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Exploring Identity Confusion Vulnerabilities in App-in-App Ecosystems

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ABSTRACT

This paper delves into identity confusion vulnerabilities within app-in-app ecosystems, a critical yet understudied area in mobile security. These vulnerabilities stem from flawed identity checks in WebView, leading to severe consequences such as unauthorized access to sensitive APIs and user data manipulation. We investigate 47 popular super-apps and reveal that all are susceptible to at least one type of identity confusion, categorized into domain name, app ID, and capability confusions. Our findings underscore the necessity for robust identity verification mechanisms and provide insights into mitigating these vulnerabilities.

Key words: identity confusion, app-in-app ecosystems, WebView, mobile security, super-apps, domain name confusion, app ID confusion, capability confusion, Alipay, TikTok

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INTRODUCTION

The proliferation of app-in-app ecosystems, where super-apps host various sub-apps, has introduced significant security challenges. Super-apps like Alipay and TikTok integrate numerous functionalities, including financial transactions and social interactions, making them attractive targets for adversaries. This study focuses on identity confusion vulnerabilities arising from inadequate identity verification processes in WebView-based environments.

BACKGROUND

2.1 WebView in Mobile Applications

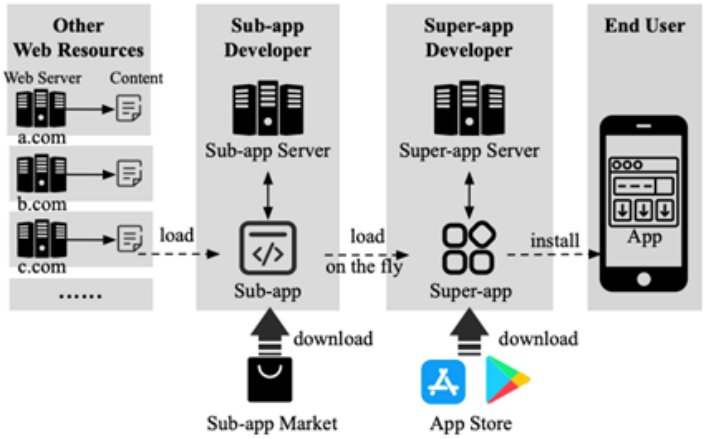
WebView is a crucial component in mobile apps, allowing the display of web content within the app itself. Despite its utility, WebView's integration has been plagued by security issues, particularly in app-in-app ecosystems where multiple sub-apps operate under a super-app's umbrella. These vulnerabilities often stem from improper handling of identity verification between the super-app and its sub-apps.

2.2 Identity Confusion in App-in-App Ecosystems

Identity confusion occurs when the system fails to accurately distinguish between different entities, leading to unauthorized access and operations. In app-in-app ecosystems, this can manifest as domain name confusion, app ID confusion, and capability confusion. These flaws enable attackers to manipulate the system, leading to severe security breaches.

METHODOLOGY

We conducted a comprehensive analysis of 47 popular super-apps to identify and categorize identity confusion vulnerabilities. Our methodology involved static and dynamic analysis of these apps, focusing on their WebView implementations and identity verification mechanisms.



3.1 Tools and Techniques

We utilized a combination of static analysis tools and dynamic testing environments to evaluate the security posture of the apps. Additionally, we developed custom scripts to automate the detection of identity confusion vulnerabilities.

FINDINGS

4.1 Identity Confusion Vulnerabilities in Alipay

Alipay, a widely used super-app, exhibits significant vulnerabilities due to identity confusion. Our analysis revealed two primary issues: domain name confusion and AppID confusion.

4.1.1 Domain Name Confusion

Alipay is vulnerable to domain name confusion due to race conditions in its customized WebView, UCWebView. This flaw allows adversaries to manipulate Alipay's backend servers by exploiting these race conditions.

4.1.2 AppID Confusion

Sub-apps of Alipay suffer from AppID confusion because of a flaw in Alipay's URL whitelist matching. Alipay uses regular expressions for string matching, but many sub-apps assume strict matching, adding domain names directly to their whitelist. This discrepancy allows attackers to exploit the URL whitelist and gain unauthorized access to privileged APIs.

4.1.3 Security Consequences

The security implications of Alipay's identity confusion are severe. Alipay only checks AppID for privileged API calls, allowing attackers to access any privileged API post-exploitation. Our analysis identified numerous undocumented but accessible APIs, including the privileged "rpc()" API, which can access Alipay's backend cloud server. This API, intended for Alipay's internal use, can be accessed by any sub-app, posing significant security risks.

4.2 Exploiting Alipay's Vulnerabilities

An attacker can exploit these vulnerabilities by crafting a phishing deep link, such as alipays://platformapi/startapp?appId=[1688]&url=malicious.com. When a user clicks this link, the 1688 sub-app executes malicious JavaScript from malicious.com, invoking the "rpc()" API to access Alipay's cloud servers and manipulate user data.

4.3 Identity Confusion Vulnerabilities in TikTok

TikTok, another widely used super-app, also exhibits identity confusion vulnerabilities. The app ID confusion stems from URL matching using endswith, while domain name confusion arises from a race condition in the customized WebView's onPageStarted handler.

4.3.1 Exploiting TikTok's Vulnerabilities

We reported these vulnerabilities to TikTok, which then deployed a patch updating its Chromium kernel. However, the patch remains vulnerable as attackers can use an error URL to delay webpage rendering and exploit the race condition. Specifically, attackers create a malicious webpage that abuses benign.com's identity by executing JavaScript with an unsupported scheme, triggering the race condition.

LESSONS LEARNED AND MITIGATION

5.1 Atomic Definition of Identity

The primary lesson from our research is that identity checks should follow the least privilege principle. An atomic definition of identity, combining domain name, sub-app ID, and capability, can mitigate identity confusion. This approach ensures clear coordination between developers of super-apps, sub-apps, and WebView.

5.2 Domain Synchronization

Mitigating identity confusions also benefits from domain synchronization between mobile and web layers of WebView. Tools like Draco provide a good example by modifying native WebView code to support domain synchronization, ensuring up-to-date domain information.

5.3 Developer Best Practices

Sub-app developers must prioritize security, particularly for sensitive interfaces like the launching webpage. Thorough understanding and implementation of super-app security checks, such as URL whitelisting, are essential.

ETHICS

We addressed ethical considerations by informing all 47 super-app developers of their vulnerabilities. Of these, 29 confirmed their vulnerabilities, and 19 have implemented fixes. We conducted all attacks on our own devices with test accounts to avoid harming real users or servers.

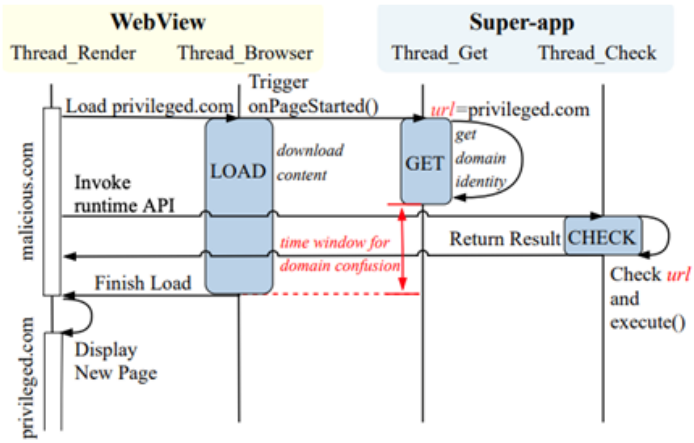
RELATED WORK

7.1 App-in-App Ecosystems

Recent studies have explored the design, prevalence, usage, and flaws of app-in-app ecosystems. However, our research uniquely focuses on identity confusion vulnerabilities, a threat model not previously studied.

7.2 WebView Security

Prior research highlights the security risks of WebView, particularly code injection and malicious ad hijacking. Our work extends these findings by examining identity confusion in WebView-based app-in-app ecosystems.



7.3 Identity Checks

Studies have investigated identity check flaws in mobile and web apps, emphasizing the importance of robust authorization mechanisms. Our research adds to this by addressing the unique challenges of identity verification in app-in-app ecosystems.

CONCLUSION

This paper provides a systematic study of identity confusions in app-in-app ecosystems, categorizing them into domain name, app ID, and capability confusions. Our findings reveal that all 47 super-apps studied are vulnerable to these issues, underscoring the need for improved identity verification processes. We also offer mitigation strategies to enhance security in these complex ecosystems.

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