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ENHANCED ONLINE BOOK STORE MODEL: ADOPTING THE PROGRESSIVE WEB APPLICATION (PWA) TECHNOLOGY

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ABSTRACT
From the physical book store to the online bookstore, business owners find a way to meet the demands of their prospective customers. The daily advancement in technology has brought about a huge change the operation of e-commerce. The development of the Progressive Web Applications (PWA) by Google has caused a revolution in mobile development. Using an online bookstore as a case study, this research work presents a PWA architectural framework that can be adopted by any e-commerce applications. This was achieved after a systematic review of existing online bookstore models was carried out – identifying the gaps which will serve as strengths for the proposed model. Also, the emerging technology of PWA was critically reviewed to solidify the proposed model. Adoption of the model will avoid current issues faced the world of mobile development especially code fragmentation. However, exploring the payment gateways and modules will help solidify the model.

KEYWORDS: Progressive Web Application (PWA), E-Commerce, Online Book Store, Service Worker.

1. INTRODUCTION
We all read books, whether it be to pass an exam, to write an article, or even just for recreational purposes. As the world has evolved, so has the ease of reading books increased. The earliest forms of books were created in Ancient Egypt, they were called scrolls. A scroll was a rolled manuscript made from the Papyrus plant, the average scroll was about 14 to 52 feet and needed to be held with both hands. Fast forward to AD 868 when the first printed book was created in China. At this time books were still only available to the wealthy and were extremely scarce. The first mass-produced book was the Gutenberg Bible in 1450 [1], this greatly increased the demand for books by the general populace. With the invention of the printing press, books became massively available. As books became massively available, so did the demand for them and thus the need for bookstores. Bookstores provided people with a means to purchase the books required which does not present a completely optimal system – the cost of transporting large amounts of books and the frailty of paper still are weaknesses of this system. With the creation of the internet and subsequent creation of web applications (web apps), books can now be uploaded, read, and purchased online. This eliminates the high cost of mass printing and transporting large amounts of books, it also eliminates the risk of permanent damage to paper by fire, water, and so on.

In the earliest days of the internet (the early 90s), most websites appeared as static documents. These websites were very hard to interact with and were not responsive to changes. A web app is a website that makes use of a web browser as its client rather than building a client for various devices. Since the code of mobile web apps conforms to standard languages, a single app delivers a uniform experience across platforms, offering fast development, simple maintenance, and full application portability [2]. Web apps offer app-like features without the stress of installing apps on your device, they are easily accessed by searching on the internet. Web apps also have the advantage over native applications of having lesser network demands and can be accessed without a very strong internet connection.

Progressive Web Applications (PWA) take the process of app development one step further by attempting to overcome the limitations of other development technology, especially for mobile devices. In recent years web development has not been tailored to mobile devices, not as much as cross-platform or native apps have been, but

a new set of standards proposed by Google Web Fundamentals group[1] is looking to change the status quo. The need for the online presence of bookstores and advancements in web technology have given rise to this study. An enhanced Bookstore Management system shall combine the best features of Online Bookstore Management systems and PWA technology to deliver a satisfying experience for customers.

Recent studies on Bookstore Management Systems have implemented web or mobile applications (mobile apps). This study will help to ease the process of buying and selling books for customers in remote areas that have limited access to the internet, by adopting the PWA to mobile development technology. This study aims to develop a PWA architectural framework that can be adopted by any e-commerce applications using an online book store as a case study. The Online book store PWA model will be developed by carrying out a systematic review of existing online bookstore models – identifying the gaps which will serve as strengths for the proposed model, the emerging technology of PWA will be reviewed as well to solidify the proposed model. The study involves the analysis of the architectural framework for an e-commerce system with an emphasis on an online bookstore sales system that can be adopted by any sole developer, a development firm, or an organization. This study looks to help out areas of society that are usually ignored during application development. Such as the lower-class members of society living in remote areas who may only have access to 3G or lesser levels of internet connectivity – they also need to access books with ease just as anyone else would.

2. OVERVIEW OF BOOKSTORES

The term "brick and mortar" refers to a traditional street-side business that offers products and services to its customers face-to-face in an office or store that the business owns or rents. Brick and mortar are traditional bookstores that sell their goods in physical shops, which need to be visited by customers to make purchases [3]. Along with knowledge comes trust such that consumers can truly immerse themselves in it. This is so because a physical location deepens trust by its mere physical presence [4]. However, issues like rent – paying for space; employee cost – paying workers their basic salary and some additional benefits; locale limitation – not having a national or global presence has led to the development of an online bookstore.

Online bookstores are online applications that allow the user to search for the item of interest, navigate, make a query, communicate, place an order, bargain, and negotiate for items. The main purpose of an online bookstore is to allow customers to shop from the comfort of their environment. Also, it provides ease in catalog management, inventory management, order management, and content management. The online bookstore was a revolution in the book industry. The introduction of PWA brought a greater revolution into the book industry.

PWA attempts to overcome the challenges and threats posed by other mobile development approaches. PWA help to develop an application (app) using a secured protocol (HTTPS) which is not the case in regular applications. PWAs require no form of installation and provide the users if the app with a native-like feel such that the app can be added to the home screen and made to run on mobile platforms (Android, iOS, Windows and so on) without prior installation [2], [5], [6]. Google came up with the concept of PWA and compiled a list of features that every PWA must possess. Some of these are offline capability, push notification, add to the home screen, background synchronization, and so on. As highlighted by [2], PWA has improved the general web experience in the following areas.

i. Conversion: PWAs are based on progressive enhancement strategy in which the lower-level functionalities are cached initially after which the advanced functionalities (depending on the browser) are progressively enacted.
ii. Reliability: With the help of Service Workers, PWAs can be loaded instantly with low or without a network connection – dependencies on networks are eliminated.
iii. Performance: There is a constant background process of service workers to ensure an instant and reliable experience for users.
iv. Engagement: Engaging users have been made easy with PWA as it supports push notification in the cloud.

To prove that PWA has an edge over other mobile development platforms [7] carried out a study to compare the features of the Native, Hybrid and PWA development platform as shown in table 1.

Table 1.: Feature comparison among the Native, Hybrid and PWA Mobile Development Approach [7]

FEATURES	NATIVE	HYBRID	PWA
Installable	Yes	Yes	Yes
Offline Capability	Limited	Limited	Yes
Testable Before Installation	No	Yes	Yes
App Market Place Availability	Yes	Yes	Yes
Push Notification	Yes	Yes	Yes
Cross-Platform Availability	No	Yes	Yes
Hardware and Platform Access	Yes	Yes	Limited
Background Synchronization	Yes	Yes	Yes
Security Layer	No	No	Yes
Link-Ability	No	No	Yes
Bookmark-Ability	No	No	Yes
Constantly Updated	No	No	Yes
Friction of Distribution	High	High	Low
Desktop Capability	No	No	Yes

Review of Related Works

In today's generation, Electronic Commerce (E-Commerce) has become a market trend where things are done electronically. As earlier established, an online bookstore is a typical e-commerce application. [8] came up with a study on the typical look and feel of e-commerce using an online bookstore management system as a typical application. The research was centered on how to construct a high-efficient and reliable online bookstore management system. The study was accomplished using Microsoft .Net environment. Microsoft Visual Studio 2005 was the development tool while C# was the programing language combined with Hypertext Markup Language (HTML). The database was designed using Microsoft SQL Server 2000. Adopting these methodologies, the front end for the customers handling registration, login of users, browsing book information, placing orders and son was achieved, the back end for the managers for maintenance of books and user order information stored in the database was designed. A major challenge of this study was the use of the Microsoft environment for the design and developmental phase – this approach does not make the e-commerce application cross-platform and cannot be adopted by major mobile devices.

An interactive book system (ibook) was developed by [9] as a web-based application that provides people with all the basic functionalities of a bookstore. ibook allow users to read books and perform certain annotations, comments, highlights, and so on both publicly and privately. This was achieved using Hypertext Preprocessor (PHP) and JavaScript Object Notation (JSON) where the Structured Query Language (SQL) database was used to keep records of the back end. The architecture of ibook deploys all the modules if the application on a single platform with the system having two main views (user and administrators). The architecture was designed in such a way that both user and admin have to register before availing the facilities. Figure 1 shows the architecture. ibook is web-based, thus it can run on both desktop and mobile (provided it was designed using a fluid layout).

Further research on the design and implementation of book management and sales system continued as [10] designed an online book shopping system based on the current understanding of e-commerce as of the year 2017. The Model View Controller (MVC) design pattern was adopted as HTML, Asynchronous JavaScript and XML (AJAX), JQuery and Java Spring Framework were adapted as development languages. The architecture of the developed system is shown in figure 2. The developed application by Yan was a desktop application which might not work adequately on all mobile devices.

Still in the quest for knowledge, [11] developed an android based online bookstore management system using Java (JDK 18) on Android Studio and database was based on Cloud Service Platform Bmob. The developed system was divided into two modules: the foreground which was basically for book buyers – similar to that of a real bookstore where a buyer can browse books, see book information, like a book and submit orders; the background design was basically for the bookstore administrators who can manage all records of the user or the books.

From the reviewed literature, it is evident that the development of the bookshop e-commerce systems did not take into consideration multiple platforms, especially for mobile devices. the world has a population of 7.7 billion of which 5 billion people possess a mobile device and 57% of the 5 billion mobile users have smartphones [12], [13]. This is to show that existing e-commerce applications (for example the online book store sales system) have to be completely re-engineered to avoid code fragmentation – code written for one mobile platform cannot be used for another platform. The common mobile platforms as of today are Android (by Google), iOS (by Apple), Windows (by Microsoft), and BlackBerry (by Research in Motion – RIM). Developing the same application each for the different mobile platforms can be a daunting task and complete waste of resources (time, money, manpower, and so on). Hence, the need to propose a PWA model for an online bookstore which can also be adopted by any e-commerce application.
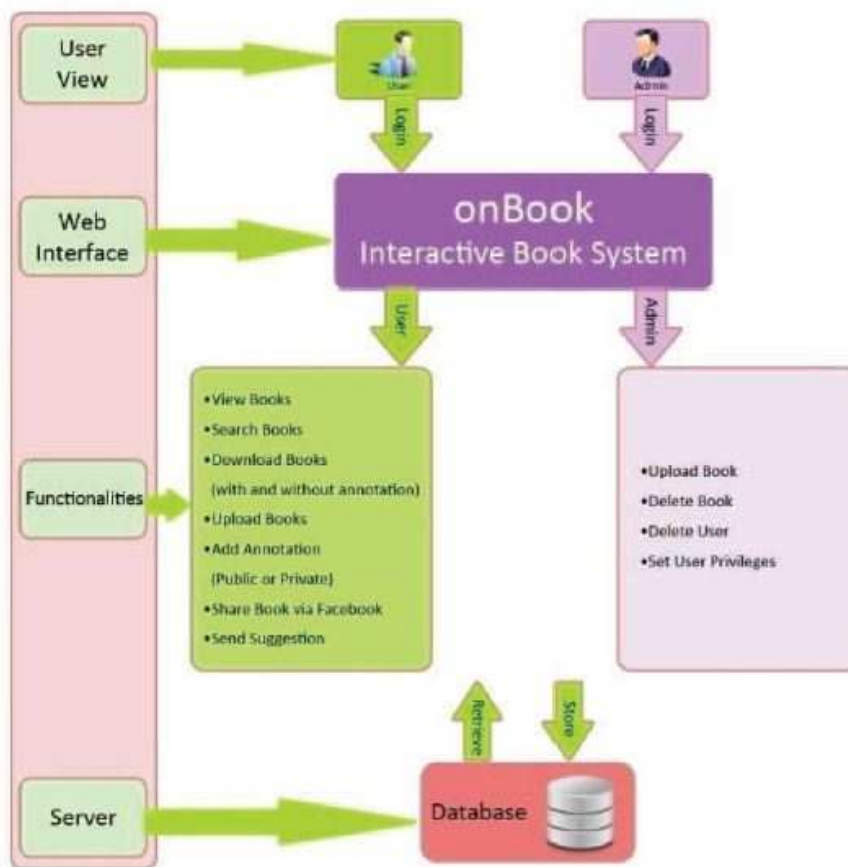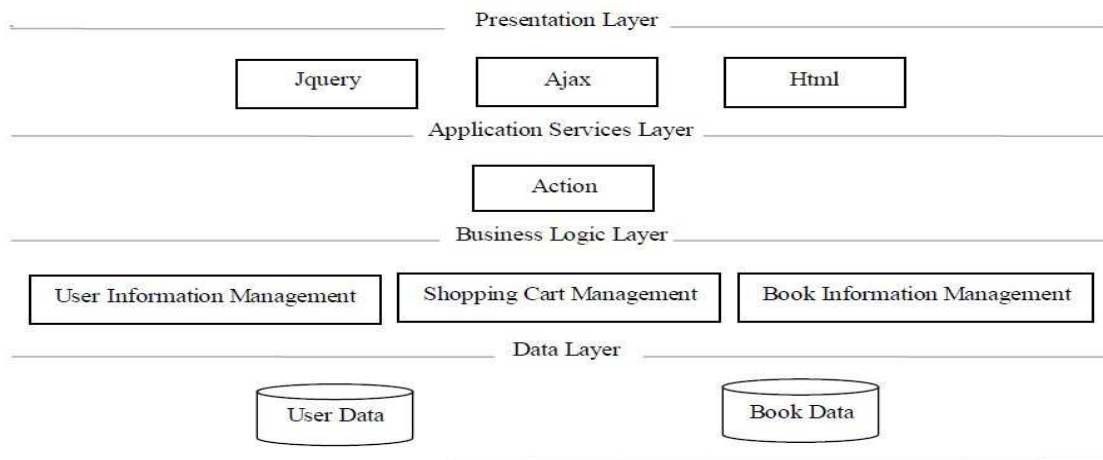

Figure 1: ibook Architecture [9]

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Figure 2: Online Book Shopping System Architecture [10]
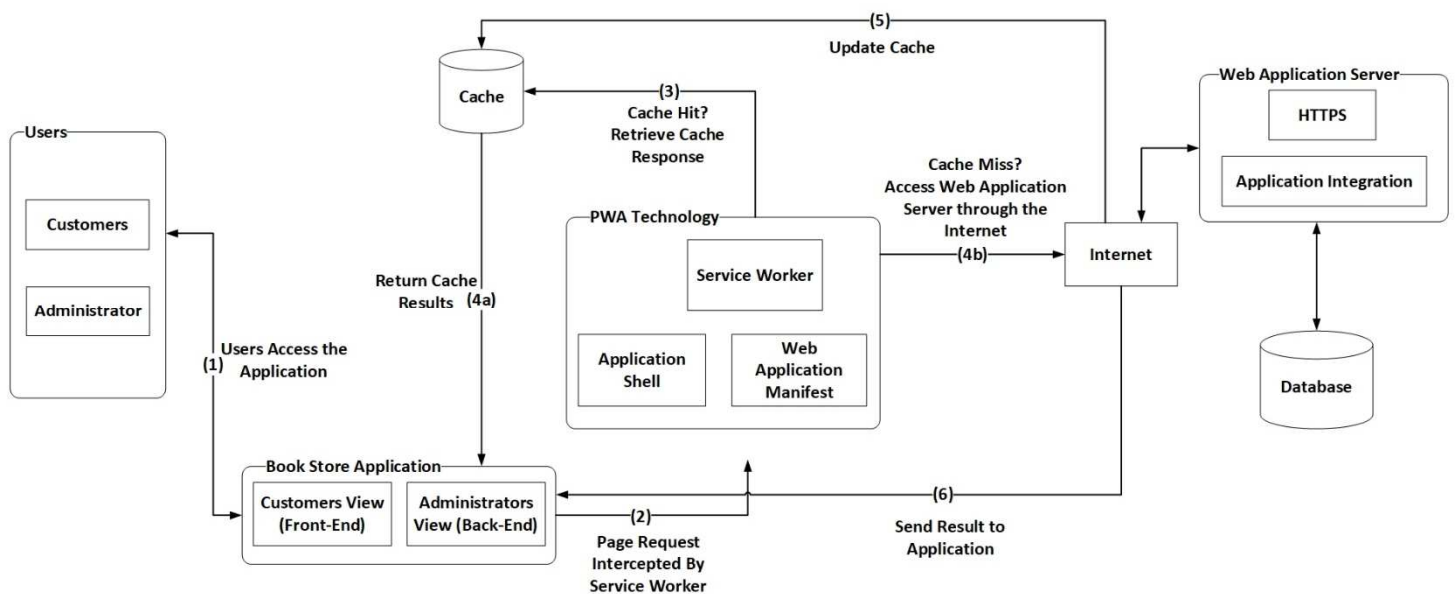
3. PROPOSED ARCHITECTURAL FRAMEWORK

Figure 3: PWA Architectural Framework for An Online Book Store Sales Management System (Researcher's Image)

3.1 Users
There are two (2) broad categories of users for the online bookstore – the customers and the administrators (this can vary based on the e-commerce application). The users can make use of any device ranging from mobile phones to smartphones to desktop or laptop computers. Irrespective of whatever platform is chosen by the users, the underlying web technologies unify the response gotten from the application through a web server and make it the same across platforms. However, because the application is built on the PWA technology, mobile or smartphone users will get the 'Add to Home Screen' notification which ensures that the application henceforth will give the user the feel of the native apps.

3.2 Book Store Application
This is the actual application that the users will interact with. It comprises of two modules that enable users to search for books, view book details, add to cart, read books, write reviews, and so on, the administrator module

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is only accessible to users with administrative privileges and correct login credentials. This module allows the administrator to manage both the user information as well as the book information. The administrator can perform the create, read, update, and delete (CRUD) operation on the database as well as manage orders.

3.3 Progressive Web App (PWA)
The PWA is the unique feature of this framework, it comprises of three components as detailed below.

    i.   **App Shell:** This store static contents of the book shop application such as the navigation bar, home page, and other resources that are constant across the app such as the HTML, Minimal Cascading Style Sheet (CSS) and JavaScript. All this are stored in the App Shell to provide a skeleton of the application when an offline request is made thereby reducing the loading time of the application.

    ii.   **Service Workers:** This is a script that runs in the background to receive messages even if the application is not active, it also handles technical issues such as background synchronization and push notifications. The service worker optimally does this by running a separate browser thread alongside other APIs to provide the native-like application features.

    iii.   **Web Application Manifest:** This handles the behavior and style of the PWA settings that could be modified by the developer such as the logo image path, application name, and so on.

3.4 Web Application Server (WAS)
The WAS exposes the business logic to the client application through a secure Hypertext Transfer Protocol (HTTPS). It handles the HTTPS requests and responds to the request. It coordinates the collection and assembly of web pages ranging from static to dynamic contents and then delivers it to the users. When a request comes into the web server, the web server then passes the request to a program that can handle it. In simple terms, it provides an environment in which a server-side program can execute a request and then pass back the generated response.

4. PROPOSED MODEL
The proposed PWA Model for online bookstore sales management systems which can also be adopted by any e-commerce application is depicted in figure 4.
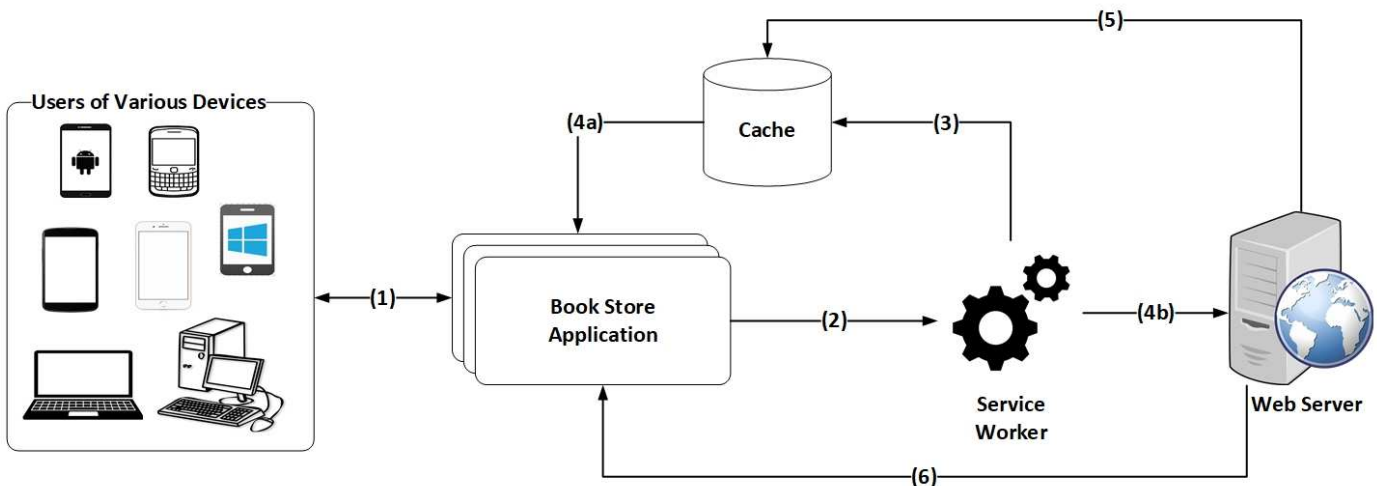

Figure 4: PWA Model for An Online Book Store Sales Management System (Researcher's Model)

Based on figure 4, the system flow is detailed below.

    i.   **Step 1:** The user from any mobile or smart device visits the URL to access the web application for the first time. After the first access, the user gets a prompt on the mobile devices to 'Add the Application to Home Screen', once this is done, the user henceforth will access the web application as a native mobile application.

ii. **Step 2:** For any page request, the service worker which is a major component of the PWA technology intercepts the user's request. Background synchronization takes place in this step as well.

iii. **Step 3:** After a successful intercept by the Service Worker, an attempt is made to retrieve the response from the cache. This could result in a cache hit or cache miss.

iv. **Step 4a:** A cache hit occurs when the response to the request is found in the cache. Hence, the response is sent to the user without accessing the Web Server.

v. **Step 4b:** A cache miss occurs if the corresponding response to the request wasn't found. The service worker then transfers the request to the webserver by accessing the user's specified Uniform Resource Locator (URL) through the internet.

vi. **Step 5:** Once the corresponding result has been found, the web server then updates the cache memory so that it can subsequently respond to a similar future request.

vii. **Step 6:** while the cache is being updated, the response to the user's request is sent to the user.

5. CONCLUSION

Technological advancement happens daily, so also, organizations and development firms must not be left out in this advancement. Development time, software testing time, and maintenance costs are too precious to be wasted over the same application across the different mobile platform. PWA has brought a revolution in web and mobile development and this needs to be embraced. Adopting PWA in an e-commerce application with a case study on bookshop will make applications run on computers of any operating system as well as mobile or smartphones of any platform providing users with the look and feel of native and hybrid applications. This research recommends the adoption of the proposed framework to ease the development of e-commerce applications and avoid the problem of code fragmentation. However, payments for purchased items and services using the PWA technology needs to be explored.

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