POSTER: Short Text, Large Effect: Measuring the Impact of User Reviews on Android App Security & Privacy

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Abstract

Application markets streamline the end-users' task of finding and installing applications. They also form an immediate communication channel between app developers and their end-users in form of app reviews, which allow users to provide developers feedback on their apps. However, it is unclear to which extent users employ this channel to point out their security and privacy concerns about apps, about which aspects of apps users express concerns, and how developers react to such security- and privacy-related reviews.

In this paper, we present the first study of the relationship between end-user reviews and security- & privacy-related changes in apps. Using natural language processing on 4.5M user reviews for the top 2,583 apps in Google Play, we identified 5,527 security and privacy relevant reviews (SPR). For each app version mentioned in the SPR, we use static code analysis to extract permission-protected features mentioned in the reviews. We successfully mapped SPRs to privacy-related changes in app updates in 60.77% of all cases. Using exploratory data analysis and regression analysis we are able to show that preceding SPR are a significant factor for predicting privacy-related app updates, indicating that user reviews in fact lead to privacy improvements of apps. Our results further show that apps that adopt runtime permissions receive a significantly higher number of SPR, showing that runtime permissions put privacy-jeopardizing actions better into users' minds. Further, we can attribute about half of all privacy-relevant app changes exclusively to third-party library code. This hints at larger problems for app developers to adhere to users' privacy expectations and markets' privacy regulations.

Our results make a call for action to make app behavior more transparent to users in order to leverage their reviews in creating incentives for developers to adhere to security and privacy best practices, while our results call at the same time for better tools to support app developers in this endeavor.

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Motivation

- Do users talk about security & privacy of Android apps?
- Does the new run-time permission mechanism make users care more about their security & privacy?
- Do users' reviews lead to app security & privacy updates?

➤ **Study the connection between user reviews and apps' security & privacy evolution**

Methodology

- **App and Review Crawler**
  - All app versions
  - All reviews

- **Review classifier**
  - Security & privacy related (SPR)
  - Not security & privacy related (non-SPR)

- **Analysis**
  - Identify app's security & privacy related updates (SPU)
  - Map SPU → SPR
  - Regression analysis → impact factors on SPU
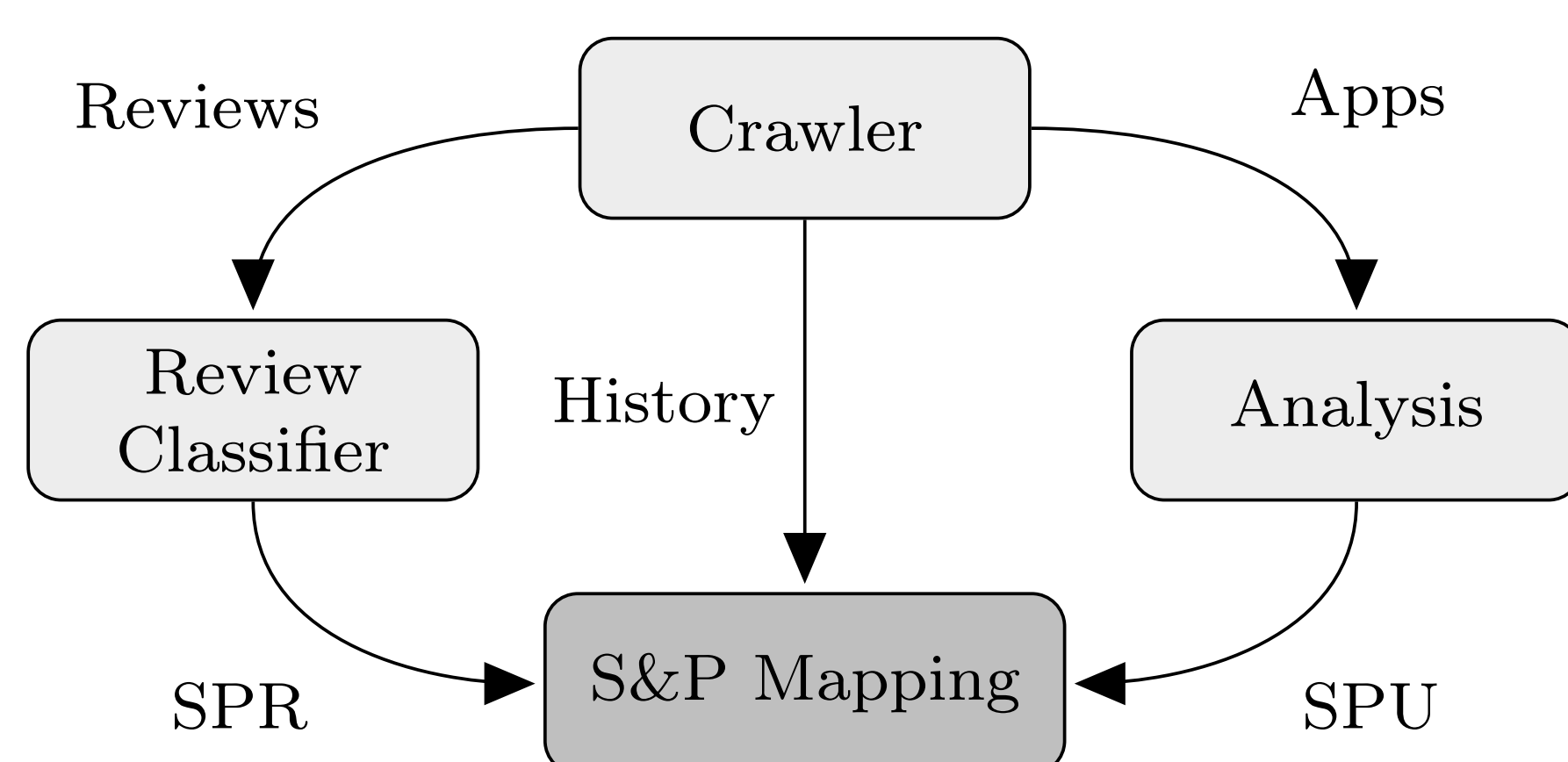
Dataset
- 2,583 app packages
- 62,838 app versions
- 4.5m user reviews

➤ **Measure the impact of security & privacy related reviews on app security and privacy updates**

Empirical Analysis

- **Security & privacy related reviews (5,527)**

Category (#app)	Total # SPR	Mean #SPR/app
Tools (221)	1,343	7.5
Heal And Fitness (30)	190	7.04
Shopping (35)	163	6.54
Business (23)	113	5.95
Productivity (73)	364	5.69
Communication (66)	322	5.55
Media And Video (66)	192	5.33
Social (56)	215	5.12
Lifestyle (48)	136	4.53
Entertainment (98)	2 51	3.92
Personalization (112)	310	3.69
Photography (141)	228	3.3
Music and Audio (73)	144	2.94
Games (889)	1,149	2.44

Security & privacy related reviews per app category of 2,583 apps

- **Security & privacy related app updates**
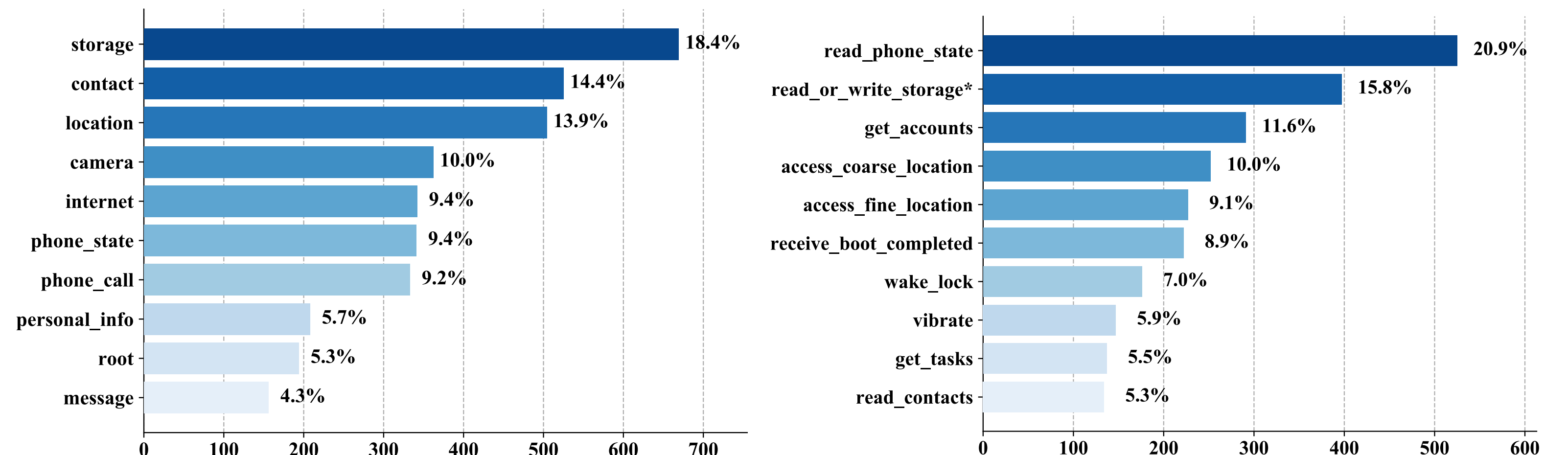
Top 10 mentioned permissions in user reviews

Top 10 permissions removed from app manifests

- **Impact factors for security & privacy updates**

Factor	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	-1.092	0.315	-3.465	<0.001
SPR ratio	2.568	0.796	3.225	0.001
Average rating	-0.094	0.006	-15.093	<0.001
Reply ratio	-0.420	0.157	-2.678	0.007
Permission mechanism: runtime	1.360	0.054	25.276	<0.001

Logistic regression model predicting SP changes
(install-time permission is the base line for permission mechanism)

Conclusion

Key findings
- User reviews have significant impact on app security privacy updates
- Developers do respond to security & privacy related reviews with app updates towards more security & privacy friendly app behavior
- Apps with run-time permission mechanism receive significantly more security & privacy related reviews than apps with install-time permission requests

Call for action
- Make app behavior more transparent to users → leverage users' feedback to create incentives for developers → more security & privacy friendly apps
- Better tools to support developers in making their apps' behavior more transparent

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