

Cross-device Cross-Platform Framework: Analyzing User Behavior and Tracking Methods

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ABSTRACT

This study explores the dynamic shifts in the digital landscape and the evolution of user journeys. Additionally, it investigates the impactful role of cross-device and cross-platform transitions in elevating the user experience. A crucial aspect addressed in this paper is the identification of tracking methods for each transition, emphasizing their pivotal role in optimizing and enhancing the overall user journey.

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Introduction

The evolution of the digital landscape has changed the way individuals interact with digital tools over the time. Digital technology moved from mainframes to laptops, phones over time. With the rise in digital tools individuals started owning multiple devices and utilizing multiple platforms to perform the needs. This type of rise increased the necessity to have seamless cross device cross platform integration. There have been multiple approaches to track the same user across cross device cross platforms. In this research paper we shall talk about some of the methods used to track the user. This paper also suggests a cross device cross platform framework and the tracking methods to be utilized across various transition combinations. In addition to understanding tracking methods it is also imperative to understand user behavior and how behavioral patterns affect the cross device cross platform transitions.

Evolution of Digital Landscape

The evolution of digital platforms and devices has been a dynamic and transformative journey, marked by rapid advancements in technology. The early days of computing were dominated by mainframe computers, large and centralized machines used primarily by businesses and research institutions. Limited accessibility and high costs restricted their use to a select few. The advent of personal computers, exemplified by the release of the IBM PC, marked a shift towards decentralization. Users gained direct access to computing power, fostering a new era of individual productivity and software development.

The introduction of graphical user interfaces (GUIs) by companies like Apple and Microsoft made computing more user-friendly. Devices like the Macintosh and Windows-based PCs became popular, bringing computing to a broader audience. The widespread adoption of the internet in the 1990s connected people

globally and laid the foundation for the World Wide Web. The web transformed how information was accessed, shared, and created, influencing the development of digital platforms. The 2000s witnessed the rise of mobile devices, with the launch of smartphones and feature phones. Devices like the iPhone and Android smartphones revolutionized personal computing, making connectivity and applications more accessible. Tablets, popularized by the iPad and Android tablets, offered a new form factor for computing. Touchscreens and intuitive interfaces contributed to a shift in user interaction patterns. Cloud computing emerged as a paradigm shift, enabling remote storage, processing, and collaboration. Services like Amazon Web Services (AWS) and Microsoft Azure transformed how applications were deployed and accessed. The proliferation of connected devices in the IoT expanded the digital ecosystem. Smart home devices, wearables, and industrial IoT applications became increasingly prevalent. AR and VR technologies added new dimensions to digital experiences. Products like Oculus Rift and Microsoft HoloLens demonstrated the potential for immersive computing.

With users seamlessly transitioning between devices and platforms, there is a growing emphasis on creating cohesive and integrated user experiences. Technologies like Progressive Web Apps (PWAs) and cross-platform development frameworks aim to provide unified experiences across different devices. The evolution of digital platforms and devices continues to be a dynamic process, influenced by technological innovations, user needs, and societal changes. As we move forward, the integration of emerging technologies and a focus on user-centric design are likely to shape the future of digital experiences.

Evolution of User Journey in Digital Landscape

In the early days of the internet, user journeys were relatively linear. Users followed a predefined path while navigating websites, often limited to static web pages and basic navigation structures. The focus was primarily on information retrieval, and e-commerce transactions were less common.

The advent of search engines like Google transformed user journeys by enabling users to access specific information directly. Users started their journeys with a search query, influencing how content was discovered and consumed. The Web 2.0 era ushered in interactive and dynamic web experiences, with the rise of social media, blogs, and user-generated content. User journeys became more participatory, involving social interactions, comments, and contributions from users. The proliferation of smartphones and mobile apps reshaped user journeys. Mobile experiences became a key consideration for designers and developers. Users started to engage with digital content and services on the go, leading to shorter, more frequent interactions. User journeys became increasingly personalized with the use of data analytics and machine learning. Websites and applications started tailoring content and recommendations based on user preferences and behavior. With the rise of multiple digital channels and devices, user journeys became more complex and interconnected. Users began transitioning seamlessly between devices, expecting a consistent experience across platforms. Mobile apps became central to user journeys, with users relying on app ecosystems for various tasks. Companies built comprehensive ecosystems to keep users within their digital environments, offering integrated experiences [1]. mentioned that cross device and cross platform combinations are major research topics which gives users the ability to navigate across any browser on any device with robust tracking methods.

Cross Device & Cross Platform Interactions

Cross-device and cross-platform experiences involve interactions that seamlessly transition across various devices and operating systems. These experiences aim to provide users with a cohesive and consistent interaction regardless of the device or platform they are using. Here are common types of cross-device and cross-platform environments.

Table 1: Types of Cross Device and Cross-Platform Environments

Cross Device Experience		
Smart Phones	IOS	Android
Tablets	Apple	Android operating Tablets
Laptops & Desktops	MicrosoftWindows operating system	macOS
Wearables	Smart Watches	Fitness Trackers
Gaming Console	Playstation	Xbox

Cross Platform Experience		
Web browsers	Google Chrome	Mozilla
Social Media	Facebook	Instagram
Messaging Apps	Whatsapp	Telegram
Cloud based Services	Google Drive	Dropbox
E-commerce platforms	Amazon	Ebay

Cross Device Tracking Methods

Organizations adopt multiple tracking methods to identify cross device users. Below are few methods:

Login & Password Authentication

Login and password credentials provide a way to track users

across devices. When a user logs into their unique identification cross device interaction can be tracked through it.

Probabilistic Method

Probabilistic matching uses various statistical algorithms to identify the cross-device users. This type of matching uses various data points to calculate probabilistic identification. Some of the data points include fingerprint or eye scanner, IP addresses, browser cookies, behavioral patterns such as time of the day the user is active, type of browser preferred. Lately, proposed using a combination of data points Typing Location Accuracy, Accelerometer on tap and Tapping duration. These types of data points help evade privacy concerns that come with fingerprint or tracking IP addresses [2].

Location Data

Location data, if available and consented by the user, can be used to identify devices that are frequently in the same physical locations, increasing the probability of a match.

Cross Device – Cross Platform Framework

Tracking user transitions across different devices and platforms involves employing various methods to establish connections and maintain continuity. In this case we assume that the user has two devices: User Device 1 and User Device 2. He uses different platforms on each device. We also assume that there are two different platforms: Platform 1 and Platform 2 to find the same product. Below are potential transitions user might make through cross device cross platform:

Transition 1: User Device 1 + Platform 1 login -> User Device 1 + Platform 2 login

Tracking methods described below are some that can be used for creating transition 1. However, there are other ways to track such as Single Sign on or cross platform session cookies. Based on the security needs and user experience ease organizations can either adopt with just 1 tracking method or can combine multiple methods.

Cross-Platform Authentication Token

Use a secure authentication token that is platform-agnostic. Once the user logs in on Platform 1, generate a cross-platform token. This token can be used to authenticate the user on Platform 2 without requiring a separate login.

Device Fingerprinting

Employ device fingerprinting techniques to create a unique identifier for User Device 1. This identifier can be associated with the user account and used to recognize the device when the user logs in on Platform 2.

Transition 2: User Device 1 + Platform 1 login -> User Device 2 + Platform 1 login

Cross-Device Authentication Token

Similar to Transition 1, use a cross-device authentication token that allows the user to seamlessly log in on Platform 1 from a different device (User Device 2).

User Account Association

Maintain a user account association mechanism where the user's account is linked to multiple devices. When the user logs in on User Device 2, the system recognizes the association with the same user account. Additional tracking methods can be device linking via QR code or email confirmation links.

Transition 3: User Device 1 + Platform 1 login -> User Device 2 + Platform 1 login

Cross-Device Authentication Token with Platform Differentiation

Extend the cross-device authentication token to also account for different platforms. This token should include information about the user's platform preferences. Upon logging in on User Device 2, Platform 2, the system recognizes the user and their preferences.

User Account Association with Platform Information

Associate user accounts not only with devices but also with the preferred platforms. When the user logs in on User Device 2, Platform 2, the system identifies the user's preferences and customizes the experience accordingly. Additional tracking methods can be push notifications for authentication or Biometric authentication.

Transition 4: User Device 1 + Platform 1 login -> User Device 2 + Platform 2 login

Comprehensive Cross-Device Profile

Create a comprehensive user profile that includes information about the user's devices and preferred platforms. When the user logs in on User Device 2, Platform 2, the system references this profile to provide a tailored experience.

Behavioral Analysis

Employ behavioral analysis to recognize patterns in user behavior. By analyzing usage patterns, the system can make educated guesses about the user's identity when transitioning between devices and platforms. Additional tracking methods can be Multifactor authentication. There are few General Considerations needed for selecting the tracking methods needed:

- **Privacy and Security:** Prioritize user privacy and security. Implement secure authentication methods and ensure that user data is protected during transitions.
- **Cross-Platform Frameworks:** If applicable, leverage cross-platform development frameworks that facilitate seamless transitions and code reuse across different platforms. According to You D selecting appropriate development framework reduces workload of creating cross device and cross platform transition [3].
- **User Consent and Communication:** Clearly communicate to users how their data will be used across devices and platforms. Obtain explicit consent for cross-device and cross-platform tracking.
- **Analytics and Monitoring:** Implement analytics tools to monitor user behavior across transitions. This data can be valuable for refining tracking methods and improving the overall user experience.

User Behavior

User behavior does follow a pattern and is not random in cross device/cross platform behavior [3]. suggest various behavioral patterns with cross platform behavior. Below are some of the types of behavior seen during cross device usages.

Memorized Visualizations

Users do memorize the visualized versions of objects seen in previous sessions on other devices. They tend to search based on the previous visualization more on the new devices to find the object. This can be helpful in ecommerce platforms.

Positioning of the Platform

Users are used to the positioning of the platform on the device.

Changes in the devices might change the behavior of the user. If the exit button is in the same position as the checkout position on another device, the user might tend to exit and come later.

Activity Type

Users tend to start the session new on the next device based on the type of activity. Activities such as a search might be a new session because of the memory and trust in recreating the same results using another device. Whereas other actions might be hard to recreate, and users tend to switch between the devices to seek the information from the previous device [4]. suggests that users tend to not shift their shopping platforms while shopping, indicating the affinity to stick to a particular platform for quick purchases [5].

Conclusion

The evolution of digital platforms, marked by advancements from mainframes to mobile devices and emerging technologies, has transformed user journeys. Seamless transitions between devices and platforms demand cohesive experiences, emphasizing the need for robust cross-device tracking methods. Authentication tokens, device fingerprinting, and user-centric design play crucial roles. Understanding user behavior reveals memorization patterns, positioning preferences, and cross-device shopping habits. As the digital landscape evolves, integrating emerging technologies and preserving user privacy will continue shaping the future of unified, personalized digital experiences across diverse devices and platforms.

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