2020

Hot Topic Report

Progressive Web Apps

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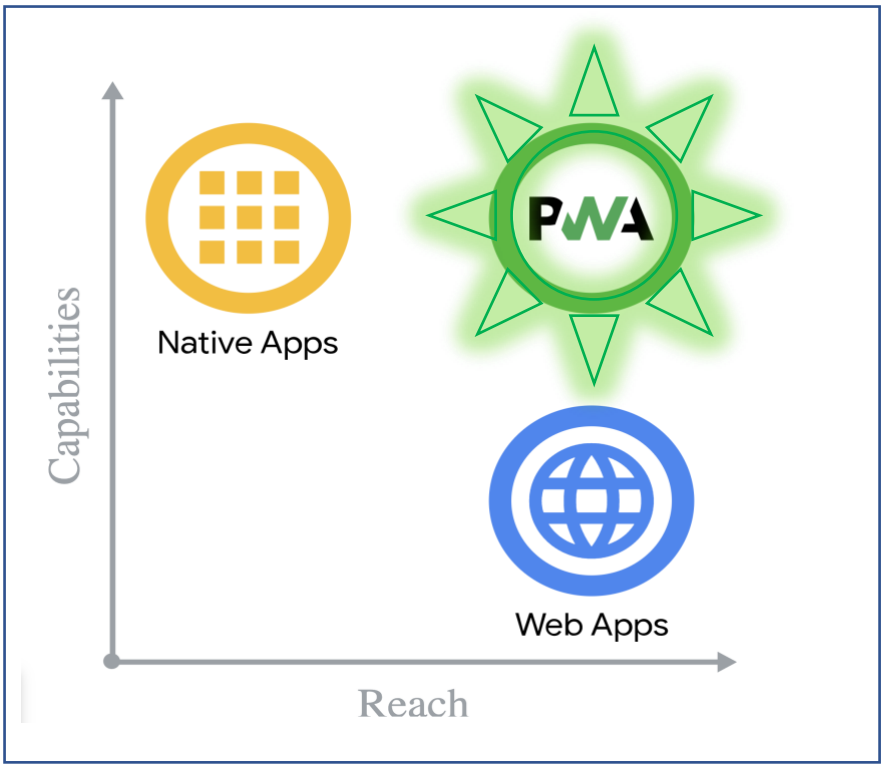
Table of Contents

1. Executive Summary

It's been over a decade now since the beginning of the age of the smartphone. With it came the era of native apps. Whether its Android or IOS or Windows, Apps continue to play a massive role in our daily life, and many business owners asked themselves multiple times: should we have a native app? It was not an easy yes/no question considering several factors. Building and maintaining a native app is cumbersome and often quite expensive. Luckily, there is another option. This option combines the joys of having a native app with the use of web technology: the progressive web app, a.k.a. PWA. Progressive Web Applications emerged as a better alternative to traditional mobile application development. Possessing the best of both native applications and web applications, PWA also offers advantages like offline loading of the application as well as services like push notifications and background synchronization to enhance user engagement.

This report tries to explain what PWA's are and how different are they from native apps. Later we will look at some under-the-hood architecture of PWA's to understand the benefits. Finally, we will look at few case studies of how PWA's have improved business metrics.



2. Definition

PWA stands for progressive web app. This is an app built using common web technologies, like HTML, CSS, and JavaScript, but with an added feel and functionality that rivals an actual native app. Thanks to a minimal development effort and couple of smart additions, we can turn almost any website into a progressive web app. This means that a PWA can be made available rather quickly, in regard to a native app that's pretty difficult to develop. On top of it, we can offer all the features of native apps, like push notifications, offline support, and much more.

Now-a-days many sites we find online are actually a progressive web app. One best example is twitter.com, for instance. If you visit that site on your smartphone, you can save it to your home screen. Now, on opening the saved Twitter site from home screen, we'll notice that it looks and performs just like a native app. There's no browser window or nothing. There's no difference in running it from an iPhone or an Android smartphone. One needs to simply visit the website which is being offered as PWA and save it to home scree. That's a major business benefit of building your web app with a PWA in mind which we will discuss in detail in further sections.

PWAs are gaining popularity with the competitiveness of markets. PWAs offer very quick and easy solution to expand user base. Many big sites are PWAs, like Starbucks.com, Pinterest.com, Washingtonpost.com and Uber.com are actually installable on your home screen and offer a comparable experience to their native apps.

Note: Although PWA's are not limited to portable devices, the discussion presented in this report is based on consideration of PWA's developed for mobile. PWA's for desktops are called "Desktop PWA's" and have been separately outlined in Section-7 of this document.

3. Native Apps vs PWAs

3.1. Problem Statement

As per mobile application utilization measurements 2018, a study led on the unprejudiced population, the vast majority delete a native application since they weren't utilizing it, or it didn't address their need. Nonetheless, an astonishing number of individuals, erase an application just in light of the fact that they need extra storage on the device. This number was stunning as organizations make a solid effort to make apps. Along these lines, to have a user download your application and afterward erase it – for reasons unknown – is a baffling circumstance. Over a portion of respondents erased an application in less than 2 weeks.

3.2. Native Apps

Native mobile apps are created to work ideally on either iOS or Android. Hence, a native application can utilise the full scope of usefulness gadget offers. To begin utilizing a native mobile application, clients need to download it from an application store. PWAs overlook this progression, and yet, they don't have some unique highlights for iOS clients.

3.2.1. Advantages

- **Great performance**: Since native apps are created and streamlined for a specific stage, they give a significant level of execution. Native apps are introduced legitimately on gadgets, permitting the product to use the device's handling speed. Since information is now put away on a device, the application loads ordinarily quicker.
- **Superior user experiences**: An extraordinary client experience has consistently been pivotal. All iOS apps must follow Apple's Human Design Guidelines to be distributed on the App Store.
- **Interactions with other apps**: Native mobile apps can collaborate with different apps, which means you can without much of a stretch associate with outsider administrations: from approval through Facebook to

transportation through FedEx, any coordination with an outer help is conceivable.

- **Customizability**: Native mobile apps give incredible open doors regarding the interface and client experience. Online storekeepers can alter their stores as they want and stand apart from the group by developing the latest features like adding barcode searches etc.
- **Geofencing**: In contrast to PWAs, native mobile apps can utilize some of the core features of the platform OS, for example, geofencing. With geofencing, when a client moves toward an area, they get a pop-up message.

3.2.2. Disadvantages

- **High cost of development**: Native mobile apps are complex to build and maintain, in contrast to PWAs. For a Non-IT based business, apps build might be outsourced leading to high costs.
- **User acquisition**: Users need to download a native app from the app store to begin using it. For most online customers, this is viewed as an additional progression in their web-based shopping venture. So, users may consider a PWA more feasible.

3.3. PWA's

A progressive web app is a website that demonstrations like a local portable app. The principle distinction between a local portable application and a PWA is that a PWA works in a program, so there's no compelling reason to download it from an app store.

3.3.1. Advantages

- **Accessibility**: An extraordinary favorable position of PWAs over local apps is that they're free from app stores. Since 25 percent of smartphone users erase apps because of shortage of storage, this freedom can be an extraordinary preferred position. Clients don't have to download PWAs and avoid filling up storage. All that is required to success multiple PWA's is a simple web browser.

- **Autonomous functionality**: Unlike native mobile app, a PWA can work in offline mode, giving users the freedom to access the online store only when required, enabling them to still browse through the site in offline/airplane mode.
- **SEO optimization**: PWAs have URLs and, consequently, are indexed by Google. Customers can easily find a PWA using a search engine which means better visibility and more traffic to the website/service.
- **Cheap and fast development**: PWAs are cheaper, faster, and easier to develop than native apps. Developing native apps from scratch requires skill on specific technologies for all mobile platforms. In the case of a PWA, all that's required is HTML, CSS, and JavaScript. And the development could be minimal if there is already a web application due to re-usability

3.3.2. Disadvantages

- **Feature restrictions**: Since PWAs are just half applications, their usefulness is restricted. There are a few highlights that PWAs can't utilize. For example, PWAs cannot access OS features such as adding events to calendar, changing themes, access to stored information. Also, a PWA can't read data from SMS or authenticate user from calls, etc. Note that this is ever changing. With IOS 14 most of the features have been made available. See reference section.
- **No indoor geolocation**. Progressive web apps can't access Bluetooth feature, which is essential to indoor geolocation.
- **Limited web browser support**: PWAs are not supported by all web browsers. Most of the Progressive web apps are Android-centric, and they don't operate on Safari. Taking into account that Safari is the leading browser in the US with 51 percent of the market share, there's a risk of not capturing the market as anticipated with PWA's.

3.4. Comparison Table

Comparison of PWAs and native apps

	Native app	PWA
Cross-platform availability	+	-
Offline mode	+	+
Available on marketplaces	+	-
Mobile-friendly design	+	+
Needs to be downloaded and installed	+	-
Push notifications	+	+
Cost of development	High	Medium
SEO-friendly	-	+
Can be added to the home screen	+	+
Security	High	Medium

4. When to consider PWA's

The advancement of PWAs brought the Golden Mean convenience for the user and efficiency for the business. If the business model intends not to enter the web or desktop niche but choose to focus solely on mobile apps, then there is no need to build a PWA.

Otherwise, Surely, when developing progressive web apps, it's a win because we only would be developing one application for Android, IOS, Windows Mobile. For Instance, Pinterest has developed a progressive web app to augment their already existent web platform and mobile app.

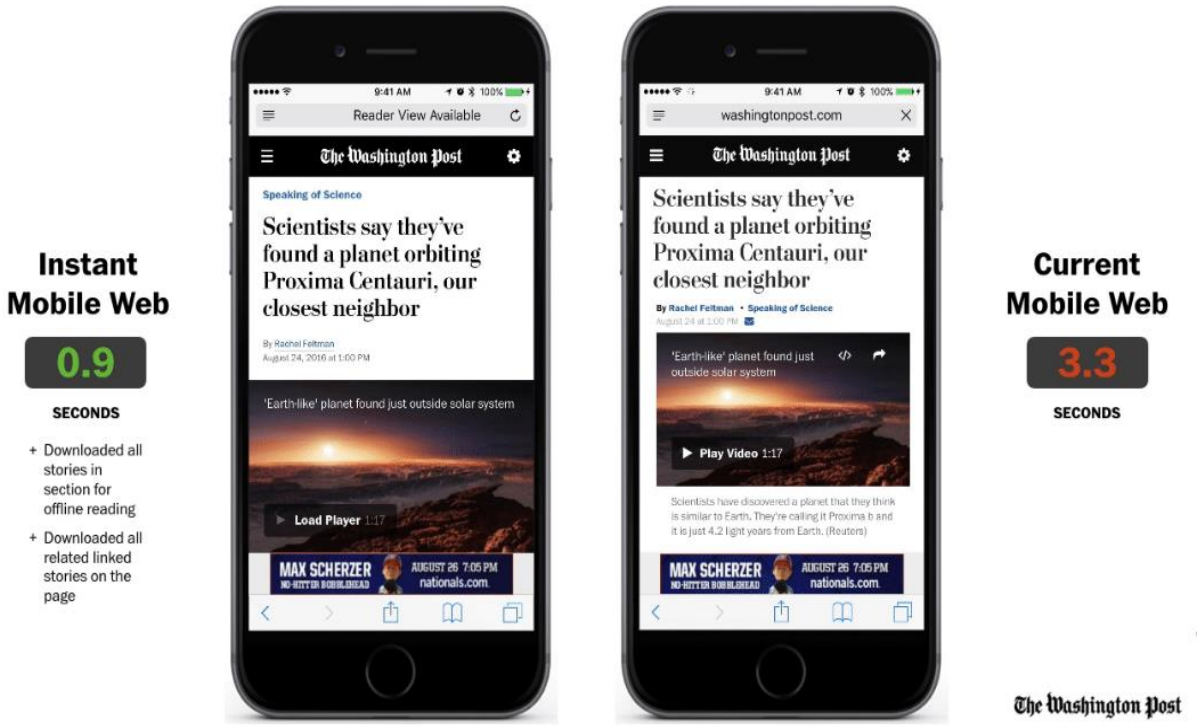
In summary, PWAs work best for the businesses targeting both web and mobile platforms.

5. Building Blocks of PWAs

There are some special technologies that help PWA to actually be progressive.

5.1. Accelerated Mobile Pages (AMP)

Standard web pages contain a lot of JavaScript that slows down the loading time. The AM-pages use only AMP library that makes the page much lighter. There is a full list of requirements for the page purification from the JS-scripts on GitHub. Essentially, either in the CMS or in the development stage publishers will clean the page from certain elements, and Google will cache the lightweight pages. This is how faster download speeds are achieved.



5.2. Cache interface

It provides a mechanism for storing cached pairs of Request/Response objects.

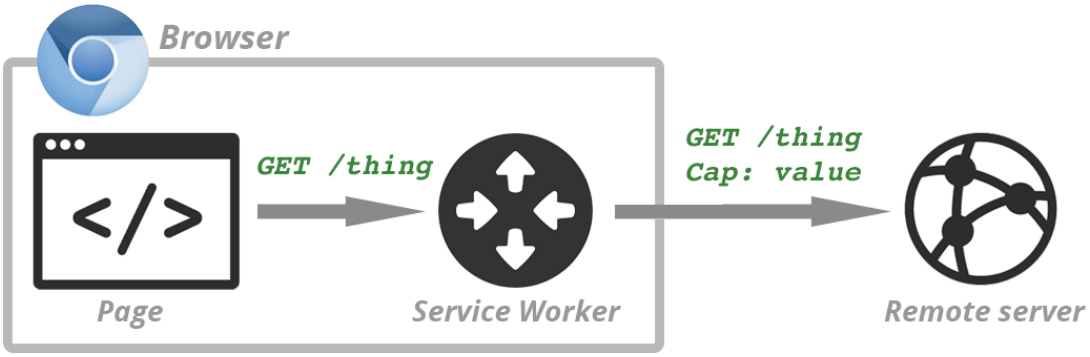
5.3. Push API

It enables web applications to receive messages sent from the server, regardless of whether the web app runs in the background, or even if it is loaded by the user at all. This allows developers to send asynchronous messages and updates to the subscribed users. As a result, users are better informed about new content. Some of the noteworthy ones are Credential API, Web Payments API

5.4. Service worker API

SW API is a function-driven worker, recorded at the source and way. It appears as a JavaScript-record that can screen the website page/webpage it is related with, block and adjust the route and asset demands, reserve assets in extraordinary detail, just as give full command over how the application carries on in a specific circumstance (most clear when the organization is inaccessible). Being a significant piece of PWA Service worker has a few highlights itself.

Service worker runs with regards to a specialist. So, it doesn't approach the DOM and runs in a different string from the principle JavaScript that controls main application, so it doesn't impede it. It is intended to work asynchronously. As a result, such APIs as synchronous XHR and local Storage cannot be used in the service worker. The service worker will catch requests from the clients under scope only. Service workers only run over HTTPS for security reasons. Being open to the general public modifiable network requests can be extremely dangerous and fraught with attacks. It runs only when an event occurs and works as much as necessary for processing the events. Hence, we've made a review of the innovation that is accepted to be what's to come!



5.5. Manifest File

This is a JSON file containing information on how your PWA should appear and function. Here, design elements such as the name, description, icons, colours, etc are defined. While saving the PWA to homepage, the data is pre-populated from this file.

Below is a sample manifest from Google:

```
{
 "short_name": "Weather",
 "name": "Weather: Do I need an umbrella?",
 "description": "Weather forecast information",
 "icons": [
  {
   "src": "/images/icons-192.png",
   "type": "image/png",
    "sizes": "192x192"
  },
  {
   "src": "/images/icons-512.png",
   "type": "image/png",
   "sizes": "512x512"
  }
 ],
 "start_url": "/?source=pwa",
 "background_color": "#3367D6",
 "display": "standalone",
 "scope": "/",
 "theme_color": "#3367D6"
}
```

6. The Current State of PWAs

Today, Progressive Web Apps are accessible via smartphones and desktops across a variety of browsers (For iOS users, only Safari can be used to add a PWA to the home screen). PWAs also support many of the same features or functions that native apps support.

- With the launch of iOS 12 in Sep-2018 the following features have been made accessible to PWA's
  - Geolocation
  - Sensors (Magnetometer, Accelerometer, Gyroscope)
  - Camera
  - Audio Output
  - Speech Synthesis (with headsets only)
  - Apple Pay
  - WebAssembly, WebRTC, WebGL, etc
- With Android OS, below are the Supported Features
  - Speech Recognition
  - Audio Output
  - Geolocation
  - Sensor Support
  - Geolocation
  - Payment System
  - Bluetooth/BLE
  - Camera
  - Google Play Store

7. Desktop PWAs

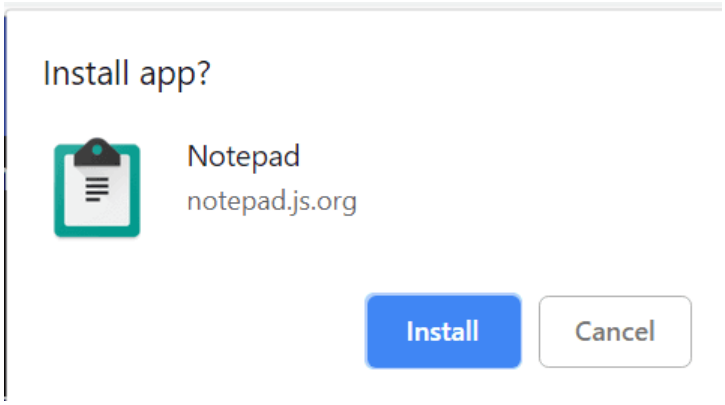
There is a common misconception that PWA's are limited to mobile only. However, there are desktop PWA's too. Chrome V 70 was released in mid-October 2018 and added several new features including desktop Progressive Web App (PWA) support.

Desktop PWAs are particularly interesting because they tend to target business applications. Desktop PWAs operate in a similar fashion as desktop applications and are supported on Chrome-OS, Windows, Linux, and MacOS.

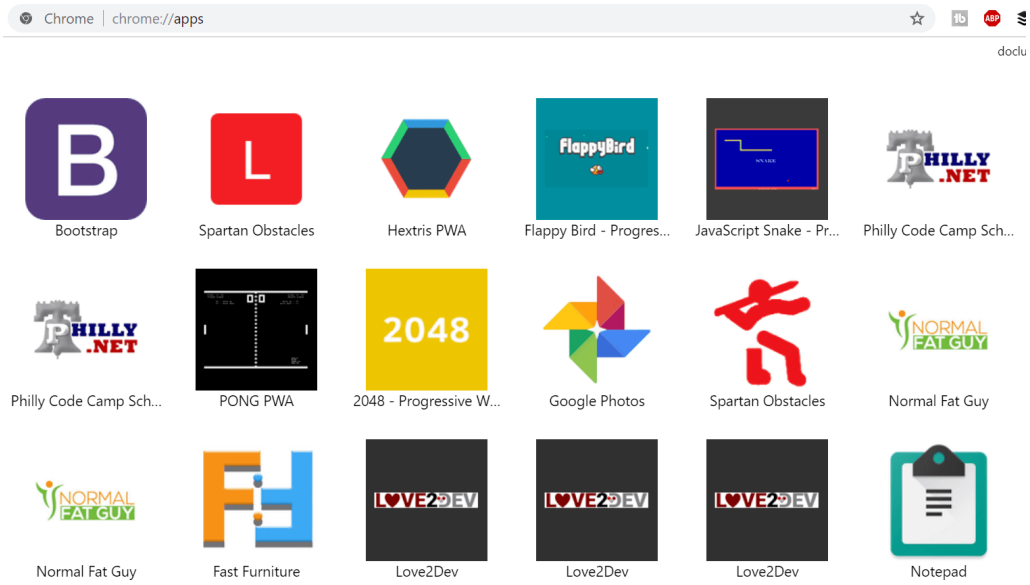
Desktop PWAs appeals to businesses and enterprises for their day to day web software. They can make them feel more like a native Windows application and open them without the browser address bar. For e-commerce, it is another channel they can leverage to engage customers as they can be prompted to add the web app to Windows/Mac-OS as an application.

7.1. Installing Desktop Progressive Web Apps from Chrome

1) Just like Chrome app on a mobile device, if PWA meets the current browser requirements the user is prompted to 'install' PWA.



2) It can also be done manually from the browser settings. (Chrome 'settings' menu, the three vertical dots in the top right corner).
3) Once the application is installed, it is available from the standard OS application launch points, the start menu and desktop in case of windows OS.
4) Because the desktop PWA is in the Start Menu, you can interact with it like other Windows applications. This means we can right click the start menu icon and run as administrator, pin to the taskbar.
5) Once Installed, progressive web apps can be managed from Chrome's App Management panel chrome://apps/.



8. PWA's Case Study

Although there are over 100 business that have benefitted from PWA's, below are some of the important one's worth calling out to understand the scale of returns PWA could bring in.

8.1. Mobile PWA's

8.1.1. Twitter

Twitter boasts 330 million monthly active users (as of 2019 Q1). Of these, more than 40 percent, or more specifically, 145 million, use the service on a daily basis (Twitter, 2019). It is no wonder that Twitter wants to keep their mobile web experience as fast, reliable and engaging as possible. This was the main objective when they decided to upgrade their web application to a PWA. And they've succeeded; Twitter Lite helped deliver a more robust experience and helped:

- increase number of pages per second by 65%
- increase number of Tweets sent by 75%
- decrease bounce rate by 20%

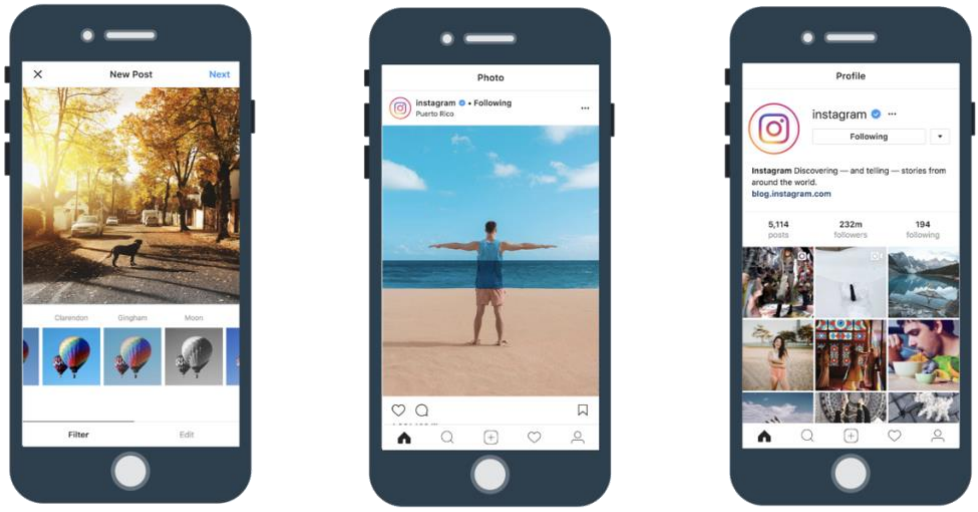
All this while saving more than 97% of device storage space compared to Twitter's native Android app.

8.1.2. Instagram

Instagram was again one of the first major social Networking companies to adapt PWA technology. Following in Twitter's footsteps, they upgraded their web application, giving web app users access to functionalities that previously were only available to native app users.

The Instagram latest PWA release now supports push notifications, has a web manifest and can be installed on both iOS and Android devices, using up much less storage space.

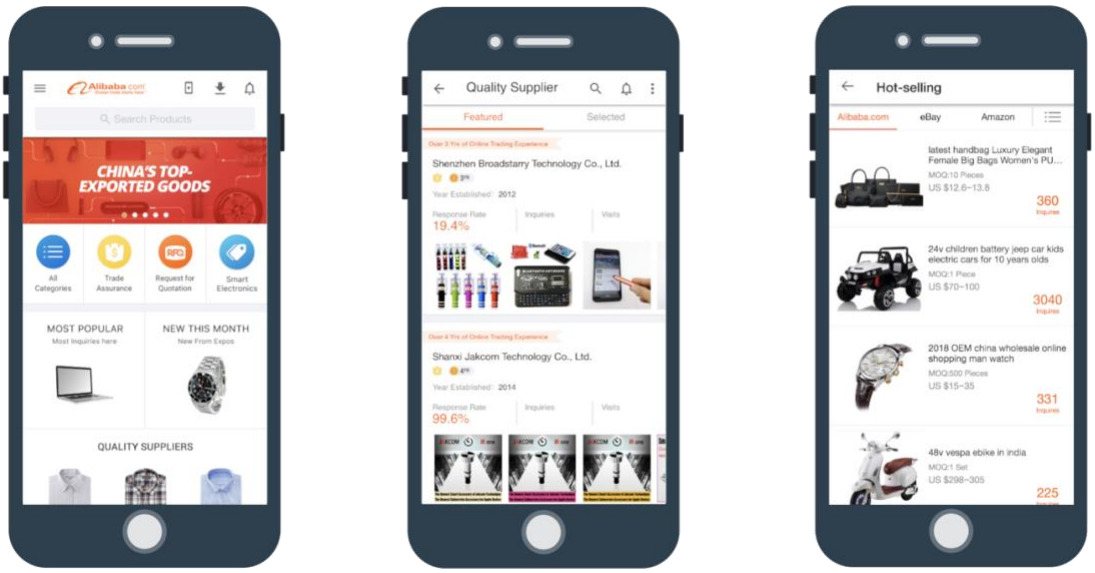
There are still some noticeable navigation issues, but the pros outweigh the cons overall in terms of user experience thanks to the increased speed and lightness of the app. As inferred from a survey, It was able to increase both its user base and daily traffic by creating this lite version of application. According to recent news, Instagram will expand the compatibility of the PWA to Windows Mobile OS as well.



8.1.3. Alibaba

Alibaba.com is a famous e-commerce store and world's largest wholesale trading platform, serving over 200 countries and regions. After upgrading their site to a progressive web app in 2016 to capture more markets, they saw a:

- 76% increase in conversions across browsers
- 14% increase in monthly active users on iOS; 30% on Android
- 4X higher interaction rate from the "Add to Homescreen" prompt



Alibaba released PWA way back in 2016, and they closed that year with $15,69 billion in annual revenues. By the end of 2019, this number raised to over $60 billion.

By understanding how mobile web users interact with their business, they were able to deliver an excellent user experience to both existing customers and new customers. Their PWA was also able to deliver push notifications the same way the native app does, achieving the same engagement rate on both android and IOS platforms.

8.1.4. Flipkart

Flipkart.com is India's largest eCommerce site. The company adopted an app-only strategy to increase customer retention and temporarily shut down their mobile website. However, they found it hard to provide a user experience that was as fast and engaging as that of their mobile app. The issue was with wide range of mobile phones which had limited storage and processing power. Flipkart decided to rethink their development approach. They re-enabled mobile website and have seen 40% increase in user traffic.

From these learnings, Flipkart soon began building Flipkart Lite, a PWA that combines the best of the web and the best of the Flipkart native app. They decided to combine their web presence and native app into a PWA, which has resulted in huge increase in business. It resulted in:

- 3x time more spent on site
- 40% increase in re-engagement rate
- 70% more conversion rate
- 3x lower data usage

8.1.5. Trivago

Trivago is one of the world's most popular hotel search engines. The travel industry has been heavily disrupted by internet technology over the past two decades. Ever since their founding, they have been fully aware that

they need to utilize emerging technologies in order to stay ahead of the competition.

More Trivago users access the service through mobile devices than on desktop and laptop computers. Users don't always accept the cost of downloading a native app just to find out if it provides the service they need. They decided to design a progressive web application to improve their user experience. And the results speak for itself.

- More than 0.5 Million people accessed the PWA
- Engagement for users increased by 150%
- 97% increase in click outs to hotel offers for PWA users.

8.1.6. Starbucks

Starbucks.com is an American coffee company and coffeehouse chain. They released their mobile ordering app in United States in 2015. The company wanted to introduce ordering functionality to their website, while also making it more accessible for emerging markets. This way the service would be available in locations where internet connections are less reliable, like rural communities.

They choose to invest into PWAs because they are built around the concept of "offline-first". Much of the application was made available without an internet connection. Customers were able to modify the product in their order, and the information was sent directly to the POS once finalised.

Starbucks today has a fast, performant, easy-to-use PWA that is 99% smaller than the 148MB native iOS app. By utilizing React, the development team was even able to include content-specific animations which are common in native apps, but rarely achieved for web apps.

8.2. Desktop PWA's

Progressive Web Apps for desktop are launched same way other applications, usually there's no visual differences (PWAs run in an independent window, without tabs and address bar). Just like with mobile apps, the PWA

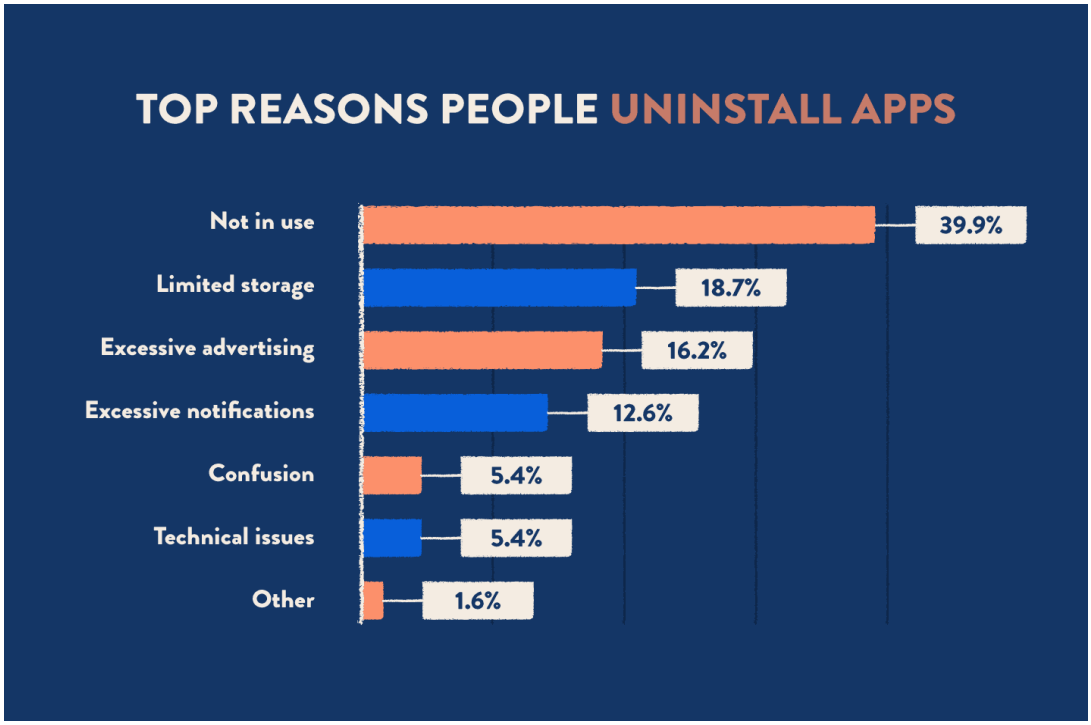
technology can provide an exceptional user experience for desktop users. We might have been using then in our daily routine but haven't noticed.

8.2.1. Spotify

Spotify, a digital music streaming service with millions of songs and podcasts, is a great example of desktop Progressive Web Apps run in their own window. Visually, Spotify PWA felt more polished and vastly different compared to its desktop app counterpart. It felt more reactive, adaptive and more responsive; the in-app animations have improved; together these changes made for an effortless and tailored experience.

9. Future Scope

Progressive Web Applications holds a strong future in the app development industry. According to a study conducted by independent organisation CleverTap, it was found that approximately 50% of the users delete apps because they are not using it or have storage issues.



It is convenient to develop a progressive web application as from the user standpoint, there would be no need to install. With internet being the backbone

of everything happening around the world today, PWAs offer an advantage of being accessible anywhere and generate responses to user's request much faster. This ensures much more user engagement. Thus, increasing it's future demand.

Several big companies have started to see increase in the user engagement as well as they have provided the user with less loading time by adopting the progressive web architectural pattern. PWAs are also ensure security as they run on HTTPS protocol. Additionally, Progressive Web Application would ensure that there would not be a need to hire different developers as a common programming language which is JavaScript is the backbone of PWA.

Progressive Web Apps offers a great advantage over native as well as web-based applications. They carry with themselves the best features of both the application development cycle. The app shell architectural pattern provides a much faster load time to the app.

All these characteristics of PWA guarantees that they are not going out of the app development market any time soon.

On the other hand, they do minimize the network bandwidth required. Service workers along with background synchronization ensures the app to load fast and make a request even in the absence of a proper internet connection. Push notifications allows the user to gain a native app like experience by increasing user engagement with the app.

9.1. Industry Experts View

- **Alex Russell**- a software engineer at Google working on Chrome, Blink, and the broader web platform

> *"Today's web development tools and practices don't yet naturally support Progressive Apps, although many frameworks and services are close enough to be usable for making Progressive Apps. In particular, client-side frameworks that have server-rendering as an option work well with the model of second-load client-side routing that Progressive Apps naturally adopt as a consequence of implementing robust offline experiences.*
>
> *This is an area where thoughtful application design and construction will give early movers a major advantage. Full Progressive App support will distinguish engaging, immersive experiences on the web from the "legacy web". Progressive App design offers us a way to build better experiences*

across devices and contexts within a single codebase but it's going to require a deep shift in our understanding and tools.

Building immersive apps using web technology no longer requires giving up the web itself. Progressive Apps are our ticket out of the tab, if only we reach for it."

- **Arthur Poot**- Digital Marketing Analyst and Business Developer at Simplabs

"PWAs can do a lot more than just two years ago and the capabilities are still improving rapidly. Google, Apple, and Microsoft are prioritising PWA support more than ever. The basic features of PWAs, such as offline capacity and install-ability, are supported by almost all mobile and desktop devices in use today. Only some native features are still not supported, especially on iOS devices."

- **Orest Hudziy-** Co-founder@inVerita

"Progressive Web App is the future of content consuming on mobile devices. It offers speed, reliability, and high quality of user engagement in a world where every second of the user's attention is valuable…

The results achieved by companies that have already implemented this technology show that it is also a profitable decision to move your website to PWA. It will attract users who, for some reason (e.g., the lack of space in the phone memory), were not willing to download your native application or don't like their device overcrowded with apps."

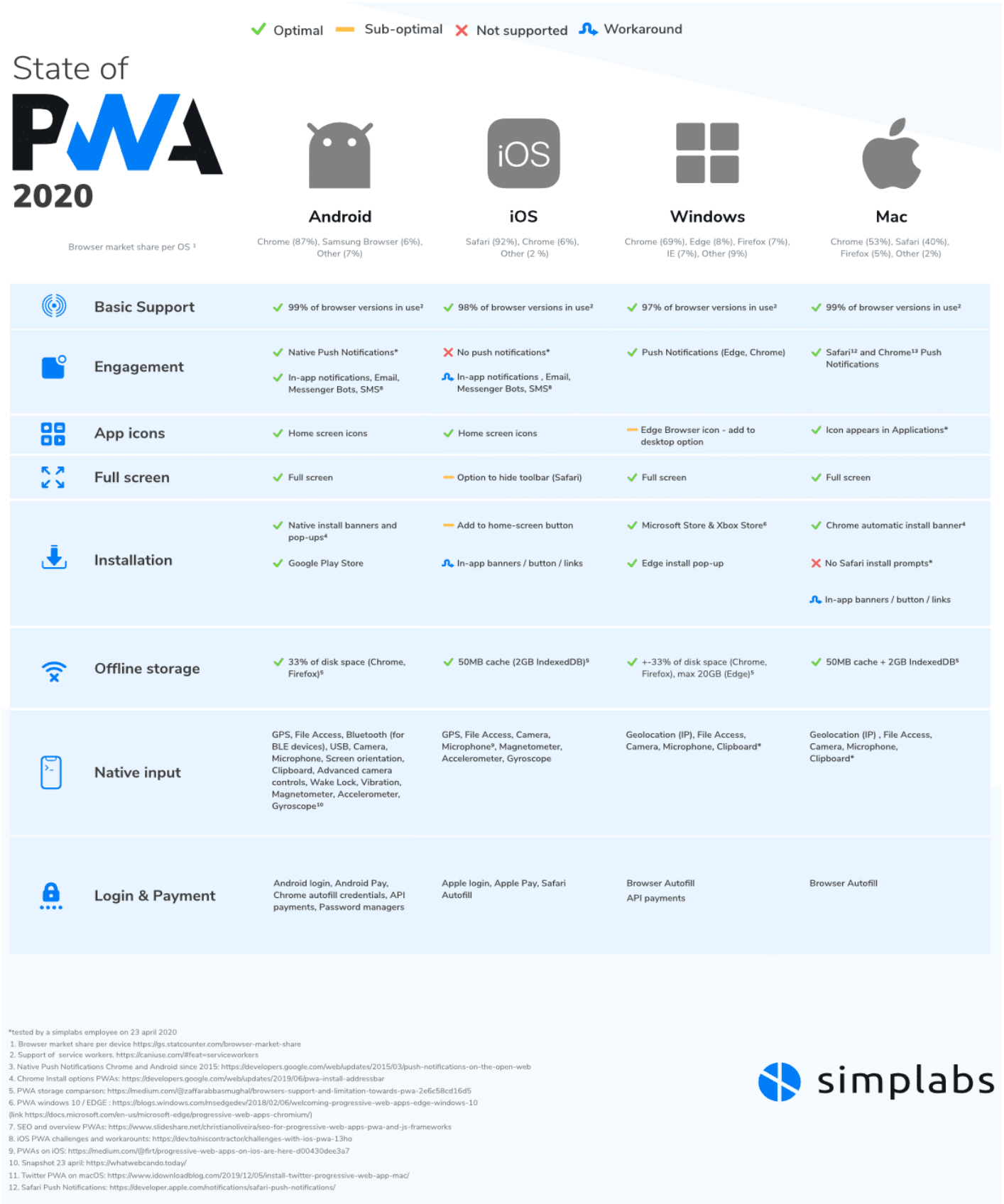
10. Conclusion

PWAs are powerful, effective, fast and app-like. It's hard to imagine a mobile web eco-system that could not be significantly improved via PWA implementation. They can also potentially eliminate the need for many "idle" native apps that exist today.

In short, now 2020 is the time to integrate these technologies into the ecosystem of customer touchpoints. Any and all businesses including efforts pertaining to the mobile web need to take a long, hard look at Progressive Web Apps.

11. Appendix

11.1. Current State of PWAs -OS wise – (Ref-15: Simplabs)



12. References

1. Progressive web apps: An alternative to the native mobile Apps- https://ieeexplore-ieee org.ezproxy.lib.usf.edu/document/8399228?arnumber=8399228
2. How a progressive web app can help you go mobile -https://www-proquest-com.ezproxy.lib.usf.edu/docview/2433076307?accountid=14745
3. Progressive Web Apps with Angular - https://link-springer-com.ezproxy.lib.usf.edu/book/10.1007%2F978-1-4842-4448-7
4. Google's Official Developer Section on PWAs: a fantastic, comprehensive resource for PWAs including videos, how-to-guides and testing tools- https://web.dev/progressive-web-apps/
5. The Current State of Progressive Web Apps- https://www2.stardust-testing.com/en/the-current-state-of-progressive-web-apps
6. Desktop Progressive Web Apps (Desktop PWA's) - https://love2dev.com/blog/chrome-desktop-pwa/
7. What are Progressive Web Apps (PWA)?- https://www.cyber-duck.co.uk/insights/what-are-progressive-web-apps-pwa
8. Examples of PWA development done right- https://www.rabitse.com/blog/examples-of-pwa-development/
9. Multi-platform mobile application development analysis. In: 2015 IEEE 9th International Conference on Research Challenges in Information Science (RCIS), pp. 181–186. IEEE, May 2015- Google Scholar
10. Development approaches for mobile applications: comparative analysis of features. https://doi.org/10.1007/978-3-030-01177-2_34CrossRefGoogle Scholar
11. 5 Reasons Your Site Isn't a Progressive Web App (and why it should be)- https://blog.filestack.com/thoughts-and-knowledge/5-reasons-progressive-web-app/
12. Should You Consider Investing In A Progressive Web App?- https://themanifest.com/mobile-apps/should-you-consider-investing-progressive-web-app

13. Safari on iOS 14 and iPadOS 14 for PWA and Web Developers - https://firt.dev/ios-14/
14. Progressive Web Apps: Escaping Tabs Without Losing Our Soul - https://infrequently.org/2015/06/progressive-apps-escaping-tabs-without-losing-our-soul/
15. The state of PWA support on mobile and desktop in 2020 - https://simplabs.com/blog/2020/06/10/the-state-of-pwa-support-on-mobile-and-desktop-in-2020/