

Introducing Privacy Threats from Ad Libraries to Android Users Through Privacy Granules

Anand Paturi

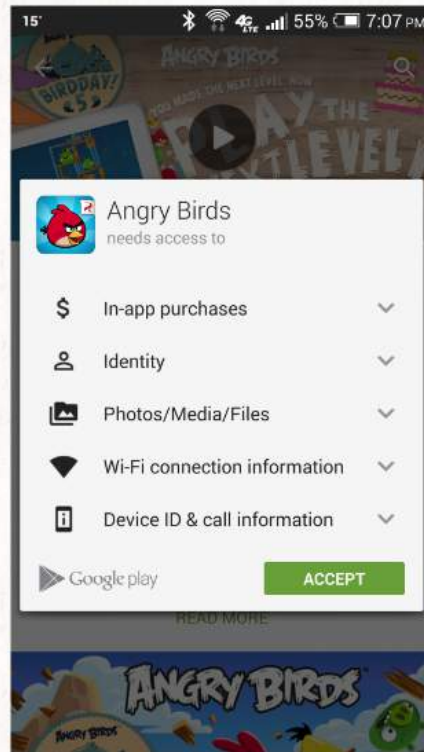
Patrick Gage Kelley

Subhasish Mazumdar



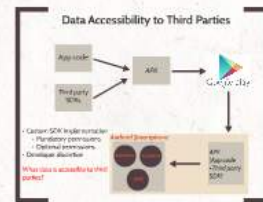
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The Problem



- Resources in the mobile device are grouped as different permissions
- List of permissions is displayed to the user before installation
- User accepts and installs the app

What about third parties?



Third Parties

Ad Networks (Libraries)



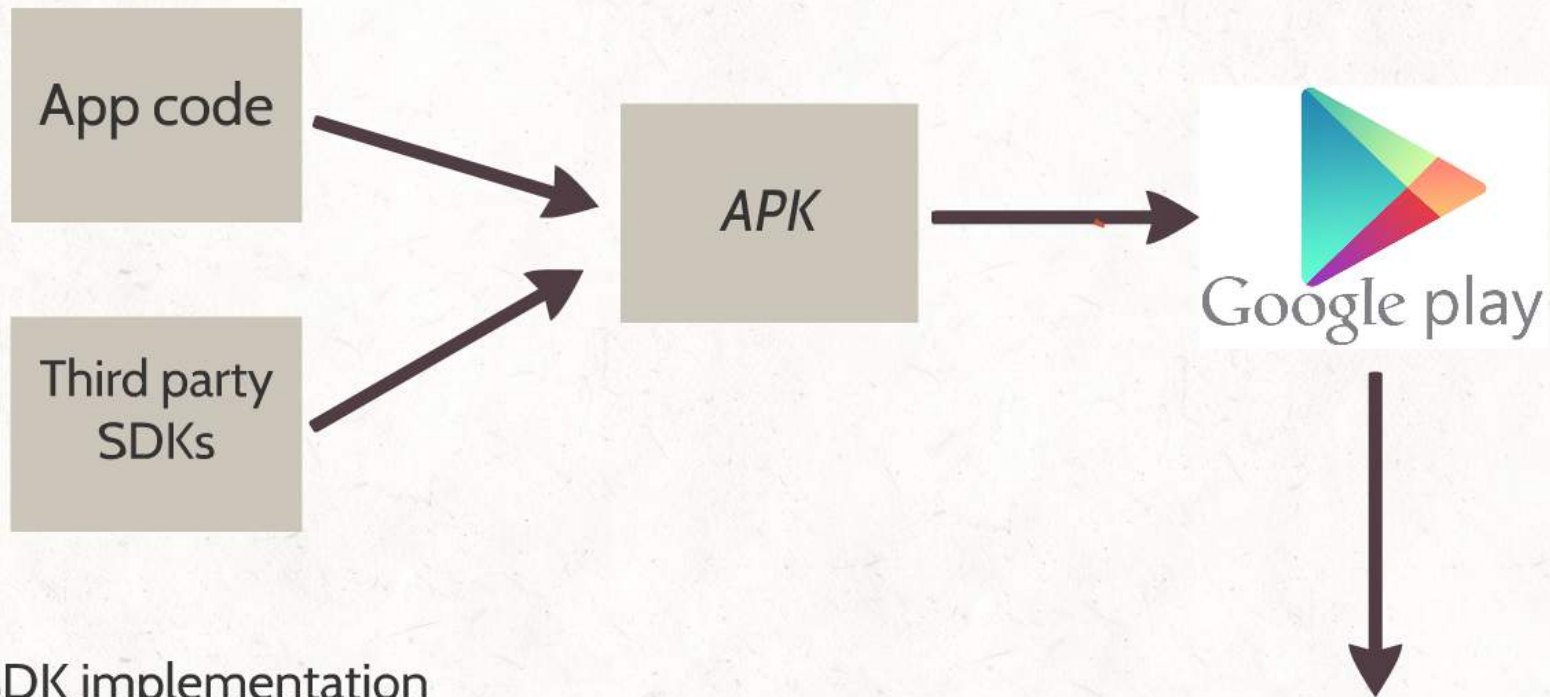
Social SDKs



Development Tools



Data Accessibility to Third Parties



- Custom SDK implementation
 - Mandatory permissions
 - Optional permissions
- Developer discretion

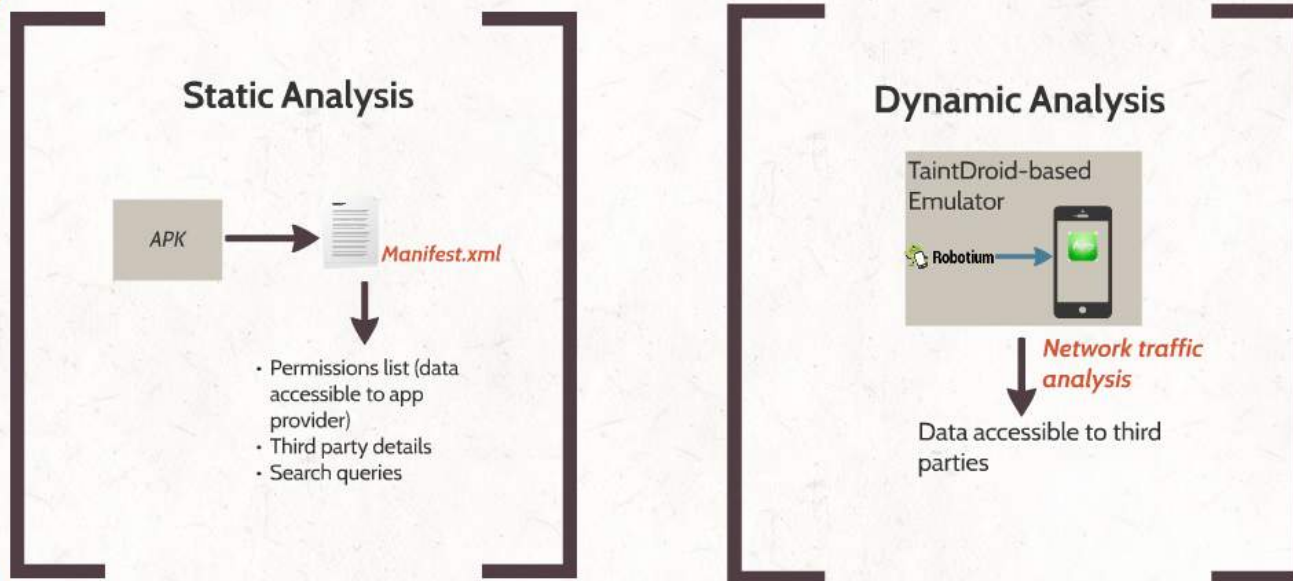
What data is accessible to third parties?

Android Smartphone



APK
(App code
+ Third party
SDK)

Determining Data Access to Third Parties



Dete

Unit

Static Analysis



- Permissions list (data accessible to app provider)
- Third party details
- Search queries

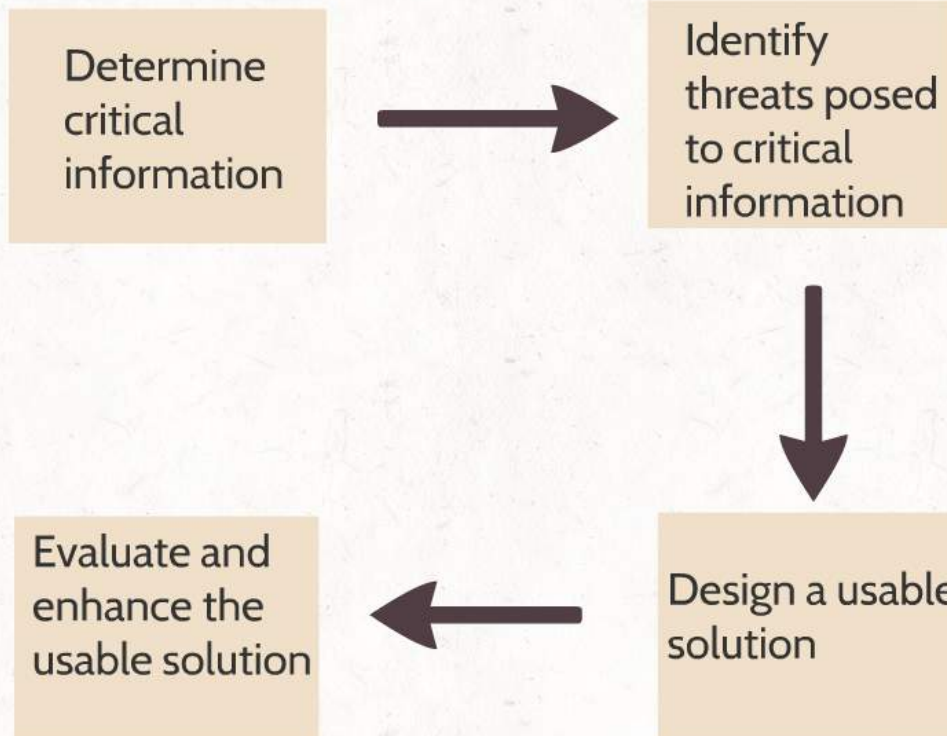
Dynamic Analysis



Network traffic analysis

Data accessible to third parties

How to Educate Users?



Determine Critical Information

Privacy granules

- Units of privacy that might be critical to user privacy
 - Location (*L*): Geographical location
 - Identity (*I*): Personal identifying attributes. *E.g.* Social accounts
 - Query (*Q*): Search query preferences. *E.g.* Nearest restaurants

L + I + Q!

Identifying Threats Posed to Privacy Granules



Google play

Top 50 free apps as
of Feb. 2014



Static and Dynamic
Analysis



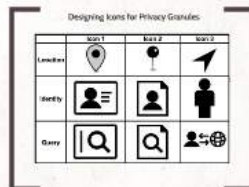
Threat enumeration

Privacy Granule	Threat from App Provider	Threat from Third Parties
Location	Static and Dynamic Analysis	Dynamic Analysis
Identity	Static and Dynamic Analysis	Dynamic Analysis
Query	Static Analysis	Dynamic Analysis









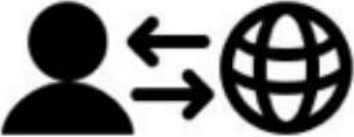
Design a Usable Solution

- Convey comprehensive threat
- Avoid text jargon
- Threat representation
- Decisive

Icon-based threat interface









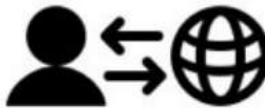


Designing Icons for Privacy Granules

	Icon 1	Icon 2	Icon 3
Location			
Identity			
Query			

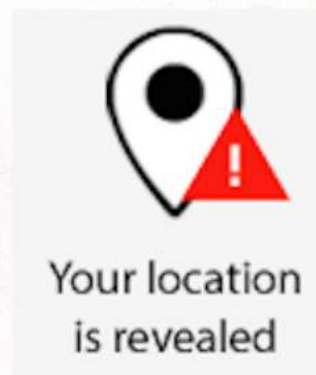
User Evaluation for Icons

- Amazon Mechanical Turk (AMT) - Human Intelligence Task (HIT)
- Questionnaire
 - "How likely are you to select image 1 to represent a person's identity?"
 - Likert scale responses: Likely (5) - Highly Unlikely (1)
 - 137 valid responses

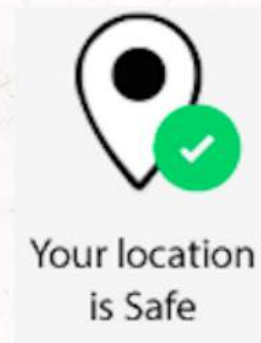
	Icon 1	Icon 2	Icon 3
Location	 76%	 43%	 30%
Identity	 56%	 29%	 33%
Query	 41%	 62%	 26%

Adding Threat Representation

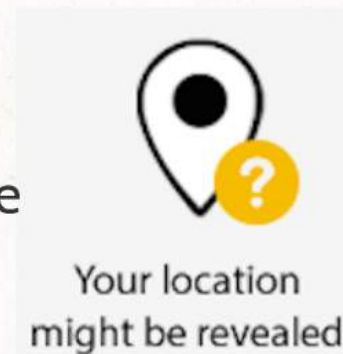
Threat to privacy granule




No threat to privacy granule (safe)















Potential threat to privacy granule











Final Interface

 **Angry Birds**
needs access to

-  In-app purchases 
-  Identity 
-  Photos/Media/Files 
-  Wi-Fi connection information 
-  Device ID & call information 





 Google play 



APP PROVIDER	THIRD PARTIES
 Your location is revealed	 Your location is revealed
 Your search queries are safe	 Your search queries are safe
 Your identity is revealed	 Your identity might be revealed
	

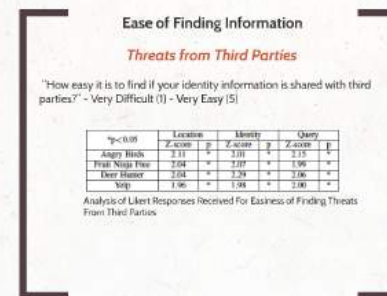
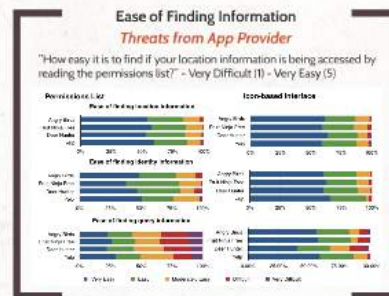
User Evaluation for Icon-based Interface

Selected 4 popular and privacy invasive apps

	<i>App Provider</i>	<i>Third Parties</i>
	I, L	I, L
	I, L	I, L
	I	I
	I, L, Q	I, L, Q

User Evaluation for Icon-based Interface

- AMT- HITs
- 4 Questionnaires - 1 for each app
 - Privacy granule explanation
 - Current permissions list evaluation
 - Icon-based interface evaluation
 - Ease of finding information
 - Impact during *app* installtion
- 272 valid responses



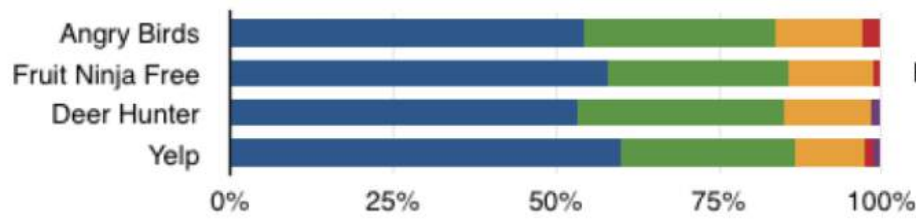
Ease of Finding Information

Threats from App Provider

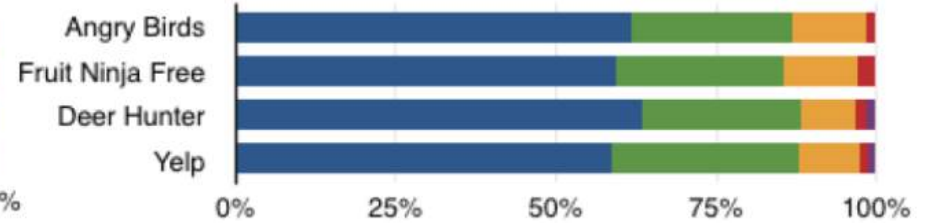
”How easy it is to find if your location information is being accessed by reading the permissions list?” - Very Difficult (1) - Very Easy (5)

Permissions List

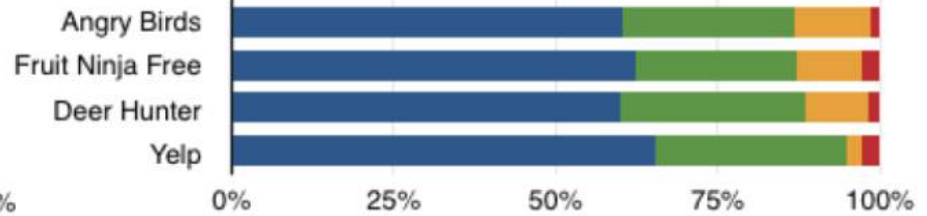
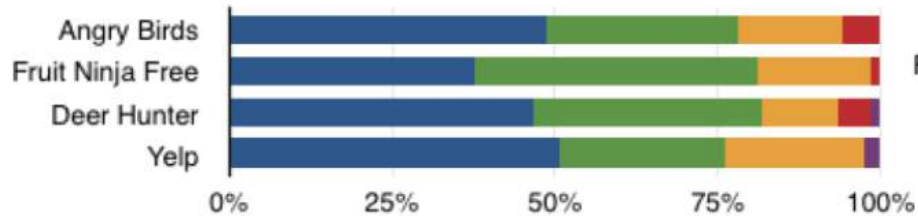
Ease of finding location information



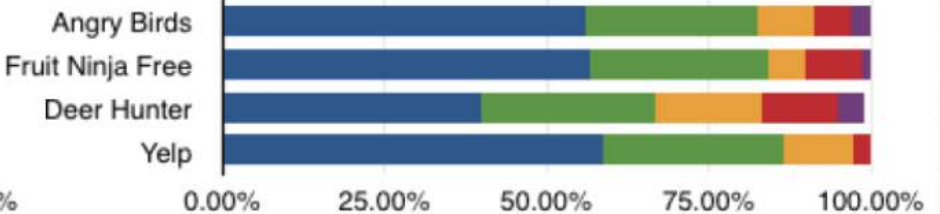
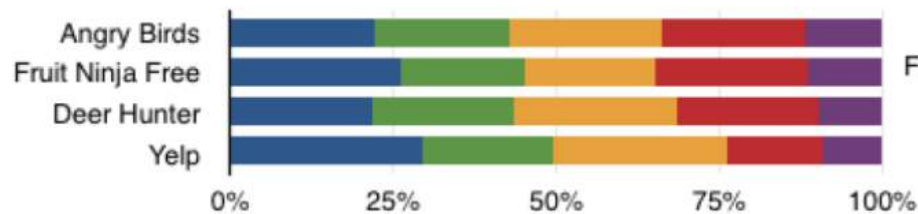
Icon-based Interface



Ease of finding identity information



Ease of finding query information



■ Very Easy ■ Easy ■ Moderately Easy ■ Difficult ■ Very Difficult

Ease of Finding Information

Threats from Third Parties

"How easy it is to find if your identity information is shared with third parties?" - Very Difficult (1) - Very Easy (5)

*p<0.05	Location		Identity		Query	
	Z-score	p	Z-score	p	Z-score	p
Angry Birds	2.11	*	2.01	*	2.15	*
Fruit Ninja Free	2.04	*	2.07	*	1.99	*
Deer Hunter	2.04	*	2.29	*	2.06	*
Yelp	1.96	*	1.98	*	2.00	*

Analysis of Likert Responses Received For Easiness of Finding Threats From Third Parties

Effectiveness of Including Threats from Third Parties

How much do you agree with following statements:

S1.This interface would help you to understand privacy risks posed to your location, identity and search query from both the app and other third parties.

S2.This interface would help you to decide whether or not to install the app because third parties accessing data is important to know.

Effectiveness of Including Threats from Third Parties

Statement	S1		S2		t-stat
	Mean	SD	Mean	SD	
Statement 1	3.85	1.05	3.75	1.05	0.50
Statement 2	3.95	1.05	3.85	1.05	0.50
Overall Mean	3.90	1.05	3.80	1.05	0.50
Overall SD	1.05	1.05	1.05	1.05	0.50

Analysis of User Responses for Questions on Effectiveness of the Requirements

Effectiveness of Including Threats from Third Parties

* $p < 0.05$	S1			S2		
	μ & σ	Z-score	p	μ & σ	Z-score	p
Angry Birds	4.63(0.54)	2.08	*	6.42(0.55)	2.04	*
Fruit Ninja Free	4.52(0.50)	2.02	*	4.56(0.50)	2.10	*
Deer Hunter	4.55(0.50)	2.09	*	4.6(0.49)	2.23	*
Yelp	4.49(0.50)	1.97	*	4.55(0.50)	2.09	*

Analysis of User Responses For Questions On Effectiveness Of The Proposed Interface

Self Reported Installation Decision

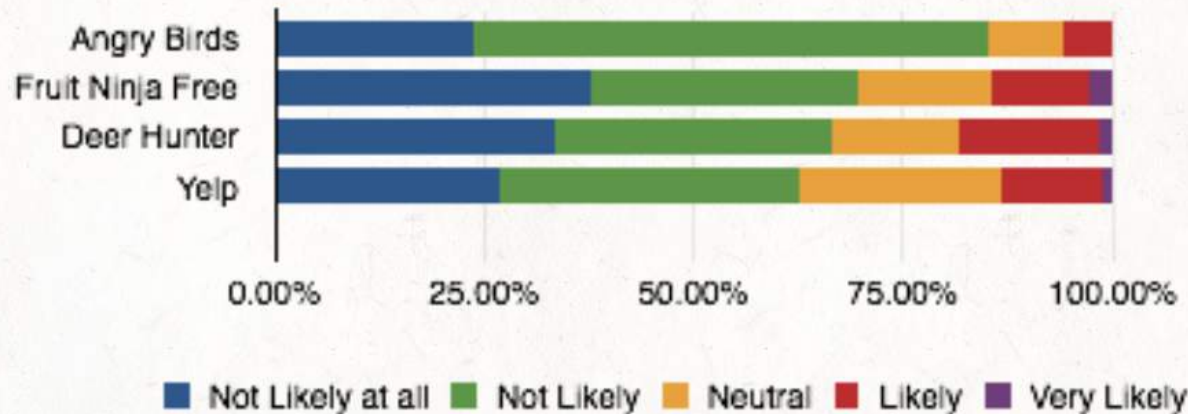
"Have you used this app before?"

Yes/No

"How likely are you to install this app after seeing the above interface?"

Not likely at all (1) - Very likely (5)

How likely are you to install this app after seeing the above interface?



App name	Before viewing icon interface		After viewing icon interface
	Yes	No	Yes → Not likely/Not likely at all
Angry Birds	38	30	31
Fruit Ninja Free	24	45	14
Yelp	33	42	14
Deer Hunter	4	56	1

Users' self reported app installation decisions

How Do Users Perceive Privacy Granule?

"In the proposed interface, identity has information related to your email address, phone number, IMEI number, phone call details, contacts details, SMS, calendar details, microphone, camera and photos. Do you think that this grouping should be split?"

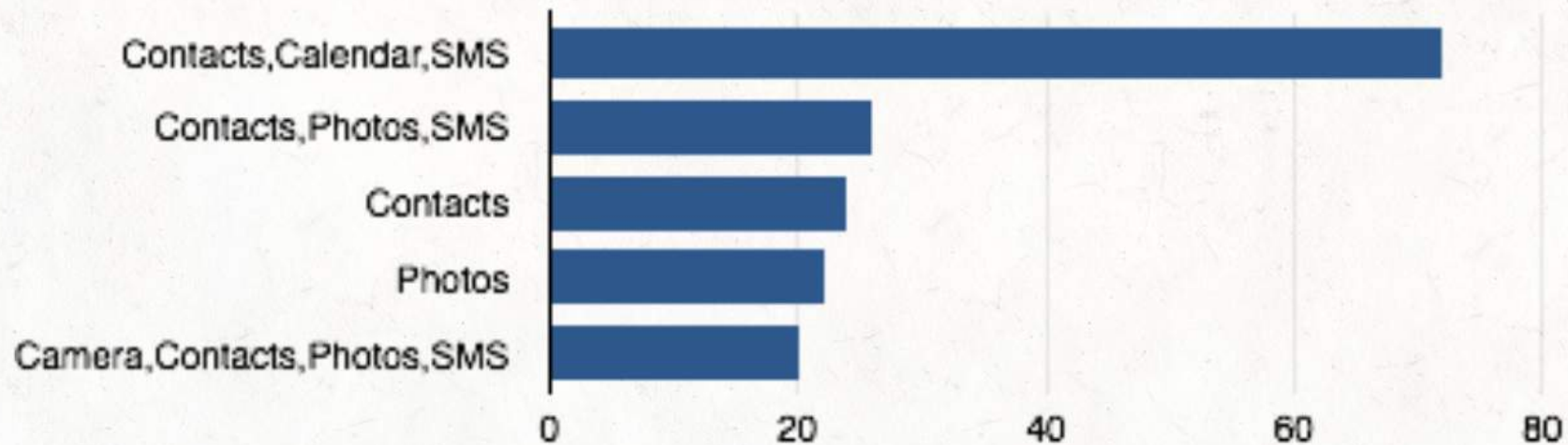
- "I think this group is good", - 62
- "I think this group is good but a couple of those things should get their own icons", - 150
- "I need all this information split up into different groups" - 38
- "I want to see every permission separately". - 22



How Do Users Perceive Privacy Granule?

”Which information that might reveal your identity would you like to see in a separate group represented by an icon for itself ?”

- Camera
- Contacts
- Calendar
- Photos
- SMS



User Comments

- Majority appreciated the novel interface 👍
- Presenting threat from third parties before installation was effective
- More granular approach and usage of data

"knowing what information is being shared with third parties will affect my judgement on weather or not to install an app."



"it's useful to see, but still unknown *why* they want access/permission at all."



Limitations

- No device-based testing
- Real world decisions might be different
- Limited data set

Future Work

- Inference levels of third parties using data across different apps
- Category wise analysis
- Recommendations

Questions



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