

# Improving Mobile Apps using analytics & feedback

## Agile India 2017

JULIAN HARTY

09<sup>th</sup> Mar 2017

Rev: 09 Mar 2017



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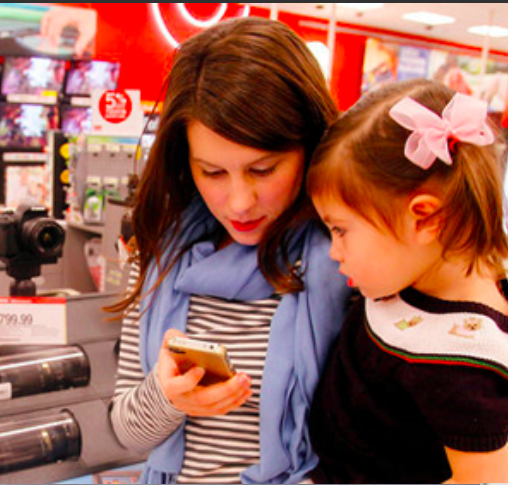
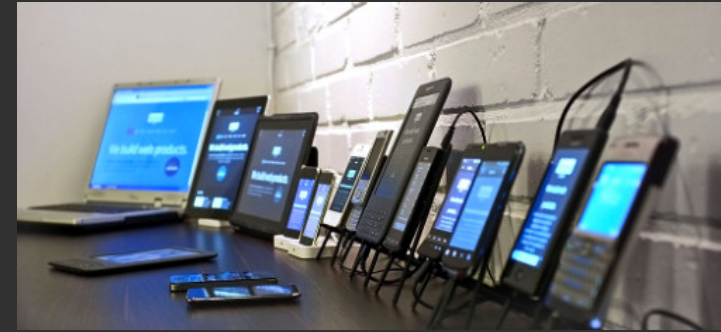


# Our Testing of Mobile Apps?





vs. Real Use





# Knowns...



Reports that say that something hasn't happened are always interesting to me, because as we know, there are **known knowns**; there are things we know we know.

We also know there are **known unknowns**; that is to say we know there are some things we do not know.

But there are also **unknown unknowns** – the ones we don't know we don't know.

And if one looks throughout the history of our country and other free countries, it is the latter category that tend to be the difficult ones.



# The dangers of knowns

*“It isn't what we don't know that gives us trouble, it's what we know that ain't so.”*

Will Rogers

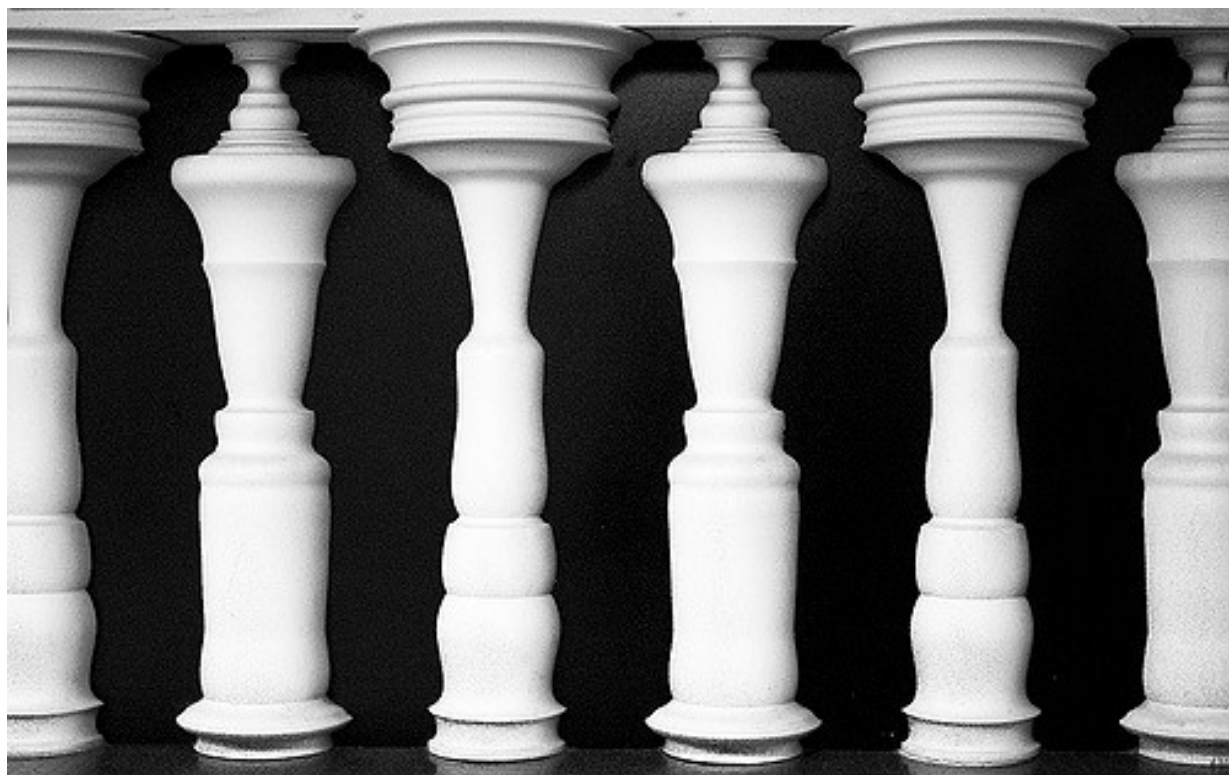
<https://www.brainyquote.com/quotes/quotes/w/willrogers385286.html>

*“It ain't what you don't know that gets you into trouble. It's what you know for sure that just ain't so.”*

Mark Twain

<https://scatter.wordpress.com/2016/01/16/the-big-short-and-the-most-ironic-quote-misattribution-ever/>

# Visible + Invisible



# Known + Unknowns in Software

Of...	Invisible	Visible
Changes		
Complexity		
Crashes		
Devices		
Emotions		
Feelings		
Flaws		
Settings		
Timings		
Usage		
Users		





# Analytics for Software Development

**Past**

**Present**

**Future**

Trends,  
Defect Reports

Engineering Activity,  
Benchmarking, Testing

Extrapolation

**Information**

What's happened?  
(Reporting)

What's happening  
now? (Alerts)

What will happen?  
(Forecasting)

**Insight**

How and why did it  
happen?  
(Factor analysis)

What is the next best  
action?  
(Recommendation)

What's the best/worst  
that can happen?  
(Modeling / Simulation)

Software quality models,  
bottleneck analysis

Specification refinement,  
asset reallocation

Failure prediction  
models

# Forms of Feedback

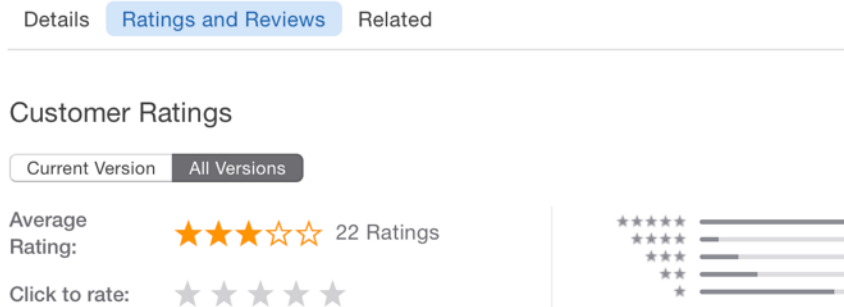
## Digital<sup>[10010101]</sup>

- Software generated
- Consistent
- Ubiquitous
- Dry
- Machine oriented

## Analogue

- People generated
- Variable
- Sparse
- Rich
- Emotional
- Human oriented

# An example of App Store Ratings

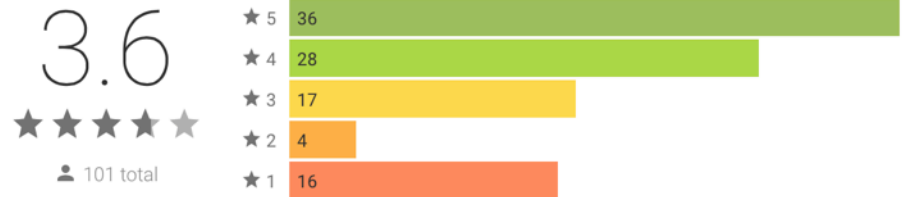


## What's New in Version 2.1.76

– Various bug fixes

## REVIEWS

 Write a Review



## WHAT'S NEW

– Various bug fixes

## ADDITIONAL INFORMATION

<b>Updated</b> February 12, 2016	<b>Size</b> 12M	<b>Installs</b> 10,000 - 50,000
<b>Current Version</b> 2.1.076	<b>Requires Android</b> 2.3.3 and up	<b>Content Rating</b> PEGI 3 <a href="#">Learn more</a>

<https://itunes.apple.com/us/app/xpocast/id538003615?mt=8>

<https://play.google.com/store/apps/details?id=air.com.inxpo.xpocast&hl=en>



# Examples of App Store Reviews

Great conference platform with limitations ★★★★★  
by mattfite – Jul 16, 2015

I use this application to attend online conferences. As other reviewers have noted, the application disrupts your session when the phone displays a notification and the application then requires you to sign in again. Other problematic "feature": viewing conference handouts, PDFs, etc., will also disrupt your session and require you to sign back in.

BusinessUser47 ★★★★★  
by Mlotzof – Aug 2, 2012

Amazing what can be done on the iPad today. Using this tool I can sit at home, watch a presentation with video, slides and desk top sharing, while collaborating with the speaker via moderated chat and other viewers via group chat. Keep it coming.

Does not work? ★★★★★  
by C-EFT – Nov 18, 2015

I am not sure I can fully agree with JPriestly and ElegantSD, but probably only because this app does not work for me at all on iOS 9.2. The version checker (what cumbersome and annoying a way to get into the app) complains that JavaScript is not enabled even though it is. The help link provided, leads to an article for OS X Safari, useless for iOS. Customer support, ... [more](#)

Was this review helpful? Yes | No | Report a Concern

Works but has issues. ★★★★★  
by bgunther – Feb 4, 2015


Works great but when I get a popup on my phone for low battery or notification it kicks me out of the conference and I have to log back in through the website.

Was this review helpful? Yes | No | Report a Concern


Meh ★★★★★  
by Il Liberatore – Oct 21, 2015

The app delivers low resolution video while hiding the clock. If you switch to another app then come back it requests that you return to your browser to click on the meeting link again which is really hokey. This is all based on an interaction with the 2015 Tabelau conference.


<https://itunes.apple.com/us/app/xpocast/id538003615?mt=8>




**Antonín Faltýnek** August 16, 2015  
★★★★★  
Missing audio-only mode, no background playback, no offline mode. At least it can resume playback from last position.




**Kevin Micke** January 29, 2015  
★★★★★  
**Allow background audio** When attending a webinar that doesn't have necessary video content, it's very frustrating that I can't turn the screen off and listen to the audio only. The most significant problem is lag in the audio if I'm on a slow network because it has to download all the video, and it also wastes battery life. Also, any time you switch to another program the feed dies, and you have to go back to the browser to launch it again - it should reconnect on its own.






**Ryan Ingram** November 25, 2014  
★★★★★  
**Works well** Used it to view a web cast worked well even while traveling. Could do with recovering from total loss of signal though.



**QD World** November 26, 2014  
★★★★★  
How? Does this work the first page itself is asking for some Web? ?? Be more specific



**Jenn W** ★★★★★  
**Xpocast sucks** Was recommended to use this for webcasts for my job, but can never get logged in from the email sent to me. Doesn't work on galaxy s4.



<https://play.google.com/store/apps/details?id=air.com.inxpo.xpocast&hl=en>

# A banking example

## Customer Ratings

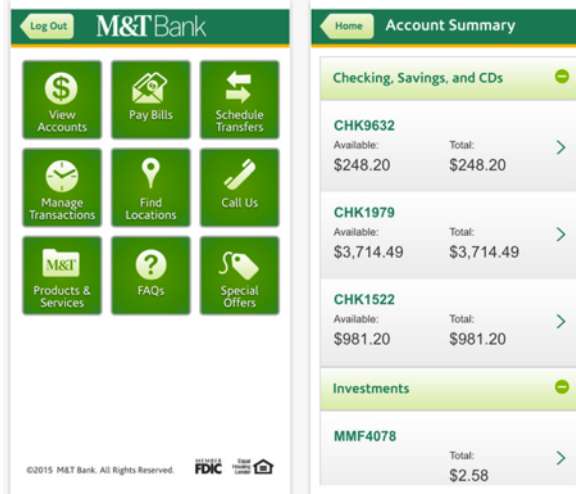
Current Version:

★½ 54 Ratings

All Versions:

★★½ 754 Ratings

iPhone Screenshot



## Customer Reviews

Touch ID login ★★★★★

by Robert96Daniel

This app is awesome. It's easy to navigate and with its simple interface and beautiful integration of the banks color scheme it's a beauty to use for checking my balance. With that in mind, I gave this app only 4 stars because without the Touch ID login that some other financial apps utilize, logging in each time gets frustrating. Other than that, the app is a huge and amazing upgrade considering the app prior to this new release!

Needs Some Work ★★★

by Gdsyhvcduv

Does what I need it to do, when I can actually sign in. If I'm not on Wi-Fi I have to enter my password 3-5 times before it will let me sign in, and sometimes even then I still can't get in. I once even had to call to reset my password because of this as it locked me out. Also, as others have stated, touch id would be a very welcome addition. This is one of very few apps I've seen that requires a login that doesn't utilize touch id.


The worse App in the App Store. ★


by Jamzxoxo

I love M&T as a financial institute but have to wonder. Are things well at M&T? The mobile app is the absolute worse. Once I break off of my home Wi-Fi the app does not work at all. It does not work when I need it the most. Mobile bank is not new technology. WHY can't you people fix this app so that it works right. Good luck with mobile check deposit. It's going to be a while before we see that. You have to completely rebuild the current app. I'm an embarrassed customer.

<https://itunes.apple.com/us/app/m-t-mobile-banking/id397761931?mt=8>

# Reviews for Google Connectivity Services

 4G 09:44

 Google Connectivity Services

# 3.8

★★★★☆

9,215

★★★★★ 5,231

★★★★ 1,088


★★★ 604

★★ 422

★ 1,870

Most helpful first

Options






Yovani Carrillo

★★★★★ 14/09/2016

**5 GHZ and 2.4 GHZ**



Really stable connection when I'm connected with a open network, but my only gripe is I was able to choose the antenna before. For example I was able to choose 5 or 2.4 before and even keep only one on. I'm not sure if this is because I'm currently using Android beta program or if they disable the option. Thanks running Android 7.0 and everything is great.


 





Daniel Jillisky


★★★★★ 28/08/2016





 4G 09:45

 Google Connectivity Services




Daniel Jillisky

★★★★★ 28/08/2016



**Project Fi Battery Drain**

Battery drain for wifi after the latest update is now my #1 battery drain overall. I am on Project Fi on a stock Nexus 6P and I had nearly 8 hours of wifi activity while not connected at work. Please fix this as it is very important for Project Fi users to have power friendly wifi




Rob Welham

★★★★★ 28/09/2016



**Networking setting**

This update claimed to provide VPN security if turned on in Settings/Google/Networking. However, initially there was no Networking setting on both Nexus 9 on Android N or Nexus 5 on Android M. Had the strong feeling this was another US only deal. However, a couple of weeks after update the Networking option appeared but only on Nexus 5. Will update in due course concerning functionality




Ahmed Almeida

★★★★★ 28/09/2016

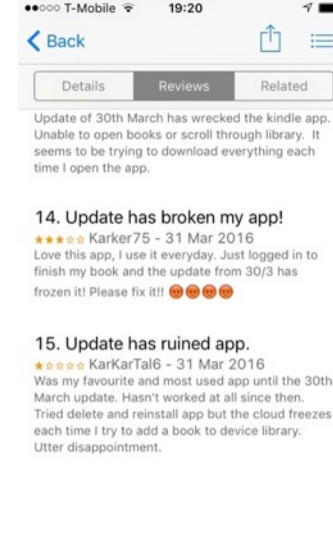
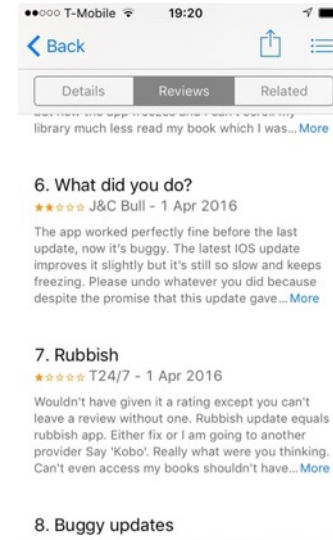
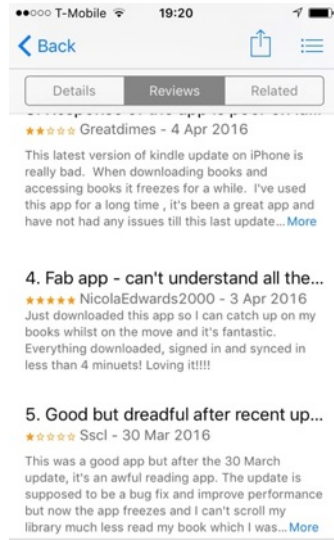
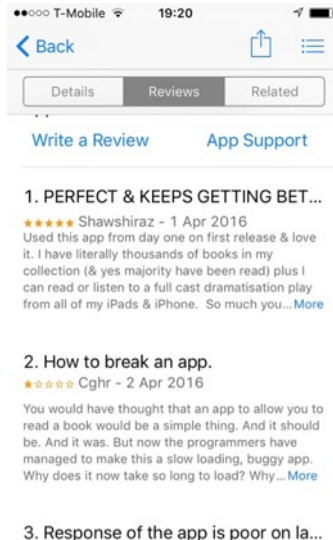
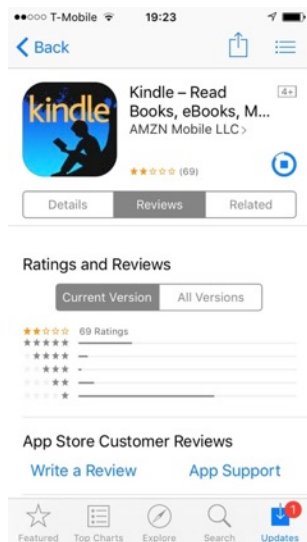
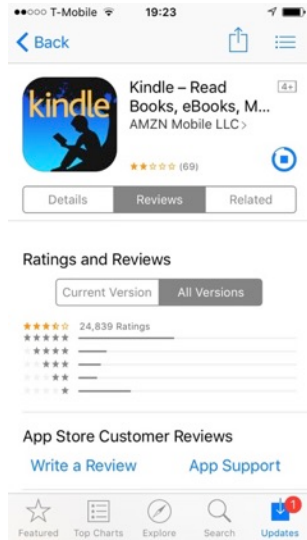
 

**Nexus 6**

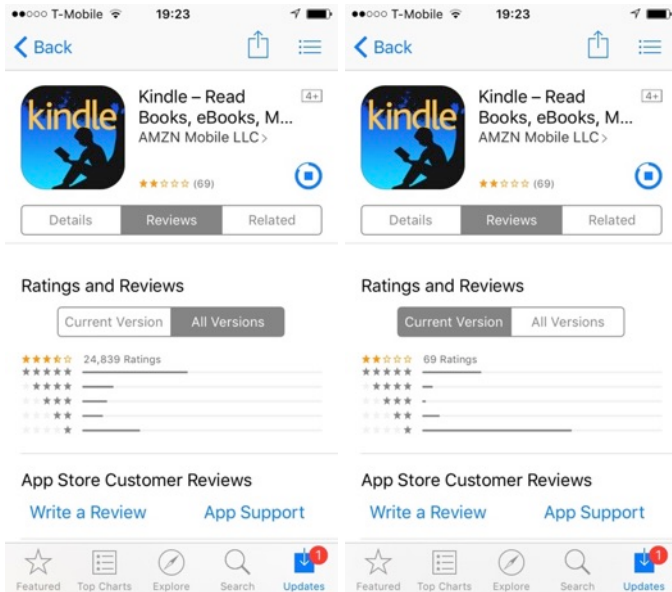




# Kindle App for iOS



# Kindle App for iOS



## Customer Ratings

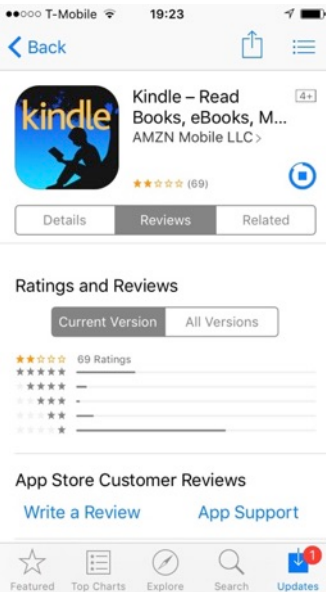
Current Version:

★★★ 22 Ratings

All Versions:

★★★★ 222887 Ratings

06 Apr 2016



## Customer Ratings

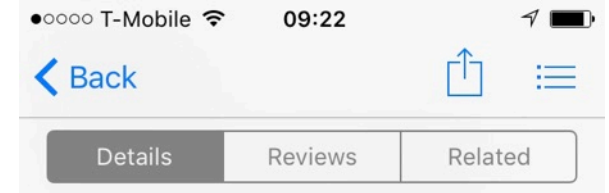
Current Version:

★★★★★ 565 Ratings

All Versions:

★★★★ 25393 Ratings

03 May 2016



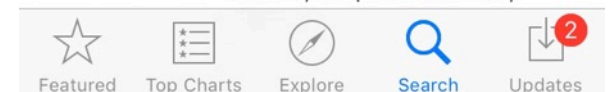
## What's New

5 Apr 2016

Performance and stability improvements

## Information

Developer	AMZN Mobile LLC
Category	Books
Updated	4 Apr 2016
Version	4.19.1
Size	86.9 MB
Rating	Rated 4+
Family Sharing	Yes
Compatibility	Requires iOS 8.0 or later. Compatible with iPhone, iPad, and iPod touch.
Languages	English, Dutch, French, German, Italian, Japanese, Portuguese, Russian, Simplified Chinese,



# Worth knowing about reviews

## Influence

Jumping from...	To...	Is Expected to Increase App Store Conversion by...
★	★★	30%
★	★★★	340%
★	★★★★	730%
★	★★★★★	770%
★★	★★★	280%
★★	★★★★	540%
★★	★★★★★	570%
★★★	★★★★	89%
★★★	★★★★★	97%
★★★★	★★★★★	4%

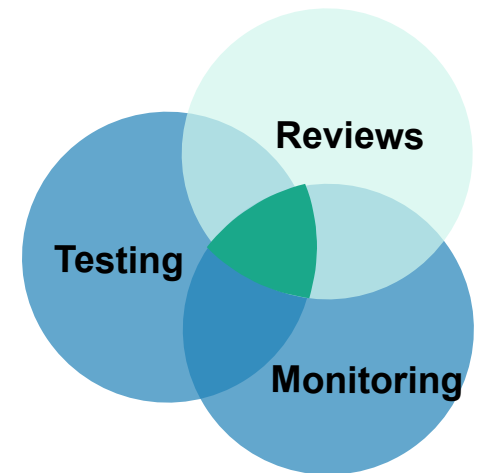
Source: Apptentive 2015 Consumer Survey  
The Mobile Marketer's Guide to Ratings & Reviews



## Measure and Engage



## Improve



Reviews affect the app ranking and the app store conversion. They are also critical for Search Engine Optimization.

Reviews have multiple dimensions which can be used to help measure the user experience.

Turn users' input into innovation

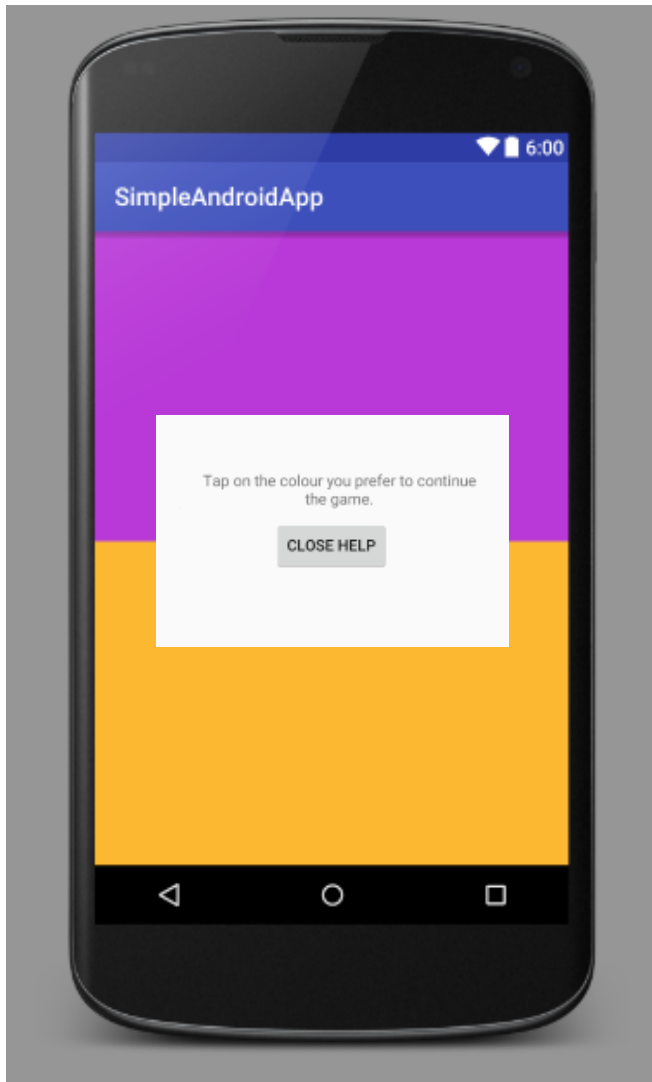


# Understand the effects



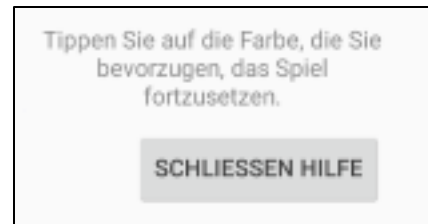
$$\begin{array}{c} 4.4 \\ \text{★★★★★} \end{array} \rightarrow \begin{array}{c} 4.3 \\ \text{★★★★★} \end{array} = ?$$

# Cause & Effects



Tap on the colour you prefer to continue the game.

Tippen Sie auf die Farbe, die Sie bevorzugen, das Spiel fortzusetzen.



Appuyez sur la couleur que vous préférez pour continuer le jeu.

ඔබ ක්‍රීඩාව දිගටම කැමති වර්ණය මත තට්ටු කරන්න.

# Google Play Developer Console



Kiwix, Wikipedia offline

org.kiwix.kiwixmobile [View in Play store](#)

**PUBLISHED** September 4, 2016

Standard publishing ▼

- Statistics
- User Acquisition
- Ratings & Reviews**
  - Ratings
  - Reviews Analysis**
  - Reviews
  - Beta Feedback
- Crashes & ANRs
- Optimization Tips
- Pre-Launch Report
- Promotions
- APK
- Store Listing
- Content Rating

## REVIEWS ANALYSIS

### BENCHMARKS & TOPICS

All APK versions ⬆ **1 year** ▼

Identify and understand trends in your app's reviews. Review analysis features use ratings from reviews written in English and aren't shown to users. [Learn more](#)

#### BENCHMARKS

Benchmarks show your app's ratings for a fixed set of topics and compare these ratings with similar apps in the **Books & Reference** category.

COMMON TOPIC ?	AVERAGE RATING	RATING VERSUS PEERS	NUMBER OF REVIEWS	NUMBER VERSUS PEERS	EFFECT ON RATING ?
<a href="#">Resource usage</a> ?	3.500 ★	+0.083 ★	4	5.78 x	
<a href="#">Speed</a> ?	4.364 ★	+0.364 ★	11	2.84 x	
<a href="#">Stability</a> ?	2.923 ★	+0.243 ★	26	3.09 x	
<a href="#">Uninstalls</a> ?	2.000 ★	+0.159 ★	4	4.68 x	
<a href="#">Update</a> ?	4.727 ★	+1.248 ★	22	5.58 x	
<a href="#">Usability</a> ?	4.200 ★	-0.467 ★	10	0.58 x	

# The 1% challenge

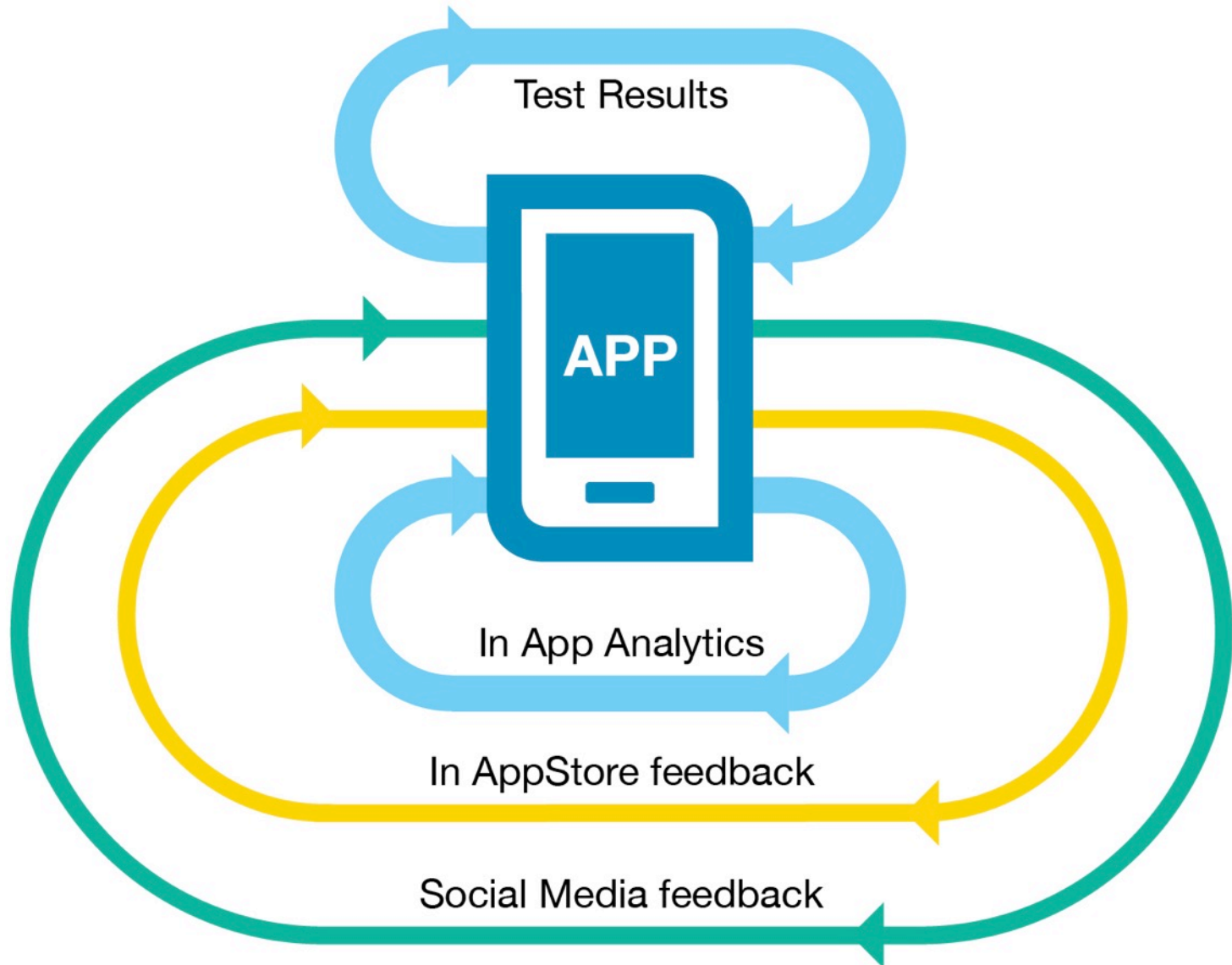


“I wrote a review”



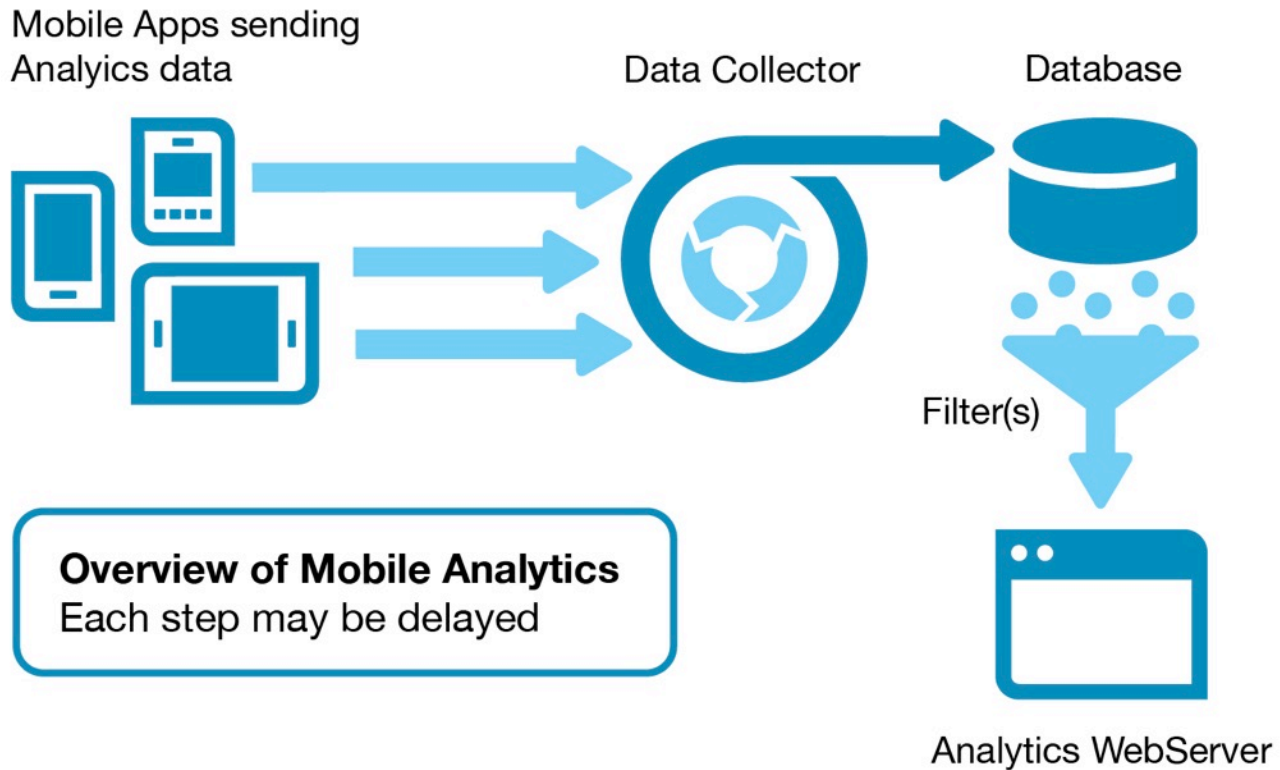
# Use Analytics & Heatmaps

# Feedback Cycles





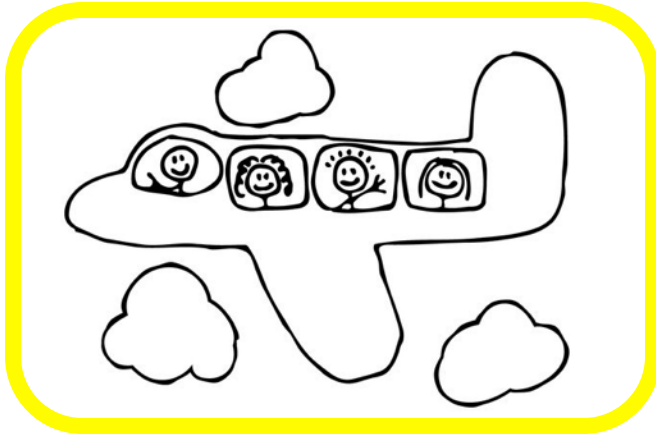
# TOPOLOGY



# Some benefits of analytics data

- No longer limited to what “we” think “they” need/do/etc. Discover how the app behaves across virtually all the population
- Lower cost of operations
- Real usage can help drive our testing and analysis; brings realism to our testing

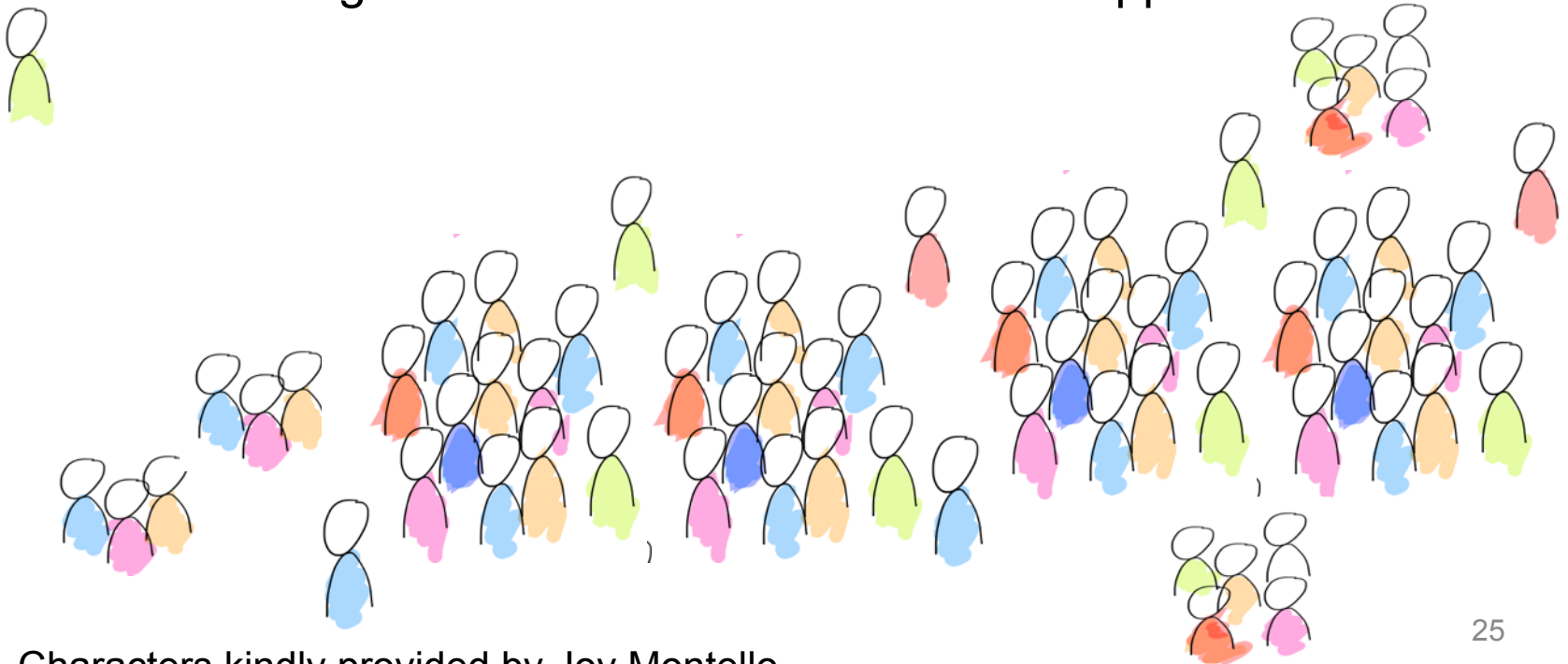
Offline



?

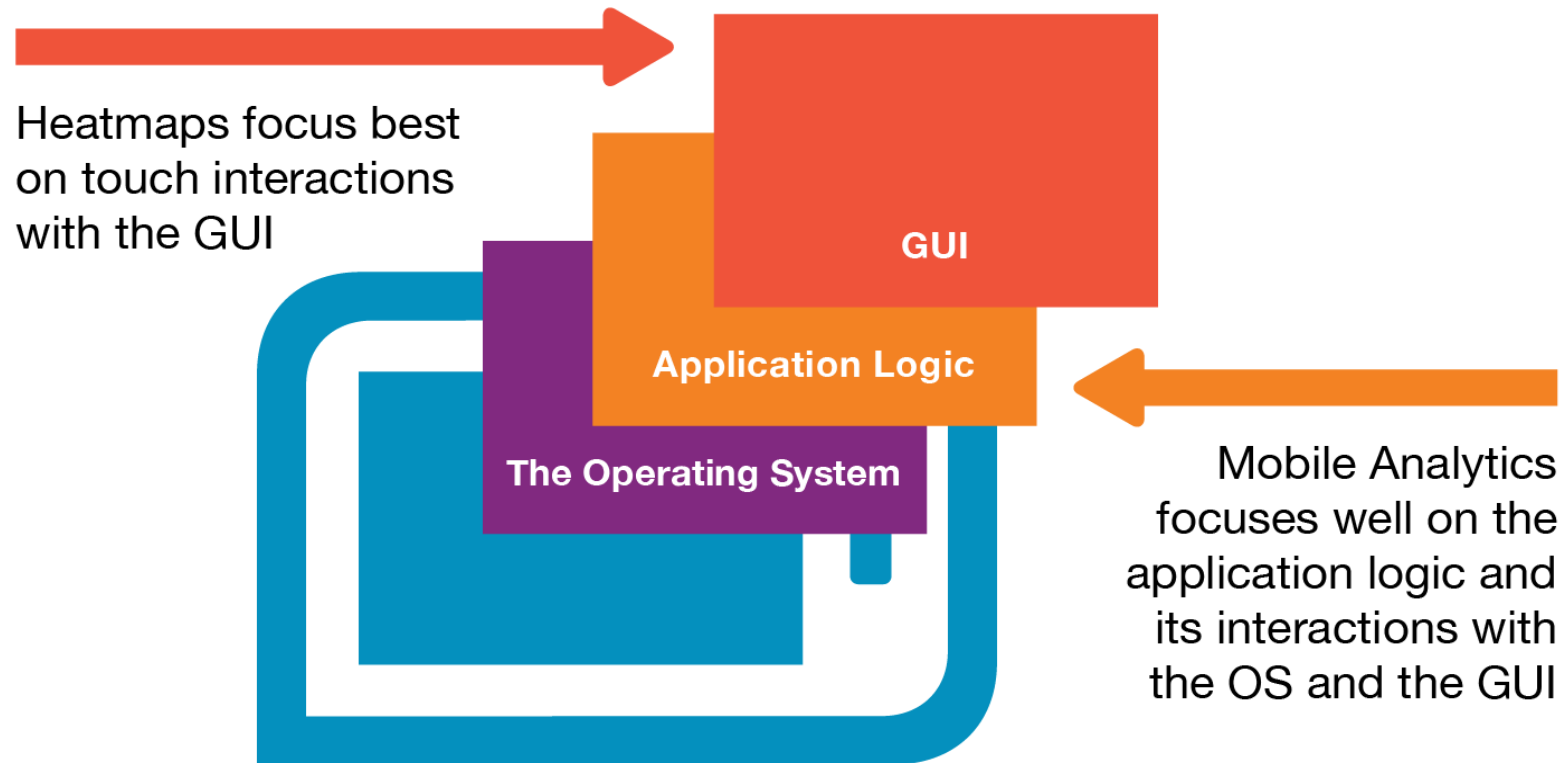
The -1% challenge

**Online** Digital feedback available when the app is used



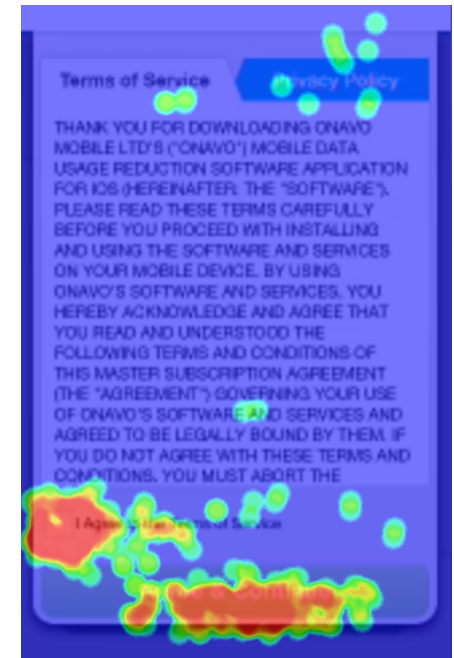
Characters kindly provided by Joy Montello.

# Layers of an App



Exploded view of the app running on the platform

# Heatmaps



Problematic UI

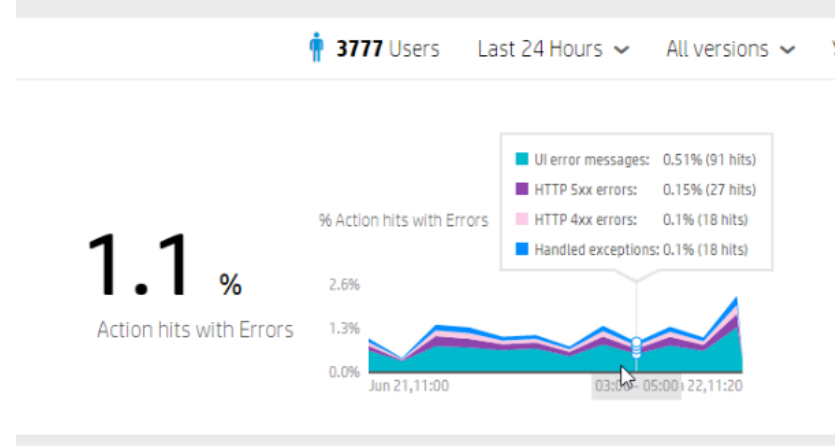
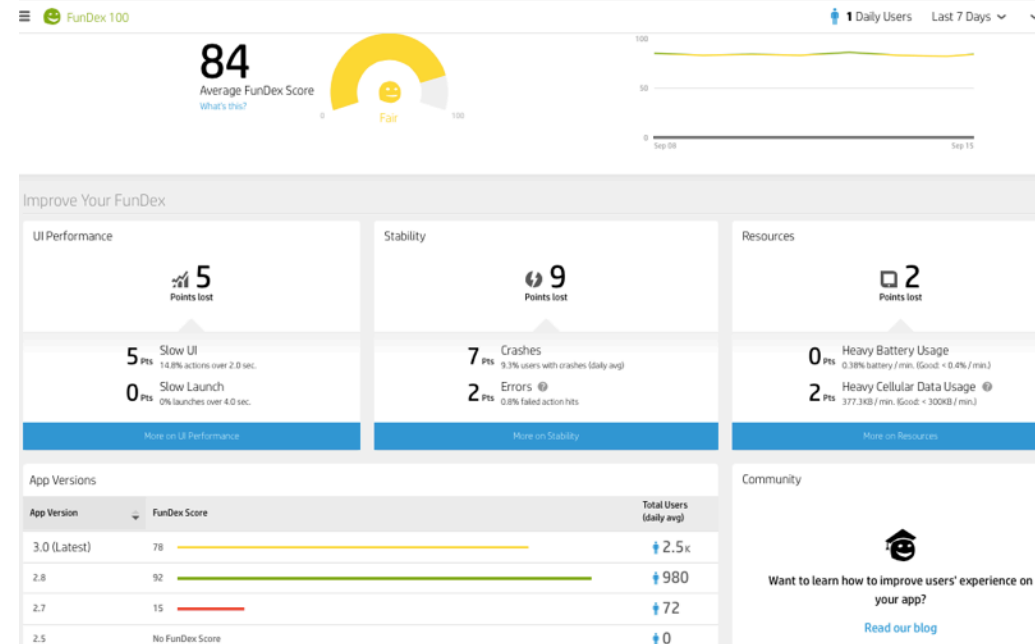
Heatmap

“8 Heatmap Tests that reveal visitor behavior.”

- [1. The Link Test](#) – Are visitors clicking on dead ends?
- [2. The Distraction Test](#) – Are irrelevant elements distracting visitors?
- [3. The Information Test](#) – Is there missing information from your page?
- [4. The Device Test](#) – Does your page work on different screen sizes?
- [5. The Depth Test](#) – Is all your content easily reachable?
- [6. The Engagement Test](#) – What are your site visitors really looking for?
- [7. The Fold Test](#) – Does your page have what it takes to keep your visitors?
- [8. The Header Test](#) – Is your page header helping or hurting your site?

Source: <https://www.hotjar.com/heatmaps>

Images source: Appsee.com



User Actions

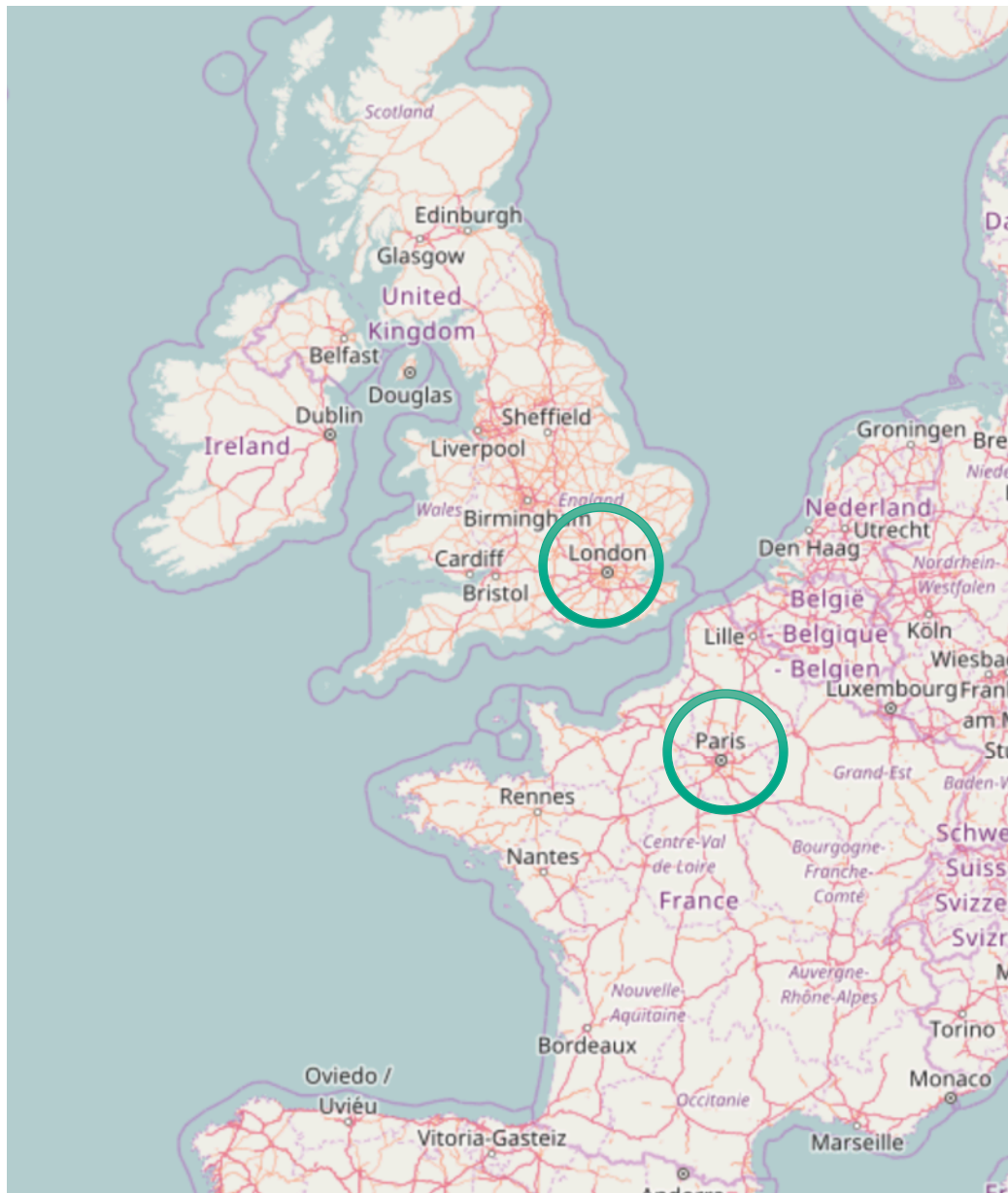
Most Used Actions

	Users (daily avg)	Hits (daily avg)	Screen	Action	Response Time (avg)	Users with crashes
	1	3	ContextThemeWrapper	Select item from drop down list	0.2s	0%
	1	1	ZimFileSelect	Tap the <u>Done</u> button	0.09s	0%
	1	1	Welcome to Kiwix!	Tap the <u>Roy-Charles-Demo.zim</u> item	0.7s	0%
	1	1	ZimFileSelect	Tap the <u>Rescan SD card</u> button	0.2s	0%
	1	1	KiwixSettings	Navigate back	0.0s	0%
★	1	1	KiwixMobile	Tap the <u>AppCompatEditText</u> button	0.1s	0%

Mobile Analytics

HPE AppPulse Mobile





Where the testers were

Where the users were

Type

Crashes

ANRs

Show hidden

YES

NO

Last reported

Last 7 days

Android version

All versions




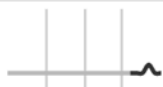


Application version

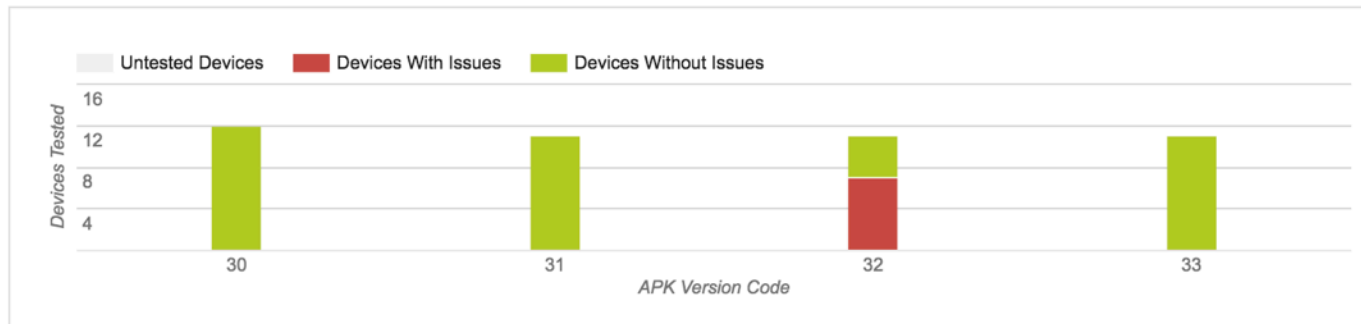
All versions

Device

Add filter

3 new crashes  | 5 total crashes

NAME	NEW 	REPORTS THIS WEEK	REPORTS TOTAL	LAST REPORTED
<b>java.lang.NullPointerException</b> in org.kiwix.kiwixmobile.ZimFileSelectFragment.deleteSpecificZi...	NEW		1	Oct 11, 1:08 AM
<b>java.lang.ClassNotFoundException</b> in dalvik.system.BaseDexClassLoader.findClass	NEW		1	Oct 9, 11:41 PM
<b>Native crash at /system/lib64/libc.so</b> in /system/lib64/libc.so (tgkill+8), /system/lib64/libc.so (pthread_...	NEW		1	Oct 9, 7:39 AM
<b>java.lang.IndexOutOfBoundsException</b> in java.util.ArrayList.throwIndexOutOfBoundsException			70	Oct 10, 8:41 AM
<b>Native crash at /data/dalvik-cache/arm/data@app@org.kiwi...</b> in /data/dalvik-cache/arm/data@app@org.kiwix.kiwixmobile-1 @...			2	Oct 9, 12:13 AM



## TEST RESULTS FOR APK VERSION 32

Devices With Issues 7	Devices Without Issues 4	Devices Tested 11
--------------------------	-----------------------------	----------------------

## DEVICES

All

Issues

	MODEL NAME	ANDROID VERSION	LOCALE	DESCRIPTION
❌	Moto G (1st Gen)	Android 4.4	Hindi	android.view.InflateException: Binary XML file line #60: Error inflating class Button
❌	LG G3	Android 4.4	English	android.view.InflateException: Binary XML file line #60: Error inflating class Button
❌	Nexus 5	Android 4.4	Arabic	-
❌	Galaxy Note3	Android 4.4	English	android.view.InflateException: Binary XML file line #60: Error inflating class Button
❌	HTC One (M8)	Android 4.4	English	-
❌	Moto G (2nd Gen)	Android 4.4	English	-
❌	Moto X (2nd Gen)	Android 4.4	English	-
✅	Nexus 7	Android 5.0	English	-
✅	Nexus 9	Android 5.0	English	-
✅	Nexus 5	Android 5.1	English	-
✅	Galaxy S6	Android 5.1	English	-

# Examples of information gleaned using mobile analytics

- **Battery drain varied by 3x** for similar hardware specifications
- Custom code added for **Kindle Fire** to reduce brightness
  - **40% less battery drain**
- Higher network latencies reduced interactivity by 40%
- Users preferred Wi-Fi
  - 69% for Parallel Kingdom, 58% for StudyBlue
- Tablets 2x usage
- Pull-out keyboard also increased usage

# How many devices are enough?

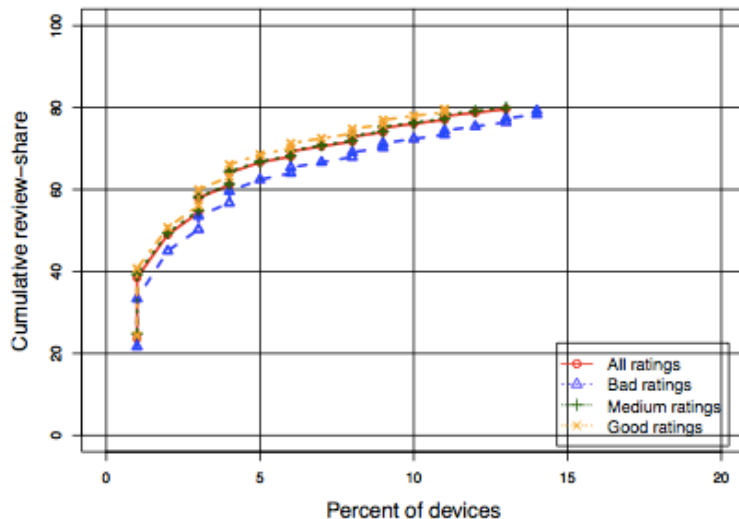
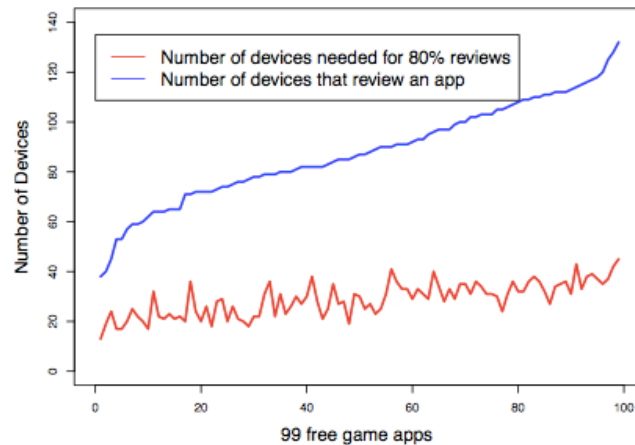
Perennial Question





# Enough for 80% of reviews

“Prioritizing the devices to test your app on : A case study of android game apps”



<= Free

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## Prioritizing The Devices To Test Your App On: A Case Study Of Android Game Apps

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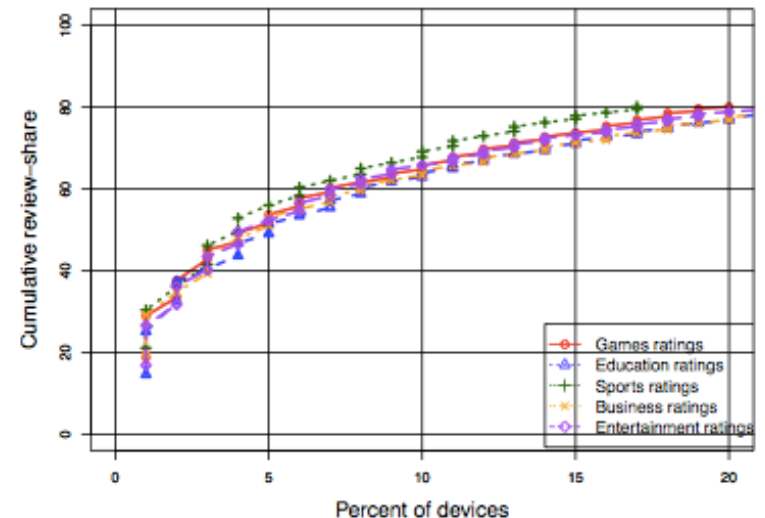
### ABSTRACT

Star ratings that are given by the users of mobile apps directly impact the revenue of its developers. At the same time, for popular platforms like Android, these apps must run on hundreds of devices increasing the chance for device-specific problems. Device-specific problems could impact the rating assigned to an app, given the varying capabilities of devices (e.g., hardware and software). To fix device-specific problems developers must test their apps on a large number of Android devices, which is costly and inefficient.

Therefore, to help developers pick which devices to test their apps on, we propose using the devices that are mentioned in user reviews. We mine the user reviews of 99 free game apps and find that, apps receive user reviews from a large number of devices: between 38 to 132 unique devices. However, most of the reviews (80%) originate from a small subset of devices (on average, 33%). Furthermore, we find that developers of new game apps with no reviews can use the review data of similar game apps to select the devices that they should focus on first. Finally, among the set of devices that generate the most reviews for an app, we find that some

and large companies are developing an enormous amount of applications (called mobile apps), designed to run on Android devices. However, the top-rated or the featured apps in the app markets, are the apps with the most downloads, and hence the most revenue [2, 3]. Also the app market is very competitive, especially for game app developers who have to compete with almost 120,000 game apps already in the Google Play store – more than any other category of apps. To compete in this environment, developers need to get (and maintain) good ratings for their apps [2]. This can be difficult since users are easily annoyed by buggy apps, and that annoyance could lead to bad ratings [4, 5]. Hence, app developers need to test their apps thoroughly on different devices to avoid a poor rating.

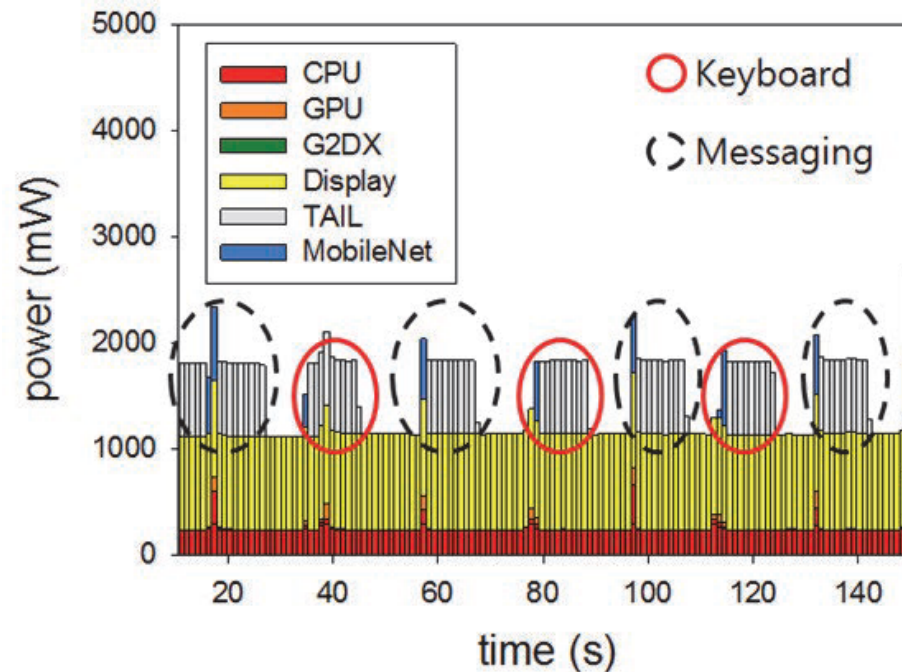
To make matters worse, there exists a large number of Android devices, each with its own nuances. In fact, dealing with device specific issues of (the many) Android devices is considered one of the biggest challenges developers face when creating an Android app [6]. A 2013 survey from Appcelerator, which has aggregated results from similar such surveys in the past three years, shows that



# Necessary but not sufficient

Listening is a means to an end

# Correlation? Causation? Appropriate?



From: User Interaction-based Profiling System for Android Application Tuning  
Figure © ACM

# Beware the automation bias

“When presented with an automated solution 40% of pilots reasoned less or none at all”

Automation Bias in Intelligent Time Critical Decision Support Systems

<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.91.2634&rep=rep1&type=pdf>

# We can use what we learn

To improve our practices, the app, and the UX

# Testing based on analytics data

## Testing based on information

- Popularity & volumes
- Locales
- User-flows, activities, etc.
- Crashes

Aims include

- Fast reproduction
- 1<sup>st</sup>-hand learning in controlled env.

## Testing based on insights

- Delta's (rate of change)
- Crossing thresholds
- Anomalies

Aims include:

- Maximising insights, agility, and ability to adapt & respond





<http://uk.businessinsider.com/facebook-2g-tuesdays-to-slow-employee-internet-speeds-down-2015-10>

# Use similar devices to your users

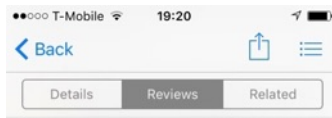


Windows Phone

**BlackBerry**<sup>TM</sup>

[wired.com/2015/10/facebook-workers-ditch-iphones-in-push-for-world-conquest/](http://wired.com/2015/10/facebook-workers-ditch-iphones-in-push-for-world-conquest/)

# Assess & Respond to Feedback



Two-Star feedback is the most serious and actionable.

**TABLE 3**

**The most frequent and impactful complaint types.\***

Complaint type	Most frequent		Most impactful	
	Rank	Median (%)	Rank	1:2 star ratio†
Functional Error	1	26.68	7	2.10
Feature Request	2	15.13	12	1.28
App Crashing	3	10.51	4	2.85
Network Problem	4	7.39	6	2.25
Interface Design	5	3.44	10	1.50
Feature Removal	6	2.73	3	4.23
Hidden Cost	7	1.54	2	5.63
Compatibility	8	1.39	5	2.44
Privacy and Ethics	9	1.19	1	8.56
Unresponsive App	10	0.73	11	1.40
Uninteresting Content	11	0.29	9	1.50
Resource Heavy	12	0.28	8	2.00
Not Specific	—	13.28	—	3.80

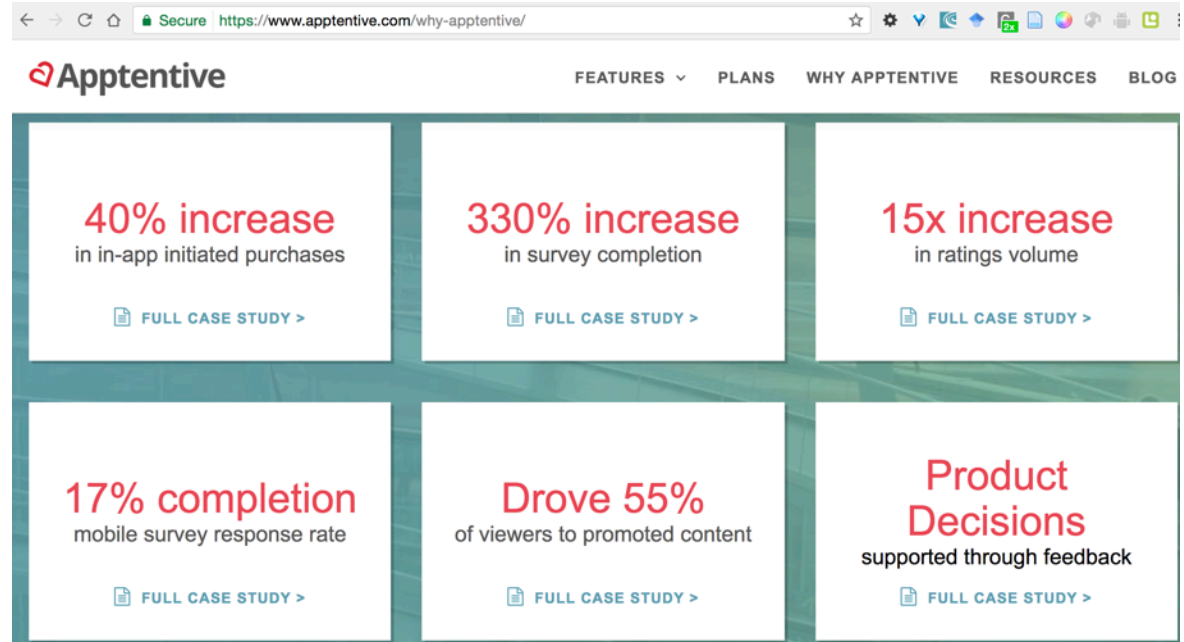
\* All results are at the 95 percent confidence level.

† This column indicates the ratio of one- to two-star ratings across all apps.

Khalid, H., Shihab, E., Nagappan, M., & Hassan, A. E. (2015). What do mobile app users complain about?. *Software, IEEE*, 32(3), 70-77.

96% of companies don't respond to feedback on App Stores

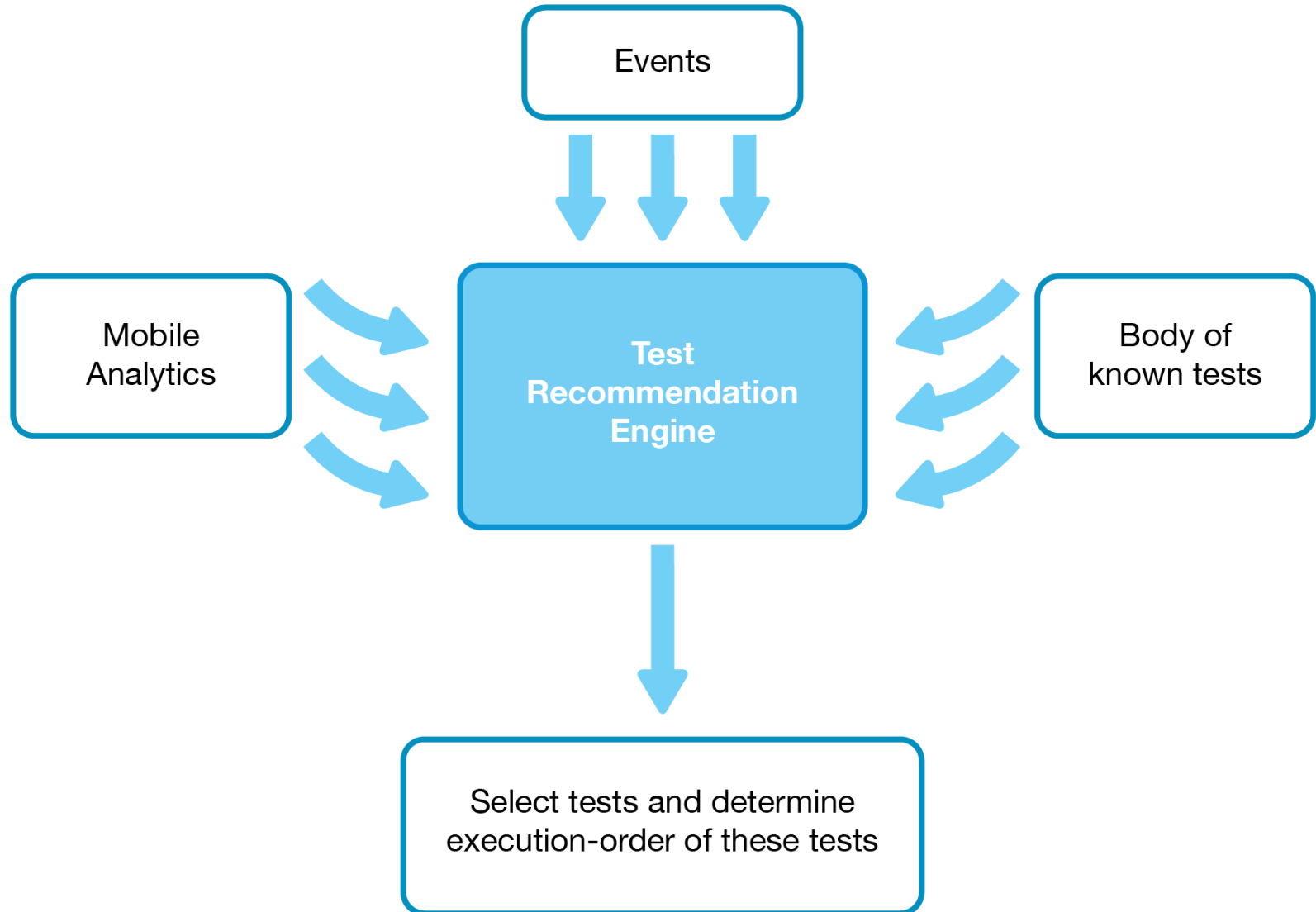
# Improve the feedback cycles



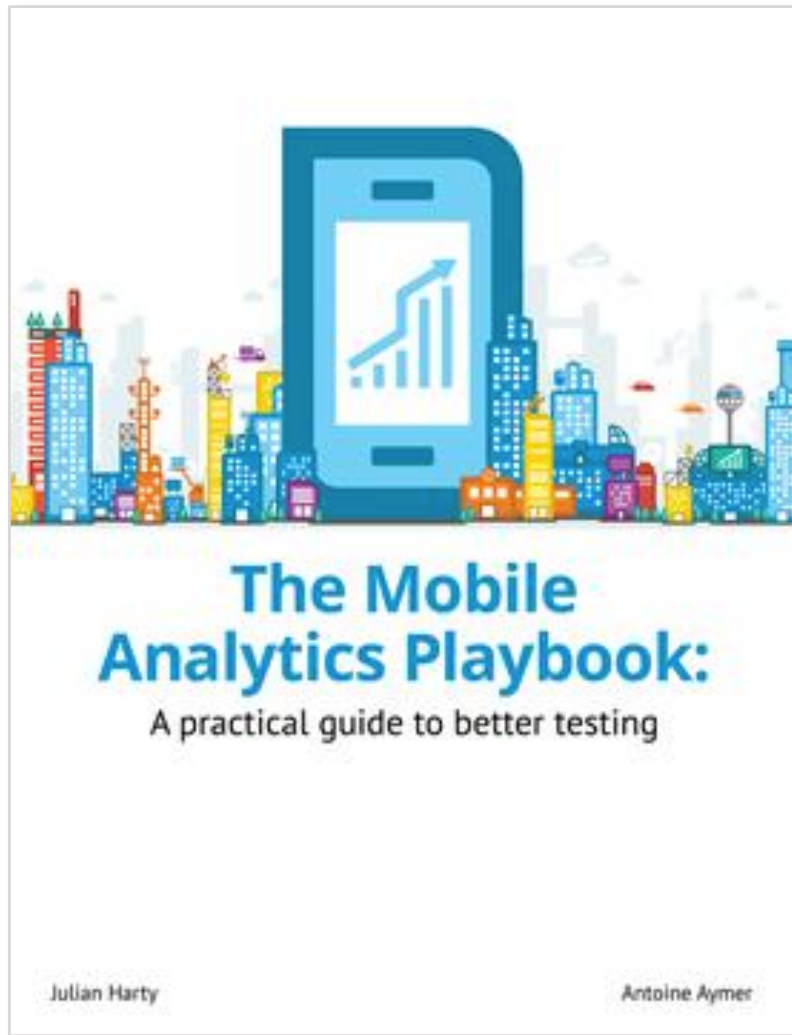
<https://www.apptentive.com/why-apptentive/>

- **Enable** direct feedback from end users
- **Encourage** their feedback
- **Academic Research** Mobile Twin Peaks paper @MobileSOFT 2017

# Test Recommendation Engine



## READ THIS BOOK 😊



<http://themobileanalyticsplaybook.com/>

## ASK QUESTIONS

Questions now?

Questions later...

[julianharty@gmail.com](mailto:julianharty@gmail.com)

## GET INVOLVED

[github.com/julianharty/app-store-reviews-app](https://github.com/julianharty/app-store-reviews-app)

# Further reading and research

The opensource project

<http://code.google.com/p/web-accessibility-testing>

<https://github.com/julianharty/web-accessibility-testing/>

Finding Usability Bugs with Automated Tests

<http://queue.acm.org/detail.cfm?id=1925091>

Fighting Layout Bugs

<http://code.google.com/p/fighting-layout-bugs/>

Experiences Using Static Analysis to Find Bugs

<http://www.google.com/research/pubs/pub34339.html>

My blog

<http://blog.bettersoftwaretesting.com/>

“Beware of Automation Bias” by M.L. Cummings

<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.91.2634&rep=rep1&type=pdf>

Designing and Engineering Time by Steven Stow

ISBN 978-0-321-50918-5

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<http://www.aim.org/wp-content/uploads/2013/09/china-cell-phone-users.jpg>

<http://cdn2.business2community.com/wp-content/uploads/2014/01/hellaphones1.png>

<http://www.business2community.com/mobile-apps/25-facts-show-mobile-become-biggest-media-advertising-channel-world-0744628#s1I8LIDzm0IKC47k.97>

<http://www.theatlantic.com/technology/archive/2010/11/cell-phone-users-through-history/66363/>

<https://newsatjama.jama.com/2013/03/15/mobile-device-users-keep-your-eyes-on-the-road-your-hands-upon-the-wheel/>

<http://devicelab.fi/>

<https://mobiletestingblog.com/>

<http://crayonsandcheckbooks.blogspot.in/2010/09/traveling-with-kids.html>