

A close-up photograph of autumn leaves in shades of orange, yellow, and red, partially visible on the left side of the slide.

A Large-Scale Empirical Study on Android Runtime-Permission Rationale Messages

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Growing Challenges in Android Privacy

Facebook Fined £500,000 Over Cambridge Analytica Scandal

California and GDPR “light”: A Match Made in Plaintiffs’ Lawyer Heaven?

Uber data breach from 2016 affected 57 million riders and drivers

Incident Of The Week: 21M Users Affected By Recent Timehop Breach

Company Says ‘Memories’ Unaffected By Hack

Android Permission Requests



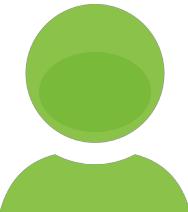
Difficulty in Understanding Permissions



Twitter:

“...to save your profile
 photo, we need
permission to access
media on your device ...”

Why does Twitter need my
storage?

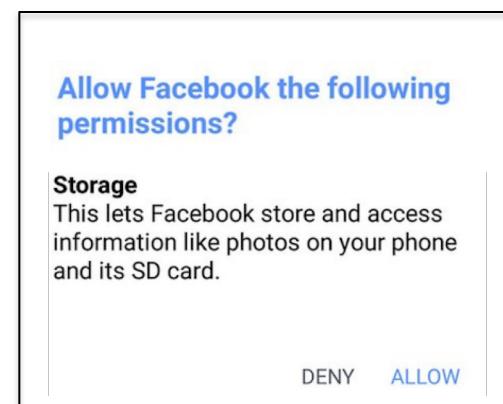
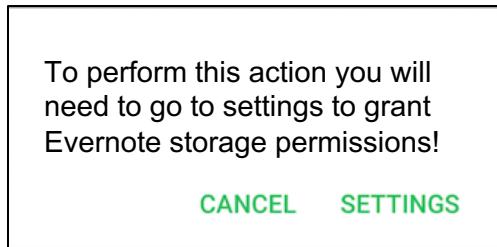
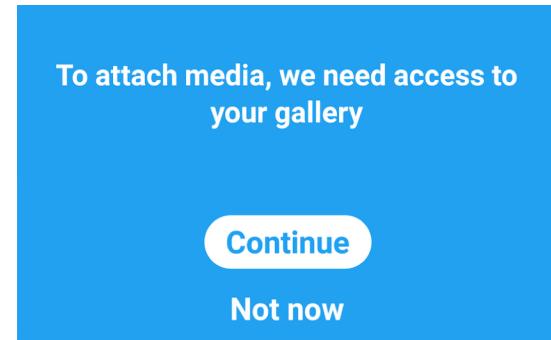
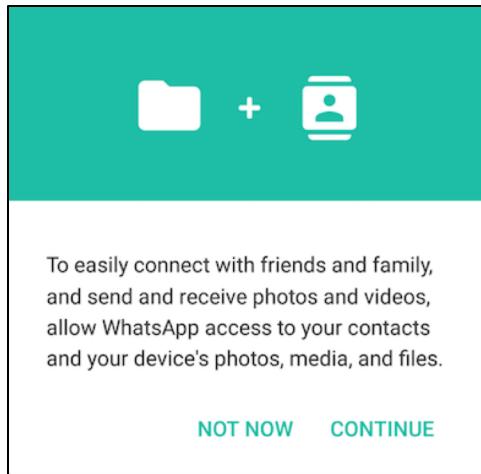


- 1/3 permissions are not understood [Felt et al. 12]
- Reduced users' security concerns [Lin et al. 12]



Permission: STORAGE

Runtime Permission Rationales (Android 6.0 Marshmallow)



Permission: STORAGE

Runtime Permission Rationales

- Customized by each app
- Displayed immediately before/after permission request or upfront

The screenshot shows a Java code snippet on the left and a corresponding runtime permission dialog on the right.

Java Code:

```
public void onRequestPermissionsResult(int requestCode, String[] permissions, int[] grantResults) {
    if (requestCode == REQUEST_PERMISSION) {
        for (int i = 0, len = permissions.length; i < len; i++) {
            String permission = permissions[i];
            if (grantResults[i] == PackageManager.PERMISSION_DENIED) {
                if (shouldShowRequestPermissionRationale(permission)) {
                    if (Manifest.permission.WRITE_CONTACTS.equals(permission)) {
                        showRationale(permission, R.string.permission_denied_contacts);
                    }
                }
            }
        }
    }
}
```

Runtime Permission Dialog:

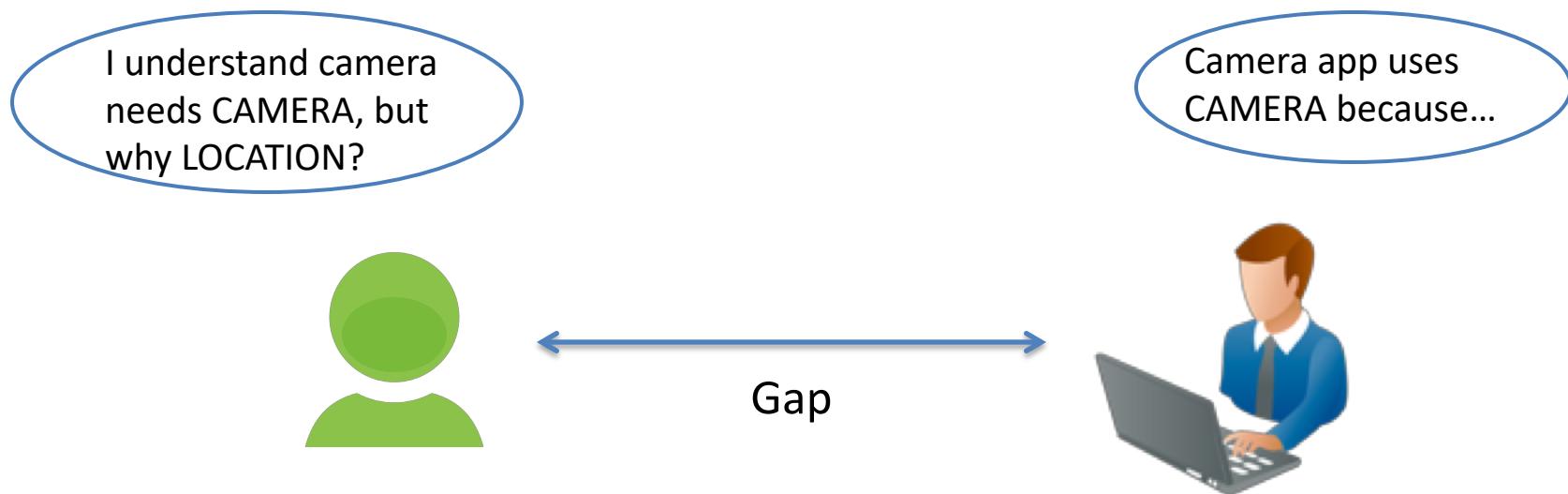
To attach media, we need access to your gallery

Don't ask again Continue Not now

The dialog is blue with white text. It asks for permission to attach media by accessing the gallery. It includes three buttons: "Don't ask again" (unchecked), "Continue" (checked), and "Not now" (unchecked). There is also a small checkbox at the bottom left of the dialog area.

Motivation

- How do apps explain permission purposes?
- **Permission explanation** vs. **user expectation**



Empirical Study on Runtime Permission Rationale

- **RQ1:** Which permission is more frequently explained?
- **RQ2:** Are less-straightforward permissions more explained?
- **RQ3:** Do rationales correctly explain the permission?
- **RQ4:** How specific are the explanations?
- **RQ5:** Is explanation in rationales correlated to the explanation in app description?

Data Collection

- Crawled 83,244 apps with a runtime permission version (Google Play store and APKPure)
- Collect 115,558 rationales from `./res/values/strings.xml`

`<string name="save_screenshot_permissions_prompt_title">To
save your screenshot, we need permission to write to your
storage.</string>`

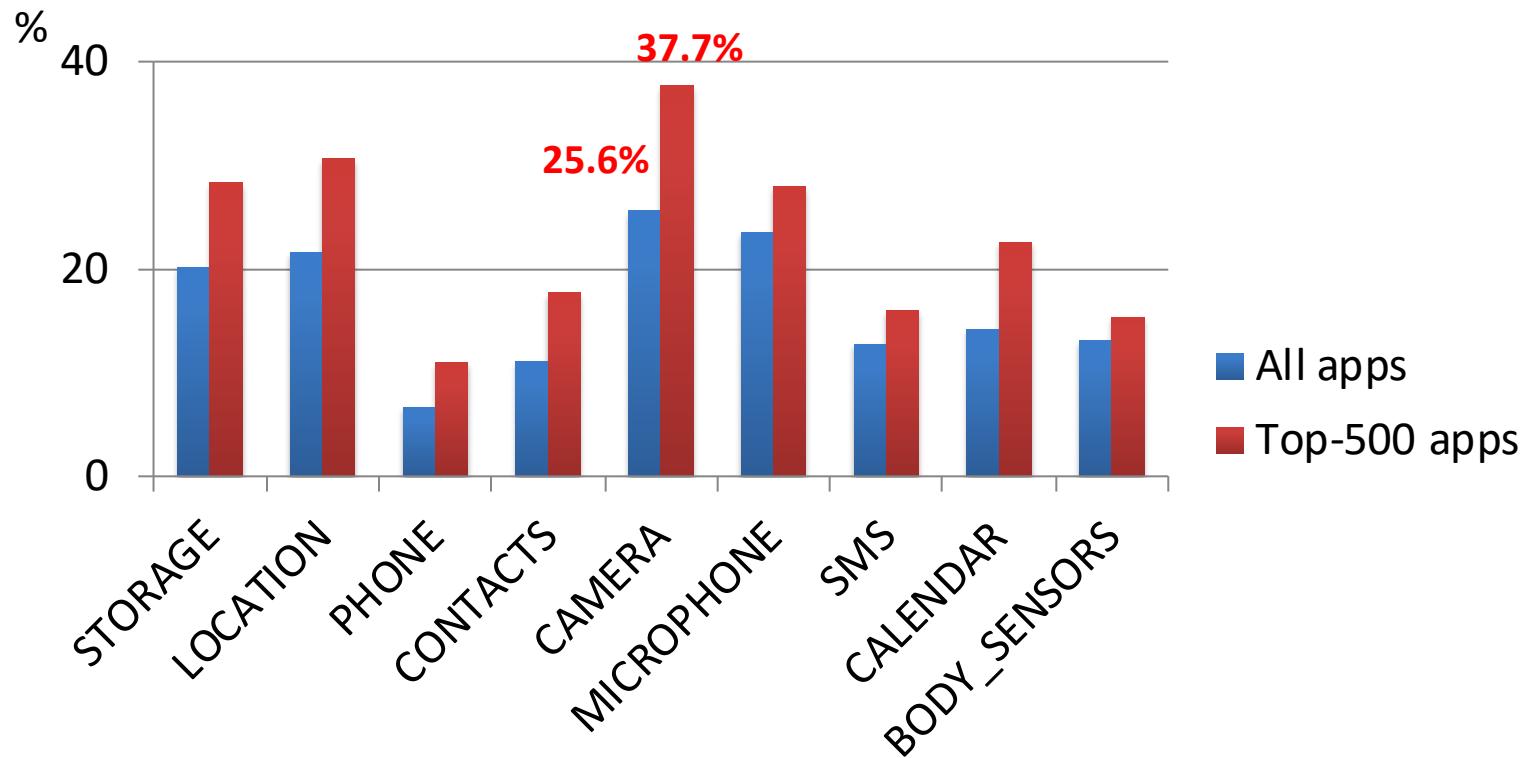
Step 1: Review of 100 matching class instances go STORAGE
Step 2: Review of 100 matching class instances go STORAGE
(positive) to a total (positive) of 6.8% (negative)

	FP	FN
Step 1	N/A	0%
Step 2	5.1%	6.8%



Permission: STORAGE

RQ1: Which Permissions are More Frequently Explained?



- ~~23.8% apps provide rationales (33.9% in top-500 apps)~~
 $\frac{\# \text{apps explaining the permission}}{\# \text{apps using the permission}}$

(explain proportion)

RQ2: Less-straightforward permissions more explained?

- Users have different expectations for different permissions [Jing et al. CODASPY'14]
 - e.g., Camera app: expect CAMERA > LOCATION
- Google I/O 2015, Android Developers Guide:
 - Developers should **prioritize** explaining **non-straightforward permission** purposes (e.g., camera apps using LOCATION) than straightforward purposes (e.g., camera apps using CAMERA)

URL:

<https://developer.android.com/reference/android/support/v4/app/ActivityCompat#showRequestPermissionRationale>

RQ2: Less-straightforward permissions more explained? (Cont.)

- Quantifying straightforwardness

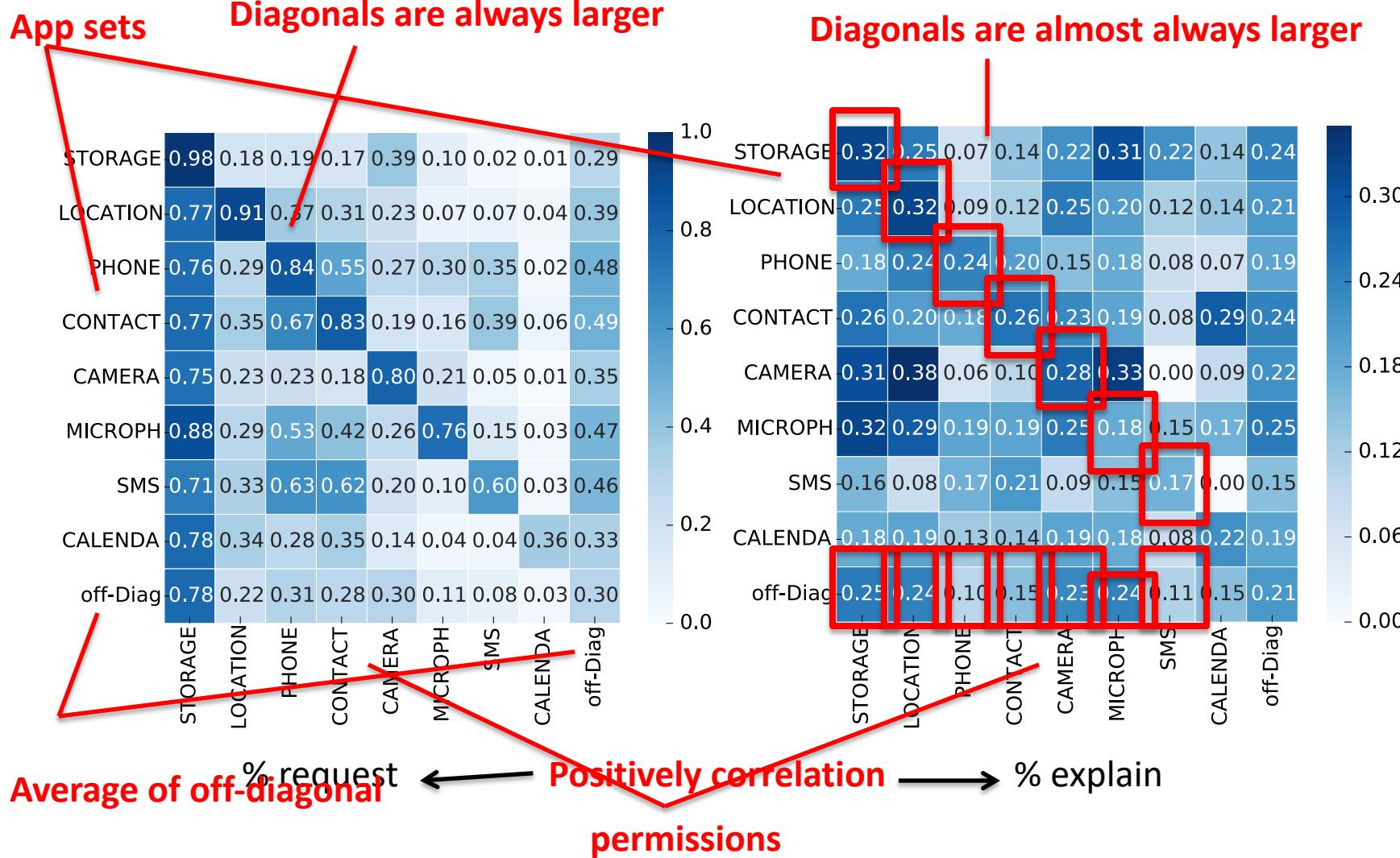
	Camera apps	GPS apps
CAMERA	$\%_{request} = \frac{\# \text{apps using the permission}}{\# \text{apps in total}}$ 71.4%	22.6%
LOCATION	23.2%	92.6%

(request proportion)

CAMERA exception: webcam app

<https://play.google.com/store/apps/details?id=com.viettelidc.cloudcamera>

RQ2: Less-straightforward permissions more explained? (Cont.)



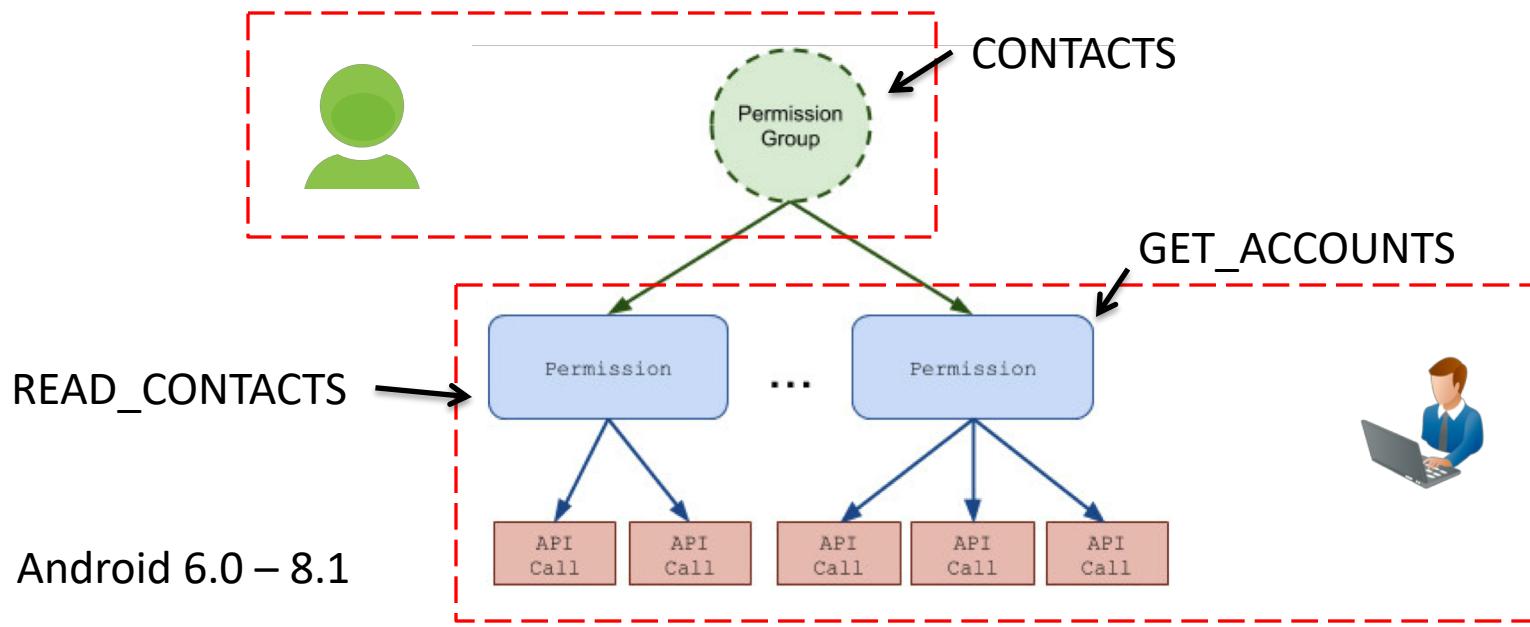
RQ2: Less-straightforward permissions more explained? (Cont.)

- Measuring the correlation among all apps
 - Divide all apps into 35 app sets based on Google Playstore category
 - For each app set, compute its %request and %exp for each permission
 - For 4/6 permissions, %request and %exp are significantly positively correlated
- **In most cases, app more frequently explain straightforward**

STORAGE		LOC		PHONE		CONTACT		CAMERA		MIC	
r	p	r	p	r	p	r	p	r	p	r	p
.4	8e-3	.6	1e-3	.5	6e-2	.8	1e-3	-.5	2e-2	.2	.5

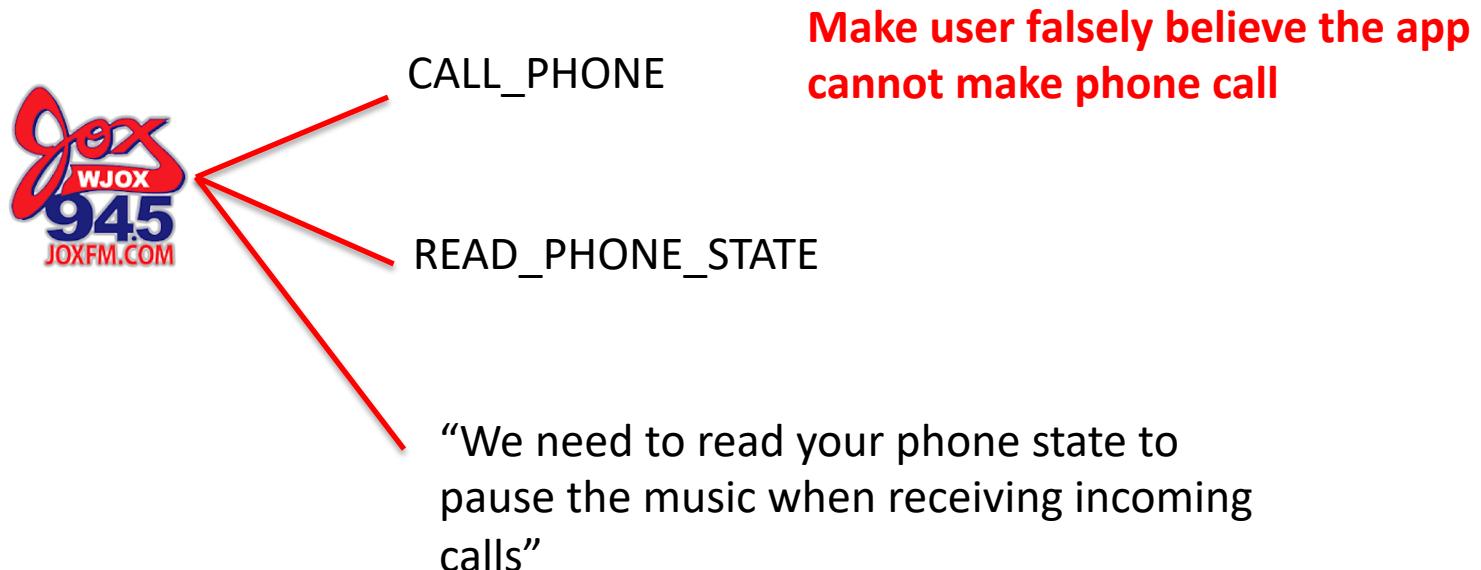
RQ3: Do rationales correctly explain the permission?

- Estimate the population of incorrect rationales, i.e., stated purpose ≠ actual purpose?
- Representing purpose by leveraging hierarchical structure of permission group



RQ3: Do rationales correctly explain the permission? (Cont.)

- Under-claimed case, permission = PHONE



URL: https://play.google.com/store/apps/details?id=com.airkast.WJOXFM&hl=en_US

RQ3: Do rationales correctly explain the permission? (Cont.)

- Over-claimed case, permission = CONTACTS



Confusing users by requesting permission unrelated to functionality

GET_ACCOUNTS

“Permission to contacts is required to use voice commands to call text someone from your contacts”

URL: <https://apkdownloadforandroid.com/com.applepie4.mylittlepet.m.p1016/>

RQ3: Do rationales correctly explain the permission? (Cont.)

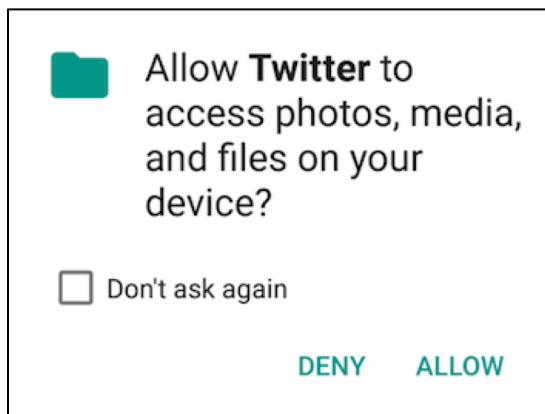
- Identifying under-claimed cases and over-claimed cases (classified by CNN, verified manually)

	CONTACTS	PHONE	LOCATION
Under-claimed	4.6%	11.3%	0.1%
Over-claimed	13.2%	4.2%	0.6%

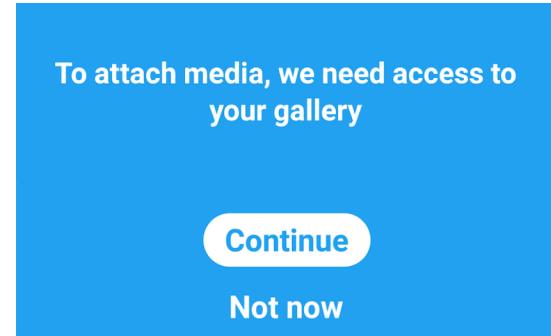
There exists a significant proportion of incorrect rationales!

RQ4: How specific are the explanations?

- Specificity is related to convincingness
- Is a rationale more specific than the permission-requesting message?

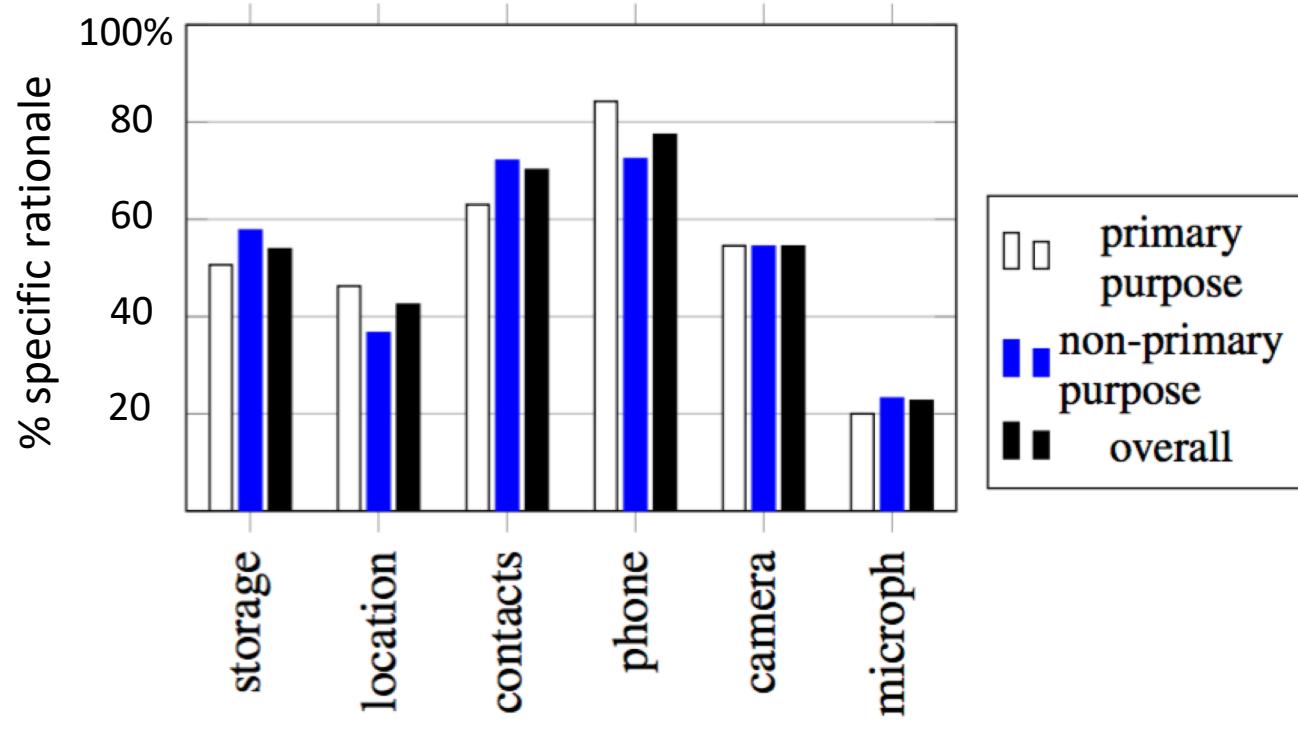


Permission-requesting message (fixed)



Runtime permission rationale (customized by app)

RQ4: How specific are the explanations? (Cont.)



22% - 77% apps provide no more information than permission-requesting message

Implication from RQ3 (incorrect rationales)

- PHONE: 10 diverse fine-grained permissions:

- READ_PHONE_STATE
- READ_PHONE_NUMBERS
- CALL_PHONE
- ANSWER_PHONE_CALLS
- ADD_VOICEMAILS
- USE_SIP

~~Increases the difficulty for understanding/explaining phone state permission~~

making calls

- READ_CALL_LOG
- WRITE_CALL_LOG
- PROCESS_OUTGOING_CALLS

~~Allow finer-grained control from user's side?~~

call log

JSep310d

Implication from **RQ1**, **RQ2**, and **RQ4**

- Less straightforward permissions are insufficiently explained
- Explained permissions are not more informative than permission-requesting message
- Official guidelines/Recommender system
 - Recommend which permissions are non-straightforward
 - Recommending example sentences for explaining permissions

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Thank you!

**Acknowledgment: NSF CNS-1513939, NSF CNS-1408944, NSF CCF-1409423,
and NSF CNS-1564274**

Rationale dataset available at: <https://sites.google.com/view/runtimepermissionproject/>

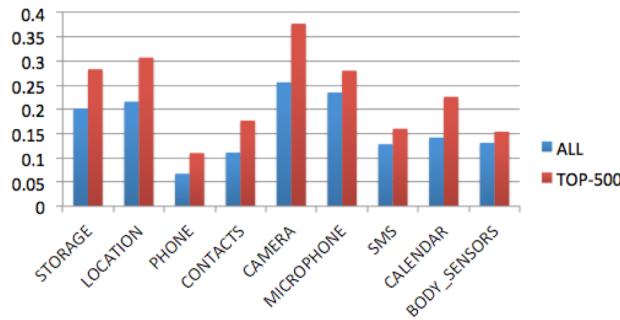
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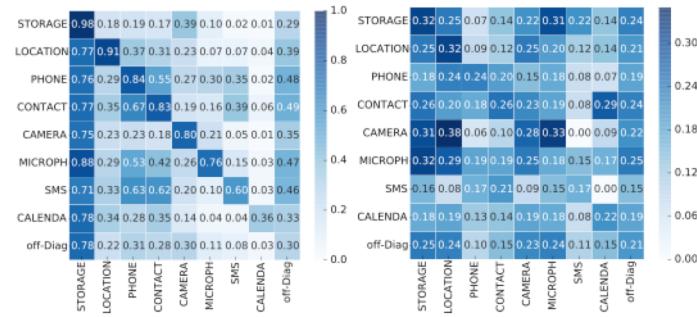
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Conclusion

RQ1: Which Permissions are More Frequently Explained?



RQ2: Do apps more frequently explain difficult permissions? (Cont.)



RQ3: Do rationales correctly explain the permission? (Cont.)

- Train a CNN sentence classifier for incorrect case #1 and incorrect case #2

	CONTACTS	PHONE	LOCATION
Incorrect case #1	4.6%	11.3%	0.1%
Incorrect case #2	13.2%	4.2%	0.6%

There exists a significant proportion of incorrect rationales!

RQ4: How specific are the explanations? (Cont.)

