CHABADA:
Checking App Behavior Against App Descriptions

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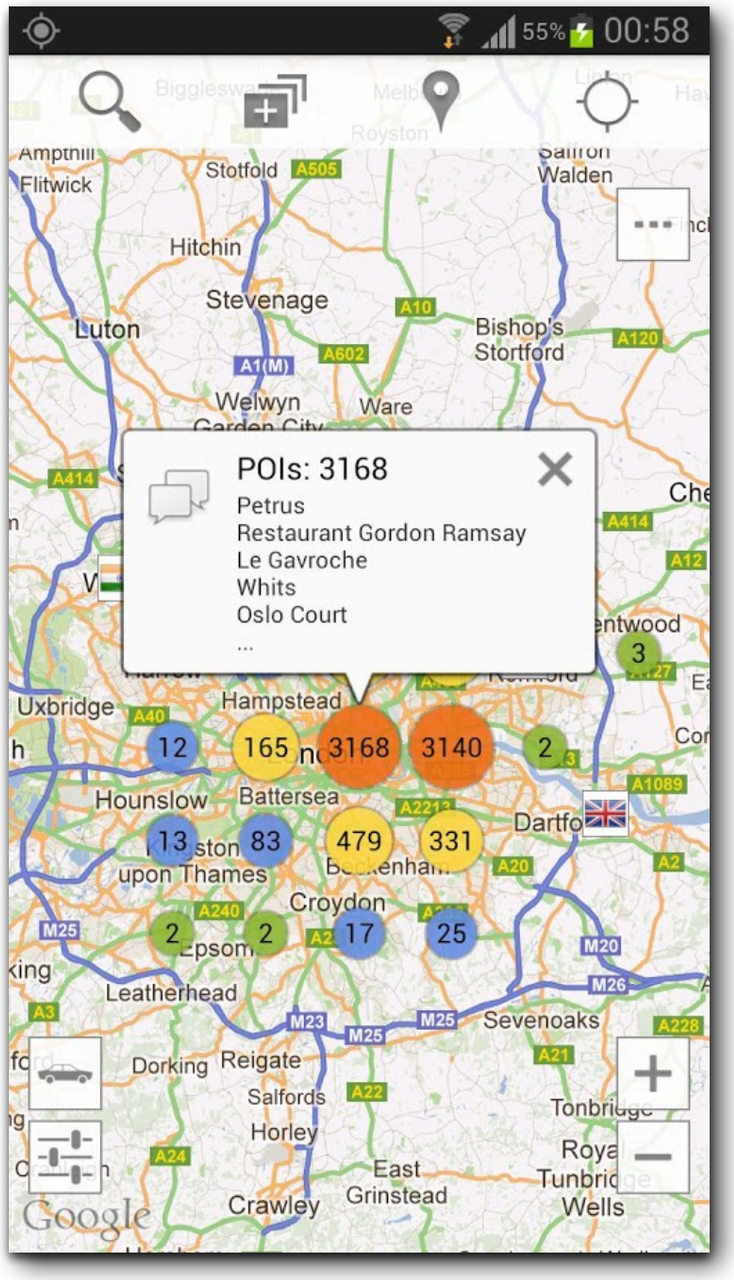
Saarland University, Germany

joint work with Konstantin Kuznetsov, Ilaria Tavecchia, Florian Gross and Andreas Zeller


S

London Restaurants



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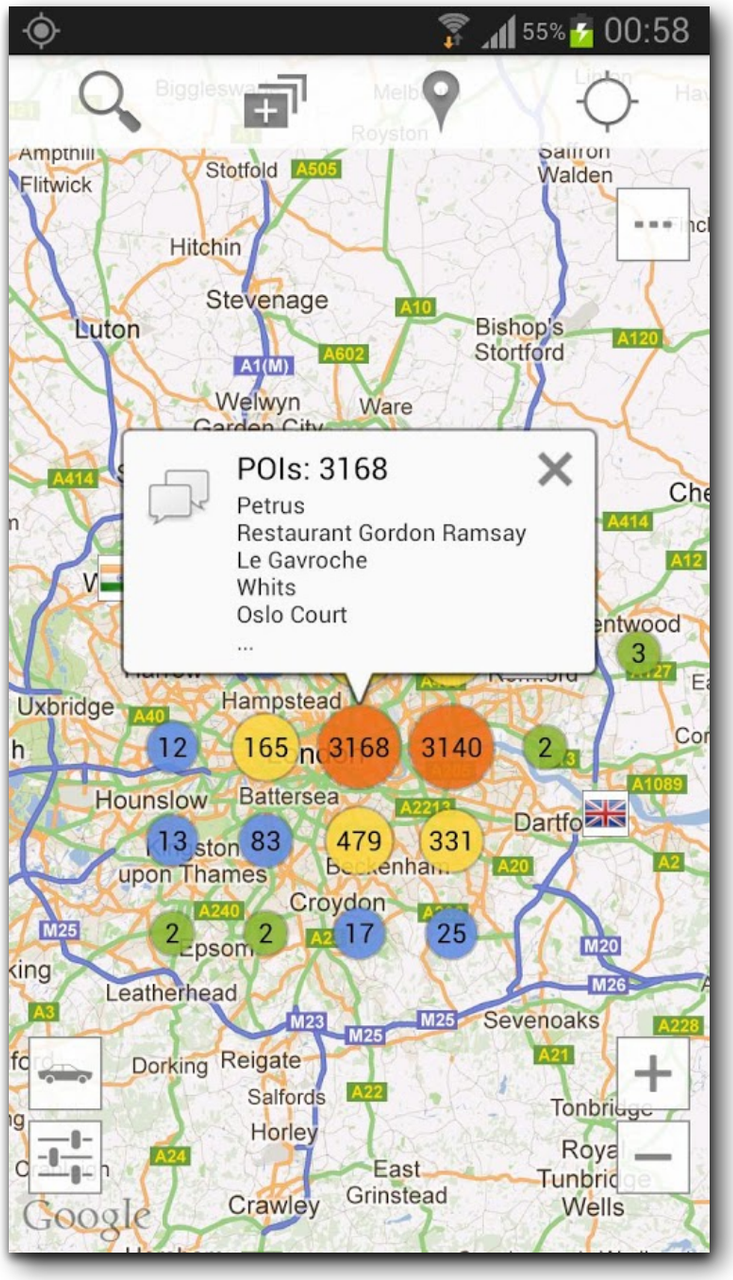
• You can use it with Navigation

Keywords: london, restaurants, bars, pubs, food, breakfast, lunch, dinner, meal, eat, supper, street view, navigation

London Restaurants



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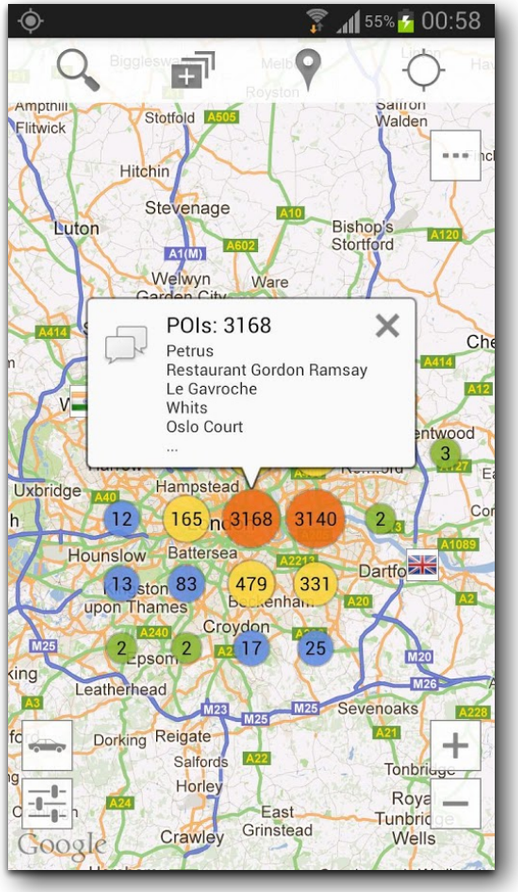
Also sends out *account info*
Also sends out *mobile phone number*
Also sends out *your device ID*

What is malicious?



London Restaurants

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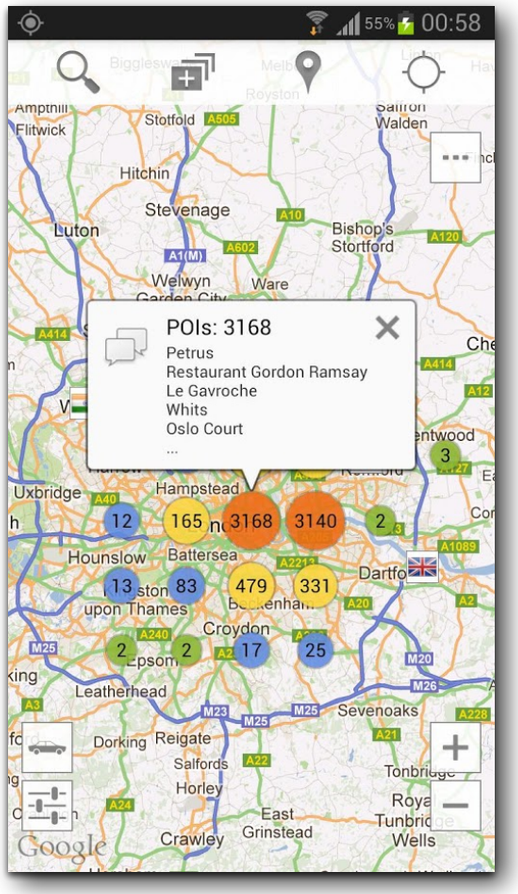

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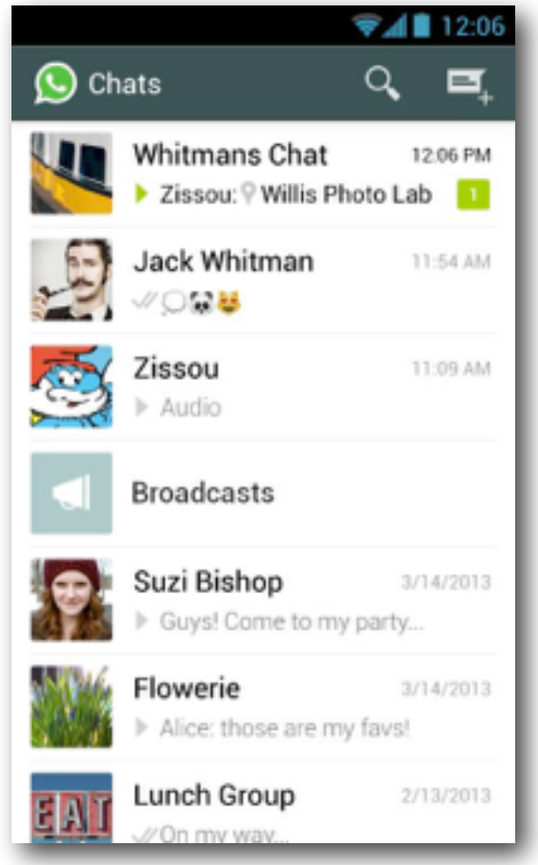
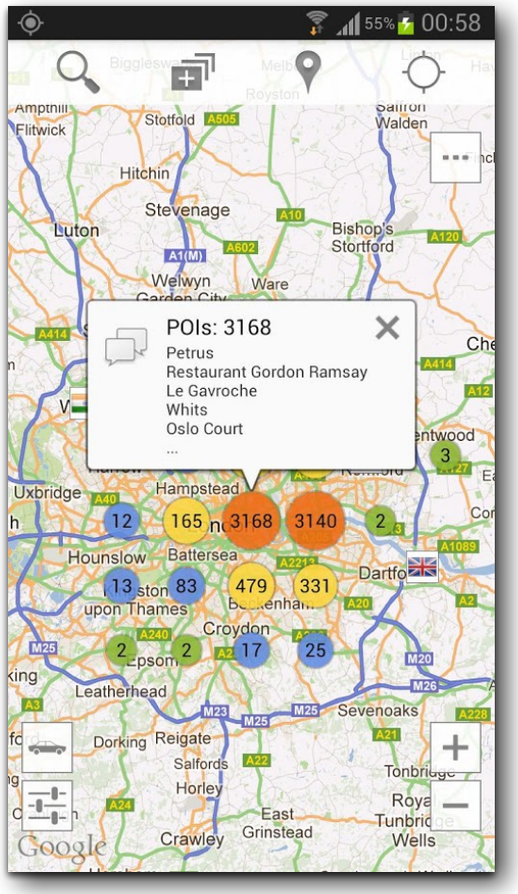


WhatsApp messenger

What is malicious?



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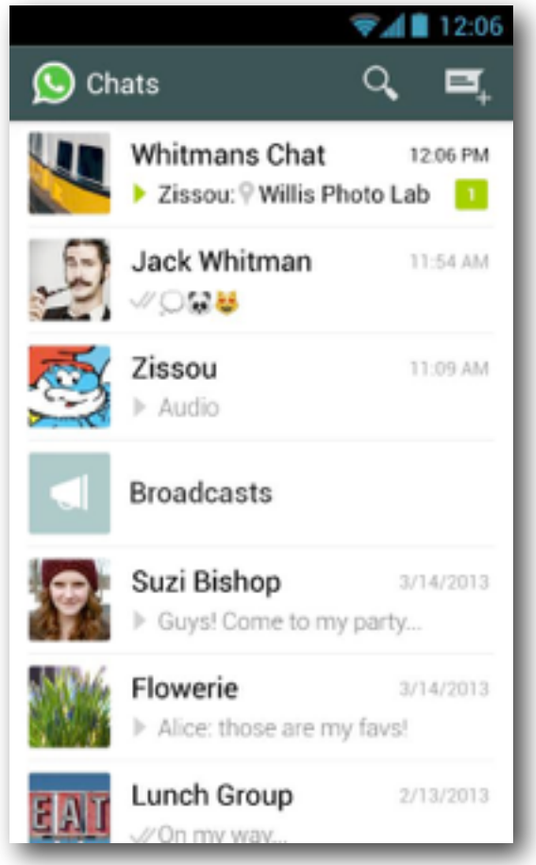
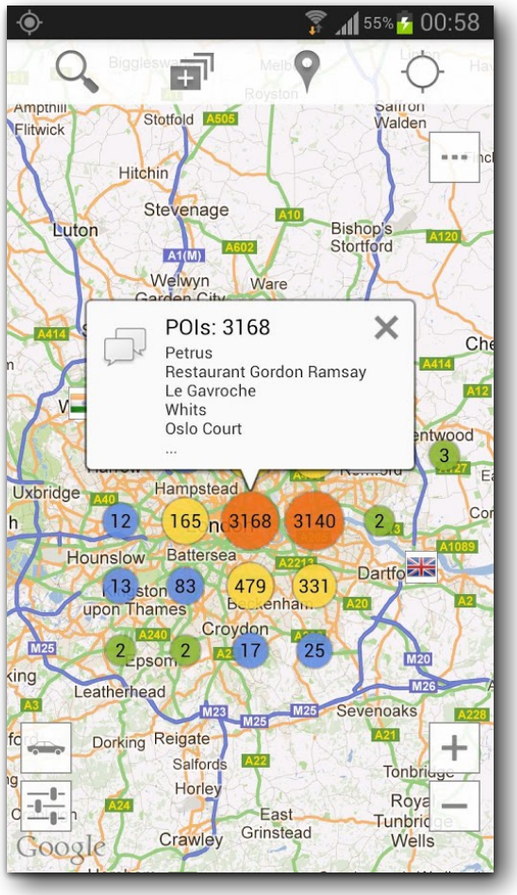


WhatsApp messenger

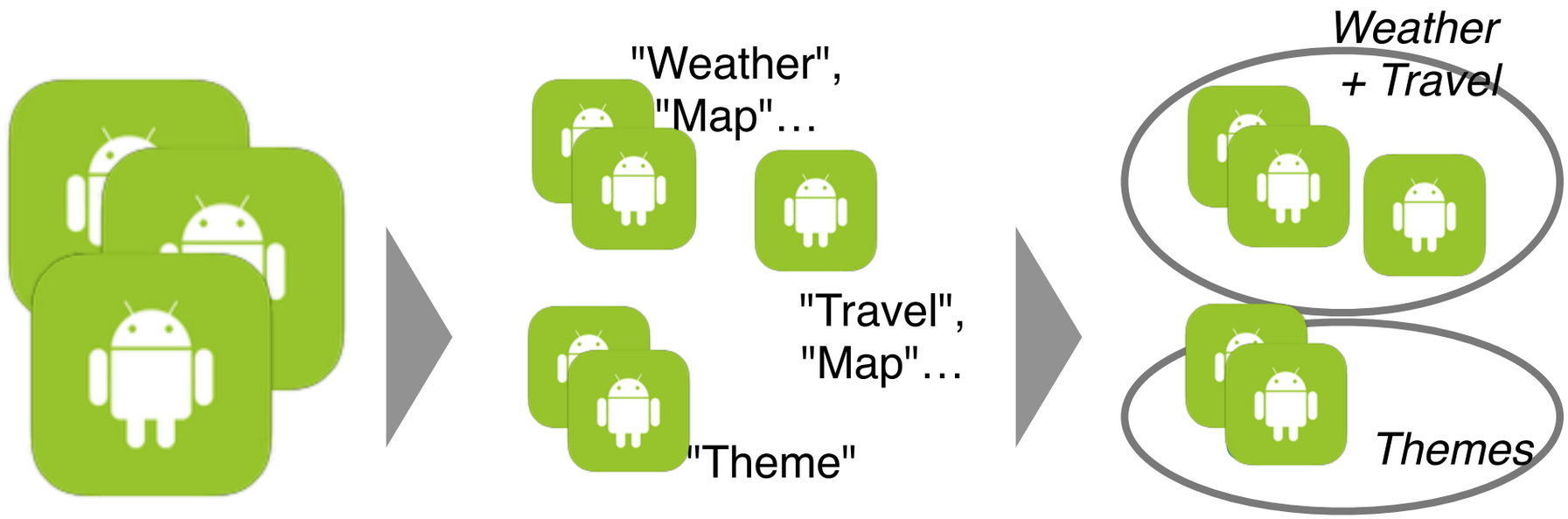
What is normal?



London Restaurants

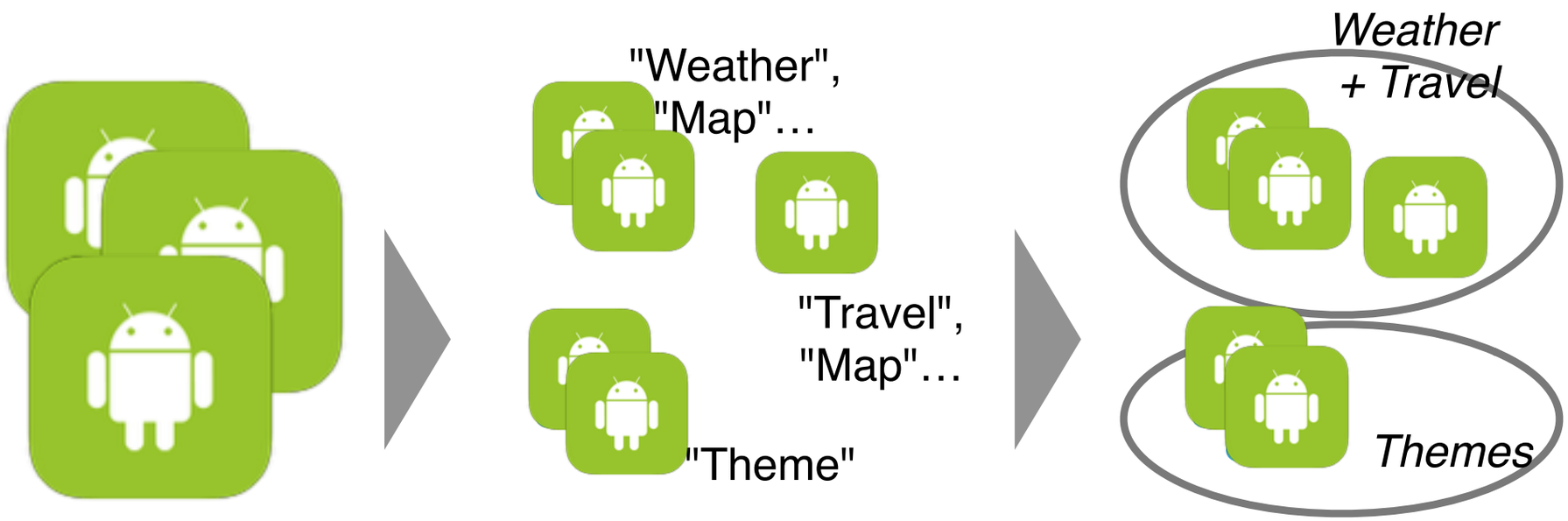
- "London Restaurants" is a "travel" app
- For "travel" apps, sending account infos is *abnormal*
- For "messaging" apps, this is far *more likely*

CHABADA



1. App collection **2. Topics** **3. Clusters**

CHABADA



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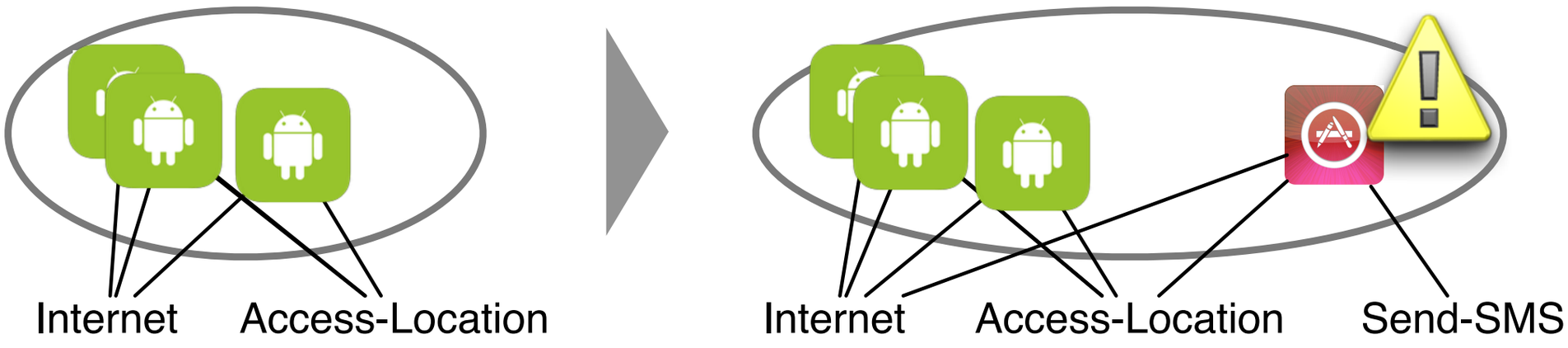

4. APIs **5. Outliers**

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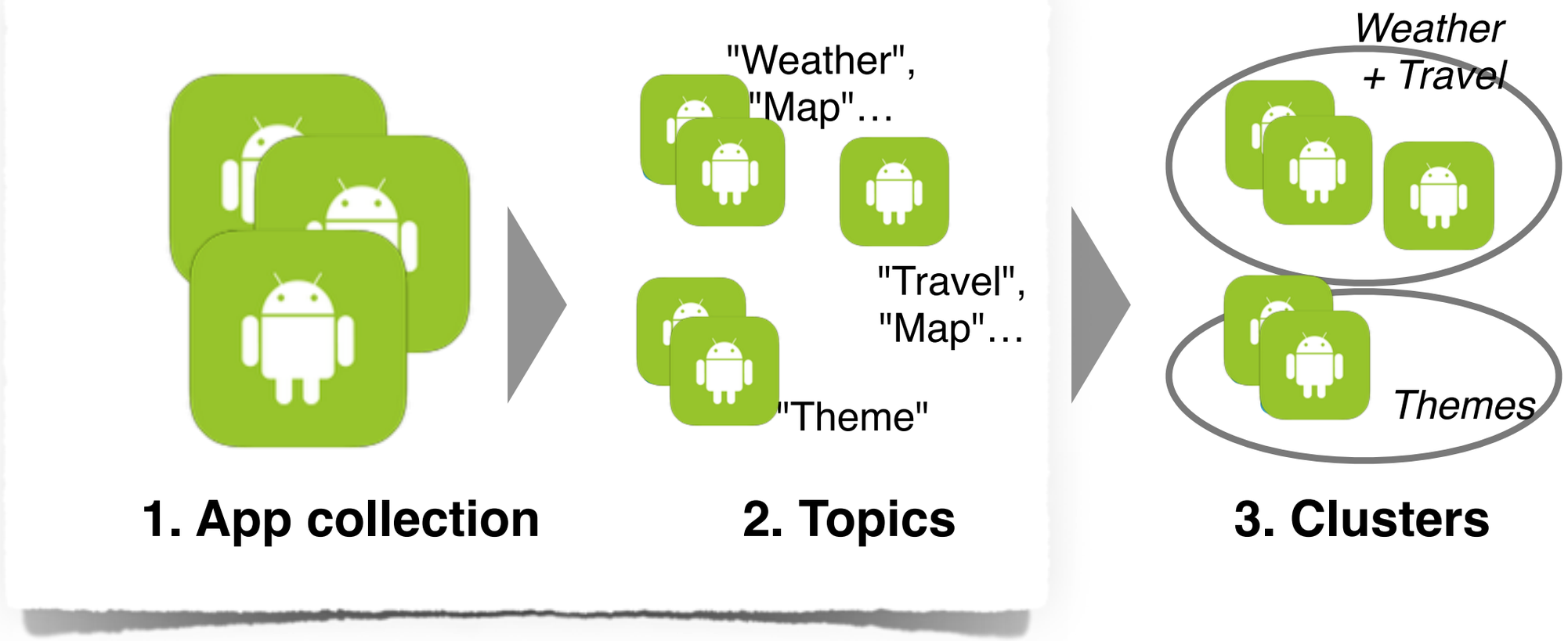

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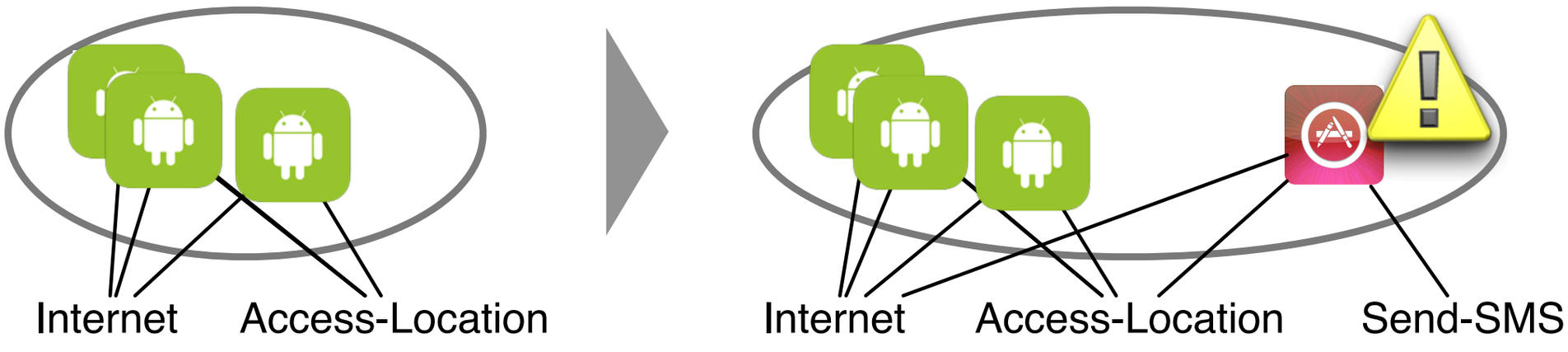

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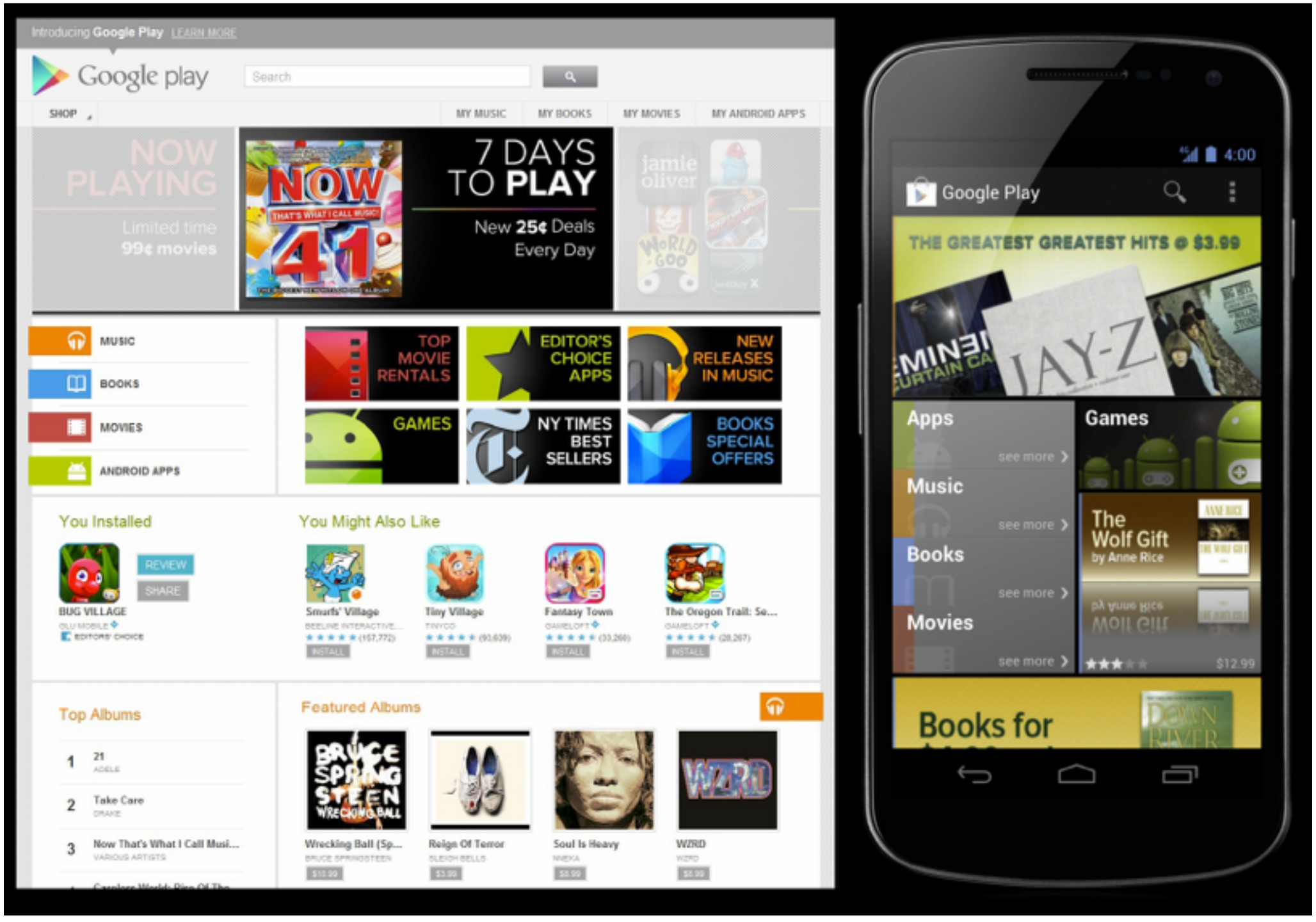
Apps collection



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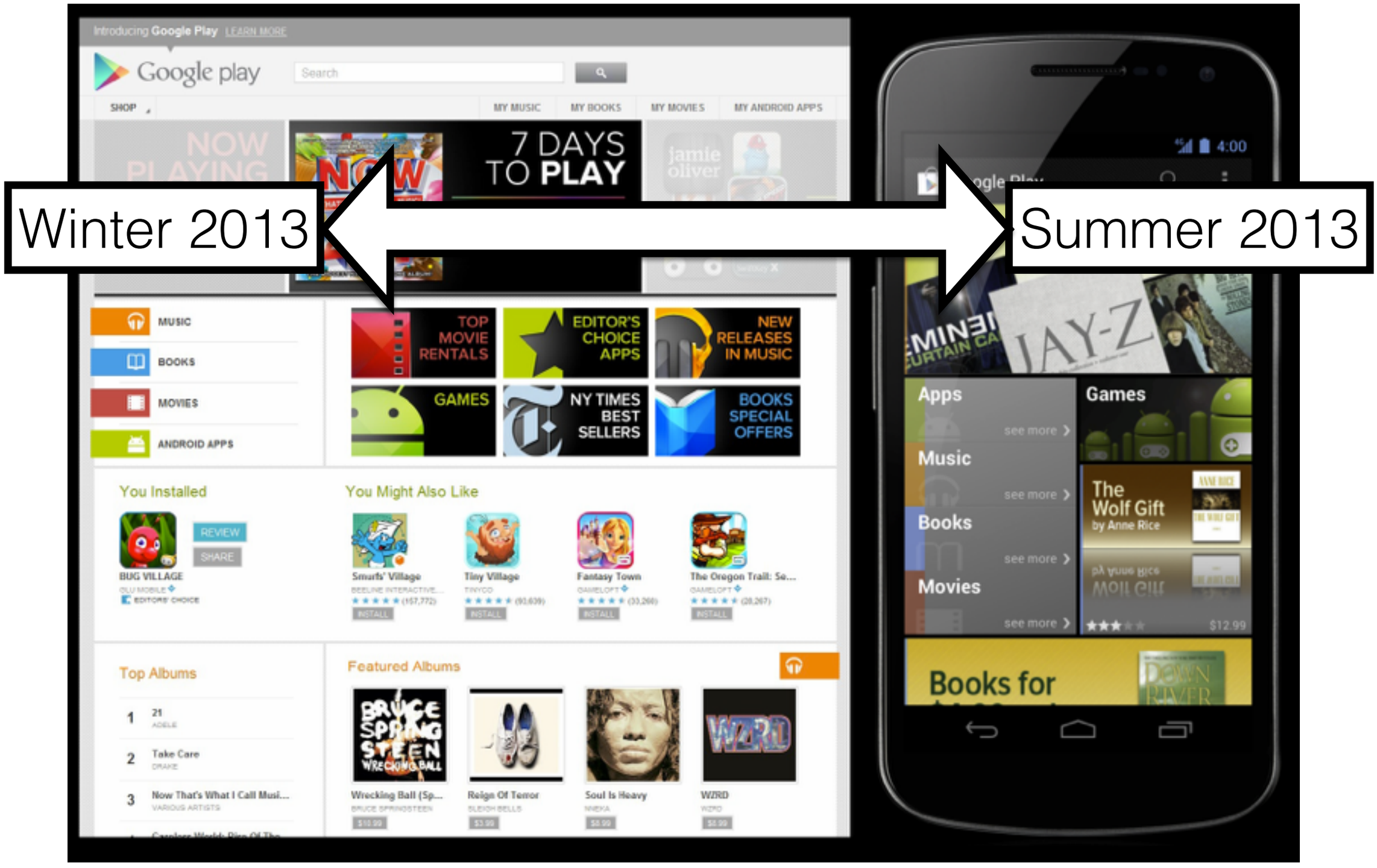
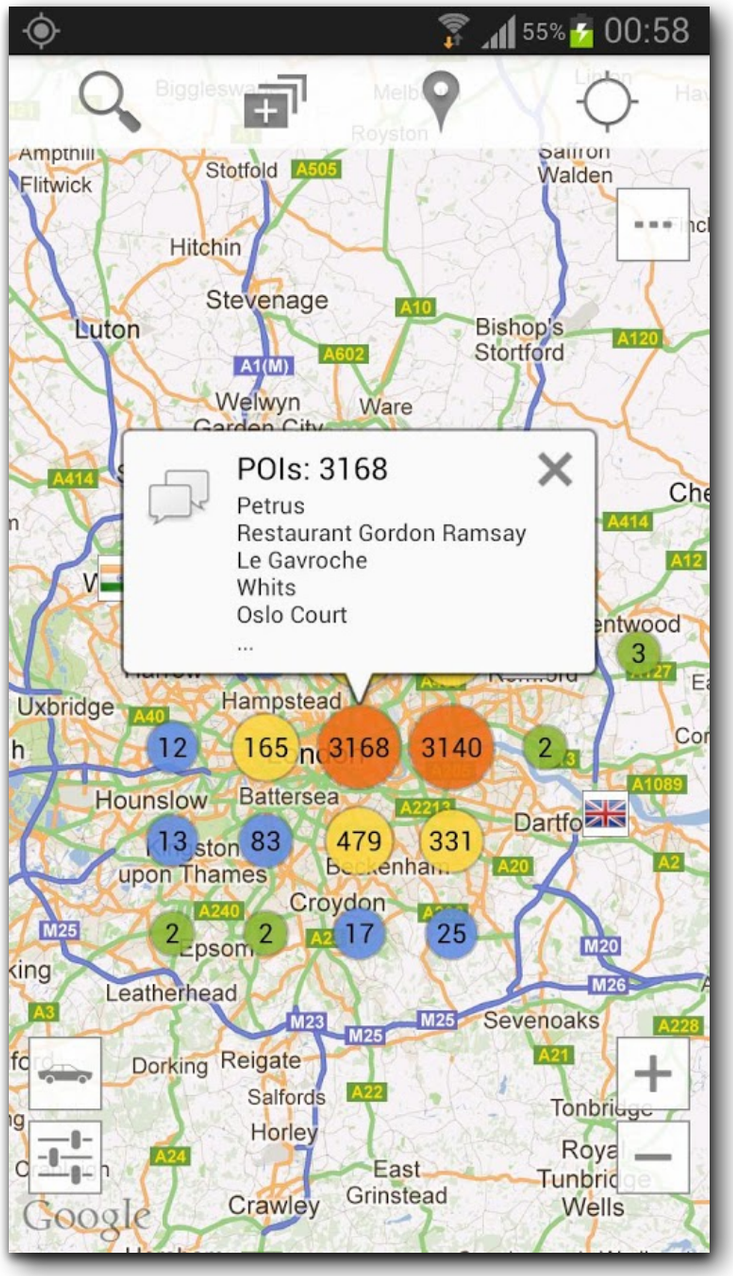


Apps collection

Stemming



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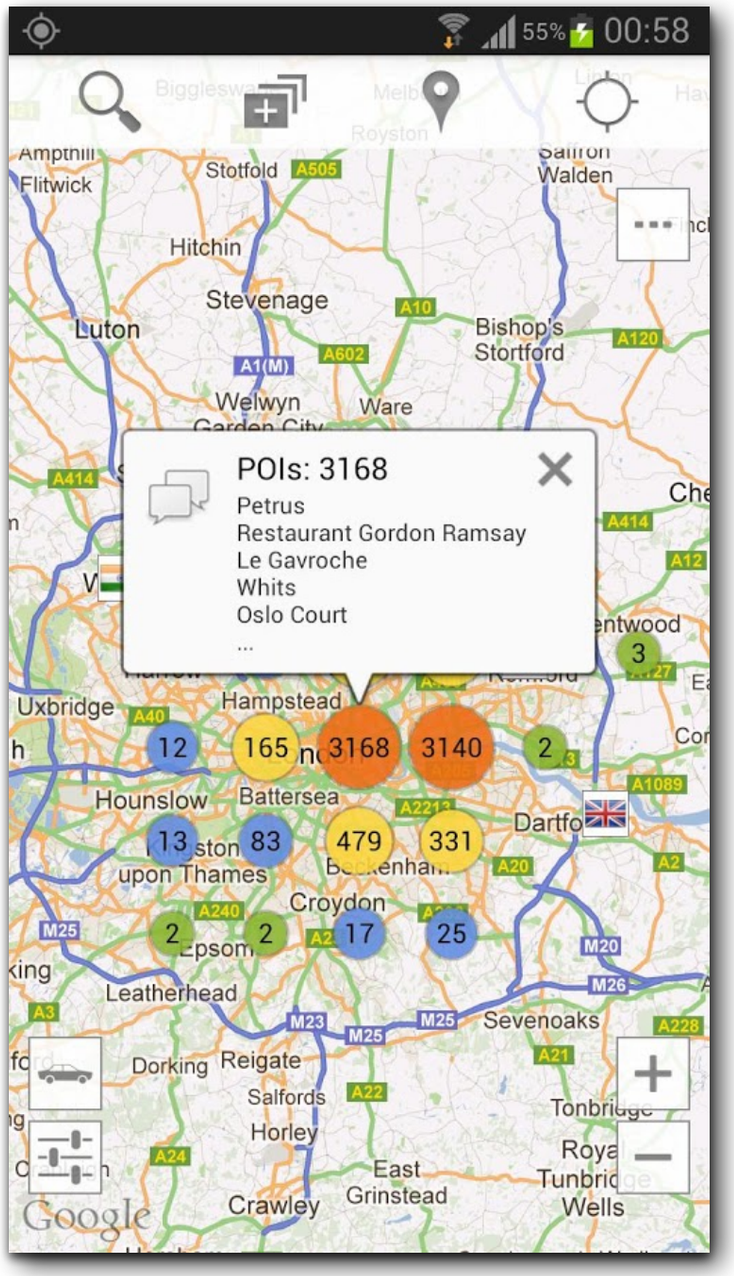

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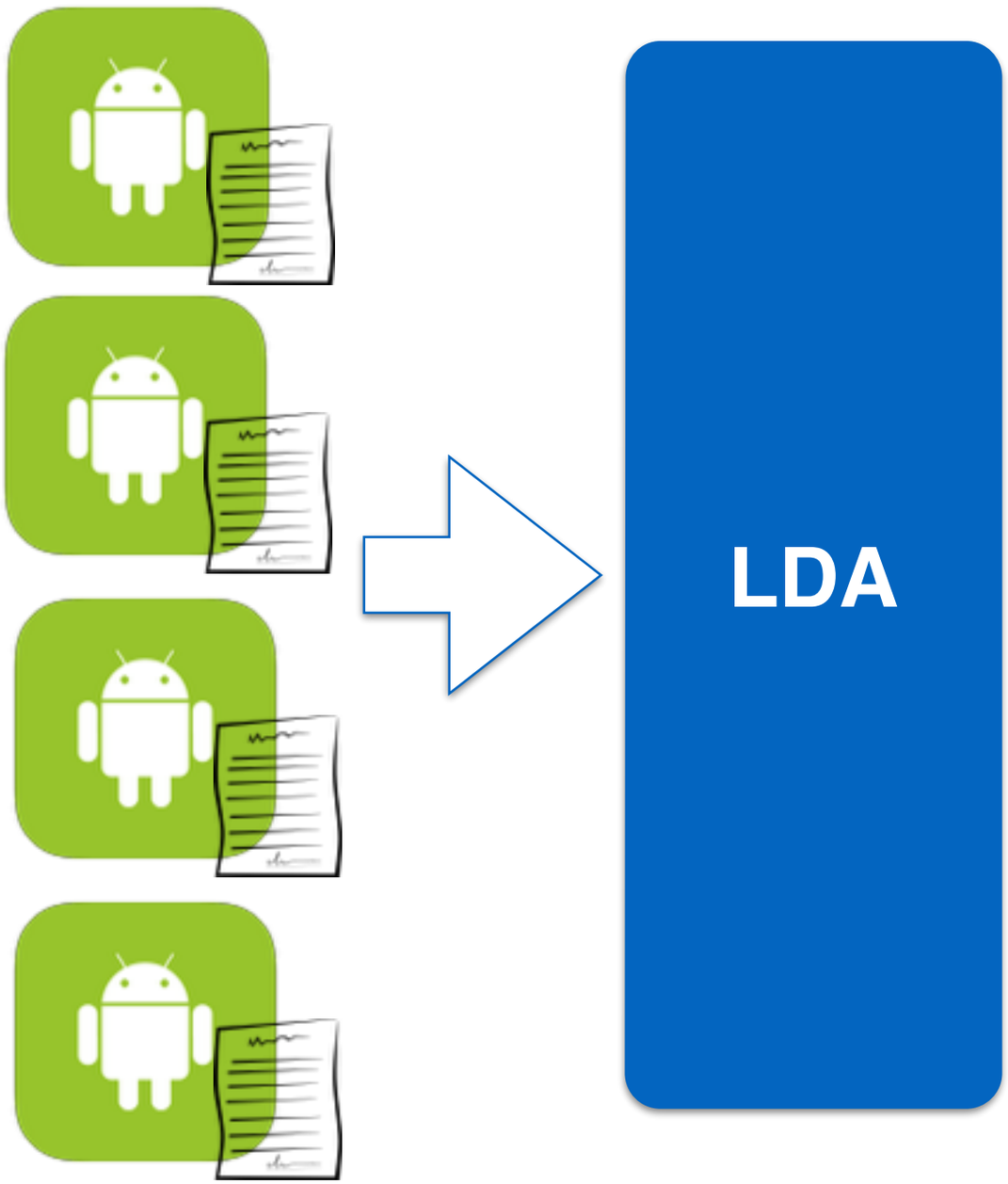
Topic Analysis

Topic Analysis



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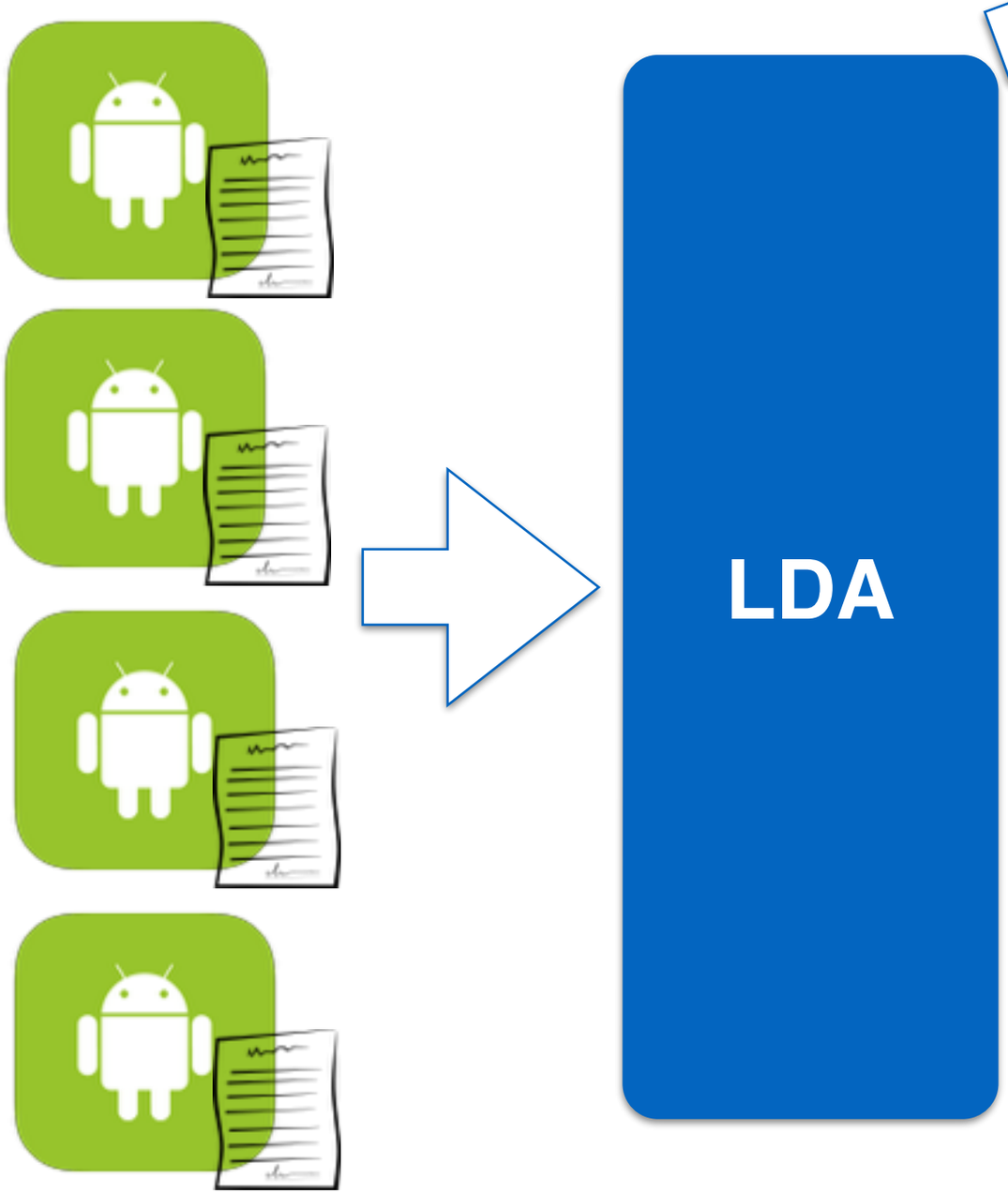
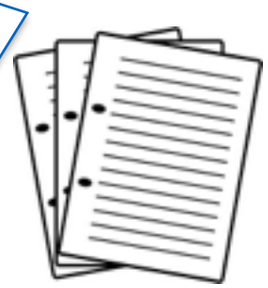


T1: [map, navigation, street,tour, …]

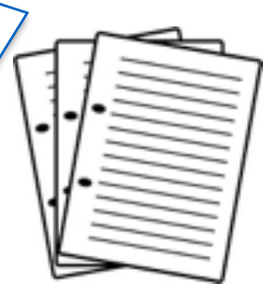


T2: [weight, body, exercise,run …]

Topic Analysis

LDA

T1: [map, navigation, street,tour, …]



T2: [weight, body, exercise,run …]

T1: 80%, T2: 20%

T2:90%, T1: 10%

T1: 70%, T2: 30%

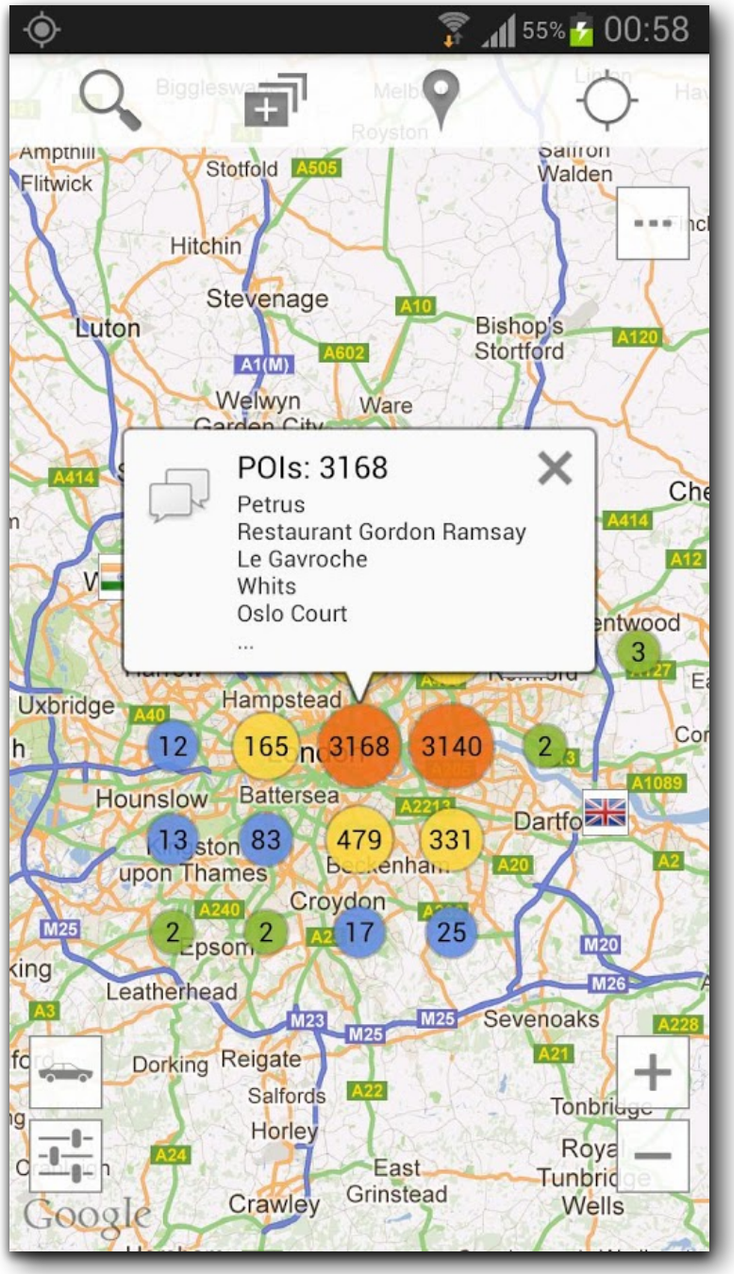
T2:80%, T1: 20%

Topics

Id	Assigned Name	Most Representative Words (stemmed)
0	“personalize”	galaxi, nexu, device, screen, effect, instal, customis
1	“game and cheat sheets”	game, video, page, cheat, link, tip, trick
2	“money”	slot, machine, money, poker, currenc, market, trade, stock, casino coin, finance
3	“tv”	tv, channel, countri, live, watch, germani, nation, bbc, newspap
4	“music”	music, song, radio, play, player, listen
5	“holidays” and religion	christmas, halloween, santa, year, holiday, islam, god
6	“navigation and travel”	map, inform, track, gps, navig, travel
7	“language”	language, word, english, learn, german, translat
8	“share”	email, ad, support, facebook, share, twitter, rate, suggest
9	“weather and stars”	weather, forecast, locate, temperatur, map, city, light
10	“files and video”	file, download, video, media, support, manage, share, view, search

13	“design and art”	life, peopl, natur, form, feel, learn, art, design, uniqu, effect, modern
14	“food and recipes”	recip, cake, chicken, cook, food
15	“personalize”	theme, launcher, download, install, icon, menu
16	“health”	weight, bodi, exercise, diet, workout, medic
17	“travel”	citi, guid, map, travel, flag, countri, attract
18	“kids and bodies”	kid, anim, color, girl, babi, pictur, fun, draw, design, learn
19	“ringtones and sound”	sound, rington, alarm, notif, music
20	“game”	game, plai, graphic, fun, jump, level, ball, 3d, score
21	“search and browse”	search, icon, delet, bookmark, link, homepag, shortcut, browser
22	“battle games”	story, game, monster, zombi, war, battle
23	“settings and utils”	screen, set, widget, phone, batteri
24	“sports”	team, football, leagu, player, sport, basketbal
25	“wallpapers”	wallpap, live, home, screen, background, menu
26	“connection”	device, connect, network, wifi, blootooth, internet, remot, server
27	“policies and ads”	live, ad, home, applovin, notif, data, polici, privacy, share, airpush, advertis
28	“popular media”	seri, video, film, album, movi, music, award, star, fan, show, gangnam, top, bieber
29	“puzzle and card games”	game, plai, level, puzzl, player, score, challeng, card

London Restaurant Topics



look london restaur search bar pub just applic fun

inform can search need everi type food want french

british chines indian etc car bicycl walk

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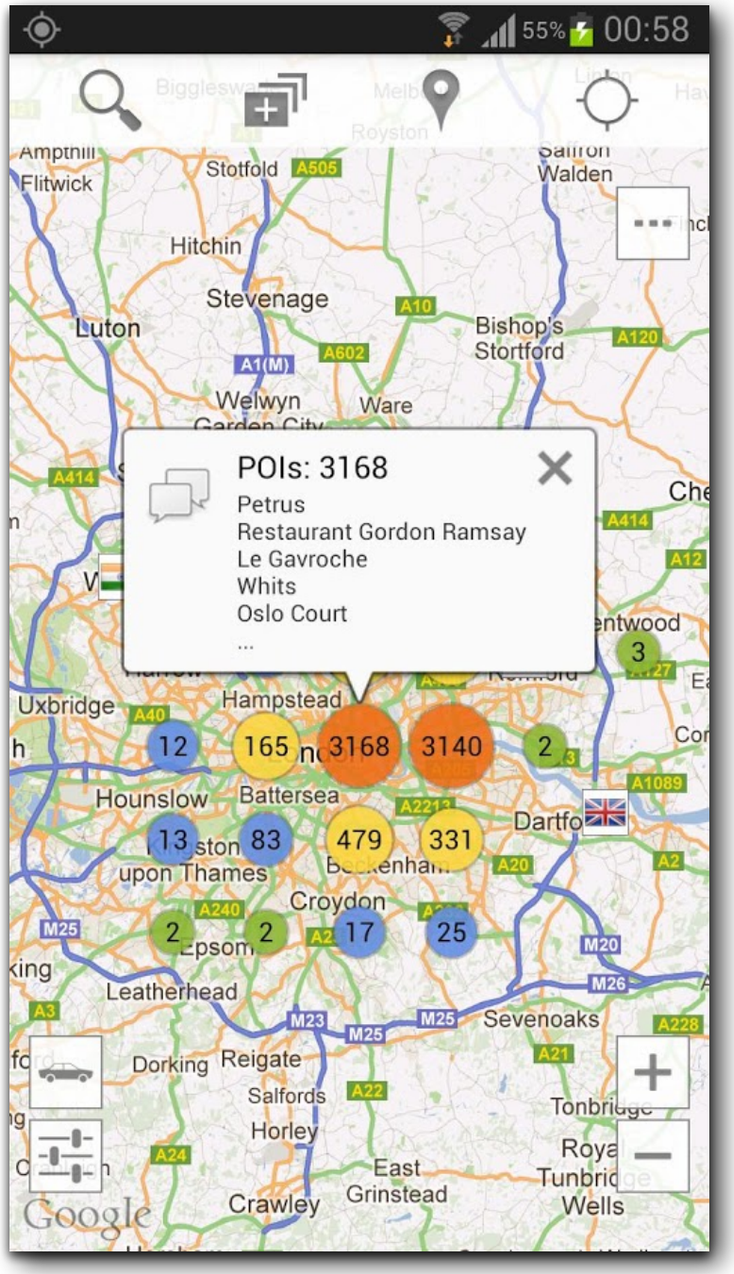
can us street view can us navig

keyword london restaur bar pub food view

breakfast lunch dinner meal eat supper street navig

London Restaurant Topics



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“navigation and travel” (59.8%)
“food and recipes” (19.9%)
“travel” (14.0%)

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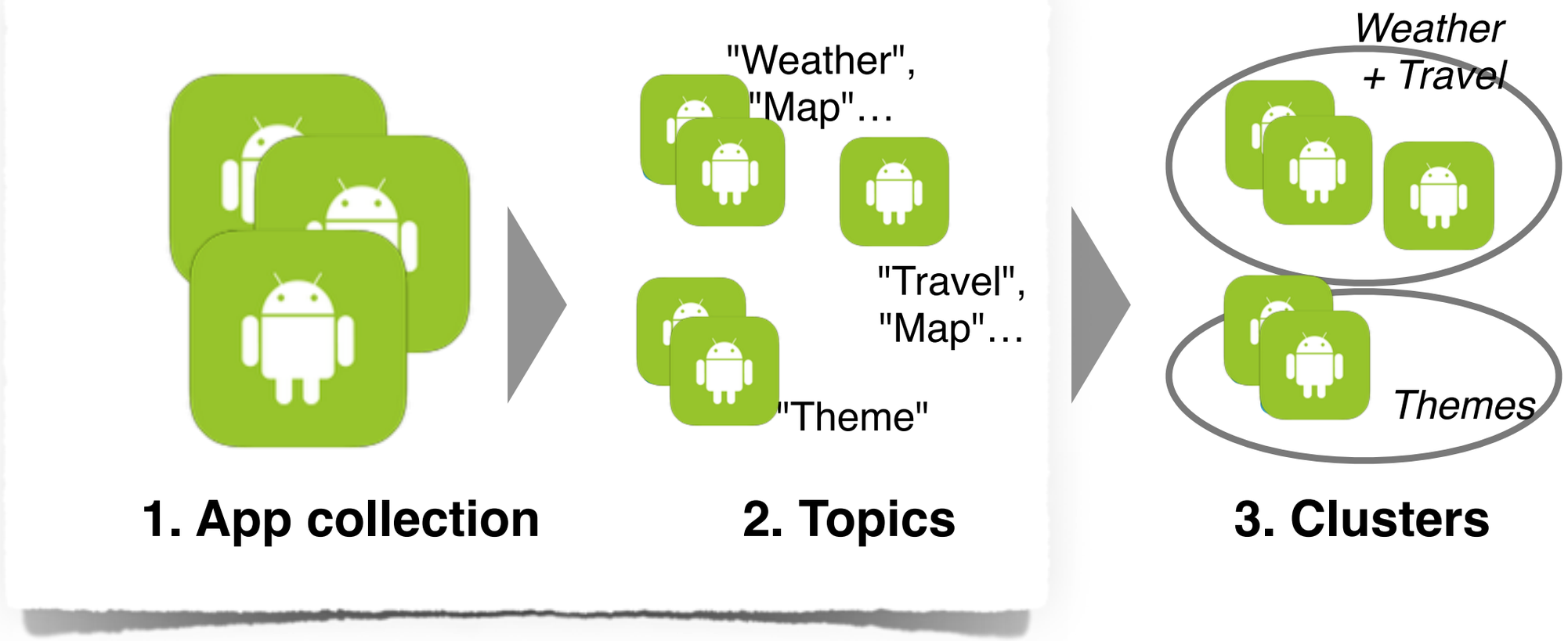

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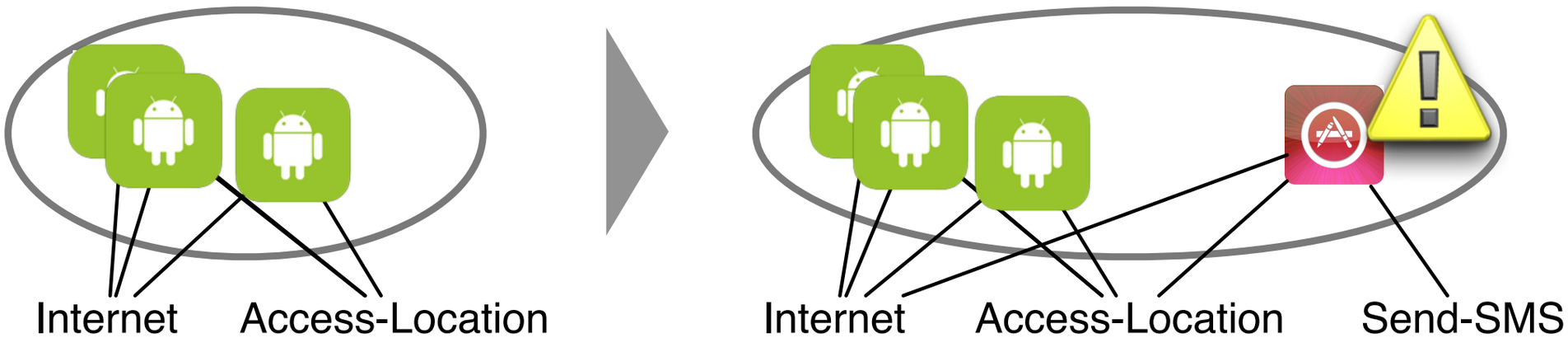

4. APIs **5. Outliers**

CHABADA

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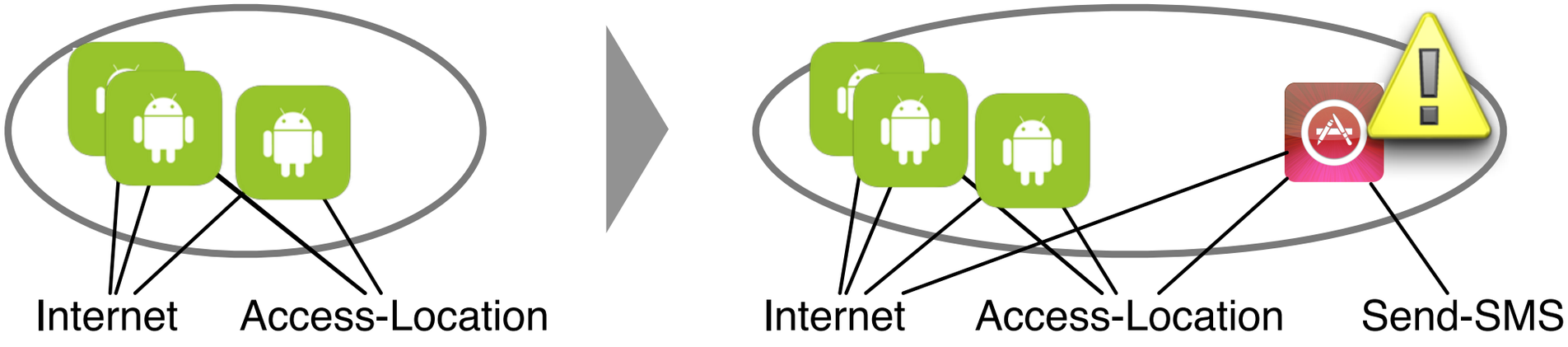

4. APIs **5. Outliers**

Clustering

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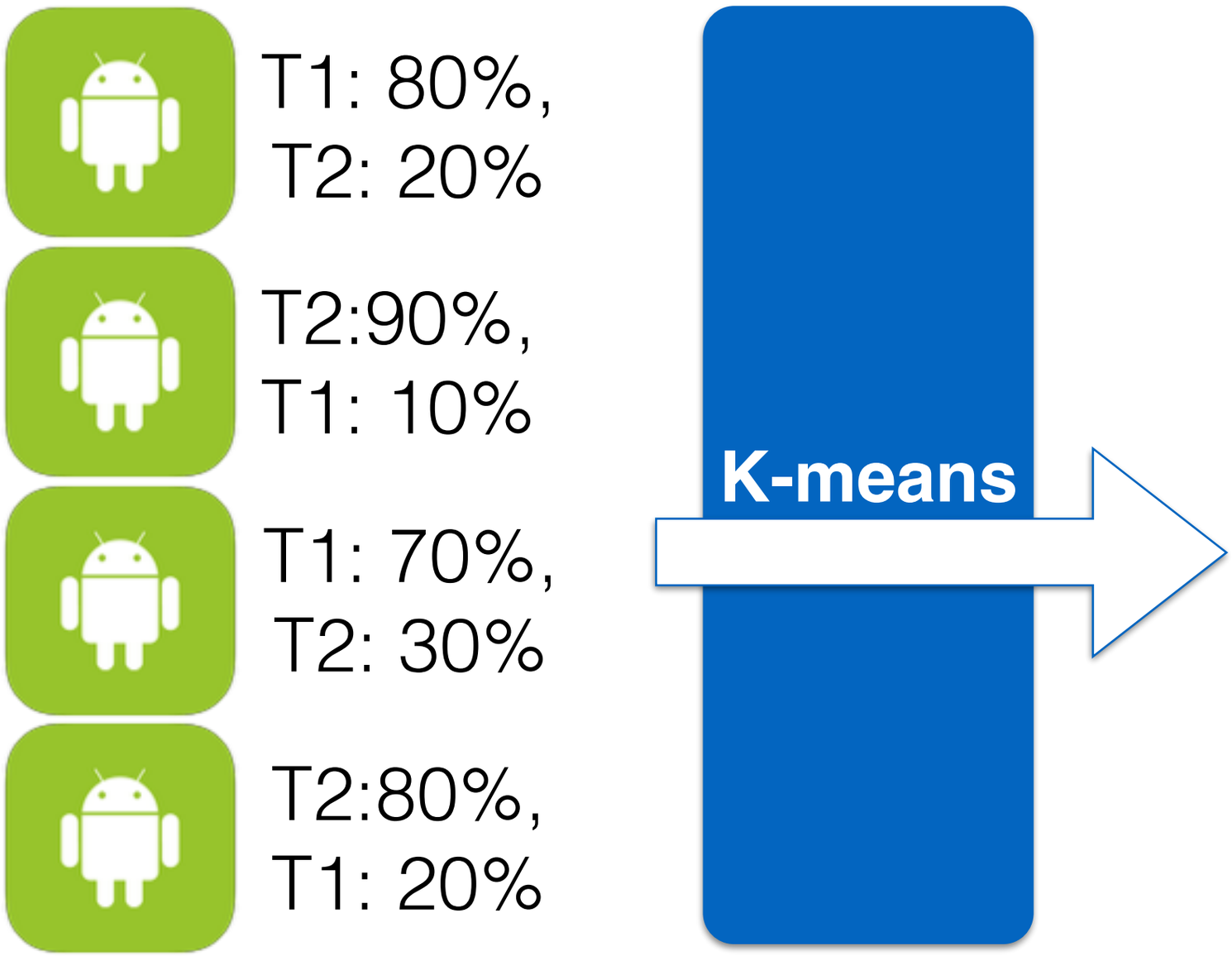

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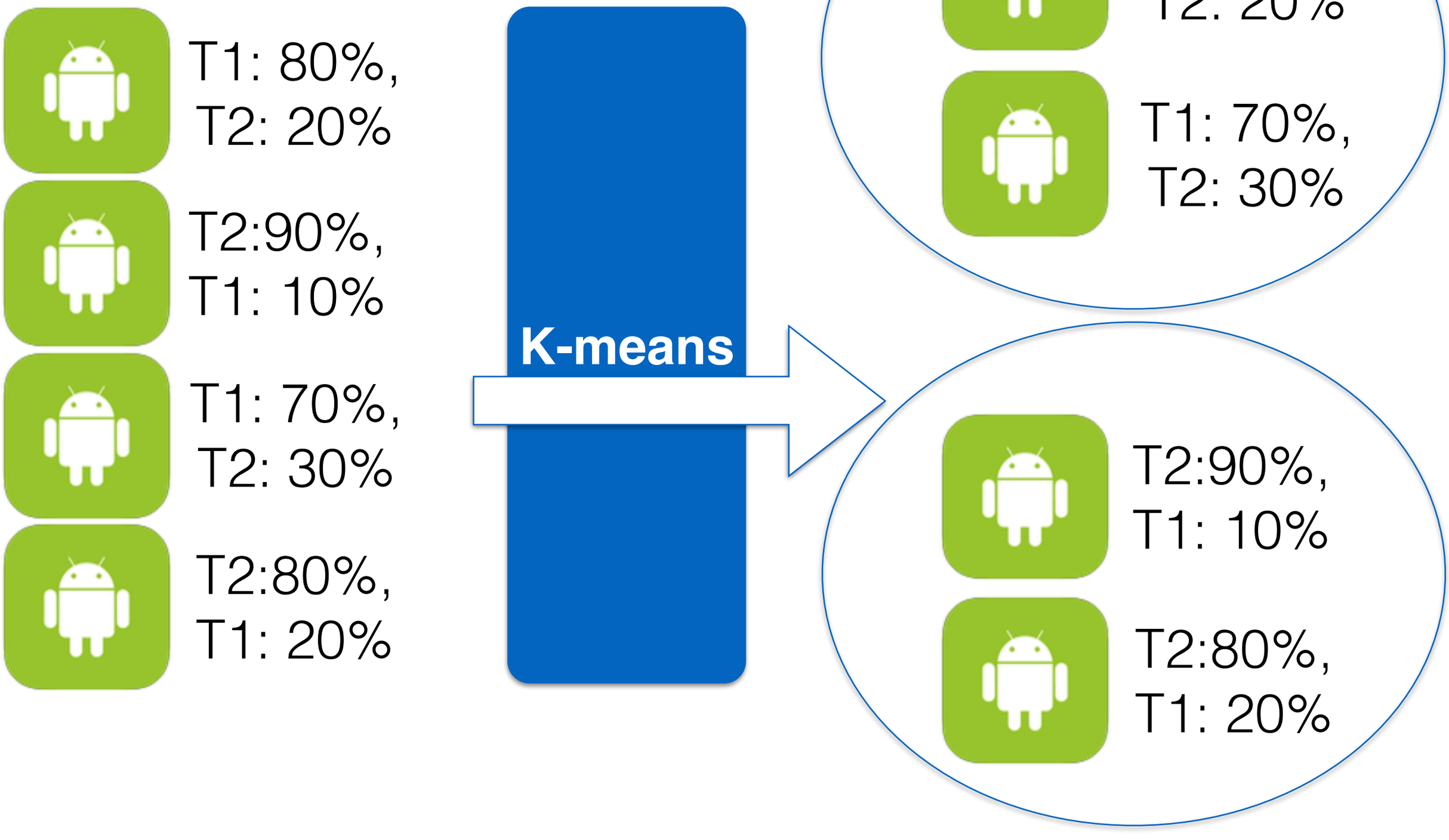
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K-means
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Clusters

Id	Assigned Name	Size	Most Important Topics
1	“sharing”	1,453	**share** (53%), settings and utils, navigation and travel
2	“puzzle and card games”	953	**puzzle and card games** (78%), share, game
3	“memory puzzles”	1,069	**puzzle and card games** (40%), game (12%), share
4	“music”	714	**music** (58%), share, settings and utils
5	“music videos”	773	**popular media** (44%), **holidays and religion** (20%), share
6	“religious wallpapers”	367	**holidays and religion** (56%), design and art, wallpapers
7	“language”	602	**language** (67%), share, settings and utils
8	“cheat sheets”	785	**game and cheat sheets** (76%), share, popular media
9	“utils”	1,300	**settings and utils** (62%), share, connection
10	“sports game”	1,306	**game** (63%), battle games, puzzle and card games
11	“battle games”	953	**battle games** (60%), **game**

19	“sports”	580	**sports** (62%), share, popular media
20	“files and videos”	679	**files and videos** (63%), share, settings and utils
21	“search and browse”	363	**search and browse** (64%), game, puzzle and card games
22	“advertisements”	380	**policies and ads** (97%)
23	“design and art”	978	**design and art** (48%), share, game
24	“car games”	449	**cars** (51%), game, puzzle and card games
25	“tv live”	500	**tv** (57%), share, navigation and travel
26	“adult photo”	828	**photo and social** (59%), share, settings and utils
27	“adult wallpapers”	543	**wallpapers** (51%), share, kids and bodies
28	“ad wallpapers”	180	**policies and ads** (46%), wallpapers, settings and utils
29	“ringtones and sound”	662	**ringtones and sound** (68%), share, settings and utils
30	“theme wallpapers”	593	**wallpapers** (90%), holidays and religion, share
31	“personalize”	402	**personalize** (86%), share, settings and utils
32	“settings and wallpapers”	251	**settings and utils** (37%), **wallpapers** (37%), personalize

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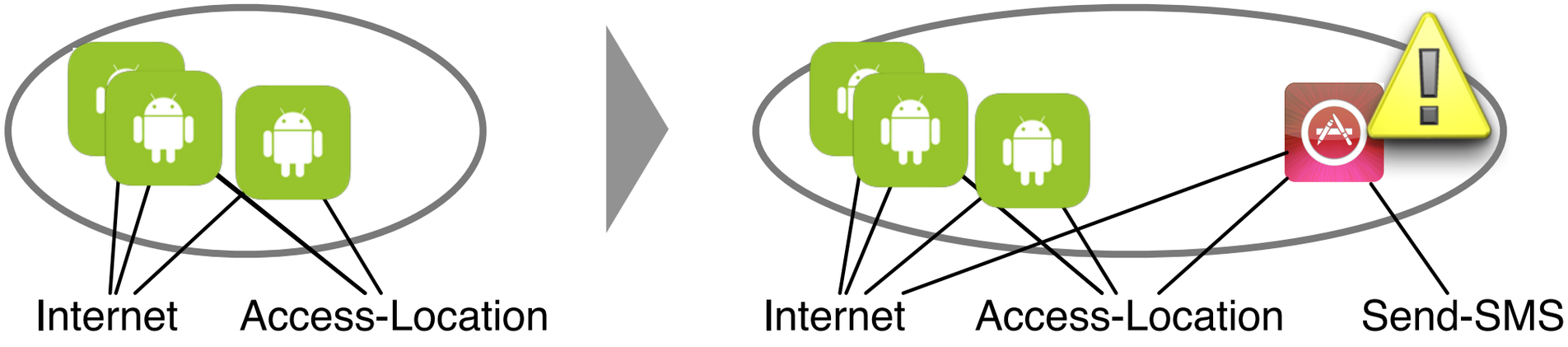

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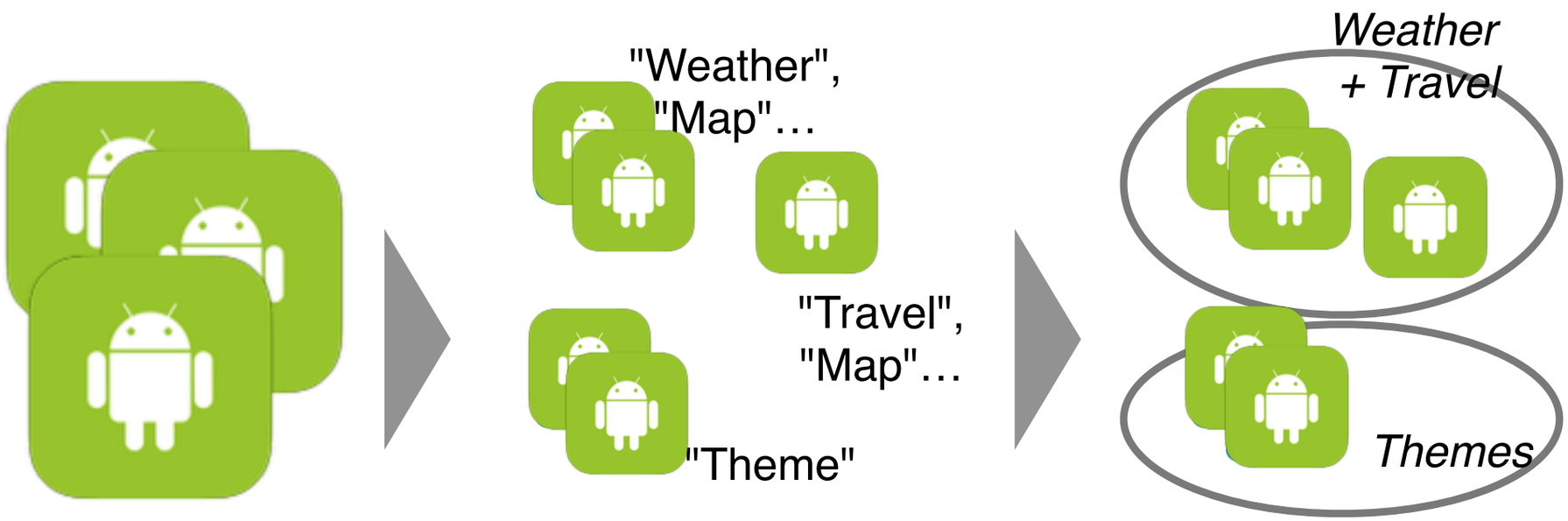

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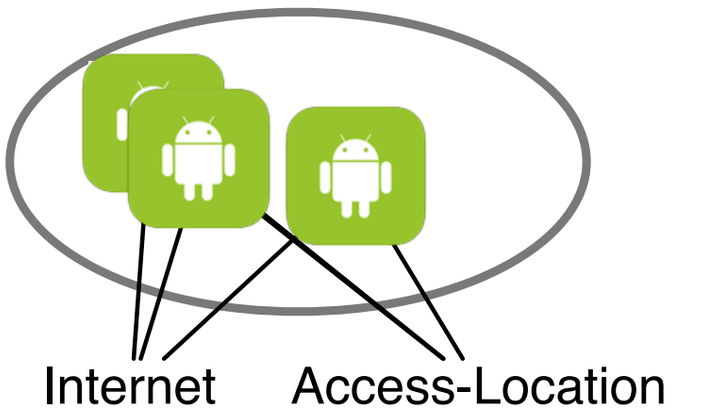

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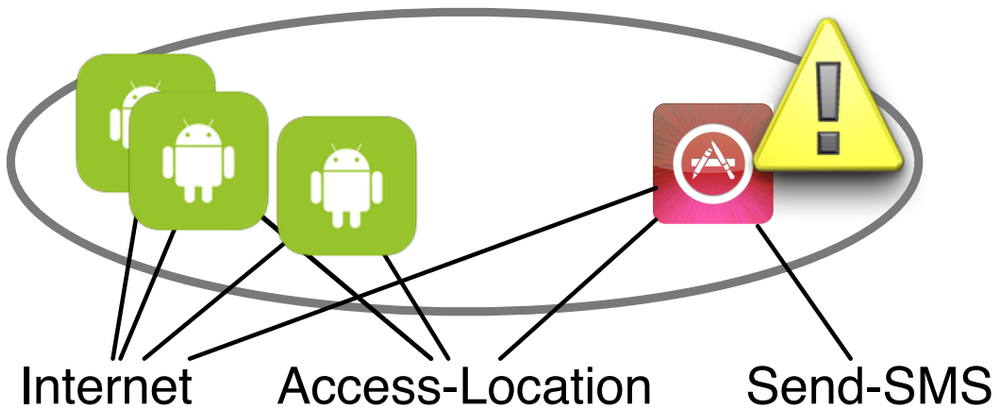

5. Outliers

API Analysis

Android APIs API level: 19

android
android.accessibilityservice
android.accounts
android.animation
android.app
android.app.admin
android.app.backup
android.appwidget
android.bluetooth
android.content
android.content.pm
android.content.res
android.database

API Analysis

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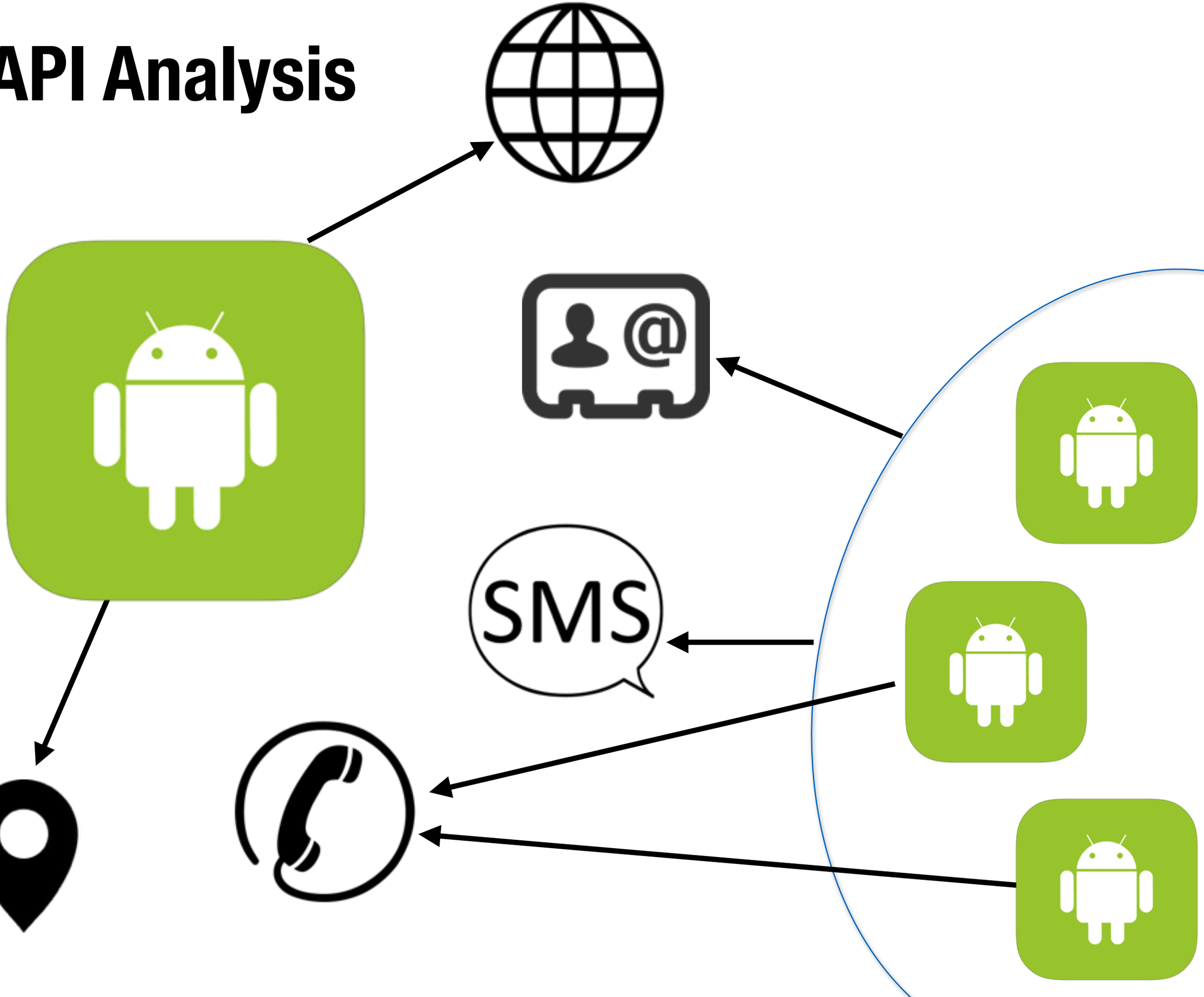
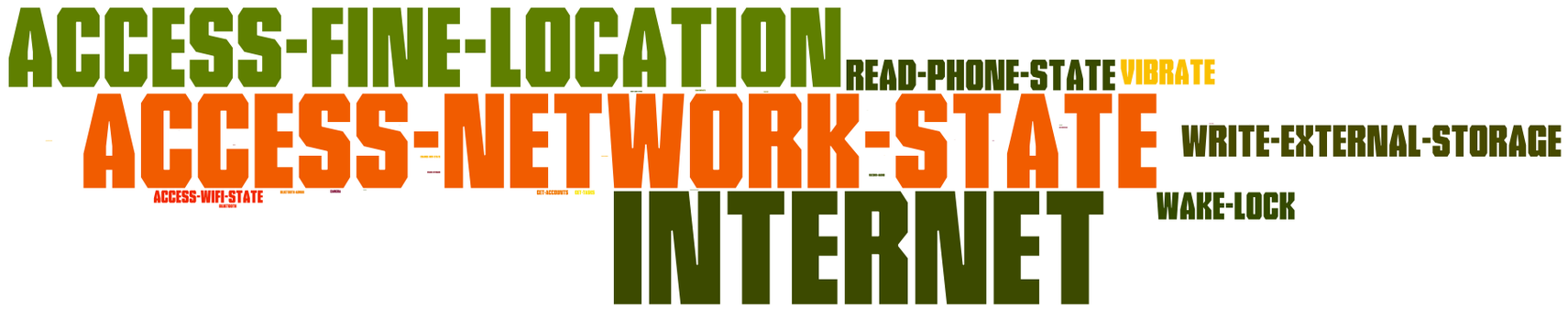


“Travel” cluster

Description

Permissions of APIs used



“Personalize” cluster

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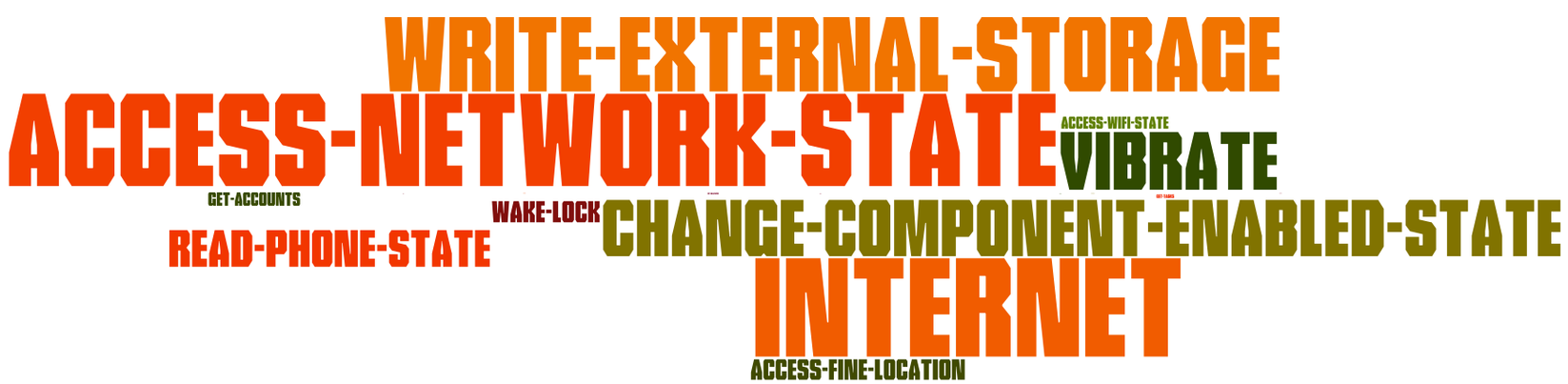

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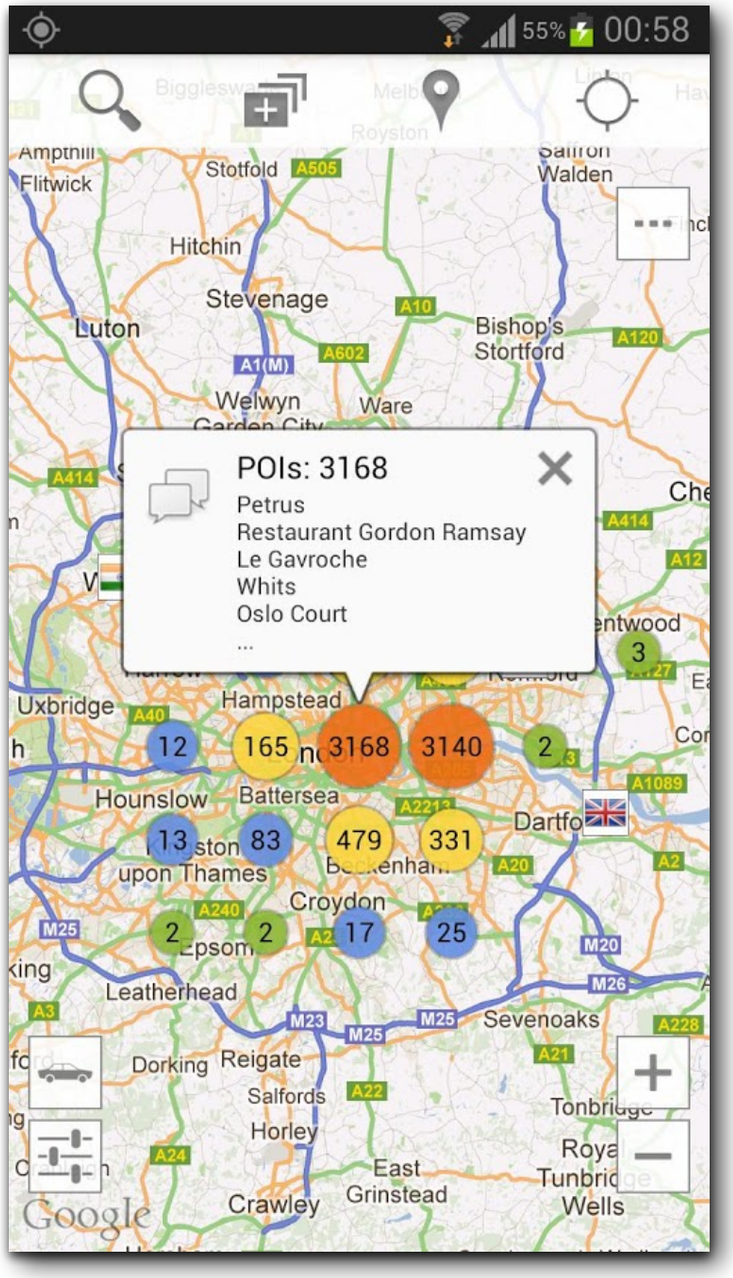
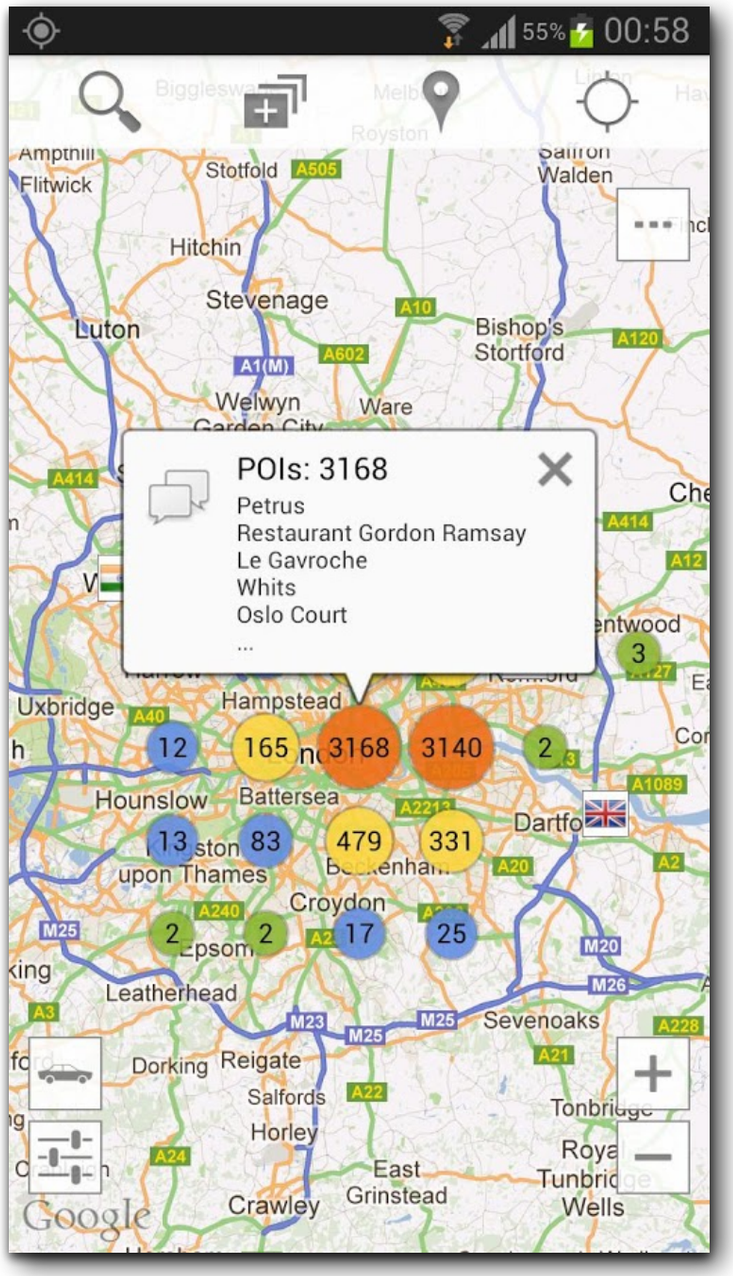


London Restaurants



android.net.ConnectivityManager.getActiveNetworkInfo()
android.webkit.WebView()
java.net.HttpURLConnection.connect()
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android.telephony.TelephonyManager.getDeviceId()
org.apache.http.impl.client.DefaultHttpClient()
org.apache.http.impl.client.DefaultHttpClient.execute()
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android.telephony.TelephonyManager.getLine1Number()
android.net.wifi.WifiManager.isWifiEnabled()
android.accounts.AccountManager.getAccountsByType()
android.net.wifi.WifiManager.getConnectionInfo()
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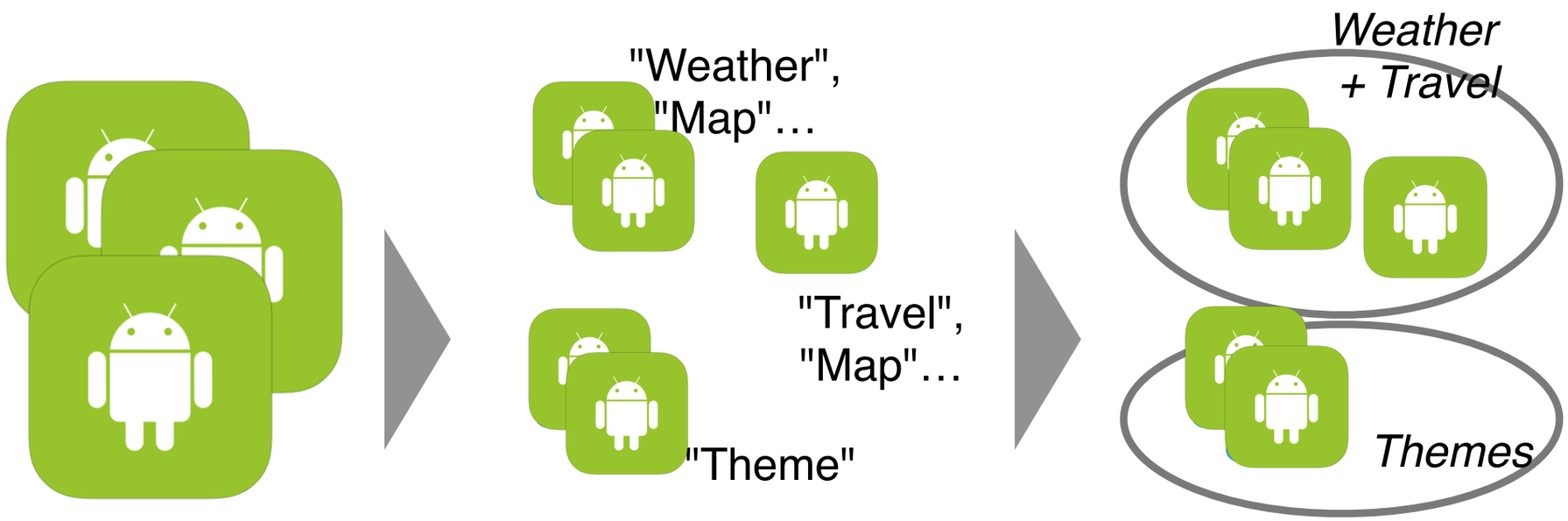
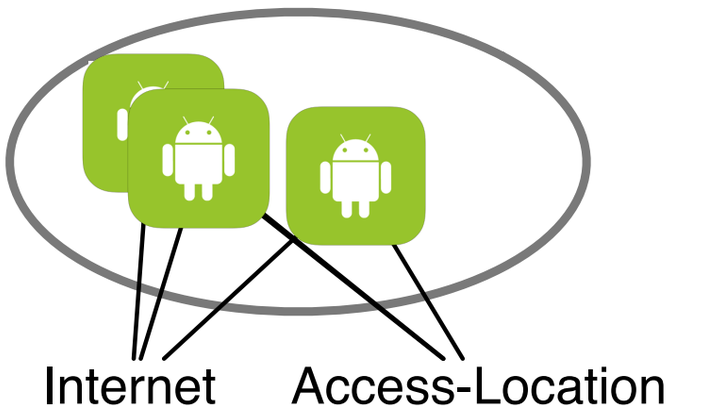
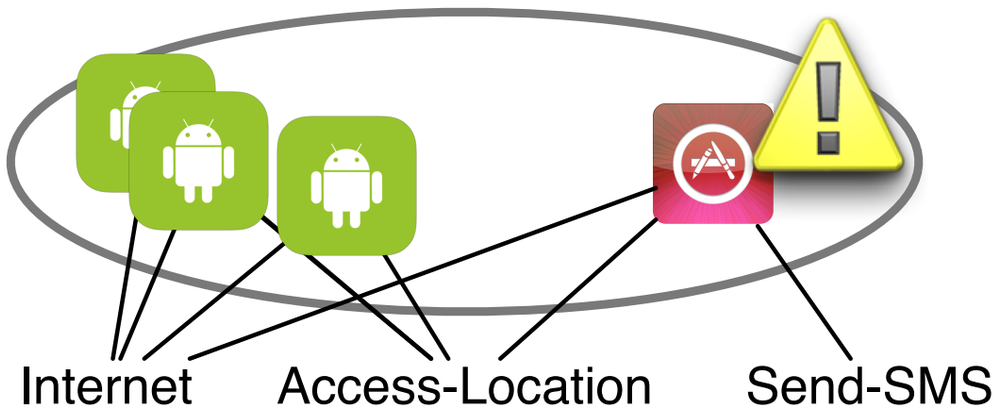
CHABADA



1. App collection **2. Topics** **3. Clusters**

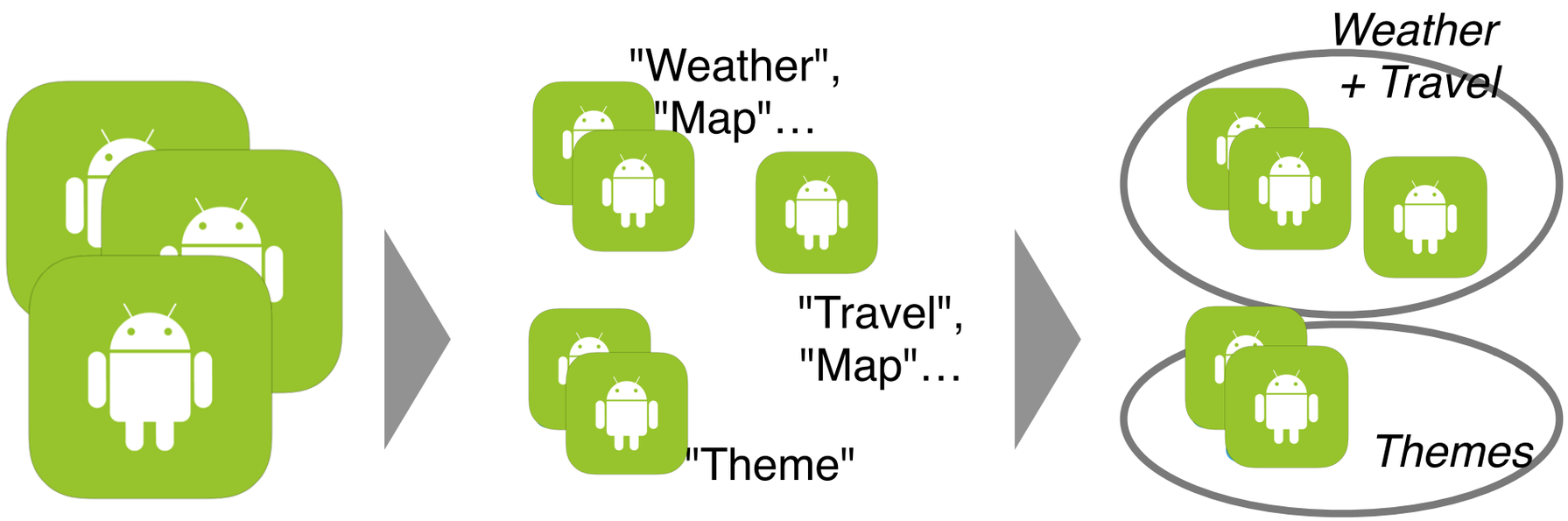


4. APIs



5. Outliers

CHABADA



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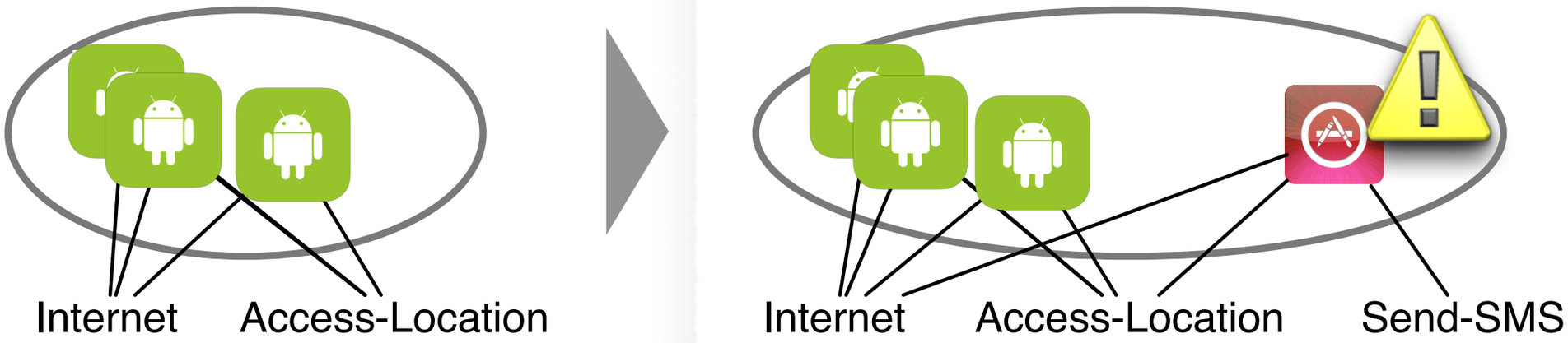
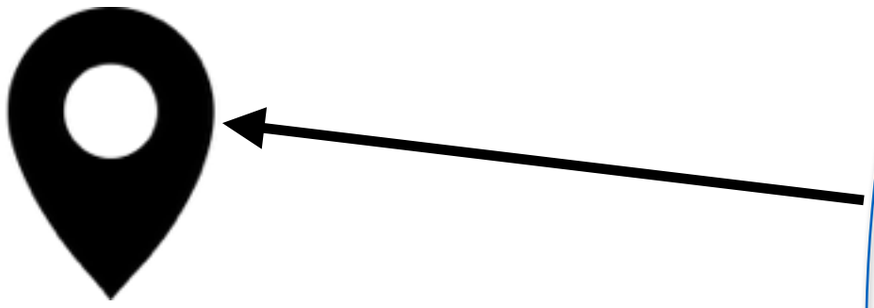


4. APIs **5. Outliers**

Anomaly detection



Anomaly detection

SMS

Anomaly detection

- In each cluster, identified anomalies through *one-class support vector machine* (OC-SVM)
- Features of each app: a vector of *(sensitive APIs, binary value)*

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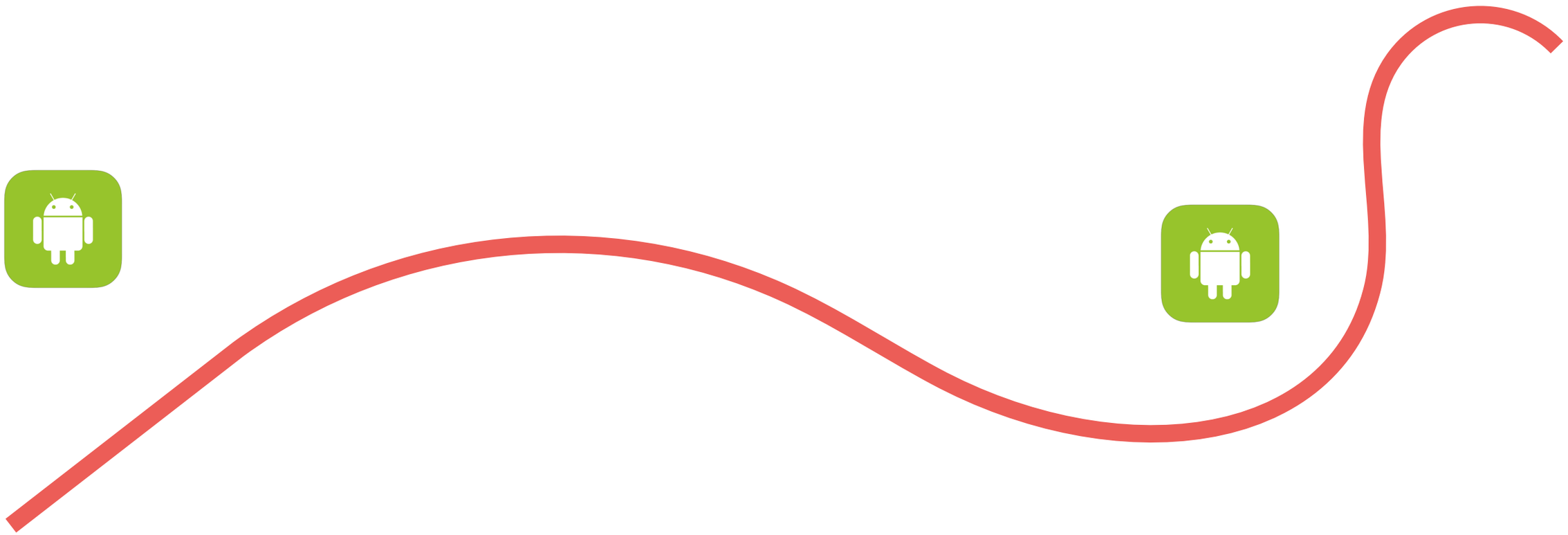

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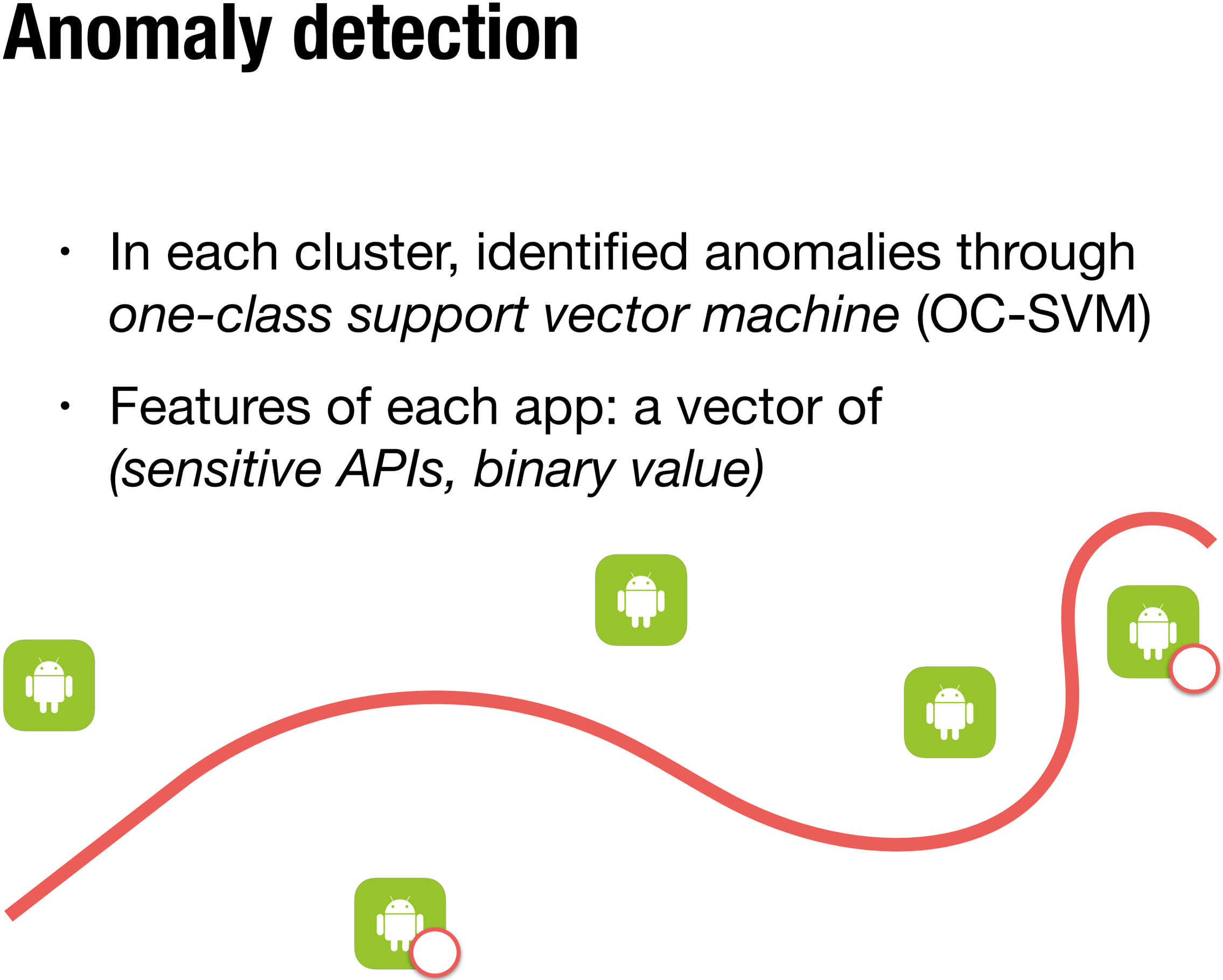

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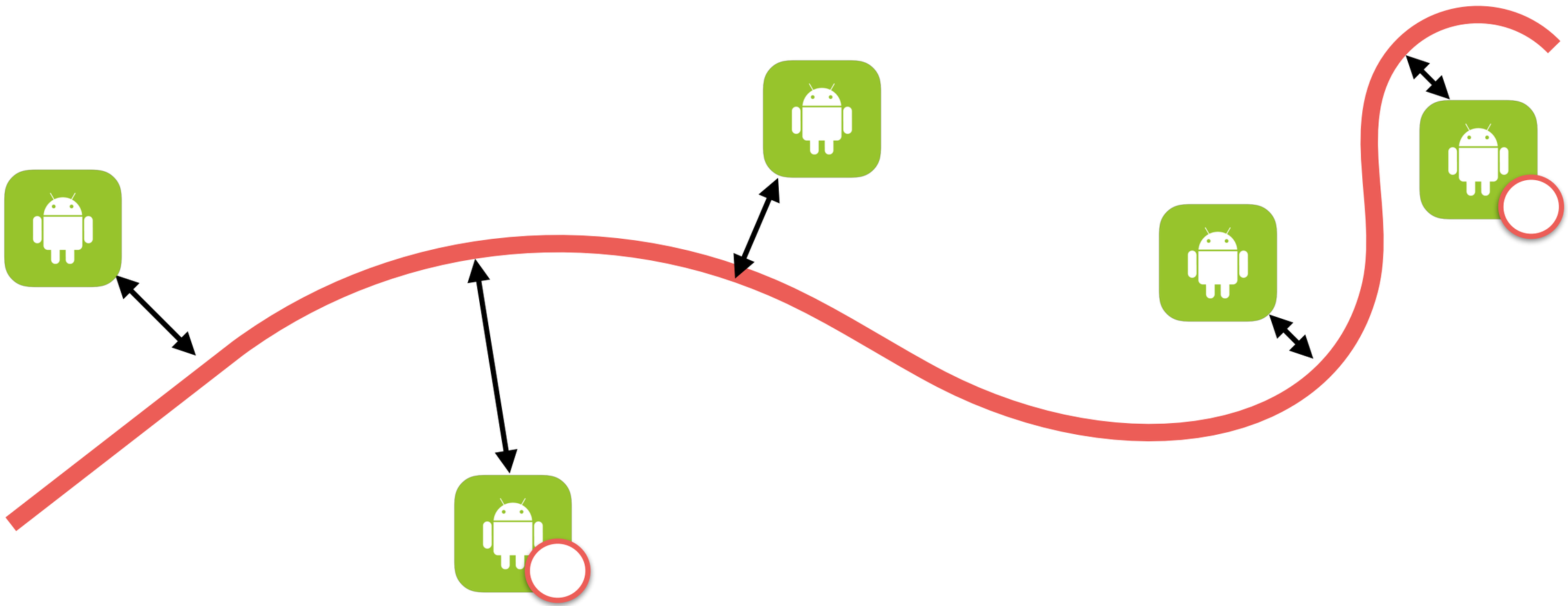

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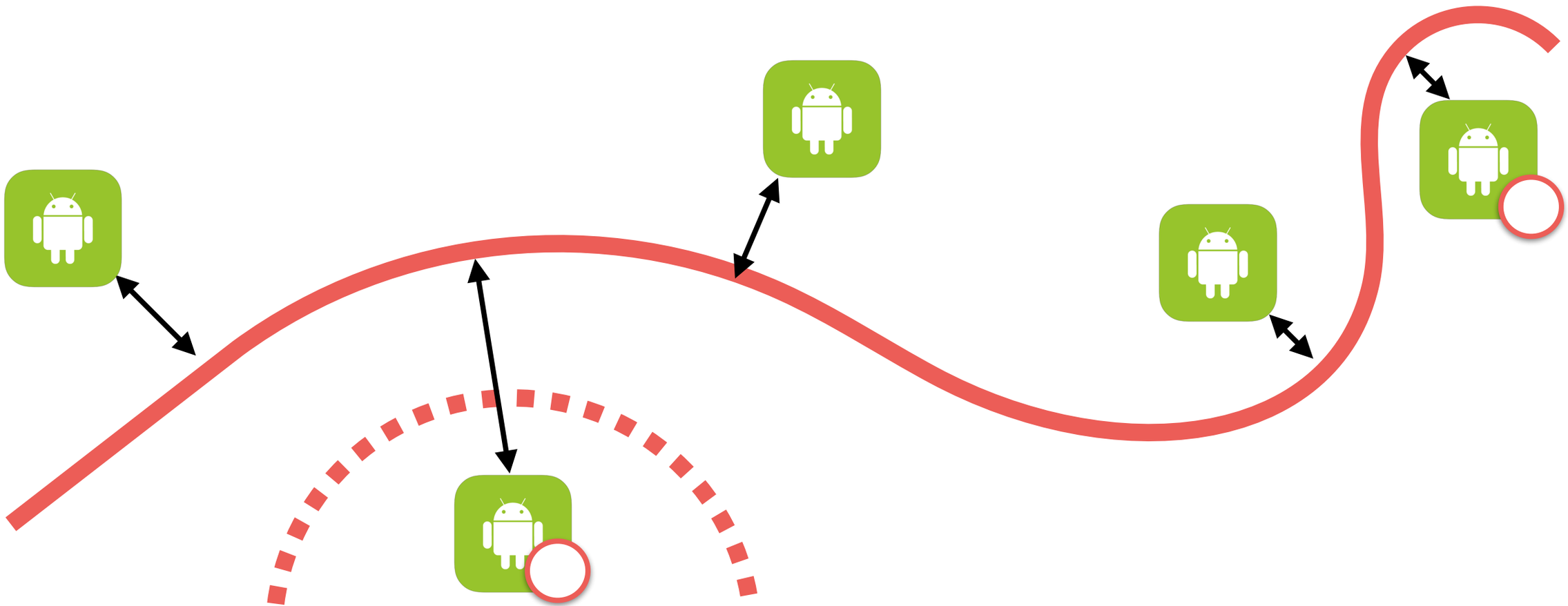
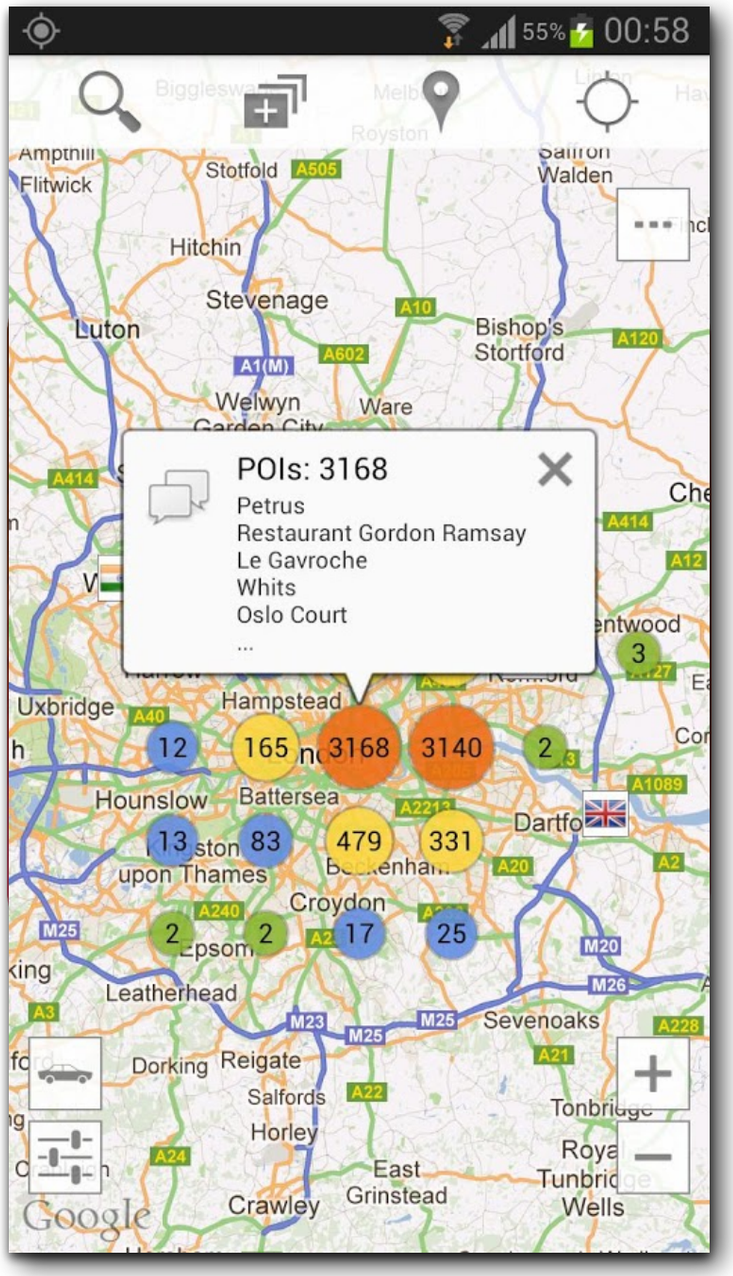


London Restaurants



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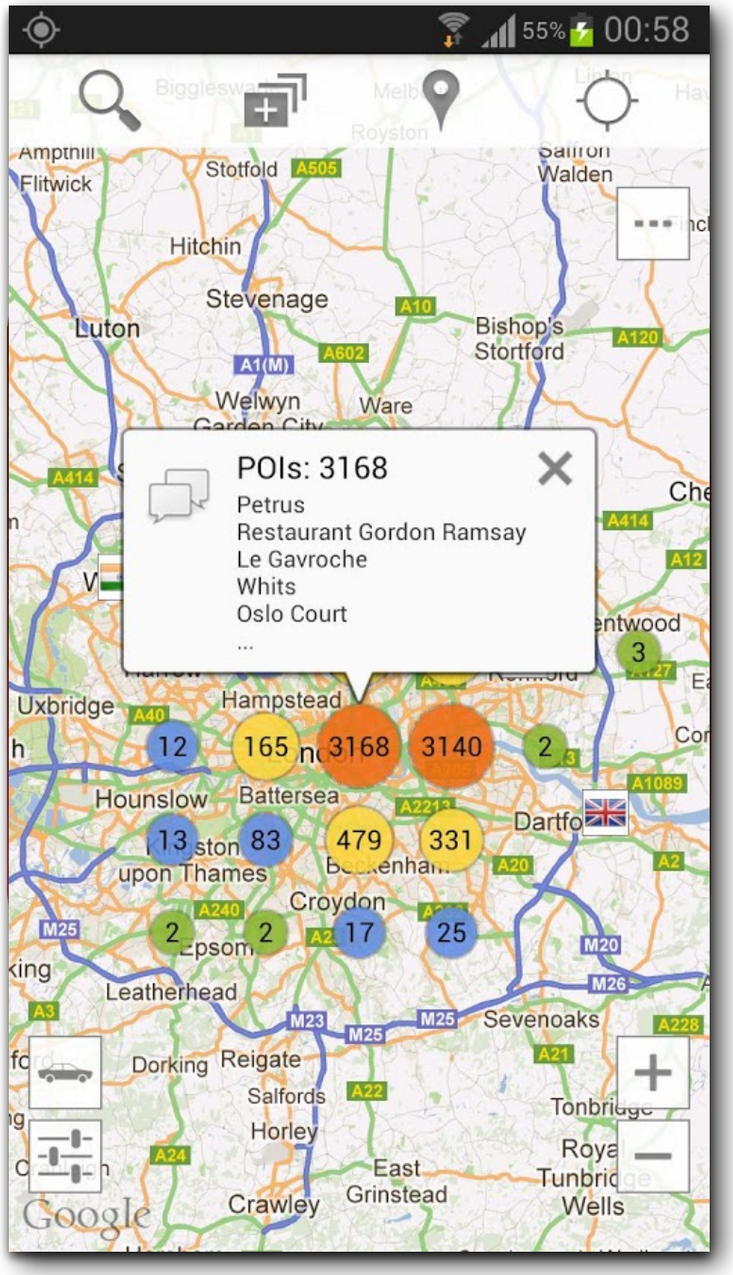

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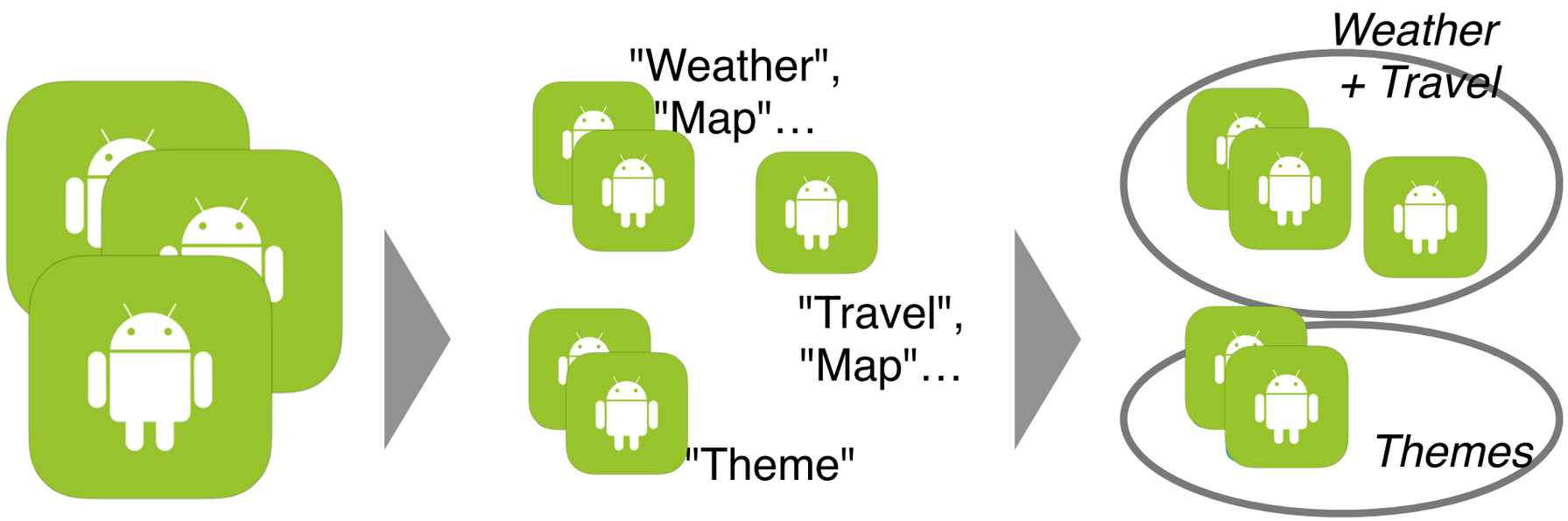
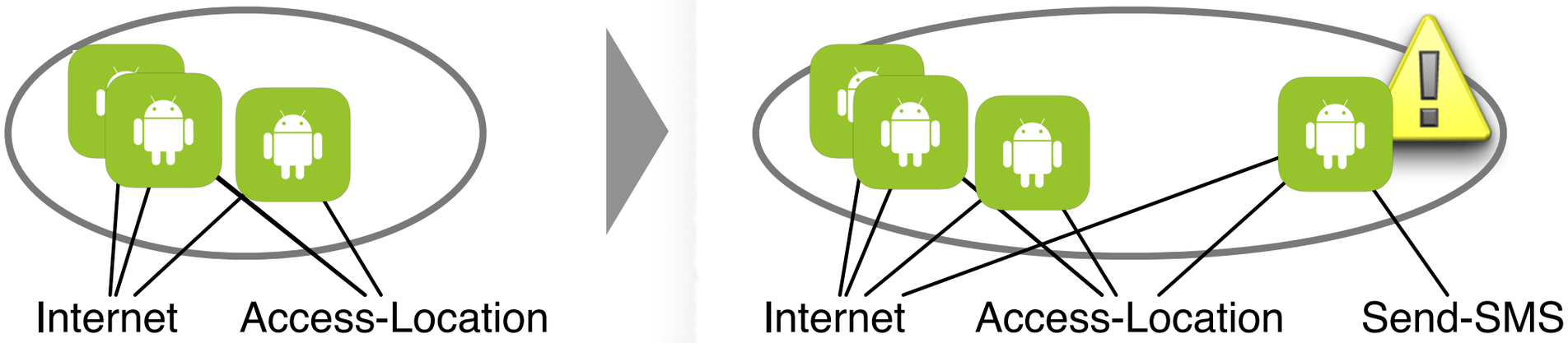
→ Identified as Anomaly

CHABADA



1. App collection **2. Topics** **3. Clusters**



4. APIs **5. Outliers**

Evaluation: Anomalies

Can CHABADA effectively identify *anomalous*(*) Android apps?

Evaluation: Anomalies

Can CHABADA effectively identify *anomalous*(*) Android apps?

(*) i.e., mismatches between description and behavior

Evaluation: Anomalies

Can CHABADA effectively identify *anomalous*(*) Android apps?

160 apps

(*) i.e., mismatches between description and behavior

Evaluation: Anomalies

Can CHABADA effectively identify *anomalous*(*) Android apps?

160 apps

26%
covert behavior

(*) i.e., mismatches between description and behavior

What makes an anomaly?

What makes an anomaly?

apploving

airpush

What makes an anomaly?

apploving

airpush

dubious behaviour

What makes an anomaly?

apploving

airpush

uncommon behaviour

dubious behaviour

What makes an anomaly?

apploving

airpush

uncommon behaviour

dubious behaviour

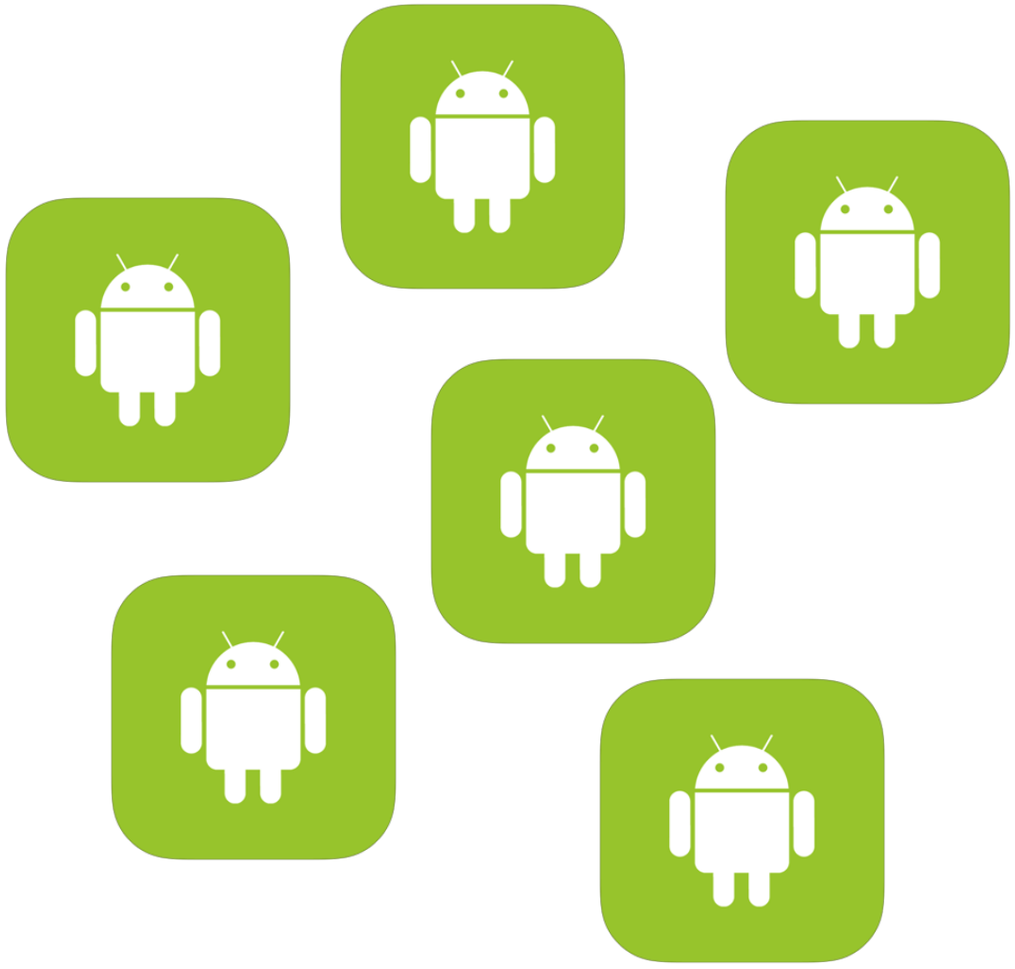
benign outliers

Evaluation: Malware

Can our technique be used to identify *malicious* Android applications?

Evaluation: Malware

Can our technique be used to identify *malicious* Android applications?



Evaluation: Malware

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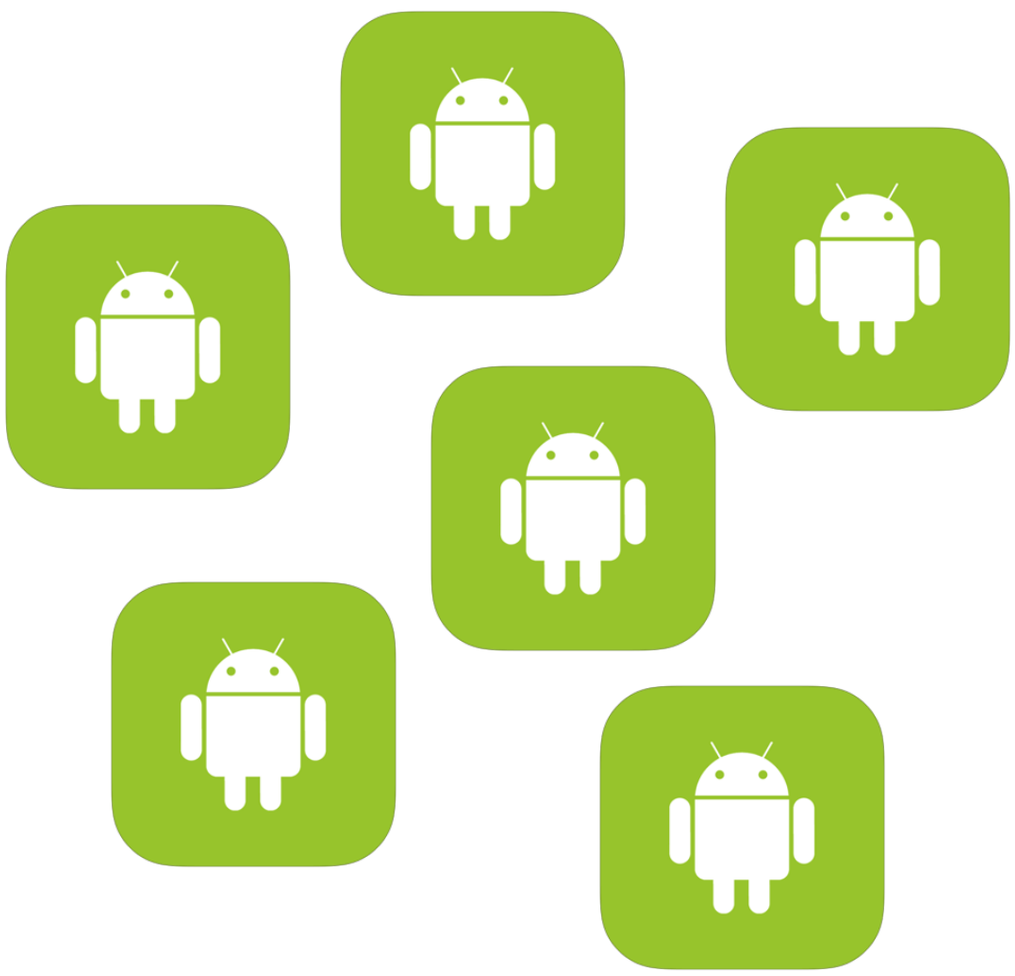
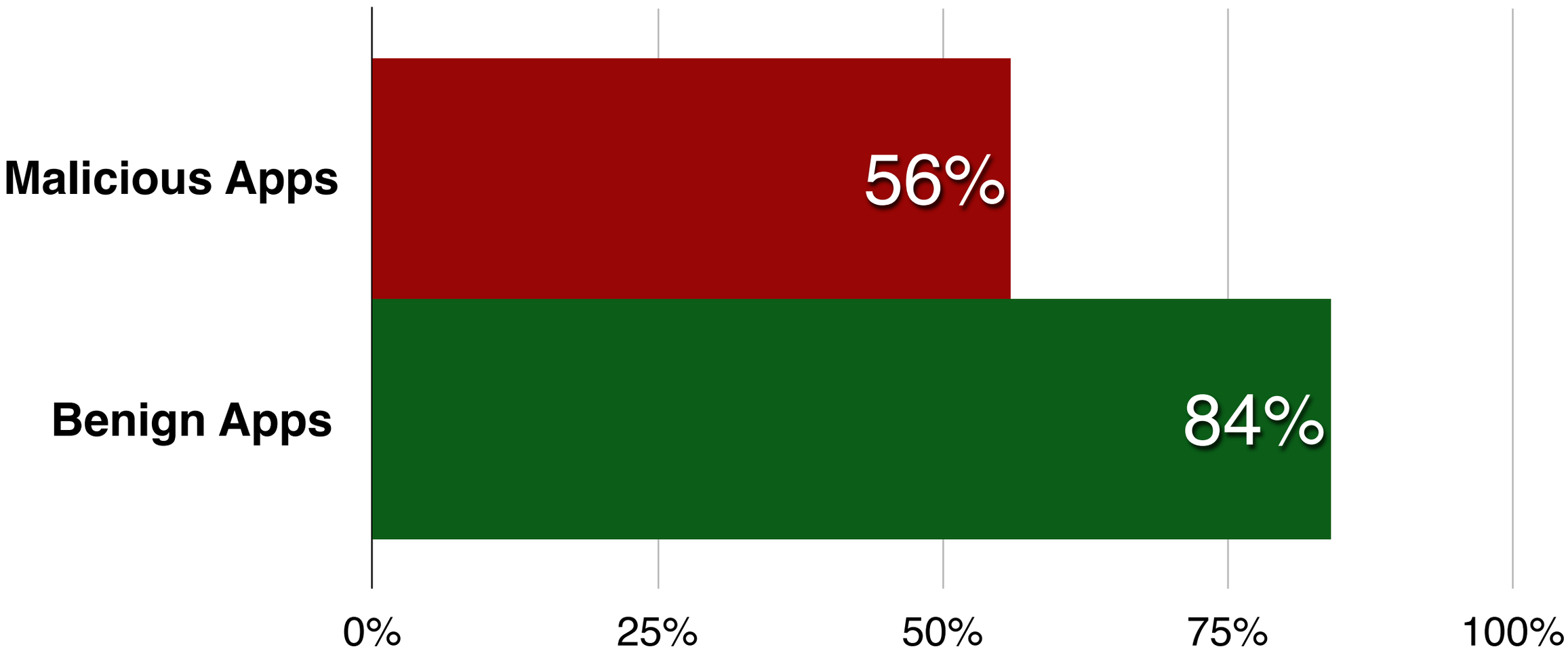


Classification with Clusters
(our approach)

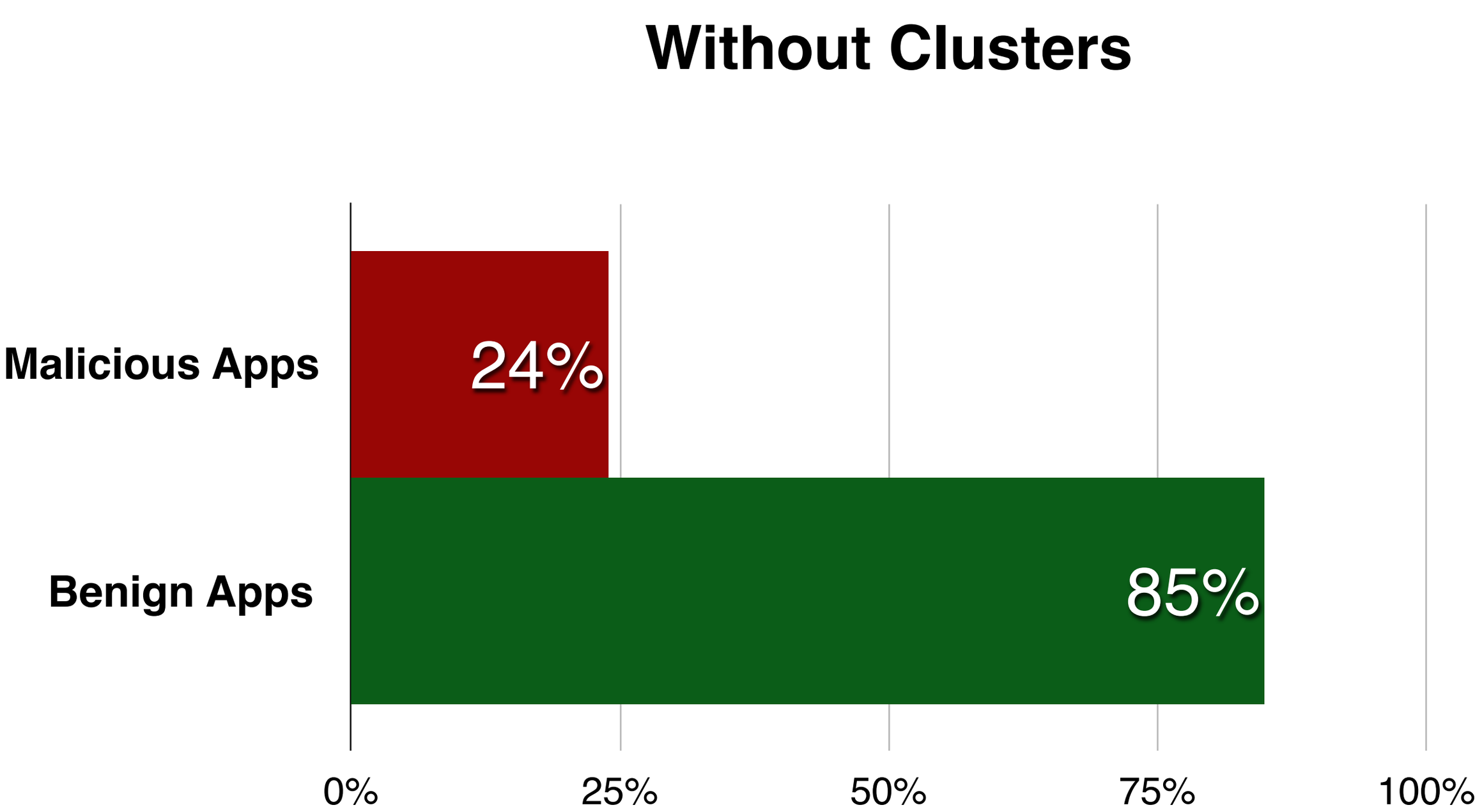
	Predicted as Malicious	Predicted as Benign
Malicious Apps	56%	44%
Benign Apps	16%	84%

Correct Classification

With Clusters (our approach)



Correct Classification



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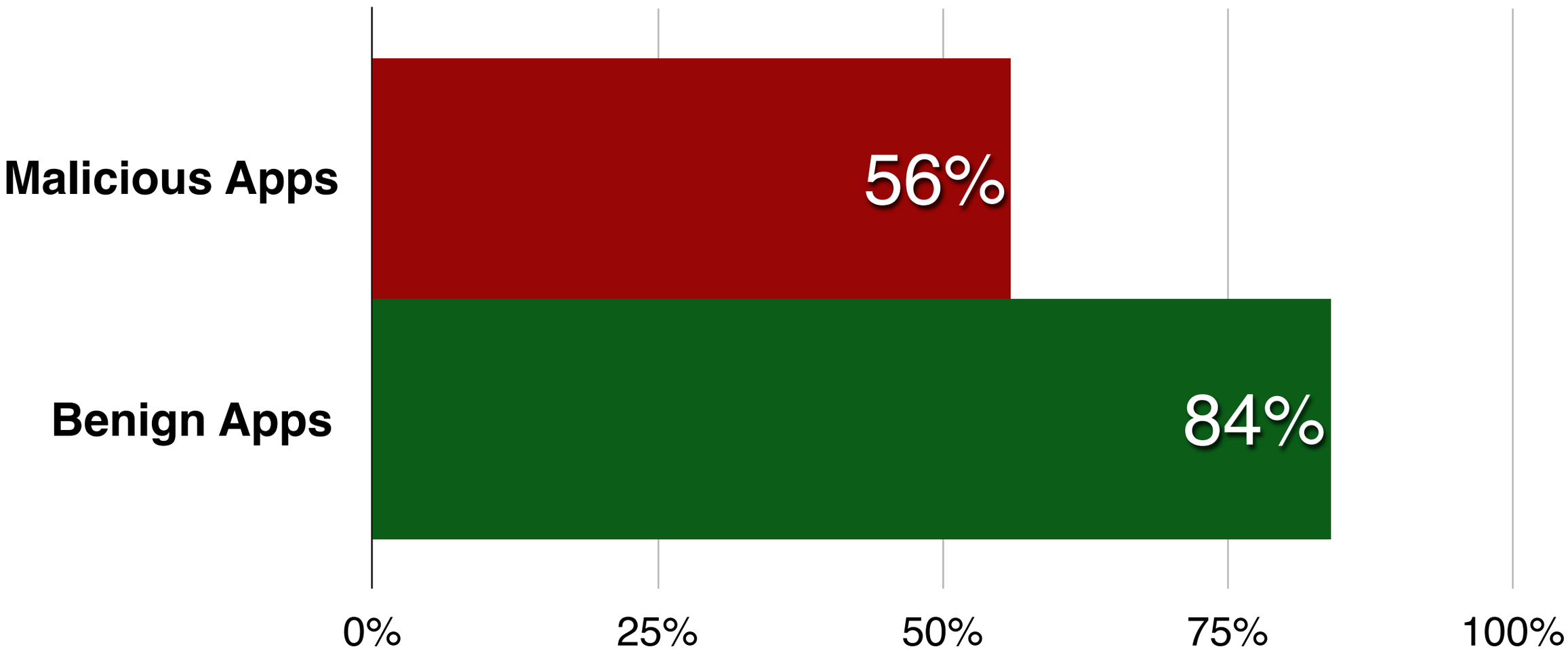

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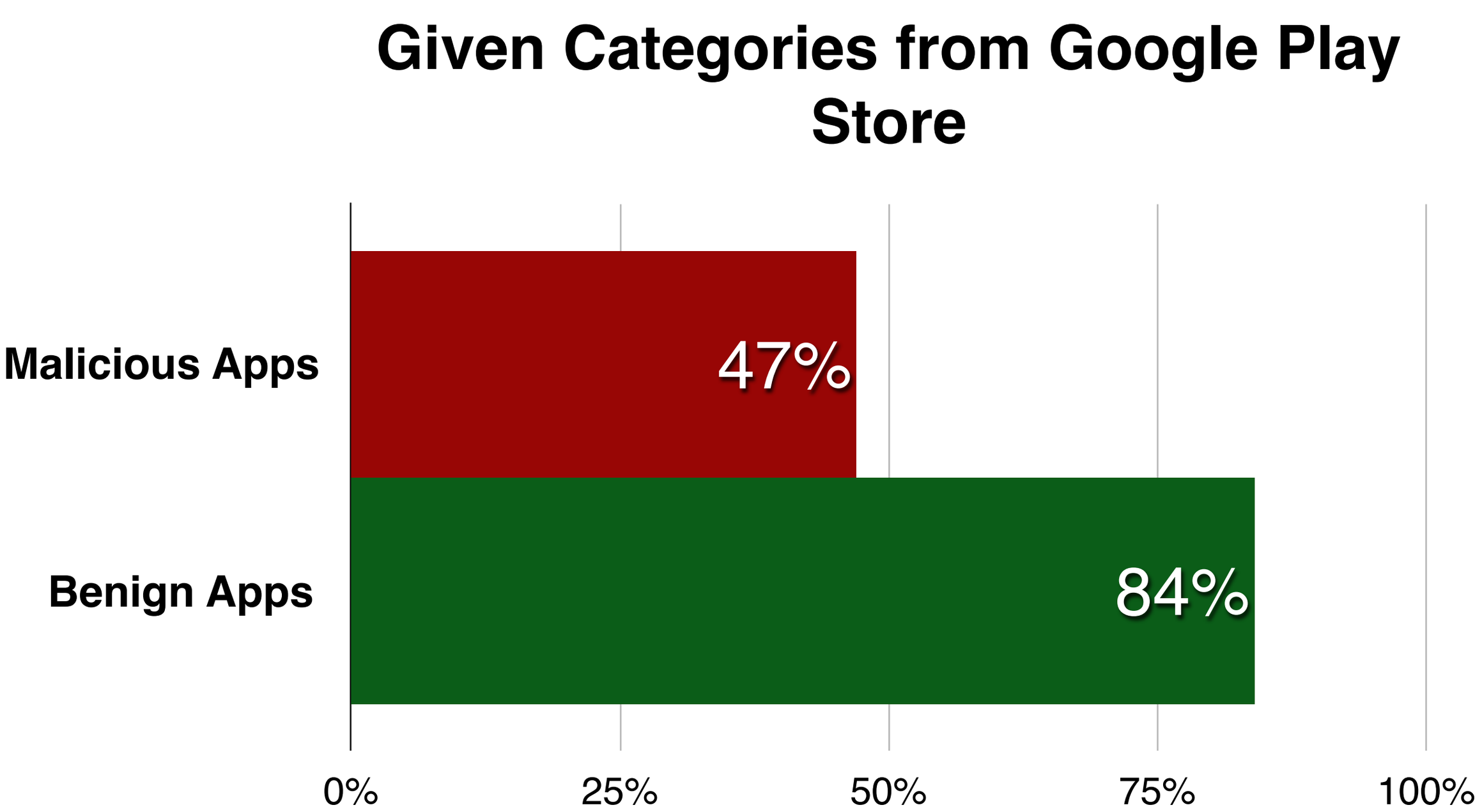

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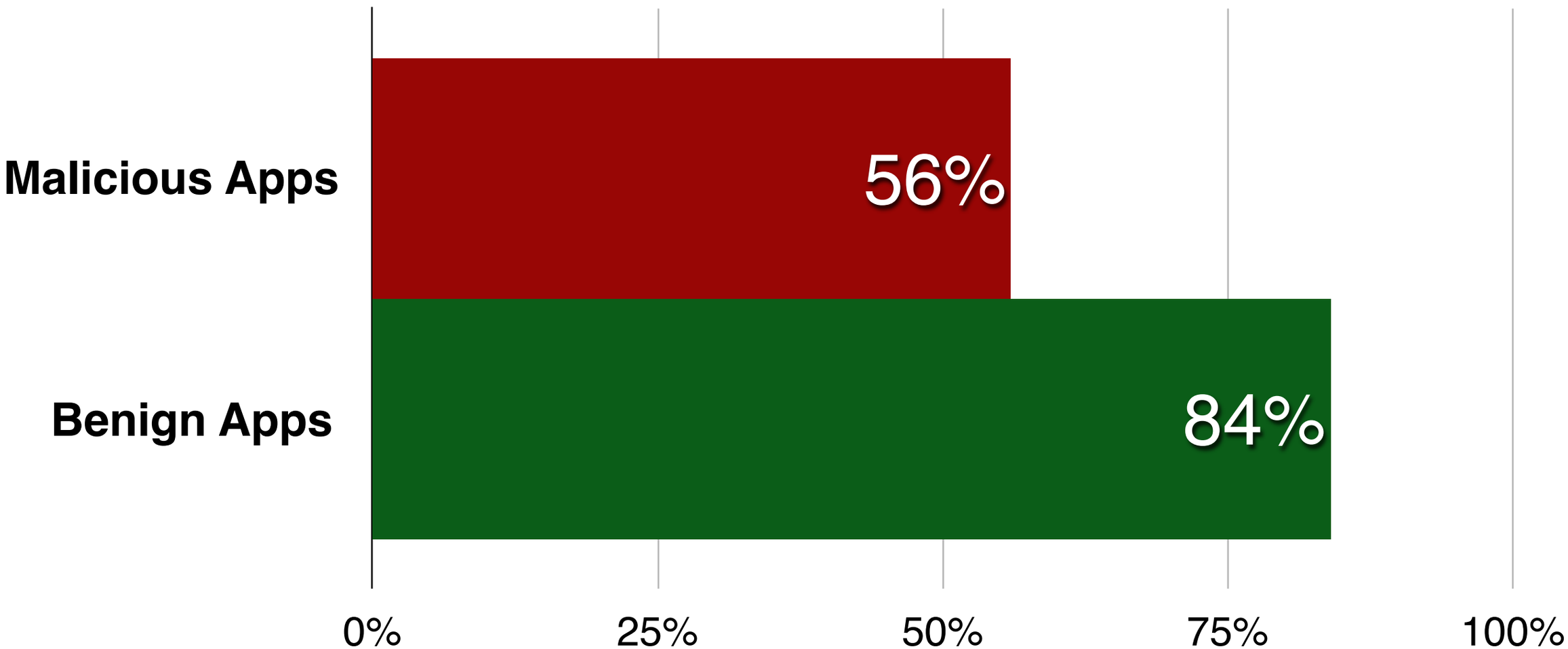
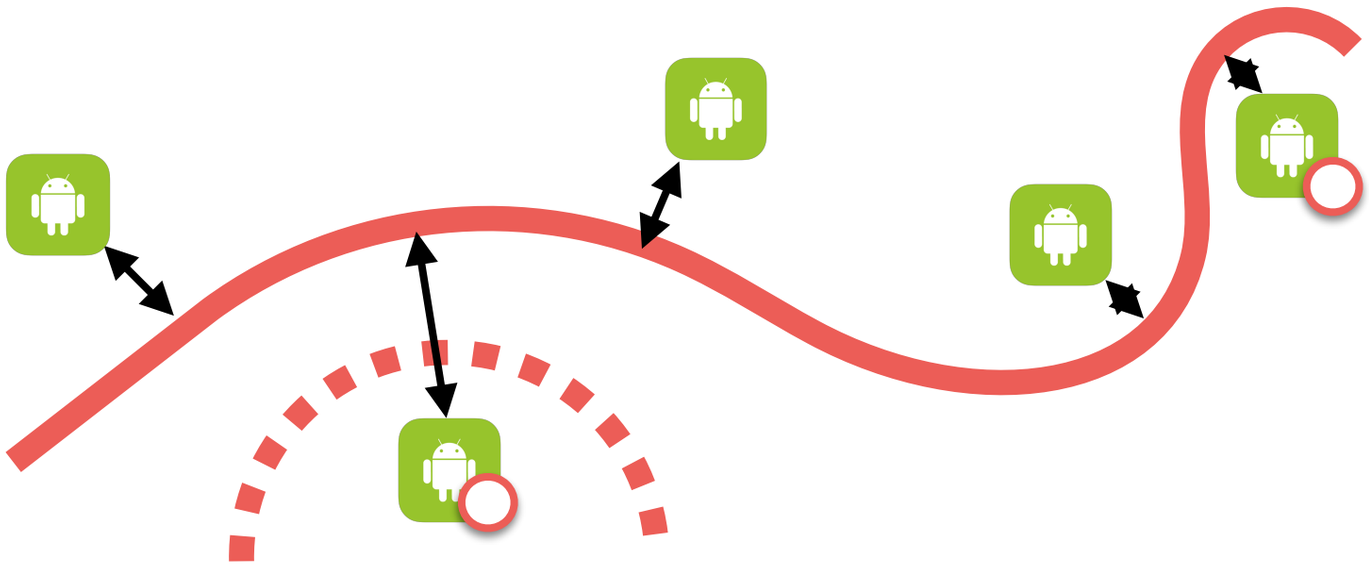
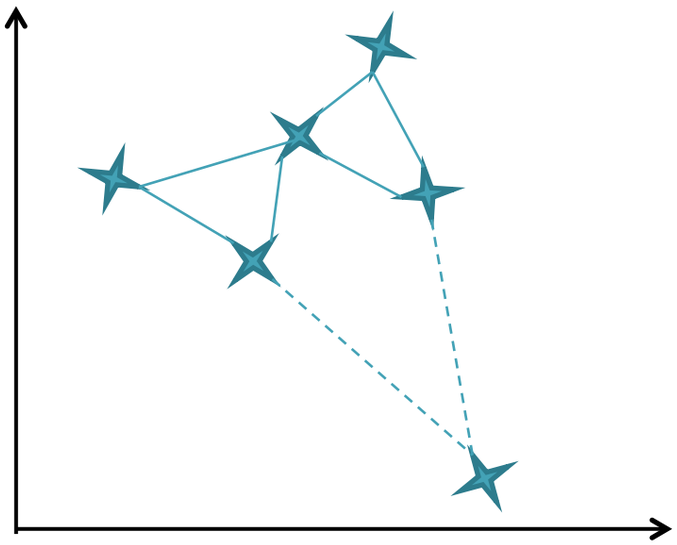


Better anomaly detection



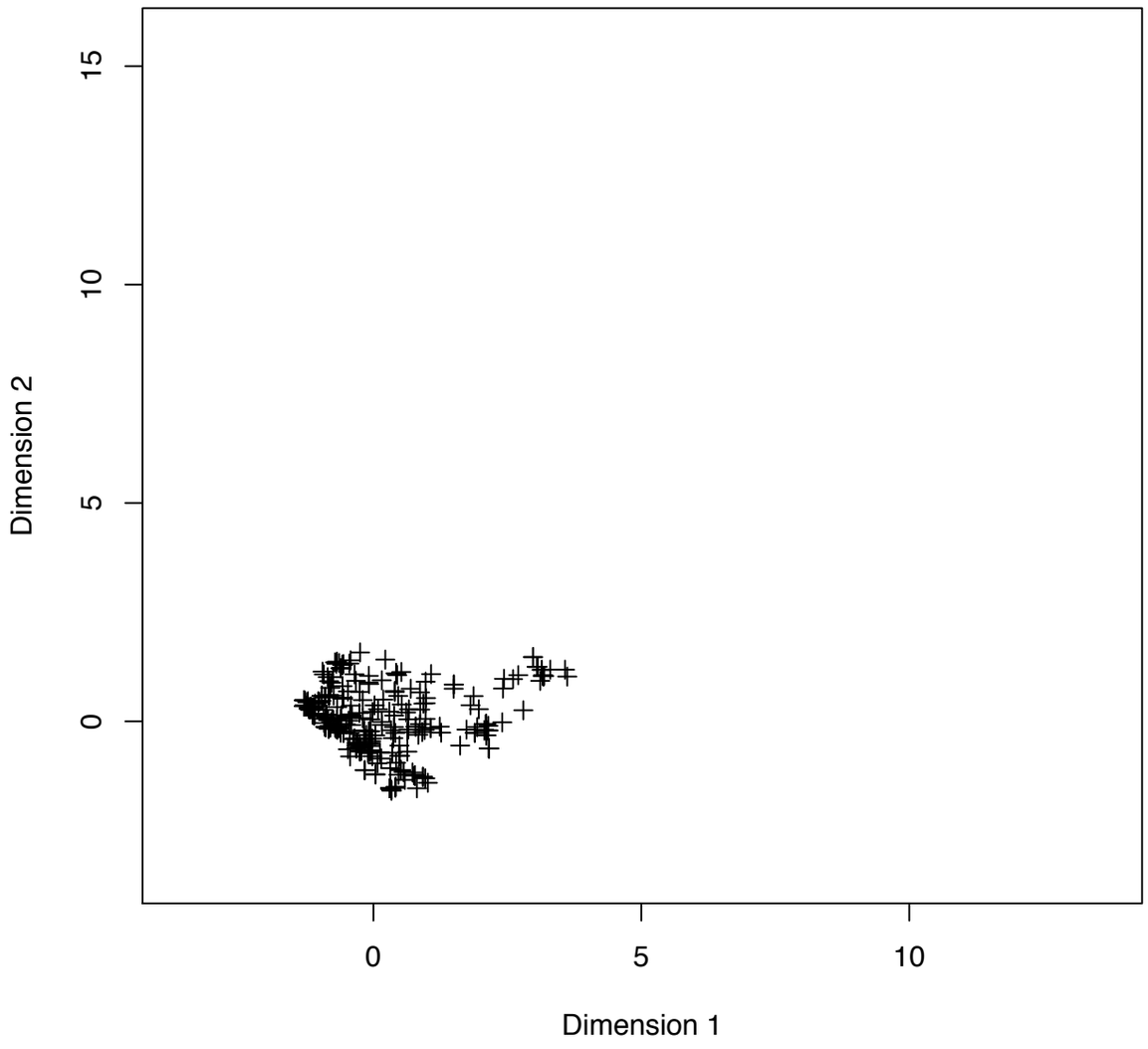
OC-SVM



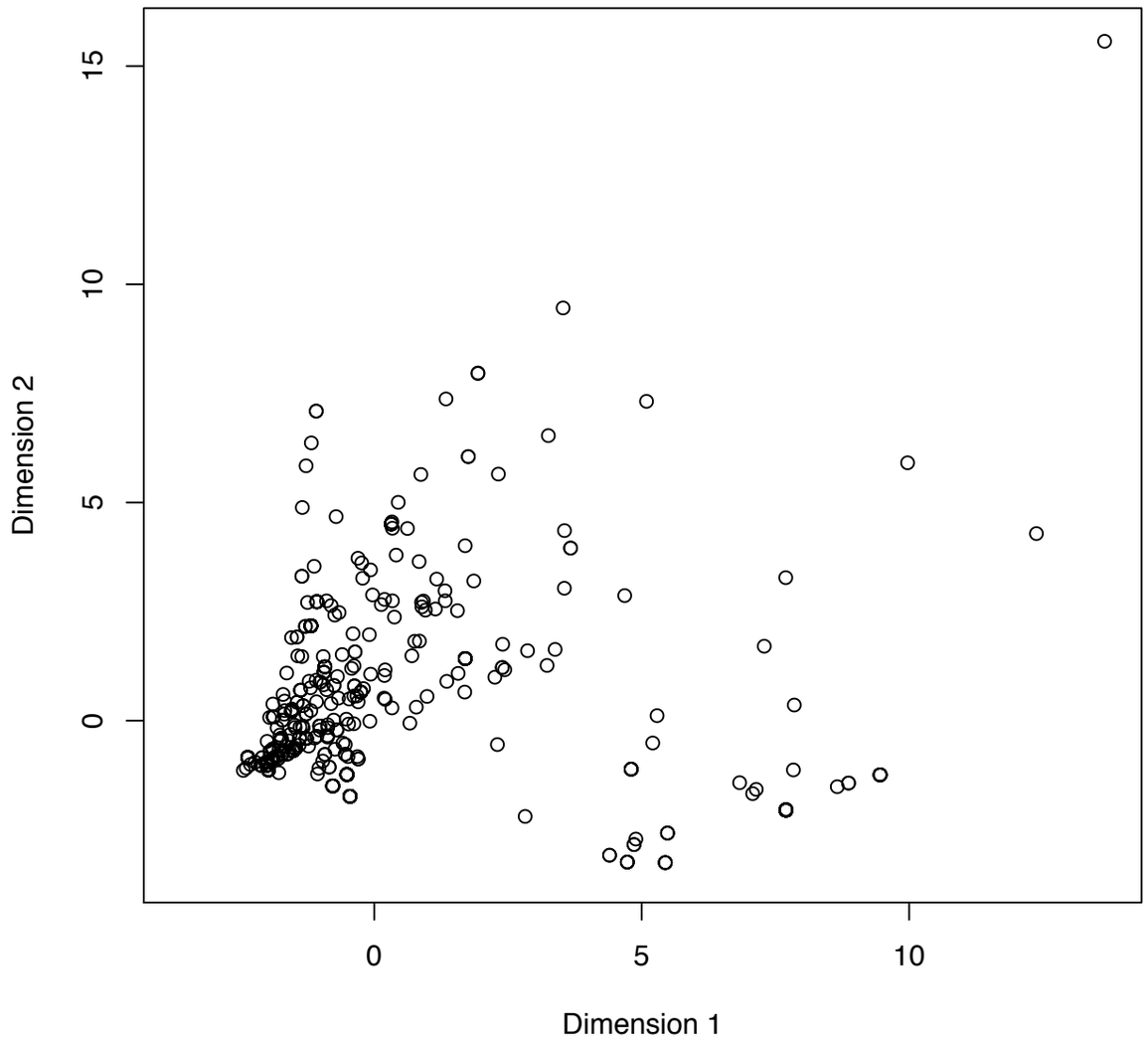
K-nearest neighbours

Better anomaly detection - API weight

cluster 29

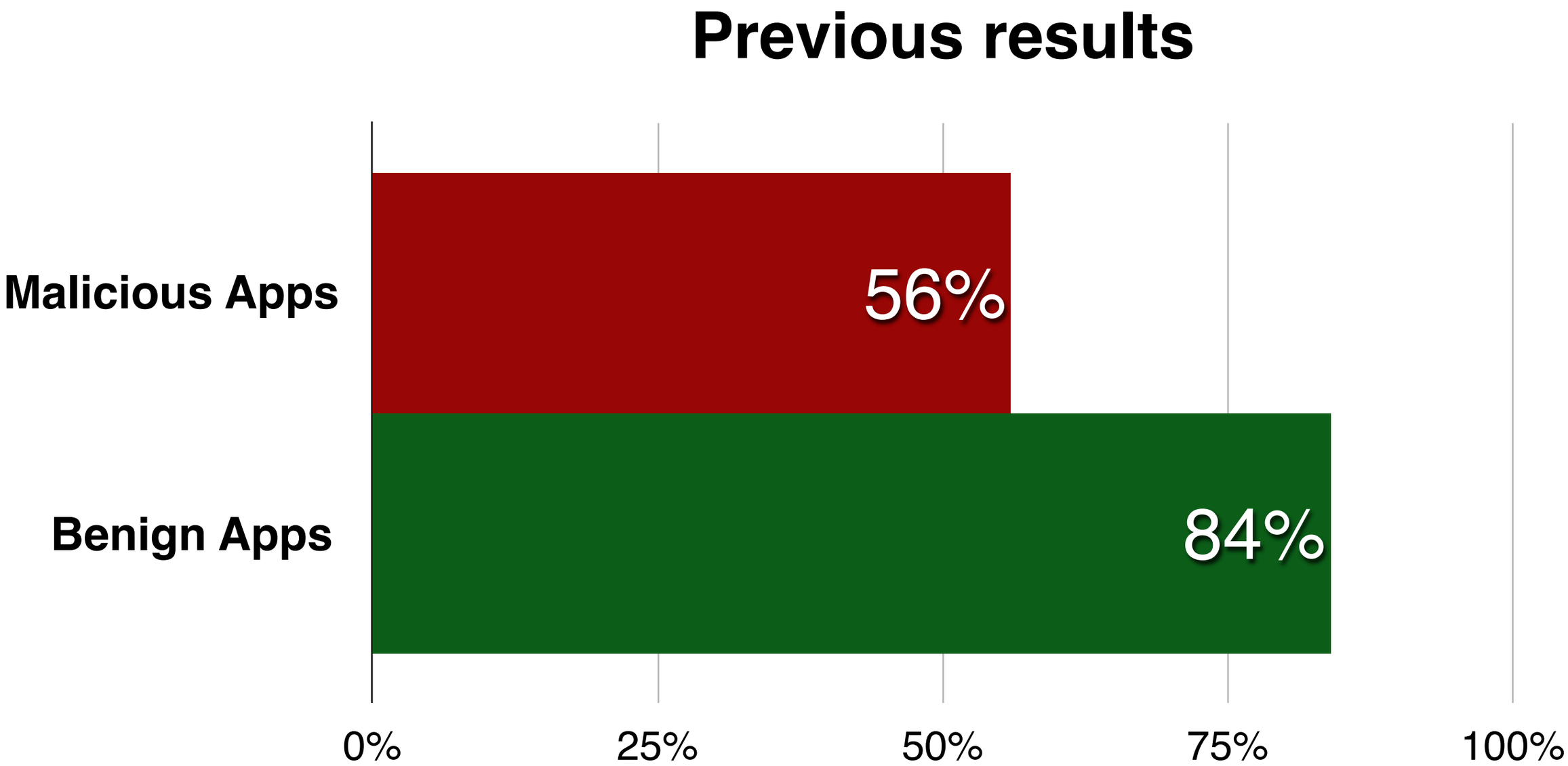


No weight



Weight with TF-IDF

Better anomaly detection



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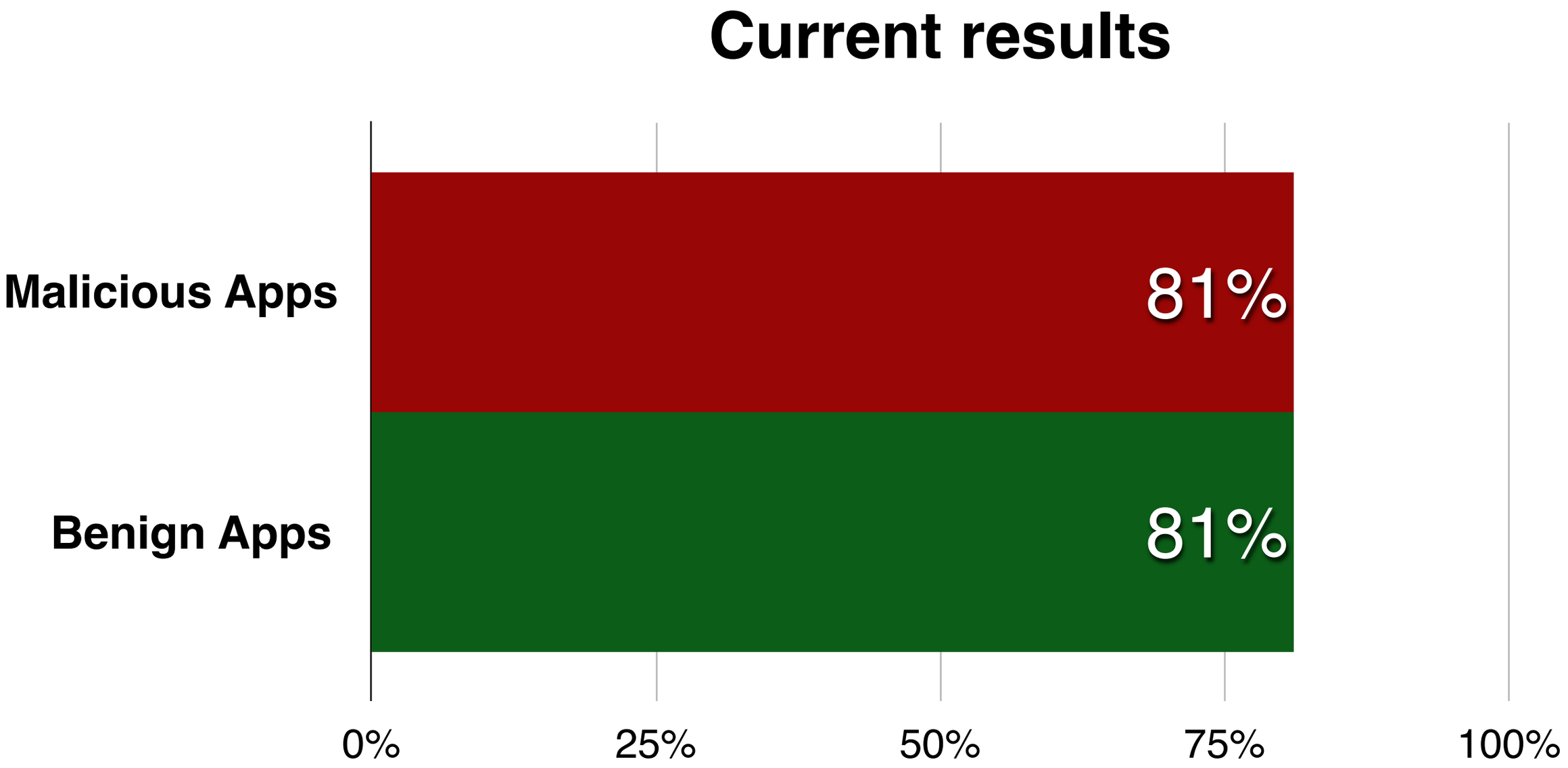
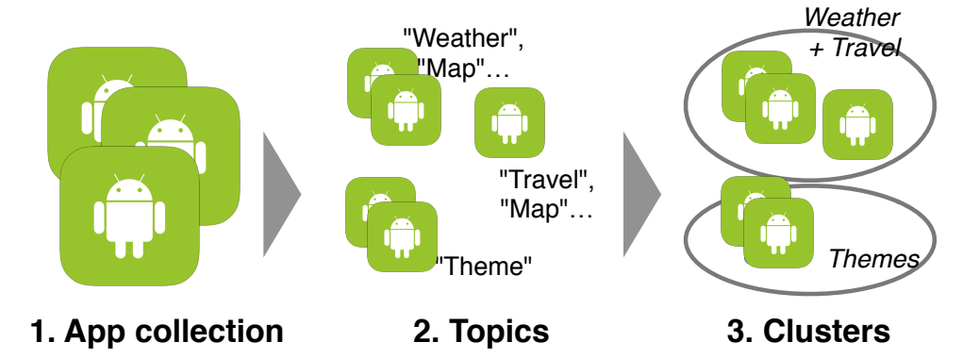


CHABADA:
Checking App Behavior Against App Descriptions

Alessandra Gorla
Saarland University, Germany

joint work with Konstantin Kuznetsov, Ilaria Tavecchia, Florian Gross and Andreas Zeller

CHABADA



BADA:
pp Behavior
Descriptions

Alessandra Gorla
Saarland University, Germany

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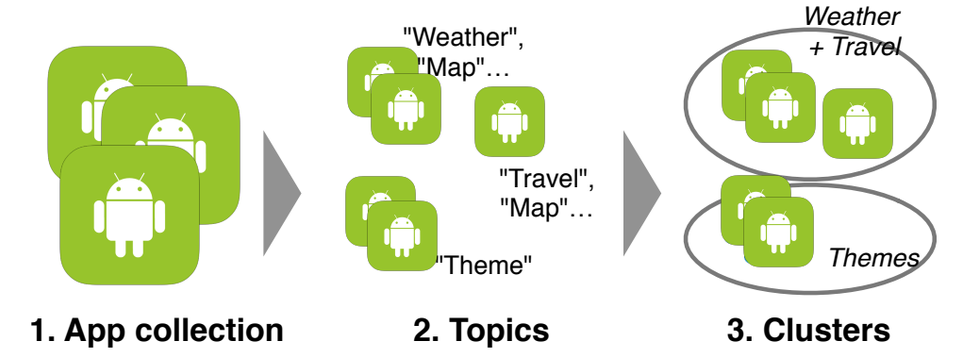
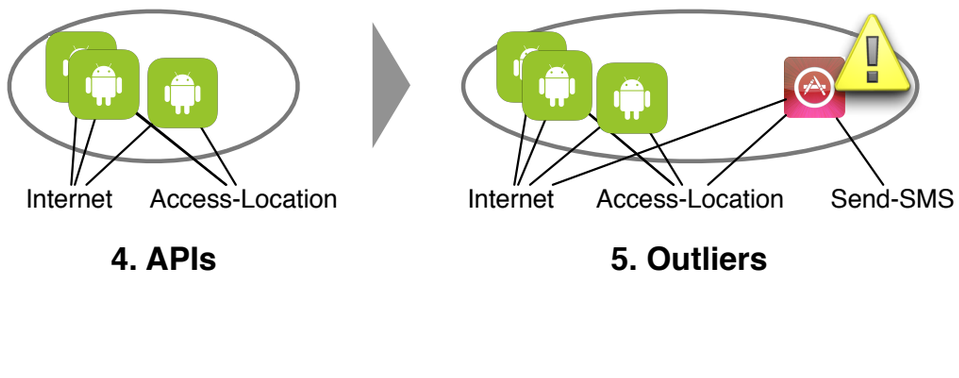
CHABADA





“Travel” cluster

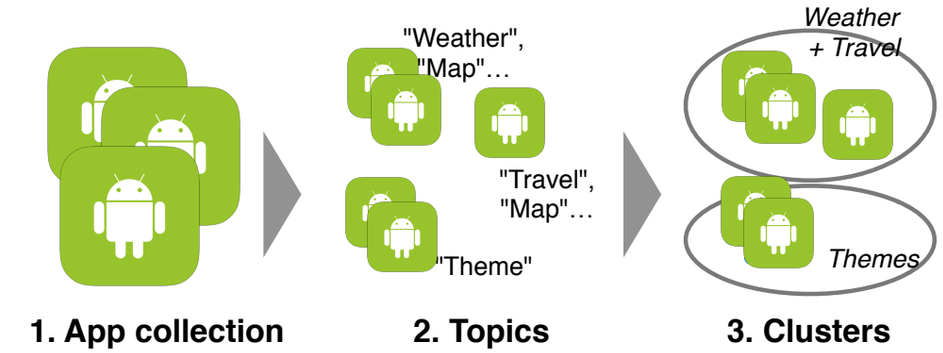
Description

Permissions of APIs used

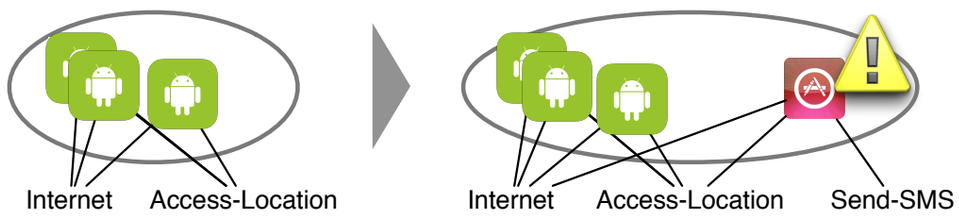
Alessandra Gorla
Saarland University, Germany

joint work with Konstantin Kuznetsov, Ilaria Tavecchia, Florian Gross and Andreas Zeller

CHABADA



1. App collection
2. Topics
3. Clusters



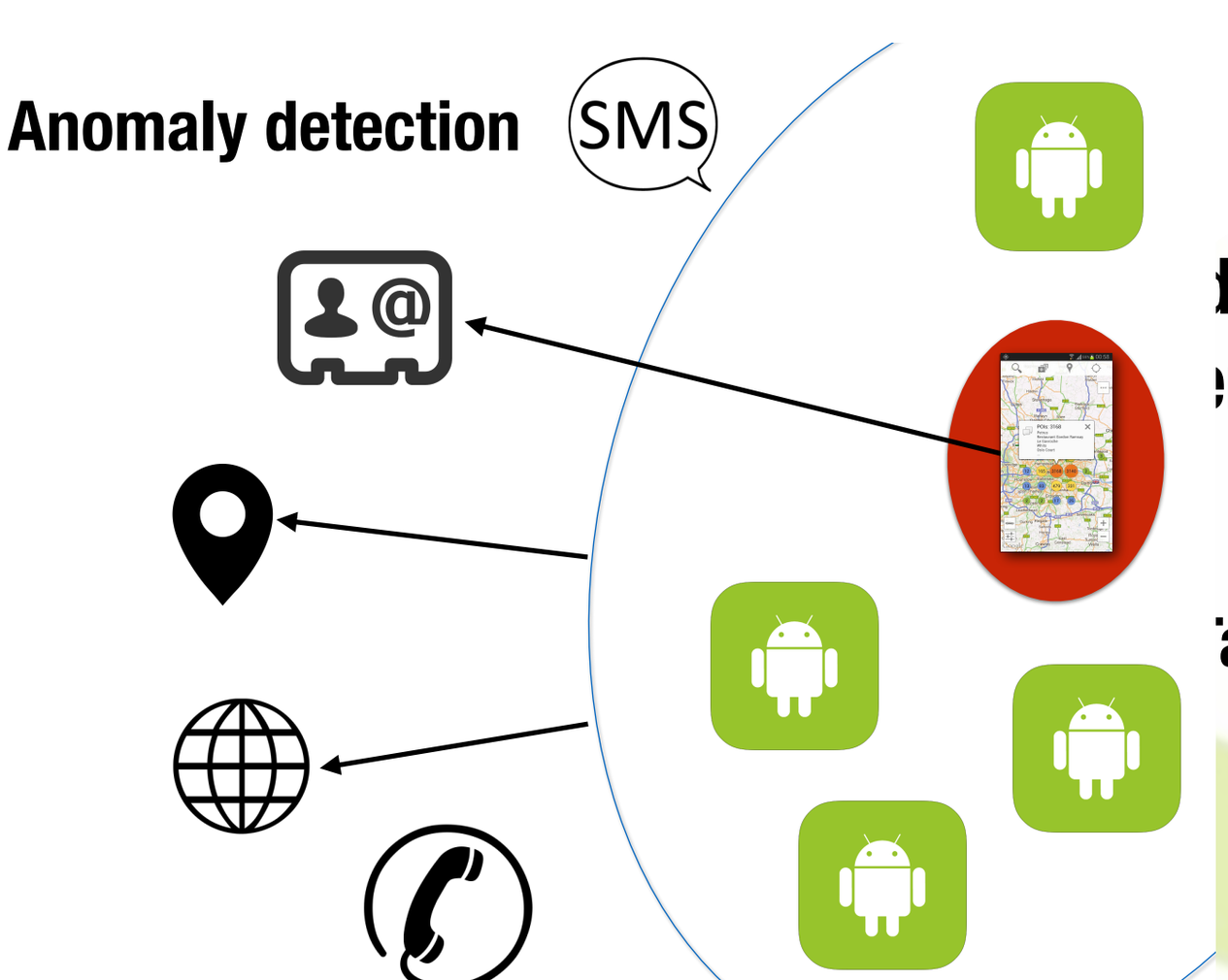
4. APIs
5. Outliers

“Travel” cluster

Description

Permissions of APIs used

Anomaly detection



dra Gorla
ersity, Germany

avecchia, Florian Gross and Andreas Zeller

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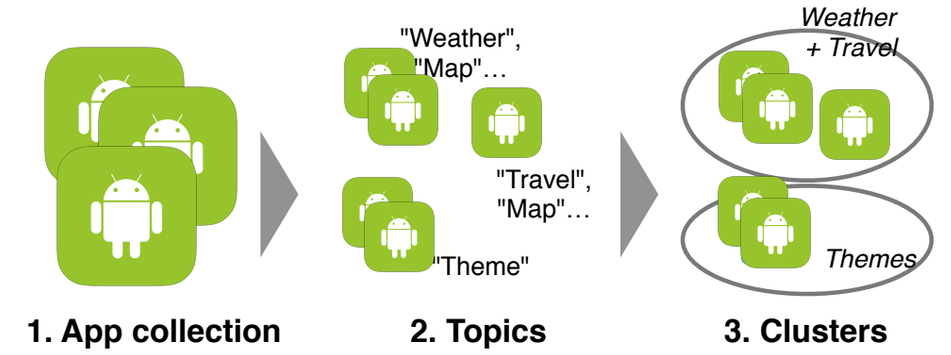

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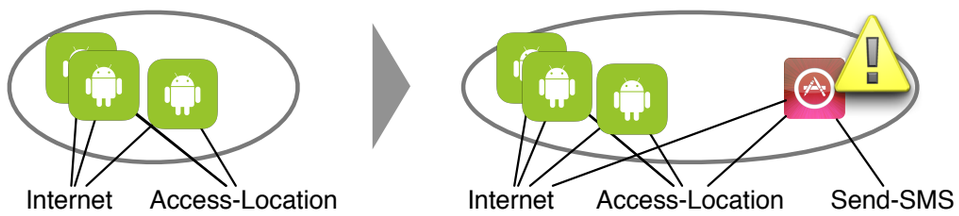

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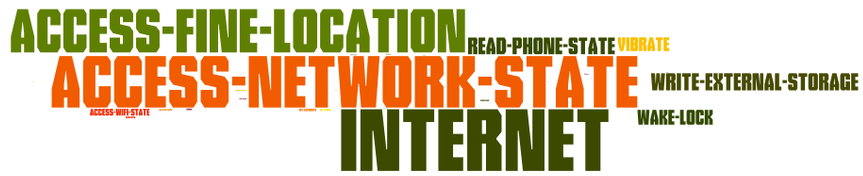

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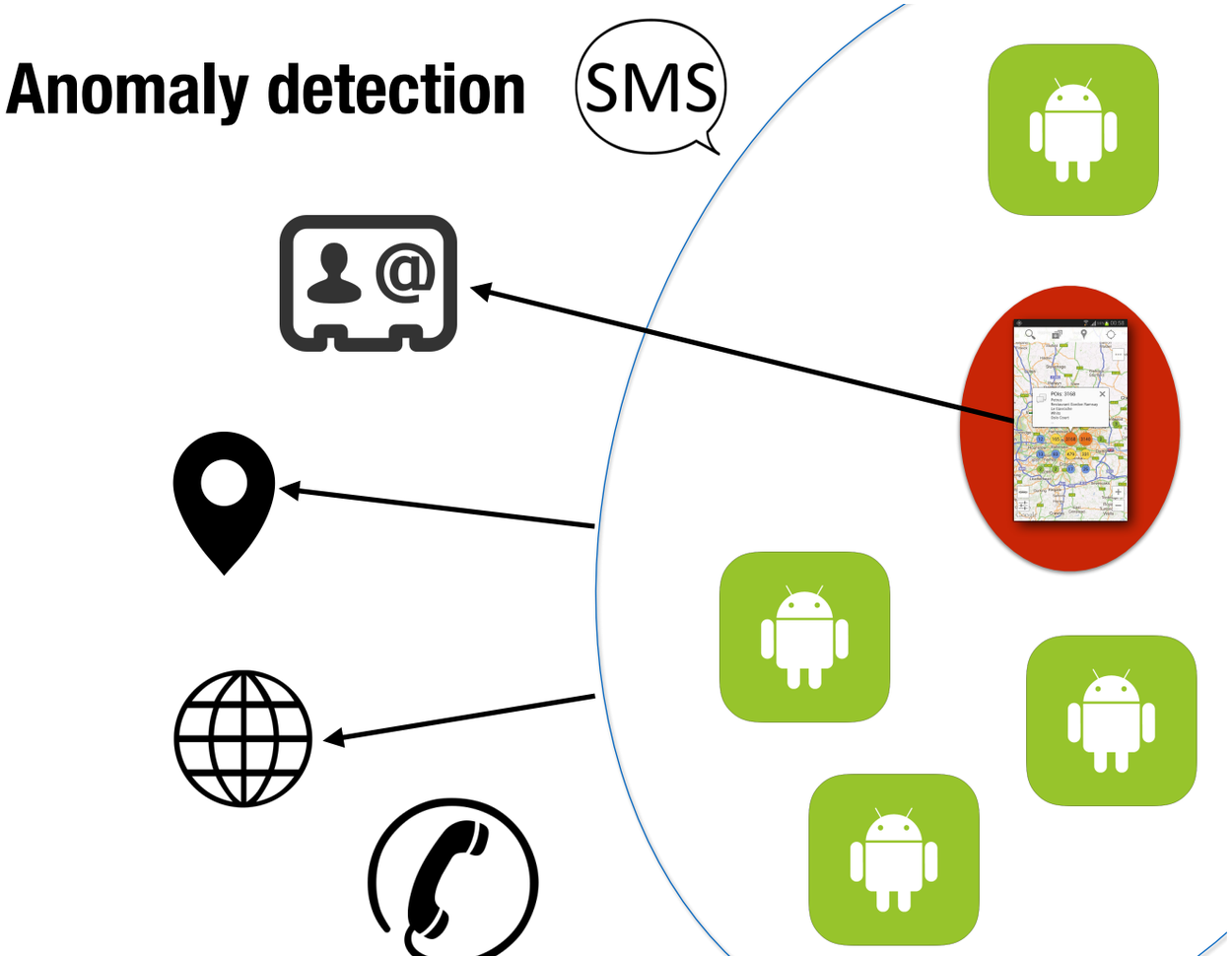
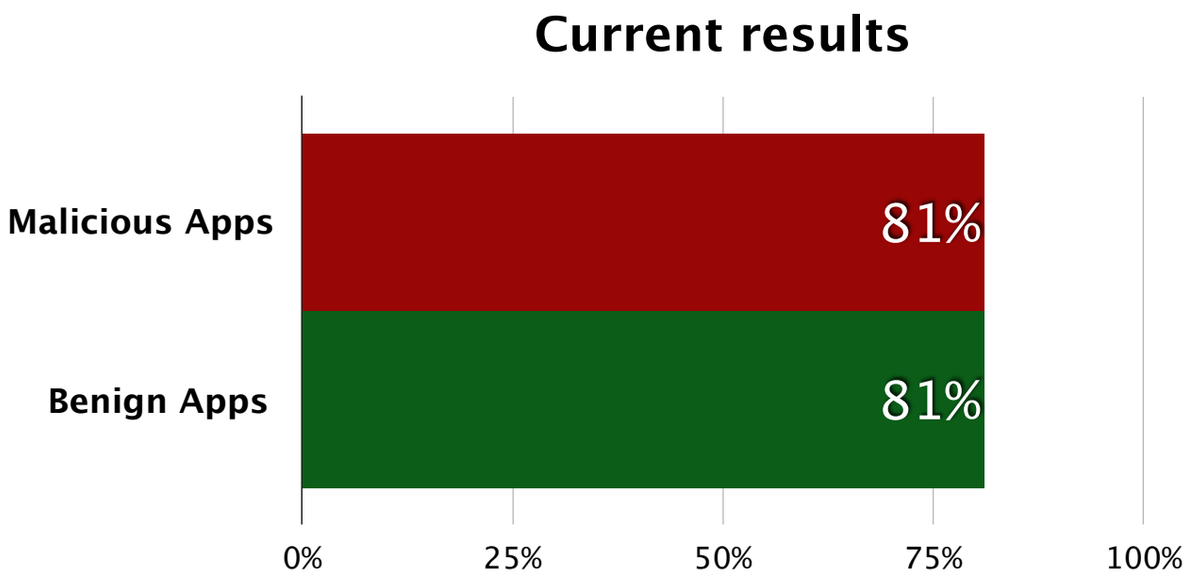


Better anomaly detection



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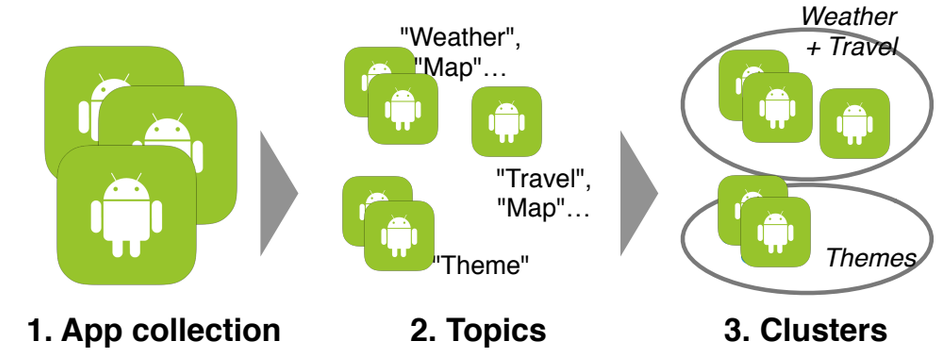
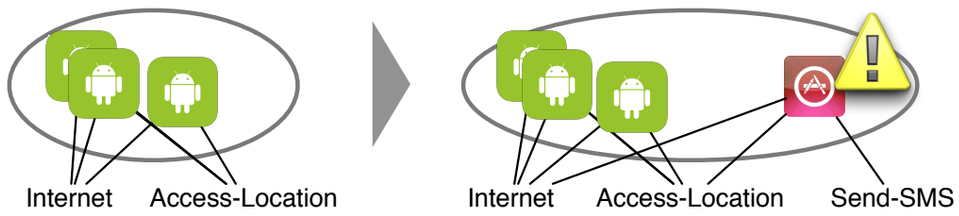


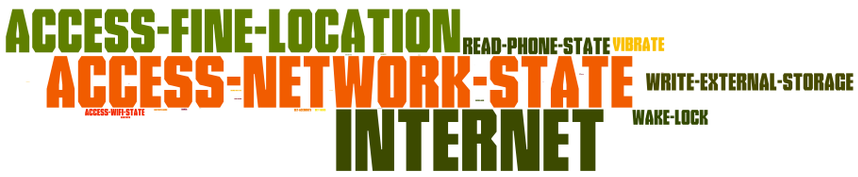


4. API

"Travel" cluster

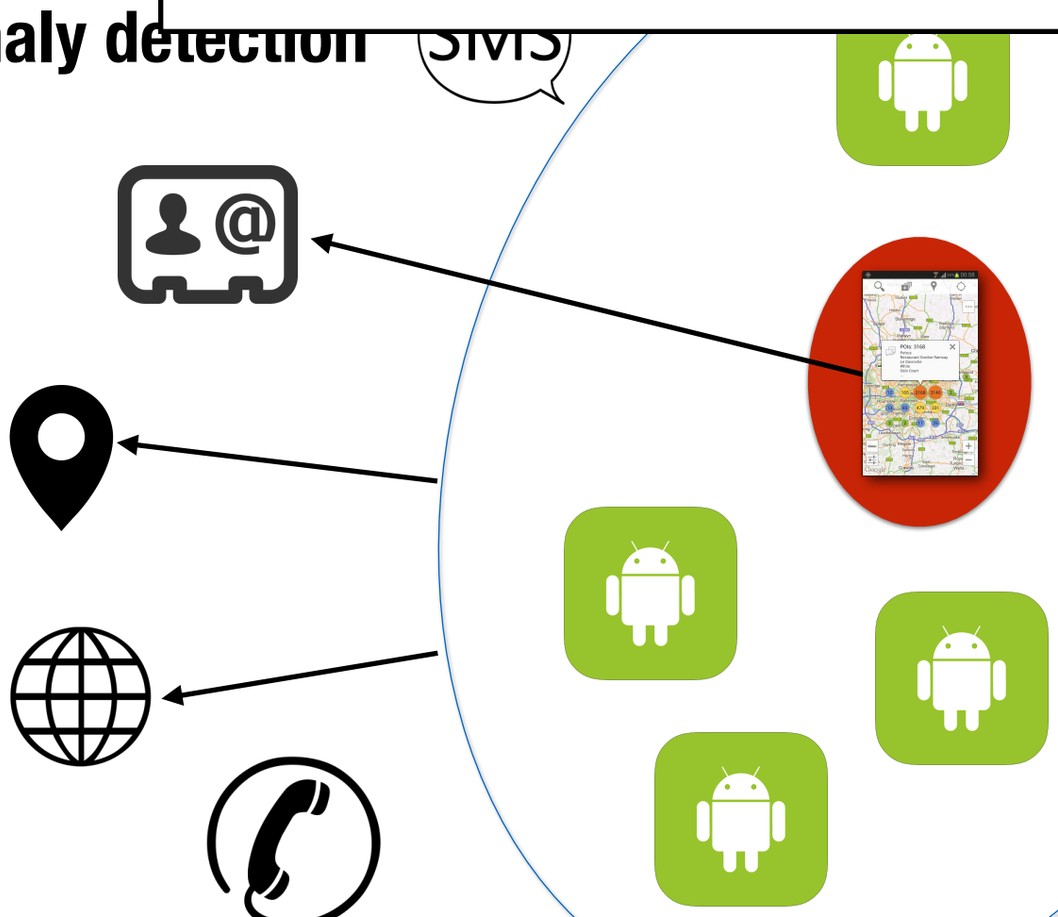
Description

Permissions of APIs used



www.st.cs.uni-saarland.de/chabada

Anomaly detection



Better anomaly detection

Current results