E-commerce Website Performance Evaluation: Technology, Strategy and Metrics

ABSTRACT - Customers can shop conveniently online with the help of the Cooperative Store Management System, an e-commerce web application, without having to go to the store in person. This technology seeks to lessen the effort of sales staff and eliminate the possibility of manual errors by automating data entry operations. Customers can save costs dramatically and gain valuable time by using this method. In addition, clients may take advantage of increased convenience and better service quality because to the fact that these services are available from the comfort of their homes, which promotes customer retention and draws in new customers. Work has unraveled the intricacies of web development process, shedding light on the challenges faced and the inventive solutions devised. From the complexities of user interface (UI) and user experience (UX) design to the thoughtful analysis of essential qualities for our online store, every facet has been meticulously examined to ensure that the platform prioritizes user involvement, seamless navigation, and efficient communication channels. A detailed study is done to analyse the drawbacks of using marketplaces instead of self-owned sites for small scale business.This work shed light on the processes that went into the creation of a website. Additionally, it provides a thorough analysis of the architecture, Technology, and system's functionality.Facebook News Feed that uses React for dynamic contents, react.js allows for efficient updates to the news feed in real-time without having to reload the entire page. while in LinkedIn Mobile its mobile app uses AngularJS for front-end development. Very limited amount of research work done till date explores the issue of web strategy in web site evaluation, and none includes web strategy in their evaluation frameworks. Citing above problem, a strategic framework was adopted to ensure consistency and provide an efficient solution.AngularJS provides a structured framework for building dynamic and responsive user interfaces.For the use case - MERN Stack website, the Largest Contentful Paint comes as 3.8 sec, First Input Delay comes as 20 milli-sec and cumulative layout shifts come with no delay. These scores provide suggestions for improving various aspects of performance, such as optimizing images, leveraging browser caching, and minimizing render-blocking resources.

Keywords—E-commerce, Web based application, Largest ContentfulPaint, First Input Delay, Cumulative Layout Shift,MERN stack .

1. Introduction

In the ever-evolving landscape of commerce, the advent of the internet has caused a paradigm shift in the ever-changing world of commerce, completely changing how consumers and organizations perform their daily operations. As online marketplaces where goods and services may be purchased and sold, e-commerce websites are at the vanguard of this technological transformation. Since they provide greater accessibility, choice, and convenience than ever before, these websites have become an essential aspect of modern life. E-commerce is the online exchange of products and services. It includes a wide range of online activities, such as business-to-business (B2B) and business-to-consumer (B2C) transactions, as well as online retail stores, auction platforms, and digital marketplaces. E-commerce websites are the online counterparts of conventional brick-and-mortar stores. They let companies display their goods and services while letting customers peruse, evaluate, and buy from the comfort of their own homes. Online marketplaces play an important role in the e-commerce ecosystem by serving as middlemen between merchants and buyers. These marketplaces offer a wide variety of goods and services from different vendors, making them a one-stop shop for customers looking for choice, convenience, and frequently affordable prices. Online markets include, but are not limited to, Amazon, Flipkart, eBay, Etsy, and Alibaba. These platforms create a vibrant and competitive economy by facilitating transactions between small enterprises, individual sellers, and huge organizations. Instead of

having to create and manage their own independent e-commerce websites, merchants can reach a large client base and browse a wide range of items and sellers, read reviews, and compare pricing. Aside from improving the overall purchasing experience, online marketplaces also provide a number of advantages such safe payment processing, alternatives for shipment and delivery, and customer service. They also frequently offer statistics and tools to sellers to help them optimize their businesses, which attracts entrepreneurs and companies trying to increase their online presence. To sum up, e-commerce websites and online marketplaces have changed how we shop and conduct business, bringing in a new era of accessibility and ease. As they develop further and become more and more integrated into the present-day economy, they offer sellers and buyers in the constantly growing digital marketplace great prospect.[1][2][3]

For understanding of building an e-commerce website, the framework of this report has been thoughtfully constructed. It starts by defining the project's general objectives and outlining the context in which our efforts are set. After that, we dig into the technology stack, specifically the MERN stack made up of MongoDB, Express.js, React, and Node.js, explaining the strategic reasoning for our decision to use these tools.

Work provides a use case assisted deep understandings into the strategic application of the MERN stack to build an e-commerce website that is unmistakably user centric. The main goal is to provide a aesthetically beautiful, and user-friendly online retail platform. The cornerstone for a successful voyage in the world of e-commerce is laid by a platform like this one, which not only speaks to the demands of modern consumers.[1][2]

This work is intended for those who are interested in learning about the complexities of web development, design philosophies, and creative problem-solving in the context of e-commerce. It also serves as a collection of knowledge and a source of inspiration. We invite our readers to travel with us on this adventure as we reimagine the online shopping experience via the convergence of technology, creativity, and user-centricity.

Paper is organized as section 2 presents literature survey and problem definition, section 3 presents architecture of an e-commerce website and online marketplace, section 4 presents the methodology proposed and technology stack employed to perform the work, section 5 provides the implementation part including use case diagram, sequence diagram, state flow diagram & estimates various metrics to evaluate the performance and finally section 6 concludes the work proposed.

1. LITERATURE SURVEY

Website quality and performance have a significant impact on customers' perceptions and attitudes about the companies. Websites with high quality and high performance interface create a more favourable impression on customers [1] [2]. This phenomenon is the same for investors and other stakeholders. Like customers, investors in the stock market get their initial impressions and information about companies from websites. Companies in the IT sector provide consultancy services about technology and informatics to other companies and individual users. [3] [4]. In this case, it is expected that the website performance of IT companies will be high. The performance evaluation criteria of the websites were determined based on the literature and expert opinion. Following are the metrics that are considered estimating the performance, Page Size (Mb), Onload Time (s), First contentful paint (ms),

Performance Score (%), Largest Contentful Paint (ms), Total Blocking Time (ms) and Speed Index (ms). [5] [6][7].

The way businesses run and how customers shop have both been altered by e-commerce. Its significance can be summarized in following ways:

i. Global Audience access:Businesses may now access a global audience thanks to e-commerce, which transcends geographical boundaries. Access to previously unreachable markets is made possible by this, enabling even small enterprises to access global markets and grow their consumer base.[13]
ii. Accessibility and Convenience.Consumers can shop online with unmatched ease. Shoppers can do their browsing, comparison shopping, and purchases while at home or on the go. Because of its accessibility, online shopping has changed consumer behaviour and become an essential aspect of daily life.
iii. Cost effectiveness: Operating an online store typically has lower overhead costs than operating a traditional brick-and-mortar store. Physical shops are unnecessary, and inventory management can be automated to cut down on operational costs.[12]
iv. Availability:Since e-commerce is available constantly, businesses can be open at all times. Due to the flexibility this continuous availability provides for the various schedules of consumers throughout the world, sales and revenue have improved.[13]
v. Diversification and Market Expansion: E-commerce enables the variety of product offers and market sectors, which expands the market. Without being constrained by physical storefronts, businesses may rapidly introduce new items or target new markets.[13]

2. The Architecture of An E-Commerce Website and Online Marketplace

The architecture of an online marketplace is a multi-layered structure. Both buyers and sellers can interact with the user interface in a straightforward way. Fast and dependable performance is ensured by the application servers handling user requests and communicating with the database servers when they interact with the platform.[14][15]

2.1 Architectural Model of an Online Marketplace:

i. User Interface:Users interact with the marketplace through the user interface (UI). The user interface (UI) is where customers start their e-commerce journey, whether it's a modern website. Customers may easily browse through a wide variety of products here, make their selections, and check out.
ii. Product Selection:Through the user interface, customers are able to browse through an extensive product inventory. This digital catalogue presents a variety of products that are all competing for the viewer's attention, acting as a visual marketplace.
iii. Shopping Cart: Products that have been chosen are added to the virtual shopping cart, much as those that are chosen from actual shelves. Customers can customize their buying experience by reviewing their selections, making changes, or even removing products completely from this basket.

iv. Order Placement:The order placing process starts as soon as the customer fills their virtual cart with the things they want. The ready-to-go customer enters the order information. This entails providing vital client information and making a careful selection of products.

v. Payment Processing:The order details are sent securely to the payment gateway. Customers entrust their payment details here, starting a stringent process of transaction processing and verification.Order Confirmation:After successfully navigating the payment gateway, an order confirmation materializes. This confirmation holds a unique order ID, offering reassurance and validation to the customer.

vi. Vendor Notification:The backend of the marketplace plans a small but crucial action as clients enjoy their flawless buying experience. The incoming order is communicated to the vendor. Vendor systems are provided with a multitude of order details, such as product specifics and the shipping address that the consumer has specified.

vii. Order Fulfilment:Order fulfilment is handled by the vendor in their own area of the online marketplace. This procedure could involve selecting goods from stock, carefully packing them, and getting the shipment ready for its upcoming voyage.

viii. Shipping and Tracking: After the box is primed and ready, the seller arranges for it to be shipped with a carrier or logistics company of their choosing. After that, the merchandise is turned over to the shipping firm, which starts the delivery process. Order tracking information is made available to clients so they can stay updatedand aware of the status of their shipments.

ix. Delivery and Confirmation:The successful delivery of the product to the customer's designated delivery address by the shipping carrier marks the end of this complex trip. Once the product is successfully delivered, the customer receives a delivery confirmation, which may include an email or notification on the marketplace app.

Figure 1. Online e-commerce process flow

There are major differences between the architectural designs of self-owned websites and online marketplaces.[15]Figure 1 depicts online e-commerce process flow. Online marketplaces function as middlemen, connecting consumers and sellers from various third parties. This complex configuration calls for the use of sophisticated seller management solutions that support many product listings, handle fees and commissions, and offer

powerful search and filtering features. Every vendor usually keeps up their profile, and rating and review systems are essential to build user confidence.On the other hand, self-owned websites are individual companies that only offer their own goods or services to customers directly. The main goal of these architectures is to provide a personalized purchasing experience while highlighting the brand's identity and improving the customer journey. Self-owned websites often have more straightforward user profiles that are focused on customers and their order histories, and they frequently do not include intricate commission structures.

3. Strategy to Choose Online Marketplace vs Retail Owned Websites

In the constantly evolving landscape of e-commerce, businesses must make the crucial choice of whether to host their own retail website or use online marketplaces such as Amazon or Flipkart. Several important considerations must be made when deciding between running a retail-owned website and listing things on an online marketplace. [15] Table 1 depict strategies for opting a particular e-commerce website.

Table 1 Strategies for opting a particular e-commerce website.

Strategy 1: Handling Care	*One of the main differences is how the products are handled and kept, there are certain notable distinctions and difficulties that a merchant must deal with while listing their products on an online marketplace such as Amazon or Flipkart.*
Strategy 2: Control over stock	*Retail-owned websites allow businesses to keep direct control over their stock, which makes it possible to manage inventory levels and provide products for sale both online and in-store. compared to this, sellers that utilize online marketplaces frequently must ship their goods to a central warehouse, where they are kept until the platform sells them. This can influence shopkeepers' flexibility and overall sales strategy since they are unable to easily sell these products in a traditional retail setting.*
Strategy 3: Payment Processing	*Payment processing is an additional crucial factor to consider. Earnings from the sale of goods on an online marketplace are typically sent to the retailer after a predetermined amount of time, usually a week or a month. The cash flow and financial planning of a business might be impacted by this payment delay, especially smaller businesses. Retail-owned websites, on the other hand, provide more control and predictability over finances due to their capacity to process payments instantly*
Strategy 4: Over Head Cost	*Using online marketplaces has several disadvantages, one of which is the possibility of product damage occurring during storage at the marketplace's warehouse. Shop owners are often in charge of paying for any damaged merchandise in these situations. Their activities may become more financially vulnerable and administratively burdened because of having to handle the claims procedure and maybe replace any damaged inventory.*
Strategy 5: Return Policy	*Additionally, retailers may experience inconveniences due to the return policies for goods sold on online marketplaces. Most internet retailers give their clients an extended return policy, often extending up to seven days or longer. Retailers are put in a difficult position since they must be ready to handle returns and process them quickly. Sometimes consumers will try a product and then return it, which makes inventory control and accounting processes even more difficult.*

In conclusion, businesses must consider several factors before deciding between an online marketplace and a retail-owned website. Websites operated by retailers have the advantage of having more control over inventory, quick payment processing, and simultaneous online and in-store sales. Conversely, online markets provide access to a large consumer base but have disadvantages as well, like the possibility of product damage in centralized storage, delayed payment processing, and a liberal return policy that may pose logistical issues Figure 2. In the end, the choice depends on the particular aims available resources, and risk tolerance of the company. To optimize sales growth and operational effectiveness, the choice frequently entails a thoughtful combination of the two methods.

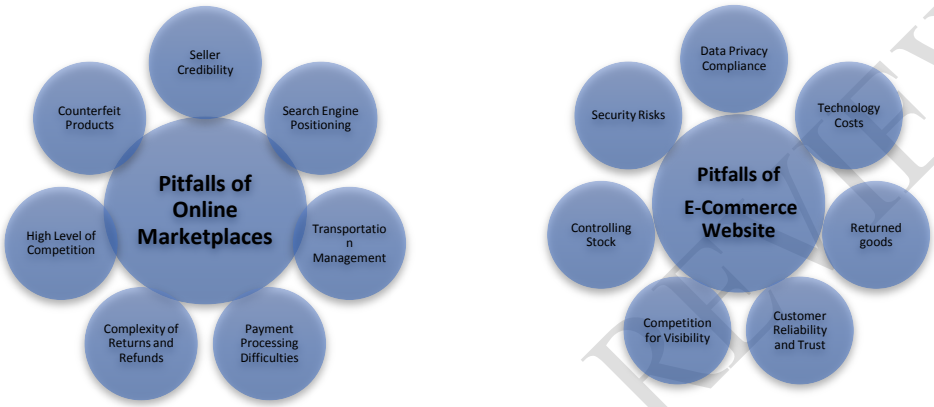

Figure 2: Pitfall of E-commerce Website and Online Marketplace

4. Proposed Methodology&Technology Stack

Our e-commerce website's development made use of a carefully chosen technology stack, which includes both front-end and back-end elements. This enabled the development of a powerful and feature-rich online shopping platform.[16][17] Figure 3 depicts flow of data through technology and table 2 describes functional operation of technology stack.

Figure 3: Technology stack.

Table 2. Functional operation of technology stack.

	Technologies	Description
Front-End Technologies:	React.js:	Its component-based architecture facilitates code modularity and maintainability by making it easier to create reusable UI elements. React's virtual DOM assures effective rendering, enhancing the website's efficiency. React was chosen because of its strong ecosystem, sizable developer community, and capacity for producing responsive and engaging user experiences.
	Redux:	Redux offers an organized way to handle complicated application states, making it simpler to transfer data across many components and assuring a predictable flow of information.
	Tailwind CSS:	Tailwind CSS simplifies the style and layout procedures. Its utility-first design and development methodology enable quick design and development while keeping a consistent and aesthetically pleasing website.
Back-End Technologies	Node.js:	It is the best option for creating scalable and high-performance server-side applications due to its event-driven, non-blocking architecture. e-commerce platform will operate without a hitch like authentication, user administration, and order processing.
	Express.js	It is a Node.js web framework that is simple to use and makes building APIs and routing easier. It gives developers a solid framework upon which to construct server-side logic, making it possible to handle HTTP requests and responses quickly.

Figure 4 depicts a rapid roadmap of the technologies employed on our website. React and Tailwind CSS are used to create an interactive and stylized user interface. Redux is used for efficient state management, which ensures consistency between components. The Node.js server manages server-side logic and API queries, whereas MongoDB is the backend database for data storage. The integration of React with Node.js allows for smooth communication and real-time changes. Finally, the Vercel platform is chosen for deployment, which offers scalability and efficient hosting. These technologies provide a

unified stack to handle UI, state, server-side logic, database management, integration, and deployment, resulting in a strong and scalable e-commerce system.

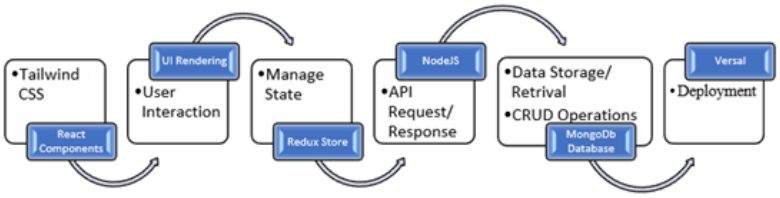

Figure 4: Roadmap of the technologies employed on our website.

5. Implementation

As a case study an eating outlet an ecommerce website for Nandini Chicken was used. It is an website addressed for an eating outlet Nandini Chicken, building a standalone e-commerce website rather than depending on online marketplaces has various strategic benefits. Nandini Chicken obtains more control over branding, customer experience, and product display by building its own platform. Furthermore, operating independently allows Nandini Chicken to have complete control over pricing, promotions, and consumer data, increasing flexibility and agility in responding to market demand. Furthermore, controlling the e-commerce infrastructure enables better administration of transportation, inventory, and customer support, resulting in increased operational efficiency and cost-effectiveness. Finally, by employing its own e-commerce platform, Nandini Chicken may establish a distinct online presence, increase consumer interaction, and preserve a competitive advantage in the ever-changing e-commerce environment.

5.1. UML Diagram for use case

A general-purpose modelling language diagram is depicted in figure 5 to define a standard way to visualize the way a system has been designed. [3][13]

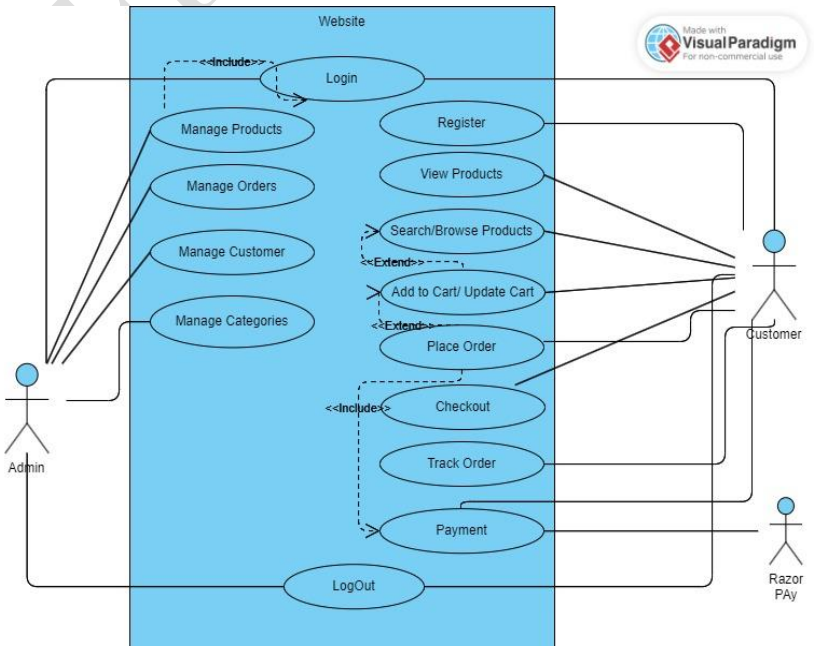

Figure 5. UML diagram for Nandini chicken

5.2. Sequence Diagram. Figure 6 depicts the sequence diagram for the use case, it captures the interaction between objects in the context of a collaboration. Sequence Diagrams provides the time focus and show the order of the interaction visually by using the vertical axis of the diagram to represent time what messages are sent and when. [18][23]

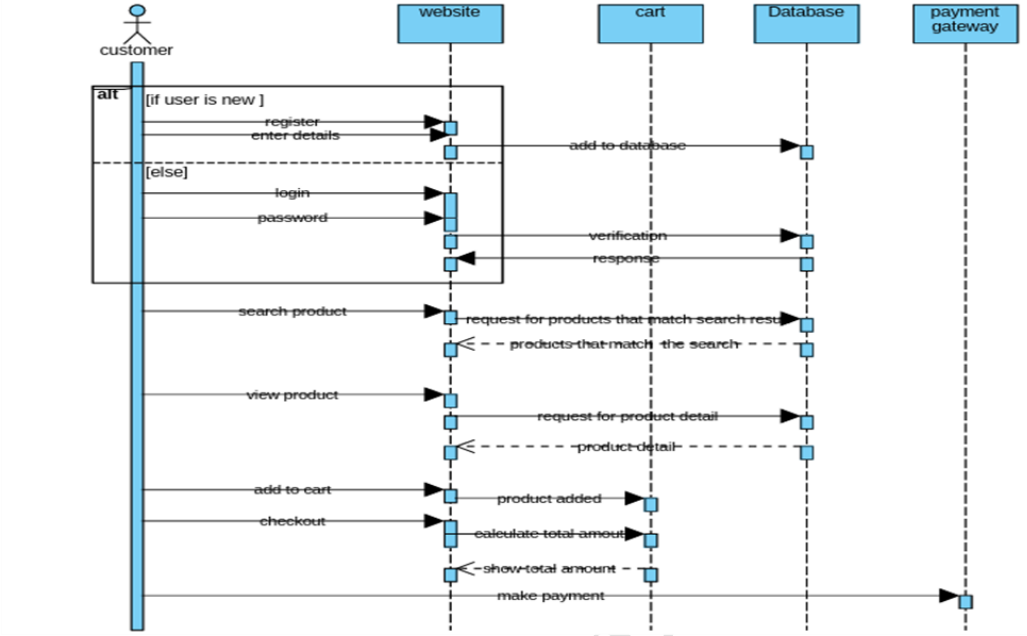

Figure 6. Sequence diagram for Nandini chicken

5.3 Use Cases and Interactions.

Entities defined for the work under study has following interaction flow. [19][20]

1. Customer Login:
    i. Customer sends a login request to the system.
    ii. The system verifies the credentials.
    iii. If authentication is successful, the system sends a confirmation to the customer.
2. Admin Login:
    i. Admin sends a login request to the system.
    ii. The system validates the admin's credentials.
    iii. Upon successful validation, the system confirms the login.
3. View Product:
    i. Customer searches for and selects a product to view.
    ii. The system retrieves and displays product details.
    iii. Customer may interact with the product details page.
4. Search/Browse Product:
    i. Customer initiates a product search or browsing activity.
    ii. The system processes the search query and displays search results or product listings.
    iii. The customer can select products for viewing.
5. Add to Cart:
    i. Customer adds a selected product to their shopping cart.

ii. The system updates the cart contents and displays the updated cart to the customer.

6. Place Order:
   i. Customer initiates the order placement process.
   ii. The system collects order details.
   iii. The customer interacts with the order details and confirms the order.
7. Checkout (with Razor pay):
   i. Customer requests to check out and make a payment.
   ii. The system calculates the order total and prepares the payment request.
   iii. The system communicates with Razor pay, sending the payment request.
   iv. Razor pays processes the payment and responds with a payment confirmation.
   v. The system confirms the order and notifies the customer of a successful purchase.

5.4. State flow Diagram.

Depicted in figure 7 isstate flow diagram, the diagram gives an illustration of all the possible behavioural states a software system component may exhibit and the various state changes it's predicted to undergo over the course of its operations. [13][18]

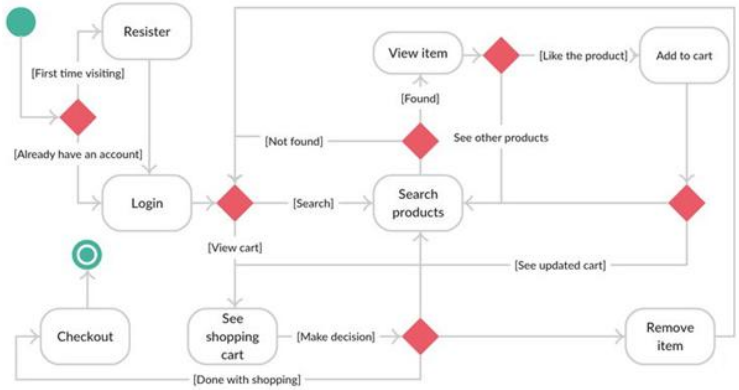

Figure 7. State flow Diagram.

This State Flow Diagram depicts how a user moves seamlessly across an e-commerce site. Beginning with the login procedure, their credentials are quickly checked. Users may access their accounts after successfully authenticating, allowing them to maintain their profiles, browse, and make purchases with ease. They like the ability to update personal information, browse products, add items to their basket, and track existing orders. When consumers are ready to make a purchase, they may easily navigate through the checkout process, resulting in a flawless payment transaction. This thorough picture offers a smooth and intuitive experience for users, increasing satisfaction and the possibility of future visits. [21][22]

5.5.Analysis:MERN Stack website

React.jsa part of the MERN stack,while react provides powerful tools for building user interfaces, it leaves many architectural decisions up to the developer. Reacts.js component-based architecture allows developers with more flexibility and composability, enabling

developers to choose their preferred patterns, libraries, and tools for managing state, routing, and other aspects of application development. This flexibility can be advantageous for projects when user requirements are dynamic. PageSpeed Insights provides various metrics and scores to evaluate the performance of a website. While there isn't a specific threshold that universally defines "good" performance, higher scores and better metrics generally indicate improved performance and user experience as depicted in figure 8. [24]

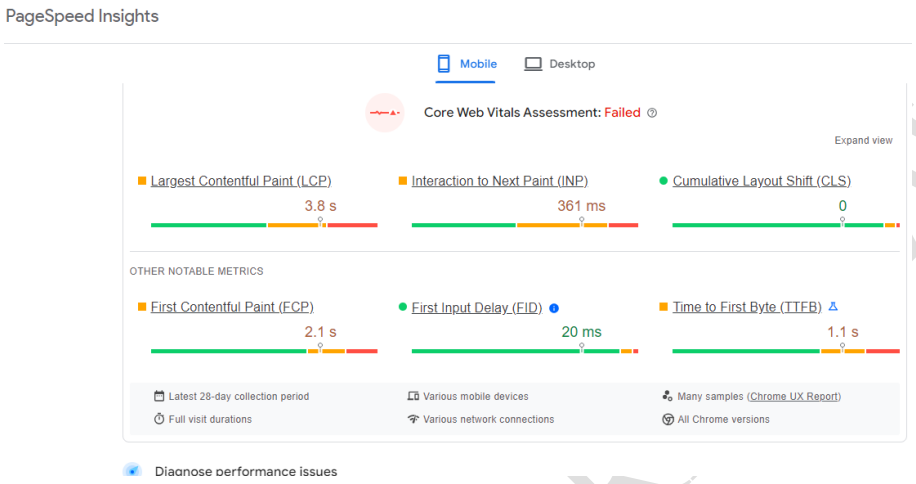

Figure 8. PageSpeed Insights.

5.6 Core Web Vitals.

Largest Contentful Paint (LCP) is a performance indicator used to assess the perceived loading experience of consumers. In simpler terms, LCP monitors how long it takes for the largest "content element" (e.g., hero picture, heading text, etc.) on your page to appear within your visitor's viewport.Thresholds for LCP are determined by the render time (in seconds) of the biggest image or text block displayed within the visitor's window. For the use case - MERN Stack website, the LargestContentfulPaintcomes as 3.8 sec, First Input Delay comes as 20 milli-sec and cumulative layout shifts come with no delay. These scores provide suggestions for improving various aspects of performance, such as optimizing images, leveraging browser caching, and minimizing render-blocking resources. [22][23][24]

i. Largest Contentful Paint (LCP): Measures loading performance. An LCP of less than 2.5 seconds is considered good.
ii. First Input Delay (FID): Measures interactivity. An FID of less than 100 milliseconds is considered good.
iii. Cumulative Layout Shift (CLS): Measures visual stability. A CLS score of less than 0.1 is considered good.

6. Conclusion

Work under taken on the meticulous exploration of databases, the strategic embrace of the MERN stack, and the careful consideration of user-centric design principles, it becomes evident that every step was taken with a singular goal in mind – to create a platform that not only meets but exceeds the expectations of modern consumers.The work has

unraveled the intricacies of our development process, shedding light on the challenges faced and the inventive solutions devised. From the complexities of user interface (UI) and user experience (UX) design to the thoughtful analysis of essential qualities for our online store, every facet has been meticulously examined to ensure that the platform prioritizes user involvement, seamless navigation, and efficient communication channels.A detailed study is done to analyse the drawbacks of using marketplaces instead of self-owned sites for small scale business. This work shed light on the processes that went into the creation of a website. Additionally, it provides a thorough analysis of the architecture, Technology, and system's functionality. There are multiple stacks of technology available for website development like LAMP, MEAN stack and MERN stack. With deep analysis of each work analyzed that MERN stack best suits to the current requirement of a dynamic website. To check the performance of a site using React.js, Page speed Insight a tool by google is used. Facebook News Feed that uses React for dynamic contents, react.js allows for efficient updates to the news feed in real-time without having to reload the entire page.For the use case - MERN Stack website, the LargestContentfulPaintcomes as 3.8 sec, First Input Delay comes as 20 milli-sec and cumulative layout shifts come with no delay. These scores provide suggestions for improving various aspects of performance, such as optimizing images, leveraging browser caching, and minimizing render-blocking resources.

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