Choice Architecture and Smartphone Privacy:
There’s A Price for That

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Adverse selection in app markets

Example: SMS

- 73% of malware uses SMS capability
- 3% of legitimate applications use it

- SMS capability signals potential malware

Advice: “Don’t use apps that require SMS”

Is it possible to follow this advice?

EXAMPLE: INSTALLATION
Step 1: Search
Step 2: Select application

- Retro Clock Widget
- Alarm Clock Xtreme Free
- Lightning Bug - Sleep Clock
- Alarm Clock Plus★
- GO Clock Widget
- Sense Analog Clock Widget
- 3D Digital Weather Clock
Step 3: View description

DESCRIPTION

Do you have problems turning off your alarm clock only to fall back asleep? Wake up gently and avoid accidentally disabling your alarm with Alarm Clock Xtreme. This alarm clock and timer includes features that prevent excessive snoozing and get you out.
Step 4: View permissions

![Android app permissions screen](image)

- **Storage**: Modify/delete SD card contents
- **System tools**: Disable key lock, modify global system settings, prevent phone from sleeping
- **Network communication**: Create Bluetooth connections, full
Step 5: View permissions...still
Step 6: Go back

DESCRIPTION

Do you have problems turning off your alarm clock only to fall back asleep? Wake up gently and avoid accidentally disabling your alarm with Alarm Clock Xtreme. This alarm clock and timer includes features that prevent excessive snoozing and get you out...
Step 7: Go back
Step 8: Select application
Step 9: View description

Retro Clock Widget is a home screen clock and date widget for Android based on the classic mechanical flipping clock. It functions as shortcuts to Alarm and Calendar.
Step 10: View permissions

This application requires no special permission to run.
Android permissions

Users don’t notice permissions

– Online survey:
  • 17.5% claimed to look at permissions

– Laboratory experiment:
  • 17% looked at permissions during installation
  • 42% completely unaware permissions existed

What permissions do users actually care about?

How does choice architecture impact user preference?
What do users actually care about?

Android currently has 124 different permissions

Only location has been extensively studied

Location represents 1% of the permission space
Experiment 1: an upper bound

When choice is made “obvious,” will users indicate a willingness to pay more to disclose less data?

Web-based survey of 483 U.S. residents

Recruited from Mechanical Turk

Asked to select app most willing to purchase
**A**

**NewsFetch**

**DESCRIPTION**

Keep up to date with current events with NewsFetch. NewsFetch allows you to synchronize your mobile device with your favorite news sites and blogs.

New features allow you to share your favorite stories with friends!

**Permissions**

- Network Communication
  - Full Internet access
- Your Location
  - Fine (GPS) location
- Hardware Controls
  - Record audio

**Accept & buy**

**US$0.49**

**B**

**Updated**

**DESCRIPTION**

Stay updated with Updated!

Updated allows you to follow your favorite news sites and blogs while you're on the go. Save favorites or even share articles with friends.

**Permissions**

- Network Communication
  - Full Internet access

**Accept & buy**

**US$0.99**

**C**

**Headlines**

**DESCRIPTION**

Read all your favorite blogs and news websites on the go with Headlines, an app that syncs new posts.

New features allow you to share specific posts with friends and bookmark specific items to read later.

**Permissions**

- Network Communication
  - Full Internet access
- Your Location
  - Fine (GPS) location

**Accept & buy**

**US$1.49**

**D**

**Reader+**

**DESCRIPTION**

Reader+ allows you to read your news sites and blogs wherever you are!

Syncing occurs automatically, so when you open the app, all unread items are waiting for you. Share selected items with friends!

**Permissions**

- Network Communication
  - Full Internet access

**Accept & buy**

**US$1.99**
Methodology

Controlled for price and permissions:

<table>
<thead>
<tr>
<th></th>
<th>$0.49</th>
<th>$0.99</th>
<th>$1.49</th>
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<tbody>
<tr>
<td>Internet</td>
<td>Internet</td>
<td>Internet</td>
<td>Internet</td>
<td></td>
</tr>
<tr>
<td>Location (GPS)</td>
<td>Record</td>
<td>Location</td>
<td>Internet</td>
<td></td>
</tr>
<tr>
<td>Record Audio</td>
<td>Audio</td>
<td>(GPS)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Counter-balanced:
- Names
- Descriptions
- Icons
- Screenshots
Hypotheses

\( H_0: \) Each price/privacy variant will be chosen with equal probability

\( H_1: \) Price-sensitive participants will choose the least-expensive option

\( H_2: \) Privacy-sensitive participants will choose the high-privacy option (i.e., most expensive)
Results

$H0$ is rejected: $\chi^2 = 102.9$, $p < 0.0005$
Exit survey

Rate the following influencing factors:
- Number of downloads
- Icon
- Size of app
- Permissions requested
- Description
- Name of app
- Rating/Reviews
- Familiarity with app
- Cost
- Manufacturer of app
Exit survey

Correlation between stated price sensitivity and price of app selected: $r=-0.39, p<0.0005$

Correlation between stated privacy sensitivity and price of app selected: $r=0.33, p<0.004$

<table>
<thead>
<tr>
<th>$1.99$</th>
<th>$1.49$</th>
<th>$0.99$</th>
<th>$0.49$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Permissions (46%)</td>
<td>1. Description (41%)</td>
<td>1. Cost (33%)</td>
<td>1. Cost (62%)</td>
</tr>
<tr>
<td>2. Description (23%)</td>
<td>2. Permissions (18%)</td>
<td>2. Description (15%)</td>
<td>2. Description (15%)</td>
</tr>
<tr>
<td>3. Icon (9%)</td>
<td>3. Cost (16%)</td>
<td>3. Icon (14%)</td>
<td>3. Ratings (6%)</td>
</tr>
</tbody>
</table>

<p>| | | | |</p>
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<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>120</td>
<td>74</td>
<td>77</td>
<td>212</td>
</tr>
</tbody>
</table>
Summary

Participants less concerned with price were willing to consider other differences (e.g., privacy)

...but this represents an idealized version of the Market, where side-by-side comparisons occur
Experiment 2: app valuation

When presented with a single app, how do permission requests impact users’ valuations?

Posed as an app developer soliciting users for a private beta.

Willingness to pay experiment modeled after Danezis et al.

Methodology

Single app presented with price ($0.99)
   – Permission requests were randomized:

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internet</td>
<td>Internet Contacts</td>
<td>Internet Location (GPS)</td>
<td>Internet Photos</td>
<td>Internet Contacts</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Location (GPS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Photos</td>
</tr>
</tbody>
</table>

How much compensation needed to install/use?
   – Reverse Vickrey auction

Suggested retail price?
DealPlus
AIRZOOM

$0.99

Find a deal!
Location:
Business Type:
Specific Business:

Sal's Deli and Pizzeria
Free Drink with Any Sandwich Purchase
Offer Expires 2/25/2012

PERMISSIONS
TERMS & CONDITIONS

Internet Access
Address Book Contacts
Your Location (GPS)
Your Photo Library

Total US$0.99
Accept & buy

5,000+ downloads
Size: 45MB
September 19, 2011

DESCRIPTION
Do you like saving money? Of course you do!

DealPlus helps you find coupons and discounts for all your favorite stores. Simply search for locations or specific businesses, and then present your...
Results

353 Android-using participants

Bids changed only with respect to contacts:

<table>
<thead>
<tr>
<th></th>
<th>$\beta$</th>
<th>$t$</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td></td>
<td></td>
<td>p&lt;0.001</td>
</tr>
<tr>
<td>Contacts</td>
<td>0.168</td>
<td>7.435</td>
<td>p&lt;0.001</td>
</tr>
<tr>
<td>Location</td>
<td>0.011</td>
<td>3.104</td>
<td>p&lt;0.002</td>
</tr>
<tr>
<td>Photos</td>
<td>-0.027</td>
<td>0.215</td>
<td>p&lt;0.830</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-0.494</td>
<td>p&lt;0.622</td>
</tr>
</tbody>
</table>

$F_3=3.294$, p<0.021

Permissions had no observable effect on suggested prices

– Strong anchoring effect
Concern with permissions

Exit survey asked about factors considered

– Cost was consistently first, regardless of permissions requested
– Permissions were more likely to be considered amongst those viewing request for all four than those only viewing request for Internet access ($U=6227, p<0.015$)
  • However, moved from 4th to 5th
Summary

When architecture supported side-by-side comparisons, 25% stated willingness to pay $1.50 over $0.49 base price for fewer permissions.

When valuating a single app, permissions are unlikely to be considered.

Relatively speaking, users unconcerned with location.
Caveats

Application-specific vs. function-specific searches

Stated willingness, rather than observation of completed transactions

Results are upper bounds
Caveats

Zombies vs. Wookies
AIRZOOM

$0.99

September 19, 2011
Size: 45MB

5,000+ downloads

DESCRIPTION
The zombies are invading the Wookie homeworld of Kashyyyk!

The festivities surrounding Wookie Life Day will be ruined without your help! Choose your weapon and head to the streets. Assemble a posse of...
Moving forward

Architecture should support comparison shopping based on \textit{concerning} permissions

...and not bother users with requests for unconcerning ones

Installation is not the most appropriate time to make most permission requests