extended lead times and fragmented production workflows are persistent in the sector due to reliance on manual systems and ineffective coordination [11]. An empirical study found that coordination failures across procurement and production units frequently result in shipment delays, largely due to poor data integration and lack of timely decision-making tools [12]. Similar findings are echoed in the Sri Lankan context, where researcher identifies underutilization of ERP systems as a key factor contributing to performance issues and missed delivery targets [13].

2.2. Process Visibility and Digitalization

In the context of global apparel supply chains, visibility – the ability to access and monitor real-time and accurate data across supply chain – has emerged as a critical determinant of performance. However, visibility is often confused with traceability. While traceability focuses on tracking historical records, visibility is proactive, enabling real-time decision-making and process optimization, which is especially relevant for managing delivery timelines[14]. Improving visibility across supply chain nodes is critical for pre-emptively addressing disruptions in the processes. The lack of system-wide visibility limits management's ability to detect delays early and make timely decisions. In the RMG industry context, poor supply chain visibility obstructs proactive intervention, especially during production or procurement bottlenecks, leading to shipment delays. Despite Bangladesh's strong manufacturing base, digital infrastructure and automation remain underutilized in the RMG sector, contributing to poor responsiveness and lack of real-time coordination [15][16].

A study that examined the underutilization of a cloud-based ERP system in a leading Sri Lankan garment firm identified key barriers such as poor vendor support, insufficient user training, lack of top management engagement, and system performance issues. Despite the system's advanced capabilities, manual processes persisted, limiting its strategic value [13]. Many organizations still rely on manual methods and spreadsheets while ERP system remain underutilized due to poor implementation or use of multiple legacy software for different functions within the organization leading to data redundancy. Data collection and recording are worthless for an industry if they don't bring benefit. Management information system (MIS) is essential in transforming data into information and make intelligent business solutions [7].

Organizations often continue using legacy ERP systems, despite them being technologically outdated and having obvious shortcomings like lack modularity, up-to-date documentation, and scalability [13] [17]. Their continued use is not only due to the high cost of upgrades but also because these systems embed detailed business rules and form the backbone of organizational information flow. In large enterprises, the primary challenge is the complexity of company-wide implementation. Refactoring or augmenting these platforms, rather than replacing them entirely, may be a practical solution for organizations seeking to improve visibility and decision support while preserving critical operational logic [17].

2.3. Dashboards as a Tool for Management Control

Target-oriented and real-time information provisioning across all hierarchy levels, from shop floor to top floor, is an important success factor for manufacturing companies to facilitate efficient manufacturing. The role of dashboards and real-time reporting tools has become increasingly important in managing production flow and ensuring timely delivery [18]. Structured data formats – hourly, daily, monthly – embedded within a cloud dashboard improve data accessibility and production monitoring [7]. A study in the aerospace sector highlights how decision-making improved significantly when web-based dashboards and visualization tools were added to legacy systems, helping reduce defects and optimize operations [19]. Similarly, the case study in Sri Lanka shows that despite having a modular cloud ERP, the absence of an accessible dashboard led to manual workarounds and poor strategic decisions [13]. Effectively designed dashboards can reduce information overload and improve process control [18].

DESIGNING PRINCIPLES OF DASHBOARDS

Dashboard design is different from other visualization systems. Some studies suggest that a well-intended dashboard should be a single-screen display free from scrollbars or multiple windows, ensuring immediate access to key information without distractions [18][20]. It should primarily present static content to avoid unnecessary interactivity that could distract users. The placement of information on the screen is also critical, with areas such as the top-left and centre being the most effective positions for displaying high-priority data [18][20].

However, in operational contexts, interactive dashboards offer greater utility by supporting manual data exploration and decision-making [21][22]. Their value lies in their ability to facilitate comparisons, performance assessments, and historical trend reviews. Unlike static dashboards, interactive ones allow users to filter and drill down into specific process areas, enabling them to identify the root causes of bottlenecks or performance deviations [21]. These features help users transition from abstract summaries to detailed operational insights, revealing hidden patterns across multiple perspectives [21].

Graphical representations, such as charts and visual indicators, are particularly effective in reducing information overload compared to tabular formats [18]. Furthermore, dashboard design should consider the diverse needs of users at different organizational levels. Executives typically require high-level overviews to monitor organizational status [23]. Managers focus on performance metrics and trends, while shop floor personnel need access to more granular, task-specific data. Therefore, role-specific dashboard customization is essential to ensure usability and relevance across all tiers of decision-making.

3. METHODOLOGY

This study adopts a mixed-methods approach combining qualitative and applied design research methods to identify operational issues and develop a technology oriented based solution. Figure 1 presents the conceptual framework of the research. The methodology consists of three major phases: problem diagnosis, system design and development, and validation through user testing. To understand the root causes of persistent shipment delays, a root cause analysis (RCA) was conducted using historical shipment data and stakeholder input. Over a period of three months, data from multiple manufacturing units of the group were analysed to quantify the frequency and distribution of shipment delays. This was followed by semi-structured interviews with five key stakeholders, including CFO, CTO, Director, and two business heads who are responsible for strategic decision making. The interviews were transcribed and analysed using thematic coding using MAXQDA to extract recurring themes and identify systemic limitations. The subsequent phase involves app development, beginning with requirement gathering and mind mapping, followed by wireframe design and backend planning. This methodology ensures that the proposed solution is grounded in empirical data and aligned with real-world business requirements.

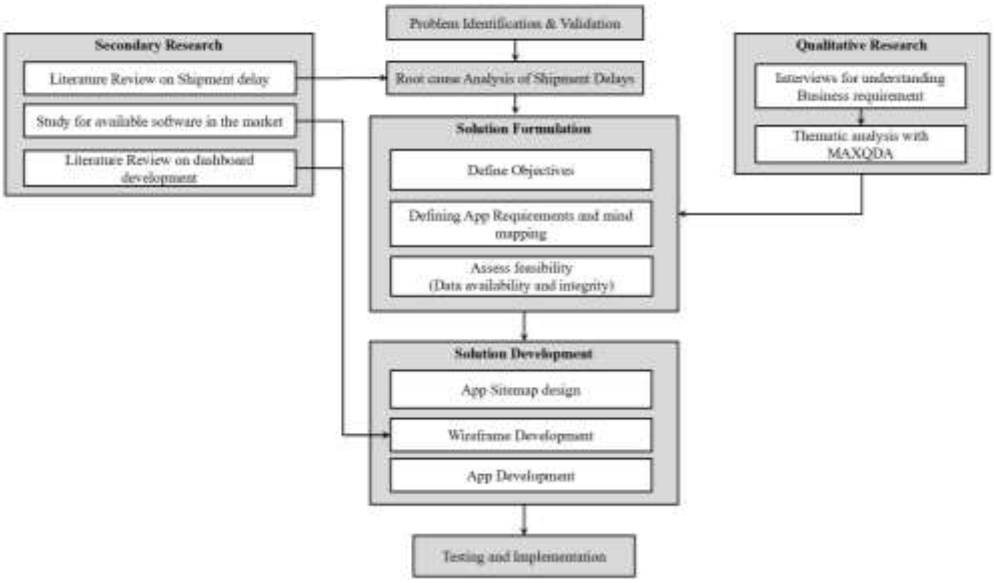

Figure 1: Research Methodology

4. ANALYSIS AND FINDINGS

The preliminary study revealed that shipment delay was one of major issues faced by BCD group. To understand the full scope and impact of this issue, a detailed investigation was undertaken. The BCD group has eleven factories and serves a range of clients across Europe and the United States, including some of the leading fast fashion brands, for whom timely delivery is critical to maintaining strong customer relationships.

To validate the problem, a data-driven approach was adopted. Shipment data from the past three months was collected and analysed to evaluate the extent of the delays. A total of 212 orders were delayed out of 516 orders that were scheduled for dispatch for the duration. Moreover, it was hypothesized that the delays may be concentrated in specific factories or associated with particular buyers.

To test this hypothesis, shipment records were segmented by buyer and factory. The dataset included order quantities and planned delivery dates based on each buyer's confirmed Time and Action (TNA) calendar. These were then compared against the actual production and shipment dates to evaluate adherence to delivery schedules. The analysis indicates that delayed order shipments are a common concern across all buyers served by the BCD Group. However, the extent of delays varies significantly, with buyer-specific shipment delays ranging from 18% to as high as 50% in some cases (Fig.2). A factory-wise comparison of planned versus actual shipped quantities reveals that most factories are dispatching only ~90% of their orders quantities on time, with the notable exception of one factory, where the on-time shipment rate is considerably lower (Fig. 3). This consistent pattern across all buyers and factories underscores the universality of the problem and emphasizes the need for comprehensive solutions to address the delays effectively.

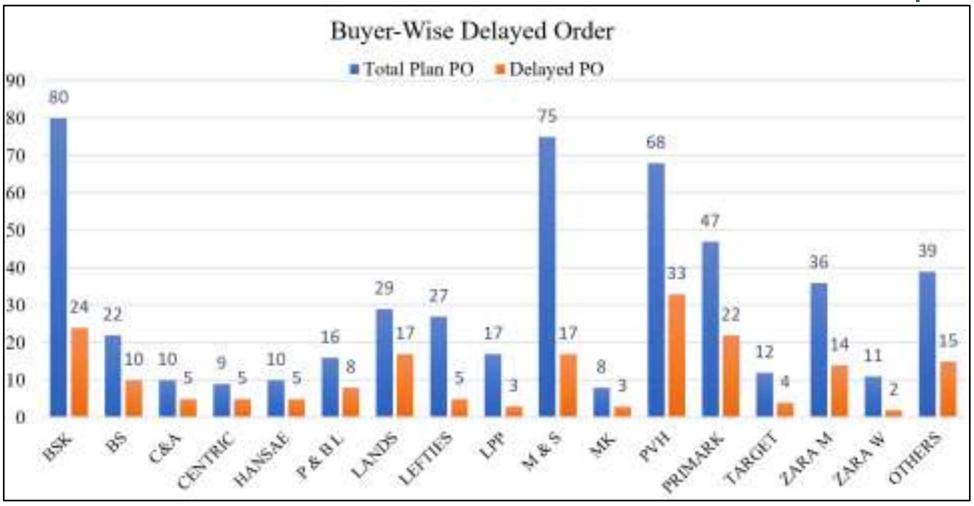

Figure 2: Buyer-wise Planned Vs Delayed Orders in 3 months

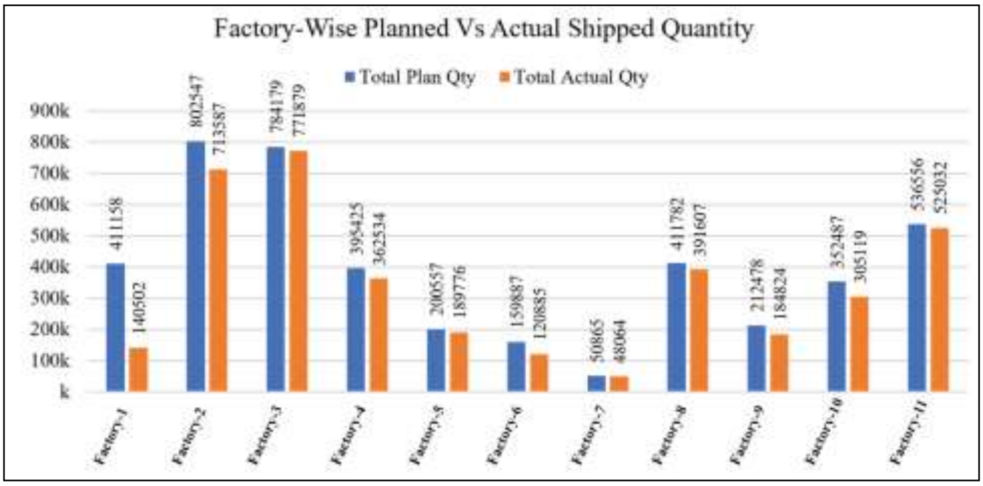

Figure 3:Factory-wise Planned Vs Actual Shipped Quantity

Following the initial analysis, a detailed examination of order-level data was undertaken to identify common reasons for shipment delays associated with various purchase orders (POs). A sample of 20 POs was selected based on two criteria: (1) highest order quantities, and (2) alignment of production commencement and scheduled shipment dates with the study period. This selection strategy ensured the availability of complete production data for each order. Additionally, efforts were made to include POs from multiple brands rather than concentrating on a single buyer, thereby enabling a more comprehensive understanding of the nature and causes of shipment delays across different client profiles. Insights gathered through discussions with five stakeholders in middle management positions further informed and shaped the root cause analysis.

4.1. Summary of Root Cause Analysis (RCA)

A detailed why-why analysis conducted across departments revealed that even though there process specific reasons for delay exist but the common challenges are limited data visibility, ineffective tracking mechanisms, and the absence of daily update reports for the head manager. This lack of timely and structured information flow significantly impairs the manager's ability to detect issues early and take corrective action. To address these challenges, it is proposed to enhance data visibility through the implementation of robust tracking systems and the provision of daily, consolidated update reports.

A digital dashboard, accessible to both top and middle management, emerged as the most effective solution. This centralized platform would serve as a real-time hub for monitoring daily operational status and facilitating informed adjustments. Its capability to deliver summarized, accessible, and actionable data aligns well with the strategic decision-making needs of leadership.

4.2. Insights from Qualitative Interviews

To gain a comprehensive understanding of the operational challenges and system expectations, interviews were conducted with key stakeholders, including top-level executives such as the CFO, CTO, and company directors, as well as middle management representatives serving as business heads. These face-to-face interviews aimed to capture the participants' perspectives on shipment delays and their specific requirements for an effective digital solution. It was emphasized that the dashboard should present data in a crisp, user-friendly format and be accessible via iOS devices, reflecting their preference for mobility and real-time access, especially while traveling.

A thematic analysis of the interview transcripts was done using MAXQDA [24]. A Code Cloud in MAXQDA visualizes the most frequently used codes as word clouds. They are particularly suitable for exploring and illustrating the use of codes in a transcript [25]. The Code Cloud (fig. 4) reveals the five essential modules for the web application: Order Booking, Order Status, Quality Production, Buyer-wise Quality, and Production. These insights directly informed the system design, ensuring the solution aligned with user needs and strategic goals.

Figure 4: Cloud Code Analysis using MAXQDA

WORD CLOUD ANALYSIS

A visual representation of the most frequently occurring words in the data, making it easy to identify common themes and topics. In a word cloud, the size of each word is typically adjusted based on its frequency, so more frequent words appear larger and are more visually prominent [25].

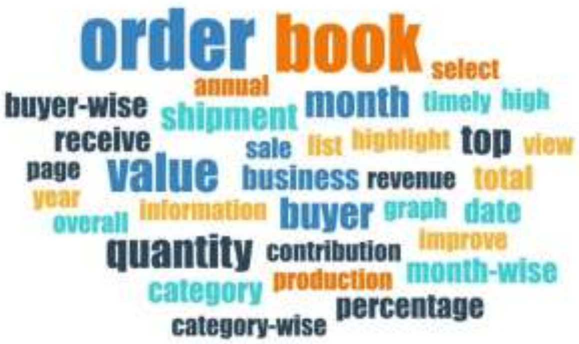

Figure 5: Word Cloud for Orders Booking

Figure 6: Word Cloud for Order Status

Figure 7: Word Cloud for Buyer-wise Quality

Figure 8: Word Cloud for Production Quality

Figure 9: Word Cloud for Production

Most frequent words for different codes have been listed below and were used for development of sitemap:

Order Booking - includes monthly order bookings, monthly shipments, annual revenue, annual sales, buyer specific order quantities, buyer-specific order values, and other relevant information (fig.5).

Order Status - These details include buyer-wise production status, shipped style status, delay style status, pending style status, buyer-wise, style-wise status and other relevant information (fig.6).

Quality - These details include monthly checked quantity, passed quantity, defective quantity, DHU%, FPY%, DHU trendline buyer-wise, etc. (fig.7).

Production - These details include monthly checked quantity, passed quantity, defective quantity, DHU%, FPY%, DHU trendline factory-wise, etc. (fig.9).

CODE RELATIONSHIP BROWSER

The Code Relations Browser (CRB) in MAXQDA visualizes the relationships between codes and displays the frequency of their co-occurrence within a document [25]. It provides a graphical representation of how codes are associated with each other, making it easier to identify patterns and connections between codes. The CRB displays codes as columns and rows, with symbols indicating the number of segments coded with both the row and column codes. This tool helps researchers analyze code relationships, intersections, and proximity within their data, offering valuable insights into the coding structure and connections within the document [24].

Code System	User Access Restriction	Buyer-Wise Quality	Quality Production	Production	Order Status	Order Booking	Data Display	Decision Making	Shipment Delay	Benefits of Data Visibility	Issue with Lack of Data Visibility	Data Availability
User Access Restriction	0	4	5	3	3	0	6	11	3	11	3	3
Module Categorization	0	0	0	0	0	0	0	0	0	0	0	0
Module Categorization > Buyer-Wise Quality	4	0	37	5	4	4	6	16	5	14	3	4
Module Categorization > Quality Production	5	37	0	6	5	5	7	17	6	15	4	5
Module Categorization > Production	3	5	6	0	3	3	5	13	4	13	2	3
Module Categorization > Order Status	3	4	5	3	0	2	4	12	3	12	2	2
Module Categorization > Order Booking	0	4	5	3	2	0	2	9	3	8	0	2
Data Display	6	6	7	5	4	2	0	14	5	16	5	6
Decision Making	11	16	17	13	12	9	14	0	17	26	20	16
Shipment Delay	3	5	6	4	3	3	5	17	0	15	6	3
Benefits of Data Visibility	11	14	15	13	12	8	16	26	15	0	12	14
Issue with Lack of Data Visibility	3	3	4	2	2	0	5	20	6	12	0	6
Data Availability	3	4	5	3	2	2	6	16	3	14	6	0

Figure 10: Code Relation Analysis

This code relation matrix clearly indicates that:

- Data visibility is the central enabling or limiting factor across modules.
- Decision-making is the most impacted theme, both positively and negatively, by visibility.
- The categorization and coding schema are coherent, with strong alignment to functional areas.
- Modules like Buyer-Wise Quality and Quality Production are especially sensitive to visibility issues and decision flow.
- Improving data display and cross-role access (especially to reduce user access restrictions) could amplify the benefits.

5. Digital Dashboard Development

5.1 Mind Mapping User Requirements

Mind maps are highly effective tools for outlining strategy, as they provide a clear visual overview of the subject and help organize detailed information. They reduce cognitive overload by breaking down complex information into manageable segments and allow users to structure insights logically. The mind map shown in fig.11 presents the strategic architecture for designing a comprehensive web dashboard tailored to monitor key operational metrics in garment manufacturing. It visually organizes five core modules based on the insights from qualitative analysis – Order Booking, Order Status, Production, Buyer-wise Quality, and Quality Production. Each module breaks down further into relevant subcategories, allowing for granular tracking and analysis.

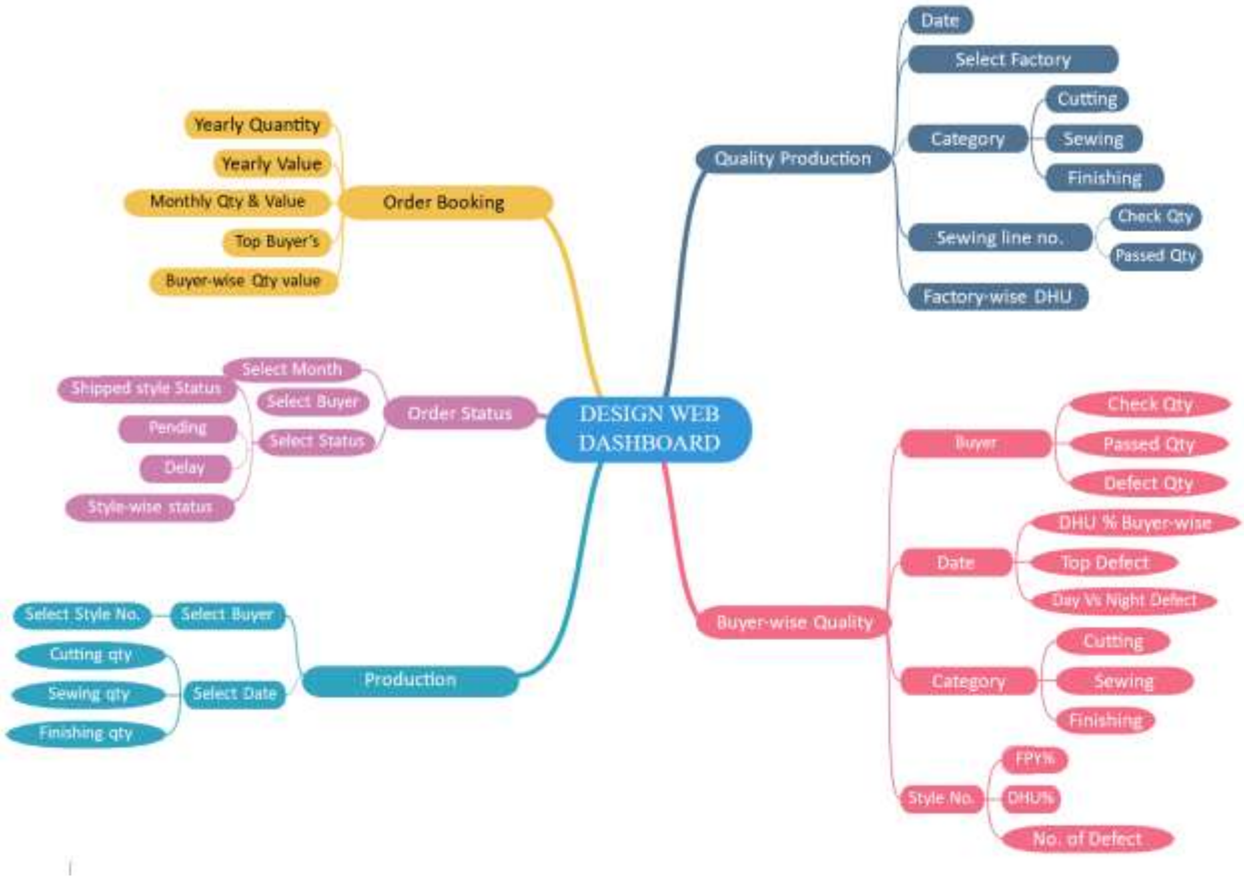

Figure 11: Mind Map for Application framework

5.2 Derivation of Site-Map from Mind Mapping

The mind map is effectively translated into a site map by treating each major branch as a feature module and the sub-branches as data points, filters, or UI elements. This derived site map (Fig.12, fig.13) forms the navigational backbone of the dashboard and helps ensure that all analytical needs are logically and intuitively accessible.

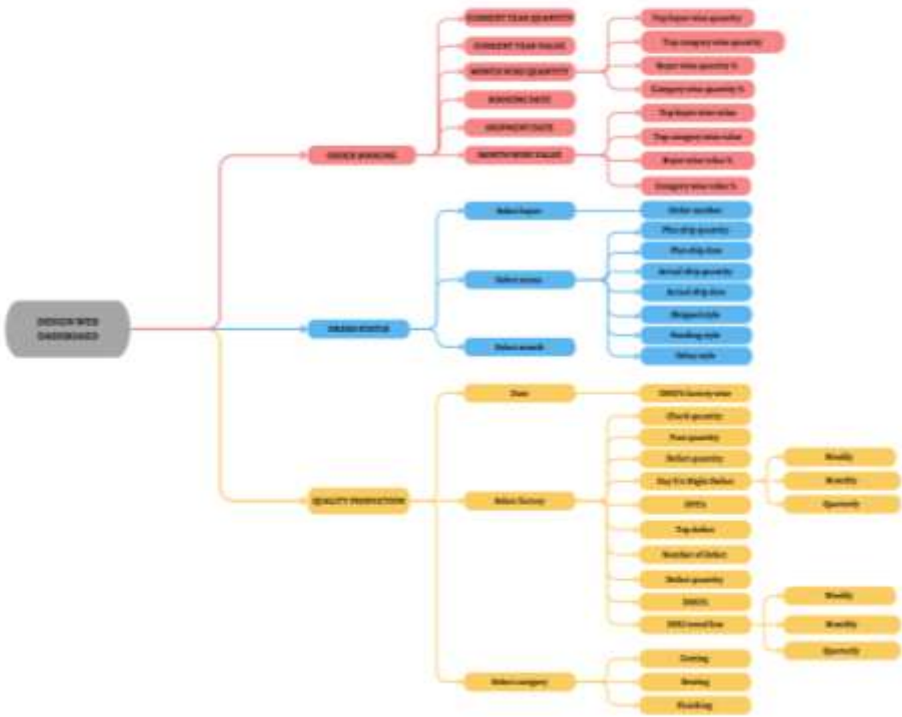

Figure 12: Site Map (Part-a)

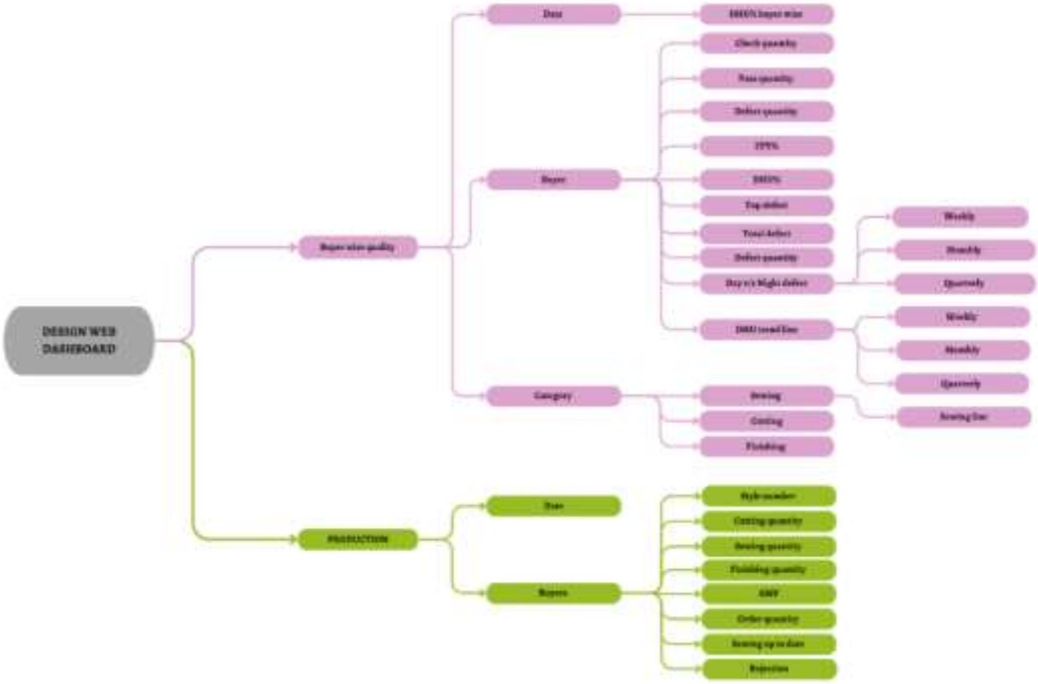

Figure 13: Site-map (Part-b)

5.3 Wireframe for Application

As part of the development process, wireframes were created using the *Moqups application* to visually outline the structure and layout of the mobile dashboard. The wireframes served as high-fidelity prototypes, helping in mapping out key interface elements, user flows, and data visualizations based on the requirements identified during the research phase. This step helped in validation of design concepts, and provided a clear blueprint for frontend development.

Figure 14: Wireframe for mobile application (Order Booking)

Figure 15: Wireframe for mobile application (Buyer-wise Quality)

Figure 16 wire-frame structure for Quality Production

5.4 Development Overview

The development process involved parallel design and implementation of frontend and backend components to ensure a seamless user experience and robust performance. The key technology and tools used are listed in Appendix-A. Once development was completed, the application was deployed to a local company server, allowing internal access over a secure Wi-Fi network.

To extend access to top management, a secure external URL was configured, restricted via authentication. The deployment involved server configuration, database setup, and implementation of basic security measures such as HTTPS and access control. The use of local hosting ensured operational reliability and the secure remote access enabled strategic decision-makers to monitor operations from outside the organization.

6. Conclusion

This study explored the operational challenges related to shipment delays in at a leading garment manufacturer with multi-factory setup and proposed a technology-based solution through the development of a data-driven dashboard application. Through a combination of qualitative interviews, thematic analysis, the research identified data visibility, decision-making limitations. The code relation and document portrait analyses further reinforced that poor access to real-time, structured information significantly hampers performance across departments. The resulting dashboard design, derived from strategic mind mapping and user centered wireframing, addresses these gaps by integrating buyer-wise, factory-wise, and process-specific metrics. Ultimately, the study demonstrates how improving data transparency and accessibility can lead to more timely decisions, reduced shipment delays, and better alignment with buyer expectations.

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Appendix A: Web Application Development Overview

A.1 Key Technologies and Tools

Frontend: React.js, Visual Studio Code, Tailwind CSS
Backend: Core PHP, Visual Studio Code
Build Tools/Runtime: Node.js (used for package management and build processes)

A.2 Frontend Development

The frontend of the web application was developed using React.js, a popular JavaScript library for building user interfaces through a component-based architecture. Visual Studio Code served as the Integrated Development Environment (IDE), providing an efficient and developer-friendly coding environment. Tailwind CSS was used for UI styling, offering a utility-first approach that allowed rapid and responsive design implementation. Node.js was used to manage packages and run frontend build tools, essential for compiling and bundling the React application.

A.2.1 React.js

React.js enabled the development of a dynamic, interactive, and modular frontend interface. Its virtual DOM and efficient state management facilitated a responsive and high-performance user experience.

A.2.2 Visual Studio Code for Frontend

Visual Studio Code provided a lightweight, extensible IDE tailored for JavaScript and React development. Its features, including intelligent code completion, debugging tools, and rich extensions, streamlined the development workflow.

A.2.3 Tailwind CSS

Tailwind CSS allowed the team to rapidly create consistent and mobile-responsive layouts. Its utility-first classes supported modern design standards and reduced the need for writing custom CSS.

A.3 Backend Development

The backend of the web application was developed using Core PHP, a reliable server-side scripting language commonly used for handling business logic, data processing, and database communication. Visual Studio Code was again used as the primary code editor. While Node.js was part of the toolchain, it was not used as a backend language but rather for managing dependencies and development utilities.

A.3.1 Core PHP

Core PHP was responsible for implementing the server-side logic, interacting with the database, and managing user sessions and API endpoints. Its simplicity and compatibility with various database systems made it suitable for the application’s backend requirements.

A.3.2 Visual Studio Code for Backend

Visual Studio Code was used for editing PHP code, supported by extensions that facilitated syntax highlighting, debugging, and version control integration.