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Do they track? Automated analysis of Android apps for privacy violations

Benjamin Altpeter and Malte Wessels, 2021-03-09

Motivation

- in 2018, GDPR went into force, mandating a framework that is not only consistent across the whole EU but also more strict than previous data protection regulation
- both interested in data protection and volunteer in a data protection non-profit, Datenanfragen.de e. V.
- recently, various reports published of apps transmitting lots of data back to the developer or even third-party providers

Research by Privacy International (2019)

NGO Privacy International manually tested 34 apps:

“We found that at least 61 percent of apps we tested automatically transfer data to Facebook the moment a user opens the app.

[...]

We also found that some apps routinely send Facebook data that is incredibly detailed and sometimes sensitive. [...] A prime example is the travel search and price comparison app "KAYAK", which sends detailed information about people's flight searches to Facebook, including: departure city, departure airport, departure date, arrival city, arrival airport, arrival date, number of tickets (including number of children), class of tickets (economy, business or first class)."

<https://privacyinternational.org/report/2647/how-apps-android-share-data-facebook-report>

Research on TikTok (2020)

“I can see 3 types of parameters:

Info about the device: device_id, device_type, device_brand, os_api, os_version, ...

Info about the app: app_type, app_language, version_code, version_name, build_number, ...

Info about the user: current_region, locale, region

While that might sound surprising to you, it really isn't. Such practice is pretty standard and you can be assured that most apps you use have the same data-retrieval process.”

<https://medium.com/@fs0c131y/tiktok-logs-logs-logs-e93e8162647a>

Quick GDPR primer

- concerns itself with the *processing* of *personal data* (Art. 2(1) GDPR)
- both terms defined in Art. 4 GDPR:
 - *personal data*: “**any information relating to an identified or identifiable natural person** [...]; [i.e.] one who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, [...], an online identifier or [...] the physical, physiological, genetic, mental, economic, cultural or social identity [...]" (Art. 4(1) GDPR)
 - *processing*: “**any operation** [...] **performed on personal data** [...], such as collection, recording, organisation, structuring, storage, adaptation or alteration, retrieval, consultation, use, disclosure by transmission, dissemination or otherwise making available, alignment or combination, restriction, erasure or destruction" (Art. 4(2) GDPR)
- explicitly very broad terms, in essence any data that can somehow be connected to a person (including pseudonymously!) and that a company deals with in some way is covered by the GDPR

Quick GDPR primer

- applicable EU-wide (Art. 3(1) GDPR), also applies to non-EU companies (Art. 3(2) GDPR) given they deliberately process the data of people in the EU in relation to the offering of goods and services; or in the case of the monitoring of the behaviour of people in the EU (→ tracking)
- important for us: companies need a legal basis if they want to process our data (more on that later)

Enter Schrems II

- recent (July 2020) Schrems II ruling by the European Court of Justice
- generally, transferring data to country outside the EU is forbidden unless it there is an exception that allows it (Art. 44–50 GDPR)
- previously, transfers to the USA usually based on *Privacy Shield* (or *Safe Harbor* before that), a so-called adequacy decision
- however, Privacy Shield was invalidated by the ruling and cannot be used anymore
- technically, it is still possible to legally transfer data to the US in narrow circumstances but the general consensus says it's pretty much impossible [1], [2], [3]

Schrems II

- in practice, so far barely any companies are fully compliant with this ruling due to the prevalence of US cloud providers etc., and enforcement is so far very limited
- however, while the supervisory authorities are currently fairly lenient on this matter, they expect companies to review their transfers to the US and only keep those that are necessary and cannot be replaced
- thus: tracking using US providers is most likely illegal, especially without user consent

Research question

- How common is tracking in apps actually?
- In particular, we are looking at tracking that happens without any user interaction (and thus, without consent).
- We want to develop a tool that can analyse this automatically for a large number of apps.
- We also manually looked at some of the interesting cases we discovered in the data.



Image: Nina Mercado (Unsplash license)

Method

Emulation

- Android SDK ships with emulator
 - Android 11 (API level 30)
 - Android 11 allows running ARM apps in x86 emulators
 - Android Debug Bridge (ADB)
 - shell and interface
 - install CA as system CA
 - /system **read only** → OverlayFS
 - prepare Honey data
 - contacts, pictures, sensor data, location,
...
▪ seed clipboard as well
 - record screen
- ⚡ Limitations
 - it's trivial to detect this Emulator
 - it's not a real device!



Image: Alexander Mils (Unsplash license)

Honey data

Quick rundown

Identifiers

- **gaid:** 827d8162-0e1c-48cd-892e-4abd3df95ba8
 - “The advertising ID is a unique, user-resettable ID for advertising, provided by Google Play services” [1]
- **external IP:** 134.169.32.95
 - location inferable
- **SSID (AndroidWifi), BSSID (02:15:b2:00:01:00), internal IP (10.0.2.16)**
 - BSSID mappable to location! [2]

Contact

- Honeypotdontcopy Mustermensch
-  055533114411
- honeypotdontemail@bn.al
- Honeypotdontvisit Lane 314, 1618 Honeypotville

Device status

- battery percentage: 77% (not charging) 
- device rotation: (Z=-5.0, X=-24.7, Y=-22.2)
- device movement: (X=1.2, Y=-0.4, Z=0.8)
- location: Martinstraße 14, 21614 Buxtehude, Germany
 - 53.4675, 9.6916

Calls and messages

- incoming call from +49 5553 2653589 (answered, 31 sec., 2021-01-04)
 - called back (answered, 10 sec., 2021-01-04)
- SMS from +49 531 470 7634 ("Honeypotdontmessage", 2021-01-04T10:44, read)
 - reply ("Honeypotdontread", 2021-01-04T10:46)

Files

- Three photos of the emulator camera picture taken and in gallery
- Two screenshots of datarequests.org in the system webview



Clipboard

- "Honeypotdontpaste"
- seed data with Clipper
 - newer Androids: app needs to be in foreground
 - seed in preparation step



Image: Isis França (Unsplash license)

Enough Honey data

Back to our method

APK acquisition

- <https://github.com/NoMore201/googleplay-api>
 - adjust dependencies (pip install requests==2.22.0) [1]
 - dedicated new Google account
- get token
- crawl for app IDs
 - open Play Store, browse popular apps
 - run JS to extract app IDs
- download APKs from Google with gplaycli
- 1,408 apps downloaded
- installation
 - grant all run time permissions!

Machine in the middle

- mitmproxy
- root CA to install on device
- proxy runs on host
 - mitmweb for manual analysis
 - mitmdump for cli usage and scripting
- capture traffic with custom addon
- dump into SQL database
- we only store the request, not the response!

Certificate pinning

- But what about certificate pinning?
- Solution:
 - Frida (“dynamic instrumentation toolkit”)
 - injects JS runtime into process
 - run JS scripts in app context, hook functions, ...
 - objection (“Runtime Mobile Exploration”)
 - uses Frida
 - SSL bypassing
 - hooks SSL verification functions
 - start app through objection to capture everything
 - let apps run for 60 seconds

Automation

- automate steps with Python script
- reset Android system after every app
 - hot boot
- run script on a physical machine
 - → hardware emulation support!
- machine:
 - Intel Core i3-9100 CPU @ 3.60GHz
 - 8GB RAM
 - 240GB NVMe
- spoiler: all resources exhausted



Image: Cesar Carlevarino Aragon (Unsplash license)

Filter background noise

Android is noisy

- **Android is really noisy by default**
 - connectivity check frequently probes
http://connectivitycheck.gstatic.com/generate_204 (1)
 - disable via adb
- even system apps have telemetry by default
- logging
 - reports every app install
 - androidantiabuse and androidcheck requests
 - Google Play logs & auth requests
 - ...
- we recorded the running system for a several hours and recorded the traffic
- created host and path based filter
 - remove everything from the recorded idle run
 - approximates lower bound

Clock widget

POST <https://ssl.google-analytics.com/batch>

```
"a": "1399991084",
"utc": ["Digital Widget", "Digital Widget", "Digital
Widget"],
"aip": ["1", "1", "1"],
"an": ["Clock", "Clock", "Clock"],
"tid": ["UA-61414137-1", "UA-61414137-1", "UA-
61414137-1"],
"utt": ["20", "4", "1"],
"t": ["timing", "timing", "timing"],
"_s": ["5", "6", "7"],
"av": ["6.2 (259367952)", "6.2 (259367952)", "6.2
(259367952)"],
"utv": ["Widget Data Fetch", "Widget Data Fetch",
"Widget Data Fetch"],
"v": ["1", "1", "1"],
"_v": ["ma18.5.89", "ma18.5.89", "ma18.5.89"],
"ul": ["en-us", "en-us", "en-us"],

"aid": ["com.google.android.deskclock",
"com.google.android.deskclock",
"com.google.android.deskclock"],
"cid": [
"beb20edf-6c5c-4e13-93bb-5a788210cb72",
"beb20edf-6c5c-4e13-93bb-5a788210cb72",
"beb20edf-6c5c-4e13-93bb-5a788210cb72"
],
"sr": ["1440x2392", "1440x2392", "1440x2392"],
"ht": ["1610975551964", "1610975553497",
"1611663930874"],
"qt": ["688540681", "688539148", "161771"],
"_gmsv": ["201.8.17\\na=1399991084",
"201.8.17\\na=1399991084", "201.8.17"]]
```



Image: Yassine Khalfalli (Unsplash license)

Initial findings



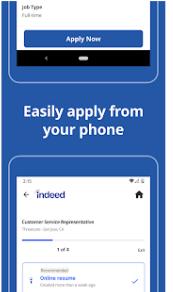
Indeed Job Search

Indeed Jobs Business
USK: All ages
Contains Ads

Install

Editors' Choice

★ ★ ★ ★ 1,236,827



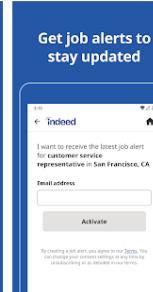
Easily apply from your phone



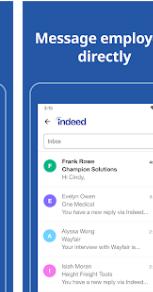
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ADDITIONAL INFORMATION

Updated	Size	Installs 100,000,000+
March 4, 2021	Varies with device	Current Version Varies with device
Content Rating	Interactive Elements	Requires Android Varies with device
USK: All ages	Unrestricted Internet	
Learn more	Permissions	
	View details	

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<https://play.google.com/store/apps/details?id=com.indeed.android.jobsearch>

Indeed Job Search

POST [https://t.appsflyer.com/api/v4/androidevent
?buildnumber=4.10.3&app_id=com.indeed.android.jobsearch](https://t.appsflyer.com/api/v4/androidevent?buildnumber=4.10.3&app_id=com.indeed.android.jobsearch)

```
"af_timestamp": "1611209035694",
"appsflyerKey": "ExLocXqS6j9TGyNebHQHrG",
"operator": "T-Mobile",
"network": "MOBILE",
"timepassedsincelastlaunch": "-1",
"open_referrer": "android-app://android",
"af_v2": "e1089f09b150658adabacd6f807c1947d072cb2",
"uid": "1611209035909-2664535545820779500",
"isGaidWithGps": "true",
"lang_code": "en",
"installDate": "2021-01-21_060319+0000",
"app_version_code": "63766",
"firstLaunchDate": "2021-01-21_060358+0000",
"ivc": false,
"model": "sdk_gphone_x86_64_arm64",
"lang": "English",
"brand": "google",
"batteryLevel": "77.0",
"deviceType": "userdebug",
"product": "sdk_gphone_x86_64_arm64",
```

```
"deviceData": [
"sensors": [ {
"sT": 1,
"svs": [0.7662141, 9.013549, 3.795387],
"sN": "Goldfish 3-axis Accelerometer",
"sv": "The Android Open Source Project",
"sve": [0.7662141, 9.013549, 3.795387]
},
{
"sT": 2,
"svs": [-17.875, 24.125, -38.4375],
"sN": "Goldfish 3-axis Magnetic field sensor",
"sv": "The Android Open Source Project",
"sve": [-17.875, 24.125, -38.4375]
},
{
"sT": 4,
"svs": [0, 0, 0],
"sN": "Goldfish 3-axis Gyroscope",
"sv": "The Android Open Source Project",
"sve": [0, 0, 0]
} ],
}
```

Still Indeed

```
"cpu_abi": "x86_64",
"build_display_id": "sdk_gphone_x86_64_arm64
    -userdebug 11 RSR1.201013.001 6903271 dev-keys",
"btch": "no",
"dim": {
    "size": "2",
    "ydp": "560.0",
    "xdp": "560.0",
    "y_px": "2392",
    "x_px": "1440",
    "d_dpi": "560"
},
"arch": "",
"btl": "77.0",
"cpu_abi2": ""
},  

"date2": "2021-01-21_070319+0100",
"counter": "1",
"date1": "2021-01-21_070319+0100",
"advertiserId":  

    "827d8162-0e1c-48cd-892e-4abd3df95ba8",
"advertiserIdEnabled": "true",
"af_v": "7a9b6ab5b95cf4cc7fb9ebb214fddc119e69580d",
"carrier": "Android",
"af_preinstalled": "false",
"iaeCounter": "0",
"sdk": "30",
"app_version_name": "47.0",
"device": "generic_x86_64_arm64",
"platformextension": "android_native",
"cksm_v1": "25f578b2fe344d152f0fc5d357404fc890"
```



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ADDITIONAL INFORMATION

Updated	Size	Installs	Current Version	Requires Android
March 3, 2021	26M	100,000,000+	3.0.0	4.1 and up
Content Rating	Interactive Elements	Permissions	Report	Offered By
USK: Ages 12+	Digital Purchases	View details	Flag as inappropriate	Google Commerce Ltd

<https://play.google.com/store/apps/details?id=com.audible.application>

Audible

POST <https://control.kochava.com/track/json>

```
"action": "install",
"kochava_device_id": "KA3731610548931t77133e5ade9f4 [...]",
"sdk_protocol": "14",
"sdk_version": "AndroidTracker 3.7.3",
"nt_id": "d45c5-1-47dfaef35-b398-40d2-a2e6-bd7bb40c88d0",
"data": {
    "screen_brightness": 0.4,
    "device_orientation": "portrait",
    "volume": 0.3333,
    "carrier_name": "Android",
    "adid": "827d8162-0e1c-48cd-892e-4abd3df95ba8",
    "device": "sdk_gphone_x86_64_arm64-google",
    "disp_h": 2560,
    "disp_w": 1440,
    "package": "com.audible.application",
    "installed_date": 1610548859,
    "os_version": "Android 11",
    "device_limit_tracking": false,
    "is_genuine": false,
    "screen_dpi": 560,
    "screen_inches": 5,
    "manufacturer": "Google",
    "product_name": "sdk_gphone_x86_64_arm64",
    "architecture": "x86_64",
    "battery_status": "not_charging",
    "battery_level": 77,
    "device_cores": 2,
    "locale": "en-US",
    "timezone": "Europe/Berlin",
    "bluetooth_name": "sdk_gphone_x86_64_arm64",
    "ui_mode": "Normal",
    "notifications_enabled": true,
    "background_location": false,
    "bms": 1610548366742,
    "network_conn_type": "wifi",
    "network_metered": false,
    "usertime": 1610548931,
    "uptime": 6.764,
    "state_active": true,
    "app_limit_tracking": false,
    "identity_link": {
        "marketingcloudvisitorid": "14340173368323804205870968500570471451"
    },
    "sdk_id": "c456-s26905-",
    "send_date": "2021-01-13T14:42:17.885Z"
}
```

ESPN

Disney Sports

USK: Ages 6+

Contains Ads · Offers in-app purchases

Editors' Choice
★ ★ ★ ★ 628,431

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ADDITIONAL INFORMATION

Updated	Size	Installs	Current Version	Requires Android
February 25, 2021	Varies with device	50,000,000+	Varies with device	5.0 and up
Content Rating	Interactive Elements	In-app Products	Permissions	Report
USK: Ages 6+	In-App Purchases	€0.99 - €84.99 per item	View details	Flag as inappropriate

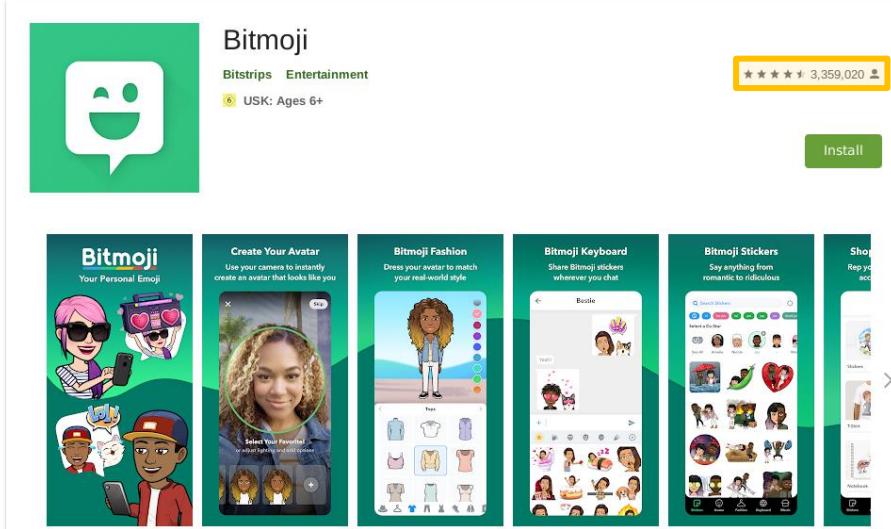
https://play.google.com/store/apps/details?id=com.espn.score_center

ESPN

POST <https://control.kochava.com/track/json>

```
"action": "initial",
"kochava_device_id":
  "KA3711610545608t639846df0756468ba090c72c5e0d1ded",
"sdk_protocol": "14",
"sdk_version": "AndroidTracker 3.7.1",
"nt_id":
  "ed86f-1-dd48fc04-f405-4c06-9ce3-b81da3fc183b",
"data": {
  "screen_brightness": 0.4,
  "device_orientation": "portrait",
  "volume": 0.3333,
  "carrier_name": "Android",
  "adid": "827d8162-0e1c-48cd-892e-4abd3df95ba8",
  "device": "sdk_gphone_x86_64_arm64-google",
  "disp_h": 2560,
  "disp_w": 1440,
  "package": "com.espn.score_center",
  "installed_date": 1610545526,
  "app_name": "ESPN",
  "app_version": "8707",
  "app_short_string": "6.36.1",
  [...],
```

```
"network_conn_type": "wifi",
"ssid": "\"AndroidWifi\"",
"bssid": "02:15:b2:00:01:00",
"network_metered": false,
"usertime": 1610545608,
"uptime": 2.005,
"state_active": true,
"app_limit_tracking": false,
"identity_link": {
  "adobevisitorid": "null",
  "unid": "NO UNID",
  "marketingcloudvisitorid":
    "39096276555537262255534371433003822371"
},
"sdk_id": "c863-s30486-",
"send_date": "2021-01-13T13:46:50.900Z"
```



Bitmoji is your own personal emoji.

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ADDITIONAL INFORMATION

Updated

March 1, 2021

Size

Varies with device

Installs

100,000,000+

Current Version

Varies with device

Requires Android

Varies with device

Content Rating

USK: Ages 6+

Alcohol Use - Occasional

Interactive Elements

Digital Purchases

Permissions

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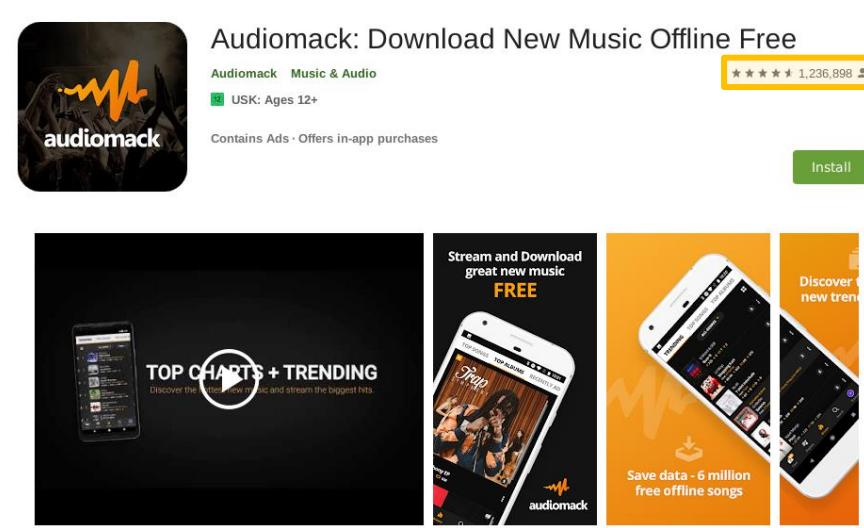
<https://play.google.com/store/apps/details?id=com.bitstrips.imoji>

Bitmoji

POST <https://bitmoji.api.snapchat.com/api/analytics/wevents>

```
"events": [ {  
    "category": "application",  
    "action": "app_open",  
    "avatarId": "0",  
    "timestamp": 1610547947100,  
    "label":  
        "{\"with_screen_read\":false,\"state\":\"cold\"}",  
    "appId": 1,  
    "has_snapchat_installed": false,  
    "session_id":  
        "5ceba0d8-46c5-4992-8142-0edf3e994bbe",  
    "experimentIds": [],  
    "sequence_id": 0,  
    "login_session_id":  
        "4104bb10-1abc-4128-a828-18b9e7413dbd"  
}, {  
    "category": "performance",  
    "action": "INSTALL_EXPERIMENT_PULL",  
    "avatarId": "0",  
    "timestamp": 1610547949712,  
    "label": "{\"latency\":2628,\"success\":true}",  
    "appId": 1,  
    "has_snapchat_installed": false,  
    "session_id":  
        "5ceba0d8-46c5-4992-8142-0edf3e994bbe",  
    "experimentIds": [274, 331, 392],  
    "sequence_id": 1,  
    "login_session_id":  
        "4104bb10-1abc-4128-a828-18b9e7413dbd"  
}, {  
    "category": "welcome",  
    "action": "page_view",  
    "avatarId": "0",  
    "timestamp": 1610547963550,  
    "label":  
        "{\"referrer\":\"\\\", \"login_version\":1}",  
    "appId": 1,  
    "has_snapchat_installed": false,  
    "session_id":  
        "5ceba0d8-46c5-4992-8142-0edf3e994bbe",  
    "experimentIds": [274, 331, 392],  
    "sequence_id": 2,  
    "login_session_id":  
        "4104bb10-1abc-4128-a828-18b9e7413dbd"  
} ]
```

```
"has_snapchat_installed": false,  
"session_id":  
    "5ceba0d8-46c5-4992-8142-0edf3e994bbe",  
"experimentIds": [274, 331, 392],  
"sequence_id": 1,  
"login_session_id":  
    "4104bb10-1abc-4128-a828-18b9e7413dbd"  
}, {  
    "category": "welcome",  
    "action": "page_view",  
    "avatarId": "0",  
    "timestamp": 1610547963550,  
    "label":  
        "{\"referrer\":\"\\\", \"login_version\":1}",  
    "appId": 1,  
    "has_snapchat_installed": false,  
    "session_id":  
        "5ceba0d8-46c5-4992-8142-0edf3e994bbe",  
    "experimentIds": [274, 331, 392],  
    "sequence_id": 2,  
    "login_session_id":  
        "4104bb10-1abc-4128-a828-18b9e7413dbd"  
} ]
```



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ADDITIONAL INFORMATION

Updated

March 4, 2021

Size

30M

Installs

10,000,000+

Current Version

5.11.3

Requires Android

5.0 and up

Content Rating

USK: Ages 12+

In-app Products

€1.08 - €4.99 per item

Permissions

[View details](#)

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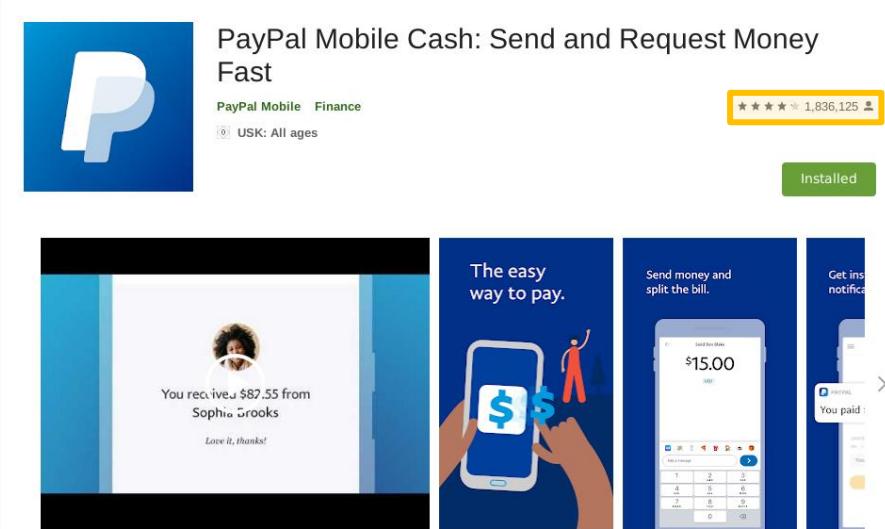
<https://play.google.com/store/apps/details?id=com.audiomack>

Audiomack

POST <https://aax-eu.amazon-adsystem.com/e/msdk/ads>

```
"oo": "false",
"dinfo": {
  "os": "Android",
  "model": "sdk_gphone_x86_64_arm64",
  "make": "Google",
  "hwv": "generic_x86_64_arm64",
  "osVersion": "11",
  "country": "US",
  "carrier": "Android",
  "language": "en",
  "screenSize": "411x731",
  "scalingFactor": "3.5",
  "ppi": "560",
  "orientation": "portrait",
  "connectionType": "Wifi"
},
"adsdk": "aps-android-8.4.0",
```

```
"slots": [
  {
    "sz": "320x50",
    "slot": "a96a0772-470b-4865-b2fa-daed2957fabe",
    "slotId": 1,
    "supportedMediaTypes": ["DISPLAY"]
  }
],
"mraida": ["1.0", "2.0"],
"appId": "fd370098318b45e083cd9826735e3f3d",
"idfa": "827d8162-0e1c-48cd-892e-4ahd3df95ba8",
"geoloc": "53.45945945945946,9.71425451253771,2000.0,13",
"isDTBMobile": "true",
"ua": "Mozilla/5.0 (Linux; Android 11; sdk_gphone_x86_64_arm64 Build/RSR1.201013.001; wv) AppleWebKit/537.36 (KHTML, like Gecko) Version/4.0 Chrome/83.0.4103.106 Mobile Safari/537.36",
"pkg": { "lbl": "Audiomack", "pn": "com.audiomack", "v": "10208", "vn": "5.10.4" },
"gdpr": { "c": "ACRAAA" }
```



PayPal Mobile Cash: Send and Request Money Fast

PayPal Mobile • Finance

USK: All ages

★ ★ ★ ★ 1,836,125

Installed

You receive \$82.55 from Sophia Brooks
Love it, thanks!

The easy way to pay.

Send money and split the bill.

Get instant notifications.

Our new PayPal app is a simple and secure way to get paid back for last night's takeaway, send money to friends who have an account with PayPal, check PayPal activity, choose currencies to send around the world and more. Plus, we've added some new features in

[READ MORE](#)

ADDITIONAL INFORMATION

Updated March 5, 2021	Size 86M	Installs 100,000,000+	Current Version 7.37.2	Requires Android 5.0 and up
Content Rating USK: All ages	Interactive Elements Digital Purchases	Permissions View details	Report Flag as inappropriate	Offered By Google Commerce Ltd

<https://play.google.com/store/apps/details?id=com.paypal.android.p2pmobile>

PayPal

POST <https://c.paypal.com/r/v1/device/client-metadata>

```
"app_guid": "20a8a72a-ee46-41ba-8070-44b88b1f0700",
"app_id": "com.paypal.android.p2pmobile",
"android_id": "576a7a191c0e94fe",
"app_version": "7.35.2",
"app_first_install_time": 1610985267665,
"app_last_update_time": 1610985267665,
"conf_url":
  "https://www.paypalobjects.com/rdaAssets/magnes/
    magnes_android_rec.json",
"comp_version": "5.1.0.release",
"device_model": "sdk_gphone_x86_64_arm64",
"device_name": "generic_x86_64_arm64",
"gsf_id": "395f6d69b136ffbc",
"is_emulator": true,
"ef": "10001",
"is_rooted": true,
"rf": "0100100",
"os_type": "Android",
"os_version": "11",
"payload_type": "full",
```

```
"sms_enabled": true,
"mac_addrs": "02:00:00:00:00:00",
"magnes_guid": {
  "id": "ef7d9022-a97a-4571-80e6-aaf8aafe34dc",
  "created_at": 1610985347998
},
"magnes_source": 10,
"source_app_version": "7.35.2",
"total_storage_space": 6240665600,
"nc": [101],
"t": false,
"pairing_id": "391bcb74073e4541ac903d518c1186d7",
"bssid": "02:15:b2:00:01:00",
"bssid_array": ["02:15:b2:00:01:00"],
"cell_id": 91,
"conn_type": "WIFI",
"conn_version": "5.0",
"dmo": false,
"dc_id": "78943ed0b393ff96d930532e9d579140",
"device_uptime": 605134,
```

Still PayPal

```
"ip_addrs": "10.0.2.16",
"ip_addresses": [
  "10.0.2.16",
  "10.0.2.15",
  "fe80::bcd3:53ff:fea1:89f2%dummy0",
  "fe80::31ec:f660:1191:9dc8%wlan0",
  "fec0::247d:2fc:2c5:25a6",
  "fec0::5901:b8e4:adba:110",
  "fe80::e066:23ff:fe9e:a31d%radio0",
  "fec0::e066:23ff:fe9e:a31d",
  "fec0::f81d:2504:8e52:c019"
],
"locale_country": "US",
"locale_lang": "en",
"location_area_code": 3,
"phone_type": "gsm",
"risk_comp_session_id":
  "7f58bf54-8420-43da-a768-e39769d24514",
```

```
"roaming": false,
"sim_operator_name": "T-Mobile",
"ssid": "\"AndroidWifi\"",
"timestamp": 1610985348295,
"tz_name": "Central+European+Standard+Time",
"ds": false,
"tz": 3600000,
"network_operator": "310260",
"c": "2",
"mg_id": "2f791641a776497424da517825871a10",
"linker_id": "b5dae4ea-0a46-4a99-b0da-a94eafc67d3c",
"pl": "111111",
"sr": { "ac": true, "gy": true, "mg": true }
```

Is that legal?

- a conclusive list of legal bases is given in Art. 6(1)(a–f) GDPR; interesting for apps:
 - consent (lit. a)
 - performance of a contract (lit. b)
 - legitimate interest (lit. f), in that cases needs to weigh their interest against the fundamental rights of the user
- in practice, processing in apps is usually based on consent or legitimate interest
- but supervisory authorities say that consent is necessary for tracking in most cases [1]
- recital 32 mandates conditions for consent: “Consent should be given by a clear affirmative act [...] Silence, pre-ticked boxes or inactivity should not therefore constitute consent. [...]”
- remember: none of the apps received *any* user input, so obviously no consent was given



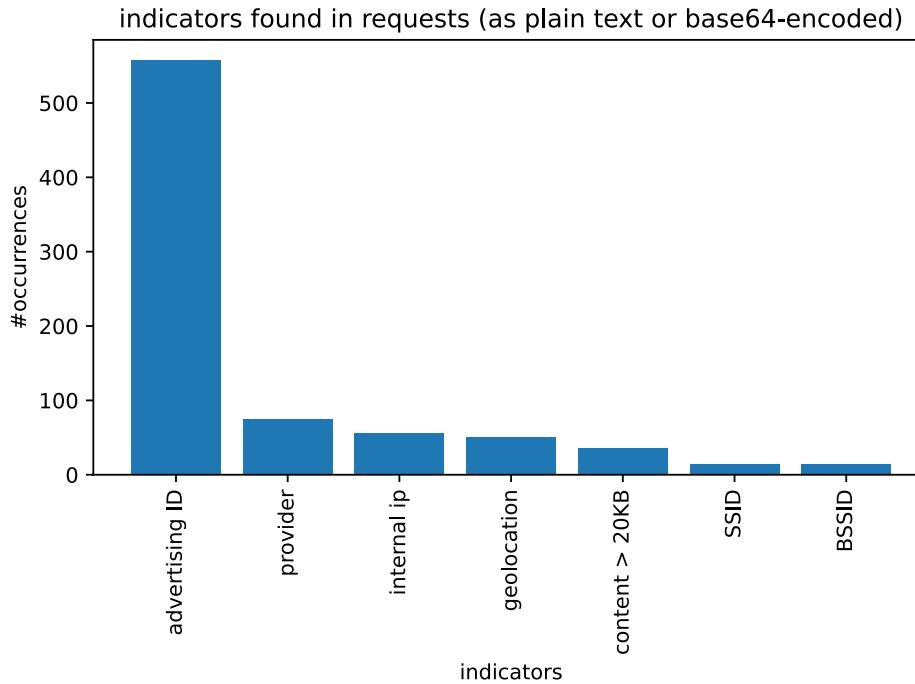
Image: William Iven (Unsplash license)

Results

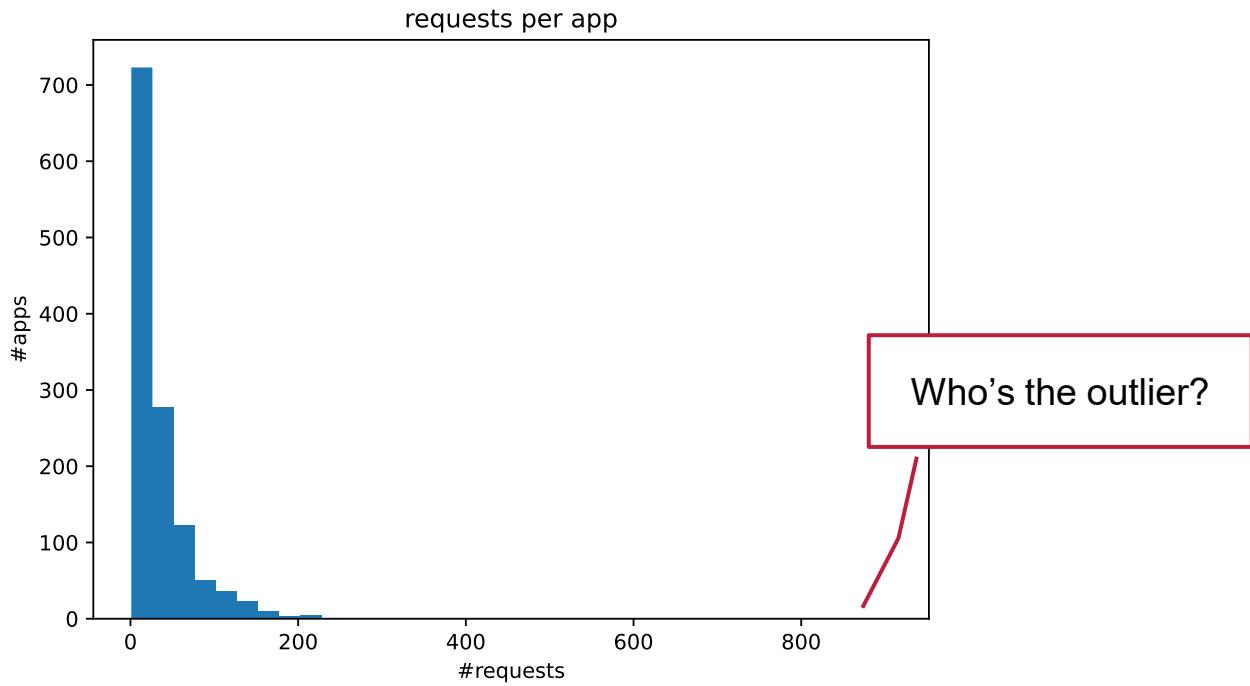
Statistics

- of the 1,408 downloaded apps, we successfully ran 1,296
- for the missing ones, Frida and objection failed to start the app with certificate pinning disabled
- limitation of our approach: we can't confirm if apps without any logged requests failed or simply didn't make any requests
- again, we can only provide a lower bound

Indicators

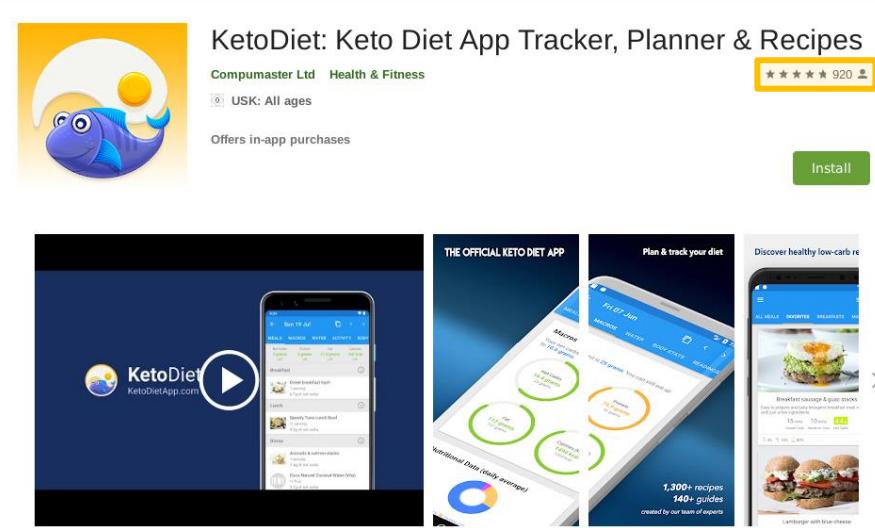


Requests per app



Requests per app: the outlier

app name	app ID	#requests
KetoDiet: Keto Diet App Tracker, Planner & Recipes	com.ketodietapp.ketodiet.full	907
Dumbbell Workout at Home - 30 Day Bodybuilding	dumbbellworkout.dumbbellapp.homeworkout	267
Shahid - شاهد	net.mbc.shahid	233
Collage Maker - Photo Editor & Photo Collage	photoeditor.layout.collagemaker	214
Who is? Brain Teaser & Tricky Riddles	com.unicostudio.whois	213
Tile	com.thetileapp.tile	205
Logo Maker - Free Graphic Design & Logo Templates	org.contentarcade.apps.logomaker	205
Tango - Live Video Broadcasts and Streaming Chats	com.sgiggle.production	204
碰碰狐儿歌—唱儿歌学舞蹈	kr.co.smartstudy.bodlebookiapsong_cn_android_googlemarket	192
Tile Connect - Free Tile Puzzle & Match Brain Game	link.merge.puzzle.onnect.number	186



KetoDiet App the original low-carb app from KetoDietApp.com

[READ MORE](#)

ADDITIONAL INFORMATION

Updated	Size	Installs	Current Version	Requires Android
February 22, 2021	132M	100,000+	3.42	6.0 and up
Content Rating	Interactive Elements	In-app Products	Permissions	Report
USK: All ages	Digital Purchases	€6.49 - €31.99 per item	View details	Flag as inappropriate

<https://play.google.com/store/apps/details?id=com.ketodietapp.ketodiet.full>

	start_time	host	path	content
1	2021-01-19 16:07:14.280531	POST infiniteedata-pa.googleapis.com	/mdi.InfiniteData/Lookup	<null>
2	2021-01-19 16:07:35.487593	POST firebaseinstallations.googleapis.com	/v1/projects/ketodiet-8dca/installations	{"fid":"fzrzj-U9QWmahkl6001cg5","appId":1}
3	2021-01-19 16:07:37.486264	POST mobile.ketodietapp.com	/KDApp.ashx?_xid=1	{"appInstallId":34373964363839322D3365393}
4	2021-01-19 16:07:38.722329	GET firebase-settings.crashlytics.com	/spi/v2/platforms/android/gmp/1:310369947550:android:26ead4de99afe332/settings?instance=6606ba809517b80492...	
5	2021-01-19 16:07:41.621474	GET mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/_local/ae181bf1b7d4fd7314fc6449a6f489a4ccbc06cf	
6	2021-01-19 16:07:41.802634	POST mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/_changes?feed=normal&heartbeat=30000&style=all_docs&active_only=true	{"feed":"normal","heartbeat":30000,"active_only":true}
7	2021-01-19 16:07:42.826298	POST firebaseremoteconfig.googleapis.com	/v1/projects/310369947550/namespaces.firebaseio:fetch	{"appInstanceId":fzrzj-U9QWmahkl6001cg5},
8	2021-01-19 16:07:43.632803	GET mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_86c1a285-e943-45d7-b674-dbac33ea2ba1?rev=2-46552b31e49cd2ec02adfd9cc013c4...	
9	2021-01-19 16:07:43.699757	GET mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_e33f5da5-d47c-40a8-8d2b-4c75609808d?rev=2-012ab8dc9b3ef2f4b72e59b4240e11...	
10	2021-01-19 16:07:43.701453	GET mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_a1c139f-4778-43f8-96bb-12b5c472a37e?rev=2-2ad8b16852a229eb96e297d9f9ec11...	
11	2021-01-19 16:07:43.701792	GET mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_00935fb5-32a3-45de-926a-048d1fd01513?rev=2-f1a93bdb2420623dbaea7343ab7a42...	
12	2021-01-19 16:07:43.703313	POST mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/_all_docs?include_docs=true	{"keys":["IBCAT_efbcadd3-798b-4fe1-923f-0b...
13	2021-01-19 16:07:44.432927	GET mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_8300b20d-4edb-48c3-bf11-ceb550fbeeaa8?rev=2-cf581e30672cca11c5fbda540af880...	
14	2021-01-19 16:07:44.434999	GET mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_25193a27-643c-4b72-a632-1744632c9e66?rev=2-3eafbfb096d2c3dce743ea6ad54769e...	
15	2021-01-19 16:07:44.436633	GET mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_504573e6-d772-465d-81ce-d6ab37e37e2?rev=2-645deddf6a9a07e53976d90cefaefc...	
16	2021-01-19 16:07:44.440239	GET mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_7f1a35fc-1474-4cd0-88c5-8fd05d354bd2?rev=2-8bdb28f97bda4e1791f735d92c2e90...	
17	2021-01-19 16:07:44.460289	GET mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_fb331120-f635-492e-8bbd-76796ad9020c?rev=2-a0135542123469fc14d20385c4e75a...	
18	2021-01-19 16:07:44.609866	GET mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_4a9d922a-ad60-47a3-8c7d-4c5845eb142b?rev=2-07773d7359aa8ba1b8e671d2700017...	
19	2021-01-19 16:07:44.783351	GET mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_59f4610d-ad95-4ce2-ba7e-4f085d4fd292?rev=2-d964aded94a2735030fb17970e1cf8...	
20	2021-01-19 16:07:44.821032	GET mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_cbe1acd3-2019-4492-af34-09031b42ccc6?rev=2-08828984ab0a93d32542c690b17601...	
21	2021-01-19 16:07:45.101919	GET mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_fc8fe40b-b24e-4509-aee5-55f8832506fa?rev=2-76dd49e908ee535691cad7145e40bf...	
22	2021-01-19 16:07:45.361309	GET mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_879c5556-0d8a-4b81-bee9-37322359f422?rev=2-710f03c41f7ae0bb05a15393d719f2...	
23	2021-01-19 16:07:45.381960	GET mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_dd011532-16c5-4382-b4db-5e3e21f932c?rev=2-9a8fe1608dde09c2fd5e97b5524...	
24	2021-01-19 16:07:45.383622	GET mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_1b31f930-76f5-436b-b265-789681324ecc?rev=2-9a13be85c42bbde918bfa339b71be7...	
25	2021-01-19 16:07:45.385239	GET mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_1719c6ee-7024-49c5-a8a2-29e11ccdf07f5?rev=2-6fc75dd703cf71bcab62435c0509be...	
26	2021-01-19 16:07:45.652492	GET mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_c5d61e1f-e115-46aa-bac1-cbe3048eba3d?rev=2-f6afea6b1f8b2bdfee76790831dc2b...	
27	2021-01-19 16:07:45.659029	GET mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_243f1f30-1095-4ee3-a1b8-e4bd9db2beb2?rev=2-a895693292587c2064c5f31e3225...	
28	2021-01-19 16:07:45.660323	GET mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_025b2b35-ca1c-4fb0-80c8-35d17534ec12?rev=2-c5996af29b3931e2df7b16cf535a88...	
29	2021-01-19 16:07:45.660834	GET mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_28d33003-42ab-4f76-97ff-b03917791b90c?rev=2-8ab5c2e62ea073cd1277e408607c6a...	
30	2021-01-19 16:07:45.700562	GET mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_8-cc50277-1344-4c5b-a9c2-2ed71bf-a203232aev-2-a434e3cb7a36db-ed10565b5209454...	

Inefficient design? A bug?

```
> curl -I "https://mobile.ketodietapp.com/Sync.ashx/ketodiet-public/IBPCS_c5d61e1f-e115-46aa-bac1-cbe3048eba3d?rev=2-f6afea6b1f8b2bdfee76790831dc2b02&revs=true&attachments=true"  
HTTP/1.1 500 Internal Server Error
```

Cache-Control: private

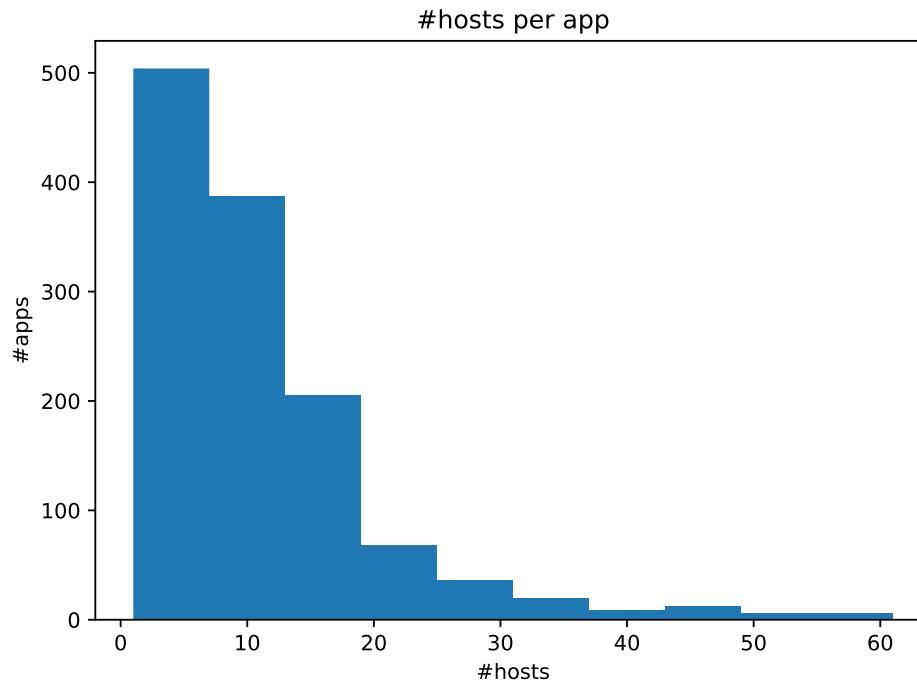
Transfer-Encoding: chunked

Date: Sun, 07 Mar 2021 13:36:20 GMT

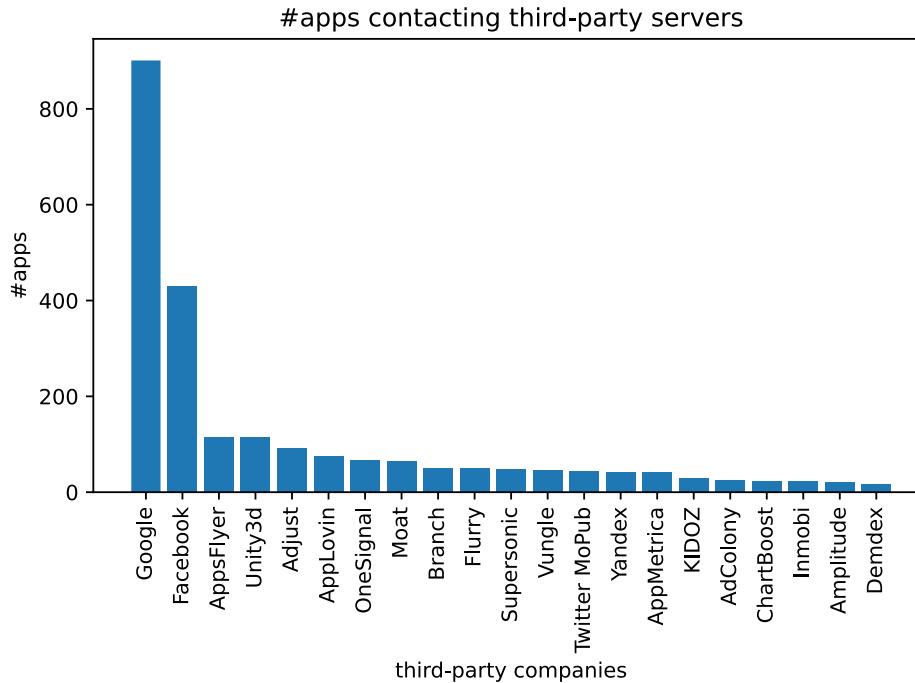


Takes 30s to respond, though.
Maybe they are DDoS-ing
their own server?

Hosts per app



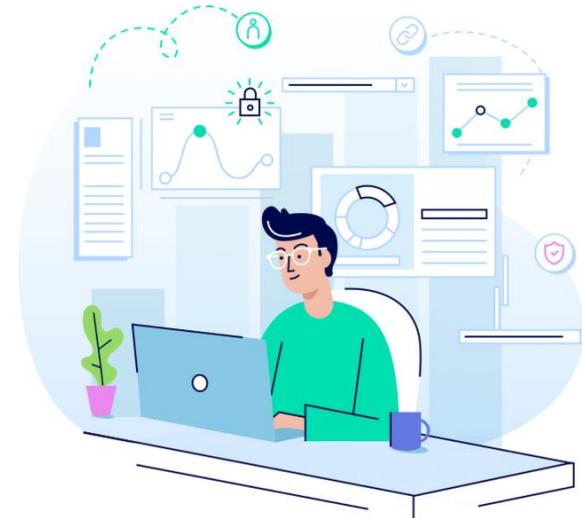
Requests to third-party tracking servers



based on Exodus tracker database [1]

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Moat Ad Search

Recent ads: AT&T, Taxslayer.com, Lladro

<https://moat.com/>



WATCH YOUR BRAND TAKE OFF

Join the World's Largest Mobile Network for Kids

PUBLISHERS

Safely Monetize
Kids' Apps

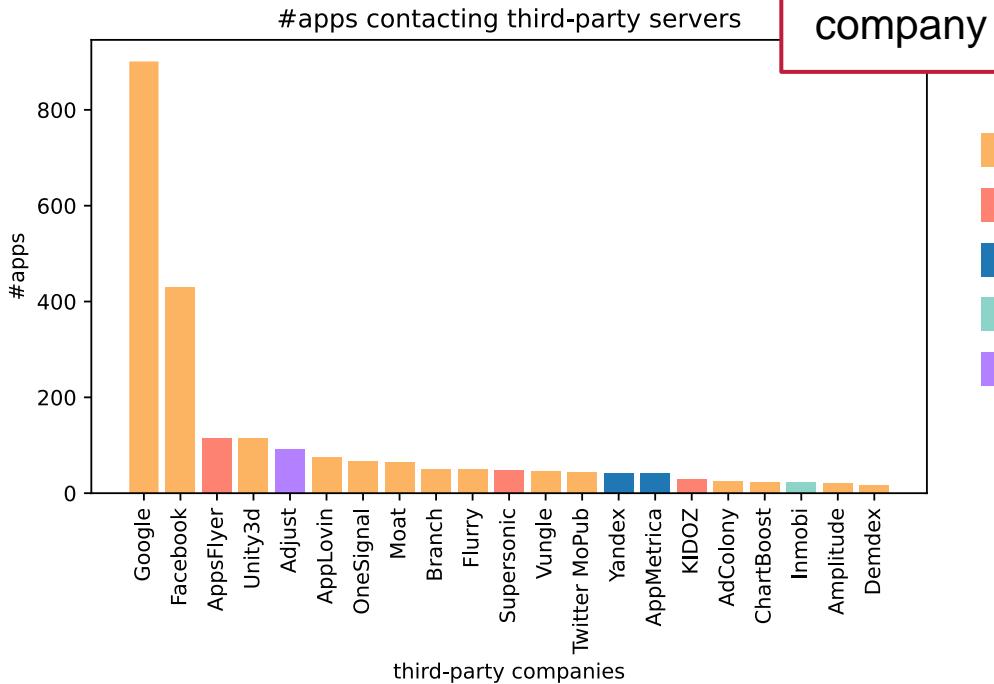
BRANDS

Reach &
Engage kids



<https://kidoz.net/>

Where are the trackers based?



all in the datarequests.org
company database (now)

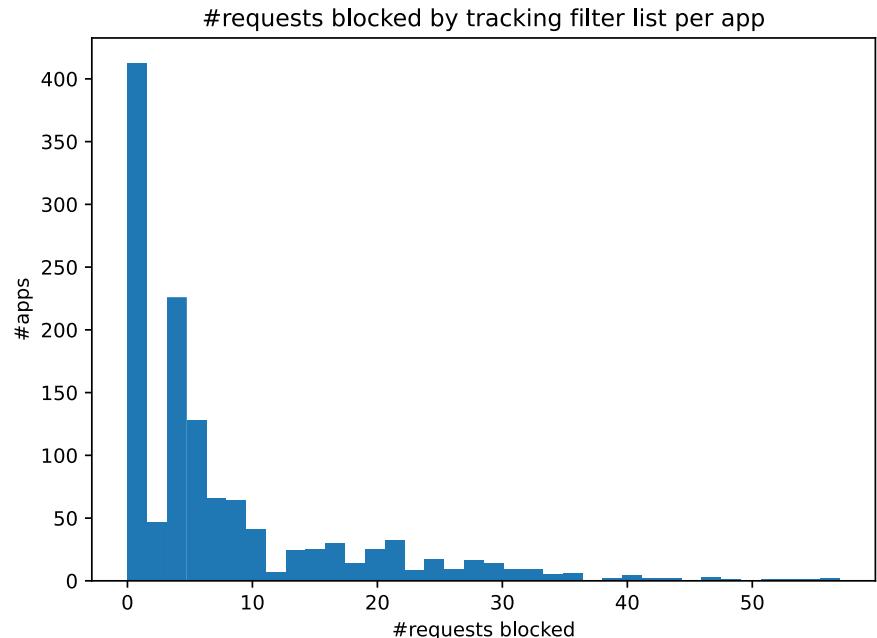
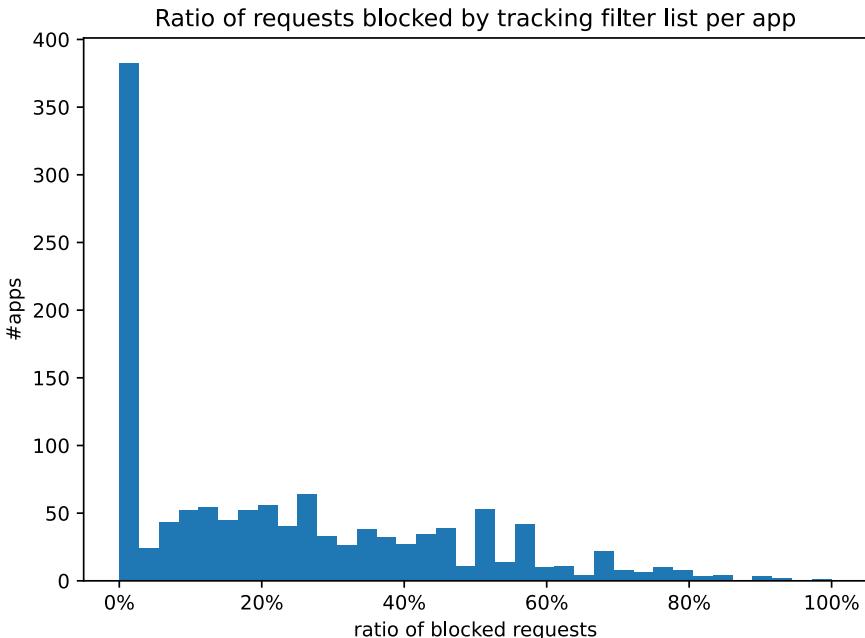
based on Exodus tracker database [1]

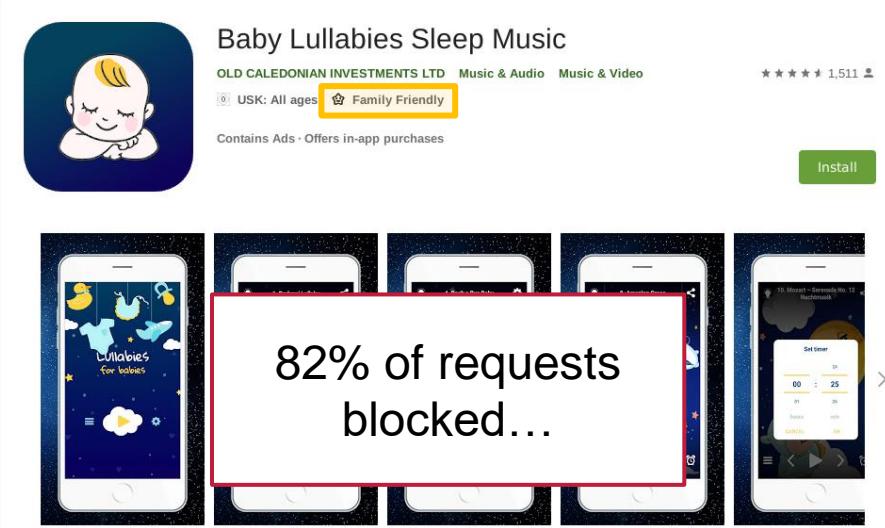
Requests blocked by tracking filter lists

- Given the large number of tracking requests, how effective would a system-wide ad blocker be?
- Three host-based filter lists combined:
 - [EasyPrivacy](#) (from EasyList project)
 - [eulaurarien](#) (first-party trackers host list)
 - [Perflyst Android tracking](#) (for PiHole)

Requests blocked by tracking filter lists

- Total requests: 41,395, requests after filtering: 31,985 (77.26%)





Baby Lullabies Sleep Music App is a free offline application which helps your baby to fall asleep faster.

[READ MORE](#)

ADDITIONAL INFORMATION

Updated March 20, 2019	Size 47M	Installs 100,000+	Current Version 1.0.2	Requires Android 4.4 and up
Content Rating USK: All ages Learn more	Interactive Elements In-App Purchases	In-app Products €2.09 per item	Permissions View details	Report Flag as inappropriate

<https://play.google.com/store/apps/details?id=com.babyrelaxchannel.lullabies2>

Maybe they at least use KIDOZ?

	id	start_time	method	host	path
1	35229	2021-01-19 07:55:58.201175	POST	infinitedata-pa.googleapis.com	/mdi.InfiniteData/Lookup
2	35240	2021-01-19 07:56:18.511178	GET	googleads.g.doubleclick.net	/mads/static/mad/sdk/native/production/sdk-core-v40-impl.html
3	35242	2021-01-19 07:56:22.873474	GET	settings.crashlytics.com	/spi/v2/platforms/android/apps/com.babyrelaxchannel.lullabies2/settings?instance=cd2966e20273b6ea16fceda4035...
4	35243	2021-01-19 07:56:24.417706	GET	googleads.g.doubleclick.net	/favicon.ico
5	35244	2021-01-19 07:56:24.420344	GET	googleads.g.doubleclick.net	/getconfig/pubsetting?app_name=com.babyrelaxchannel.lullabies2&client=ca-app-pub-5853277310445367&admob_appc...
6	35245	2021-01-19 07:56:27.717550	GET	googleads.g.doubleclick.net	/mads/static/mad/sdk/native/sdk-core-v40-loader.html
7	35246	2021-01-19 07:56:28.156900	GET	googleads.g.doubleclick.net	/mads/static/mad/sdk/native/sdk-core-v40-loader.js
8	35247	2021-01-19 07:56:28.901206	GET	googleads.g.doubleclick.net	/mads/static/mad/sdk/native/production/sdk-core-v40-impl.js?n=true&lv=sdk_20190107_RC02
9	35248	2021-01-19 07:56:28.908303	GET	googleads.g.doubleclick.net	/mads/static/mad/sdk/native/sdk-core-v40-loader.appcache
10	35249	2021-01-19 07:56:29.210823	GET	googleads.g.doubleclick.net	/favicon.ico
11	35250	2021-01-19 07:56:29.908494	GET	googleads.g.doubleclick.net	/mads/gma?hl=en&render_in_browser=false&seq_num=1&rv=5&_activity_context=true&ms=CpUCCoACEytR5uxiju5Z60bfNU...
12	35251	2021-01-19 07:56:32.035024	GET	imasdk.googleapis.com	/admob/sdkLoader/production/video_en.js
13	35252	2021-01-19 07:56:32.066741	GET	tpc.googlesyndication.com	/pagead/js/r20210112/r20110914/abg_lite_fy2019.js
14	35255	2021-01-19 07:56:34.874968	GET	googleads.g.doubleclick.net	/pagead/images/gmob/video_loading.svg
15	35256	2021-01-19 07:56:35.682696	POST	csi.gstatic.com	/csi?v=2&s=ima&dmc=2&puid=1-kk3jpehia&c=1660031470899&slotId=830015735449.5&qqid=CM73i-nCp-4CFVOPGAo...
16	35257	2021-01-19 07:56:35.825608	GET	app-measurement.com	/config/app/1%3A738882303123%3Android%3Ae4d61fe12335414?app_instance_id=8dd4baa15aaaf4c34af8734859773a81f&p...
17	35258	2021-01-19 07:56:35.997879	GET	googleads.g.doubleclick.net	/pagead/interaction/?ai=Cb3barZAGYI7tPN0eYrefvgMMPv3sLT_CbKvpamvCRABILTFyN1gLfqXgqwHiAEBoAGbhr34A8gBakCHYH...
18	35259	2021-01-19 07:56:36.328194	GET	r5---sn-i5h7lner.goglevideo.com	/videoplayback?Expires=1611071790&ei=rPAGYKTCoWHTATNvzaQQA&ip=134.169.32.95&id=50eadb372860f49a&itag=18&sour...
19	35260	2021-01-19 07:56:36.579186	GET	yt3.ggpht.com	/yc/AAUvwnhhLHxp9uxhrJE4j3s2YpbNk4ghM1bHQH-aKcC=s48-c-k-c0x0fffffff-no-rj
20	35261	2021-01-19 07:56:36.639442	POST	csi.gstatic.com	/csi?v=2&s=ima&dmc=2&puid=2-kk3jpei4k&c=1660031470899&slotId=830015735449.5&qqid=CM73i-nCp-4CFVOPGAo...
21	35262	2021-01-19 07:56:36.672117	GET	csi.gstatic.com	/csi?v=3&s=gmob&action=js_webview_partial&it=wtsrt_.2,tbsd_.2567,tbnd_-.2633&srt=2&e=318475418,318477624,318...
22	35263	2021-01-19 07:56:37.998192	GET	csi.gstatic.com	/csi?v=3&s=gmob&action=js_webview_partial&it=wtsrt_.2,tbsd_.2567,tbnd_-.2633&srt=2&e=318475418,318477624,318...
23	35264	2021-01-19 07:56:38.129647	POST	app-measurement.com	/a
24	35266	2021-01-19 07:56:39.630895	GET	csi.gstatic.com	/csi?v=2&s=ima&dmc=2&puid=2-kk3jpei4k&c=1660031470899&slotId=830015735449.5&qqid=CM73i-nCp-4CFVOPGAo...
25	35267	2021-01-19 07:56:42.752819	POST	app-measurement.com	/a
26	35268	2021-01-19 07:56:43.554773	POST	app-measurement.com	/a
27	35270	2021-01-19 07:56:44.632210	GET	csi.gstatic.com	/csi?v=3&s=gmob&action=js_webview_partial&it=wtsrt_.2,tbsd_.2567,tbnd_-.2633&srt=2&e=318475418,318477624,318...
28	35271	2021-01-19 07:56:44.903002	POST	app-measurement.com	/a



Early Learning App For Kids

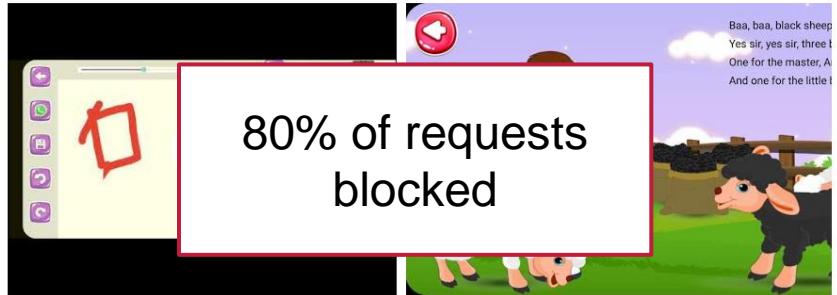
Early Learn Education Education

★★★★★ 5,495

USK: All ages

Contains Ads

Install



Early Learning App For Kids is for preschool kids, toddlers and kindergarten kids who want to learn ABC, rhymes, numbers, animal names, fruit names and more easily in an interactive and fun way. It is educational learning games for kids. It is the best one, expand

READ MORE

ADDITIONAL INFORMATION

Updated

January 31, 2021

Size

8.5M

Installs

500,000+

Current Version

5.1

Requires Android

5.0 and up

Content Rating

USK: All ages

Permissions

[View details](#)

Report

[Flag as inappropriate](#)

Offered By

Google Commerce Ltd

Developer

[Visit website](#)

<https://play.google.com/store/apps/details?id=earlylearn.kidslearningworld>

Same story here

	# id #	# start_time #	# method #	# host #	# path #
1	73997	2021-01-21 19:49:44.305754	POST	infinitedata-pa.googleapis.com	/mdi.InfiniteData/Lookup
2	74005	2021-01-21 19:50:10.274707	POST	firebaseinstallations.googleapis.com	/v1/projects/easyearlyLearn/installations
3	74018	2021-01-21 19:50:18.026587	GET	raw.githubusercontent.com	/jiteshdugar/random/master/abc-kids.gif
4	74013	2021-01-21 19:50:18.923604	POST	firebaseconfig.googleapis.com	/firebasenewtonconfig
5	74017	2021-01-21 19:50:26.941818	GET	googLeads.g.doubleclick.net	
6	74019	2021-01-21 19:50:33.931597	GET	googLeads.g.doubleclick.net	
7	74021	2021-01-21 19:50:34.580709	GET	googLeads.g.doubleclick.net	
8	74022	2021-01-21 19:50:34.584986	GET	googLeads.g.doubleclick.net	
9	74024	2021-01-21 19:50:40.101841	GET	googLeads.g.doubleclick.net	
10	74025	2021-01-21 19:50:40.514811	GET	googLeads.g.doubleclick.net	
11	74026	2021-01-21 19:50:41.901395	GET	googLeads.g.doubleclick.net	
12	74027	2021-01-21 19:50:41.916148	GET	googLeads.g.doubleclick.net	
13	74028	2021-01-21 19:50:42.538653	GET	googLeads.g.doubleclick.net	
14	74029	2021-01-21 19:50:44.395451	GET	googLeads.g.doubleclick.net	
15	74031	2021-01-21 19:50:44.579810	GET	googLeads.g.doubleclick.net	
16	74030	2021-01-21 19:50:44.584675	GET	googLeads.g.doubleclick.net	
17	74032	2021-01-21 19:50:44.845425	GET	googLeads.g.doubleclick.net	
18	74033	2021-01-21 19:50:47.278059	GET	app-measurement.com	
19	74034	2021-01-21 19:50:50.202617	GET	imasdk.googleapis.com	
20	74035	2021-01-21 19:50:50.207988	GET	tpc.googlesyndication.com	
21	74036	2021-01-21 19:50:50.630372	POST	app-measurement.com	
22	74038	2021-01-21 19:50:54.200992	GET	googLeads.g.doubleclick.net	
23	74039	2021-01-21 19:50:54.730668	POST	csi.gstatic.com	
24	74040	2021-01-21 19:50:54.733719	POST	csi.gstatic.com	
25	74041	2021-01-21 19:50:55.257729	POST	app-measurement.com	
26	74042	2021-01-21 19:50:55.510626	POST	csi.gstatic.com	
27	74044	2021-01-21 19:50:56.469921	POST	csi.gstatic.com	
28	74043	2021-01-21 19:50:56.513680	POST	app-measurement.com	
29	74046	2021-01-21 19:50:57.646188	POST	app-measurement.com	
30	74047	2021-01-21 19:50:58.482648	POST	app-measurement.com	
31	74048	2021-01-21 19:51:00.526606	GET	googLeads.g.doubleclick.net	/pagead/interaction/?ai=CBAYIFNsJYLDG8f1Y5Pfj_gMAO_H700V0c_oxriDEBABIPI-5yjlgfXggwHiAEByAEFqQKTJHLTKGtNPq...
32	74049	2021-01-21 19:51:00.631732	GET	yt3.gstatic.com	/yt/AAUvwNHShAawINc6ajaGoE40hpsf_14XoGz2X8jVizp=s48-c-k-c0x0fffff-no-rj
33	74050	2021-01-21 19:51:00.835508	GET	googLeads.g.doubleclick.net	/pagead/interaction/?ai=CvgrcFNsJYICSKYKeYOpiktgBAO_H700V0c_oxriDEBABIPI-5yjlgfXggwHiAEByAEFqQKTJHLTKGtNPq...
34	74051	2021-01-21 19:51:01.313667	GET	googLeads.g.doubleclick.net	/pagead/interaction/?ai=CBYZoFNSJYIrNtkayuYisgBAO_H700V0c_oxriDEBABIPI-5yjlgfXggwHiAEByAEFqQKTJHLTKGtNPq...
35	74052	2021-01-21 19:51:01.788408	GET	googLeads.g.doubleclick.net	/pagead/interaction/?ai=CJLqFNSJYIrRkdlqYqjLuMgeAO_H700V0c_oxriDEBABIPI-5yjlgfXggwHiAEByAEFqQKTJHLTKGtNPq...

Special protections for children

- GDPR has even higher bars for processing data of children:
 - “Children merit specific protection with regard to their personal data, as they may be less aware of the risks, consequences and safeguards concerned and their rights in relation to the processing of personal data. [Especially] for the purposes of marketing or creating personality or user profiles and the collection of personal data with regard to children when using services offered directly to a child.” (recital 38)
 - “Where the child is below the age of 16 years, [processing based on consent] shall be lawful only if and to the extent that consent is given or authorised by the holder of parental responsibility over the child.” (Art. 8(1) GDPR)
 - “processing [...] for the purposes of the legitimate interests [...], except where such interests are overridden by the interests or fundamental rights and freedoms of the data subject which require protection of personal data, *in particular where the data subject is a child*” (Art. 6(1)(f) GDPR)

Consent by the parents?



POST https://app-measurement.com/a

[...]

. _fr _e. ^Úü³ò. ^Úü³ò... _fot ... ; ò.... ^Úü³ò.... _fi î¬ÿ³ò.... _lte .
Í¤ÿ³ò. (^Úü³ò. 0^Úü³ò. B.androidJ.11R.sdk_gphone_x86_64_arm64Z.en-
us`<j.manual_installr.earlylearn.kidslearningworld...5.0..Eò...Ù"...\$827d8162-0e1c-48cd-892e-4abd3df95ba8
... a.
5b69b8a3ec488f391ebe7d64c959c259°. ¶. åÜïä. 5, .. È. &1:27655582681:android:f28806842a55c85fà.. ò.. cj73krKSSEWvc4C
BWM_A72ø. 2... -" xðë. è. ³ì.. ð..
.... 1
. _o... auto
. _sid. öµ§..
. _sno.... _s. f¥ý³ò. ... B
. _o... auto
. _sc.
HomescreenNew
. _si. ü°Ä!Ð;ò. ¥... _vs.. ïý³ò. ^Úü³ò... _fot ... ; ò.... ^Úü³ò... _fi f¥ý³ò... _sno f¥ý³ò... _sid
öµ§.... å. ÿ³ò... _lte å. ÿ³ò... _se .
Í¤ÿ³ò. (f¥ý³ò. 0. ïý³ò. 8^Úü³ò. B.androidJ.11R.sdk_gphone_x86_64_arm64Z.en-
us`<j.manual_installr.earlylearn.kidslearningworld...5.0.. Eò...Ù"...\$827d8162-0e1c-48cd-892e-4abd3df95ba8
... a.
5b69b8a3ec488f391ebe7d64c959c259°. ¶. åÜïä. 5, .. È. &1:27655582681:android:f28806842a55c85fÐ. ^Úü³ò. à.. ò.. cj73krK
SSEWvc4CBWm A72ø. 2... -" xðë. è. ³ì.. ð..



Image: Agence Oolloweb (Unsplash license)

Noteworthy examples



RegenRadar - Vorhersagen & live Wettermeldungen

WetterOnline GmbH · Weather

★ ★ ★ ★ 148,075

USK: All ages

Contains Ads · Offers in-app purchases

[Install](#)



Top Funktionen der RegenRadar App:

- Aktuelles Radarbild für Deutschland, Österreich und die Schweiz

[READ MORE](#)

ADDITIONAL INFORMATION

Updated

February 23, 2021

Size

22M

Installs

5,000,000+

Current Version

Varies with device

Requires Android

Varies with device

Content Rating

USK: All ages

Interactive Elements

In-app Products

In-app Purchases

€0.99 - €6.99 per item

Permissions

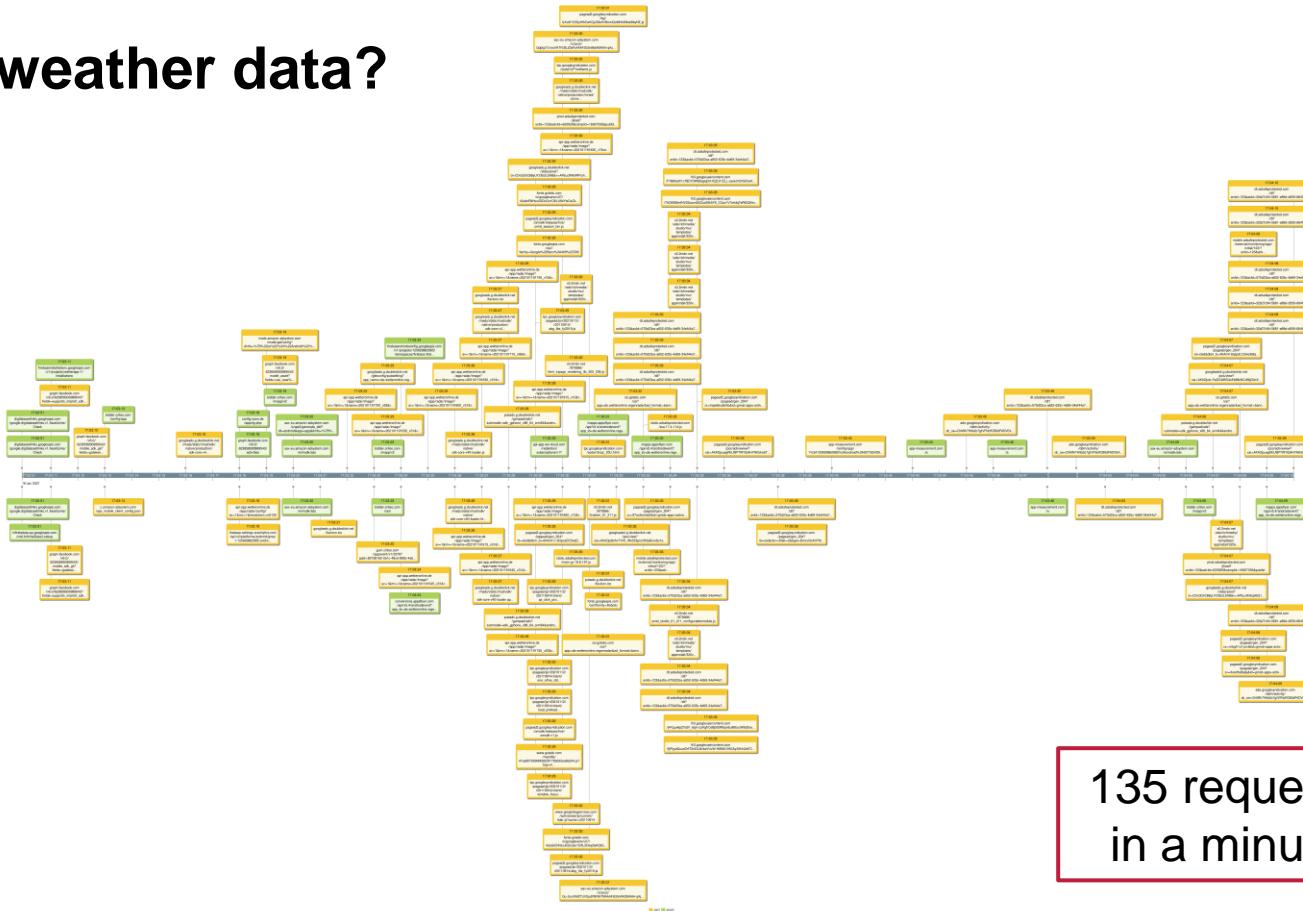
View details

Report

Flag as inappropriate

<https://play.google.com/store/apps/details?id=de.wetteronline.regenradar>

Lots of weather data?



135 requests
in a minute

Dragon Family

- “Smart chore list for your kids”
- “Individual to-do list for each child”
- “No need to keep track of who does what
- the app will do it for you.” 😊

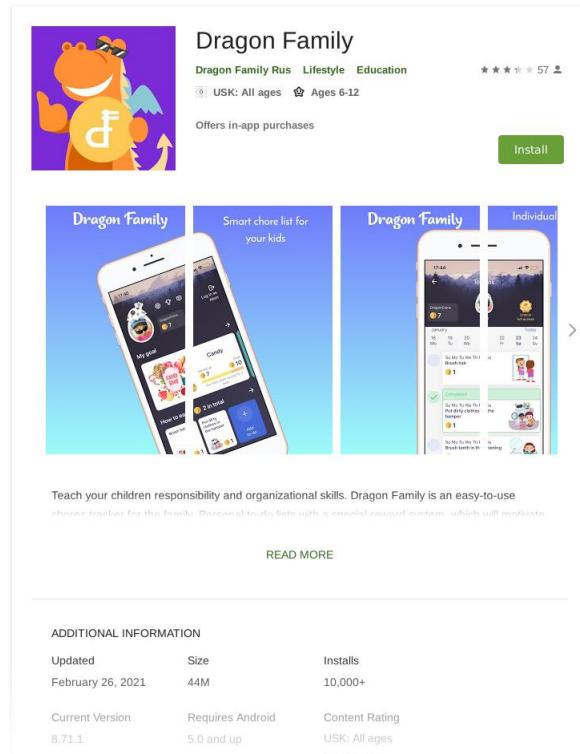
Content-Disposition: form-data;

name="video_data";

filename="session_record.mp4"

Content-Type: multipart/form-data;

Content-Length: 133929



The image shows the Google Play Store page for the "Dragon Family" app. At the top, there's a large thumbnail featuring a cartoon dragon holding a coin with a dollar sign. Below it, the app's name "Dragon Family" is displayed in a large, bold font. To the right, there are rating stars (3.5), reviews (57), and a "Install" button. Underneath the main title, it says "Dragon Family Rus Lifestyle Education". It also indicates "USK: All ages" and "Ages 6-12". A note states "Offers in-app purchases". Below the main section, there are two screenshots of the app interface: one showing a list of chores and another showing a more detailed view of a specific chore. At the bottom, there's a descriptive text: "Teach your children responsibility and organizational skills. Dragon Family is an easy-to-use chore tracker for your family. Convenient reminders with a visual reward system makes self-rewarding". There's also a "READ MORE" link.

ADDITIONAL INFORMATION		
Updated	Size	Installs
February 26, 2021	44M	10,000+
Current Version	Requires Android	Content Rating
8.71.1	5.0 and up	USK: All ages
Learn more		

<https://play.google.com/store/apps/details?id=com.df.dragonfamily>

Dragon Family: Video

No more nagging kids
to do chores

- Smartlook.com
 - “Analyze user behavior in ways never possible before”
- but: app not targeted to EU citizens and only 10,000+ installs
 - is the only one in our data set doing this
 - but probably not the only app in the world doing this...

 [Sign up with email](#)

or sign up with



Have an account? [Sign in](#)

Dragon Family

← Registration

Dragon Family

[Redacted]
[Redacted] 
[Redacted]
[Redacted]

Dad Mom

I agree to the [privacy policy](#) and the [terms and conditions](#)

Proceed

[Redacted]





Wordscapes

PeopleFun Word

USK: All ages

Contains Ads · Offers in-app purchases

★★★★★ 933,280

Install



Playing Wordscapes 10 mins a day sharpens your mind and prepares you for your daily life and challenges! ❤️

READ MORE

ADDITIONAL INFORMATION

Updated

Size

Installs

Current Version

Requires Android

March 5, 2021

130M

50,000,000+

1.13.1

4.4 and up

Content Rating

Interactive Elements

In-app Products

Permissions

Report

USK: All ages

In-Game Purchases

€0.99 - €99.99 per item

View details

Flag as inappropriate

<https://play.google.com/store/apps/details?id=com.peoplefun.wordcross>

Wordscapes

```
"appVersion": "1.13.0",
"appName": "com.peoplefun.wordcross",
"advertisingId": "827d8162-0e1c-48cd-892e-4abd3df95ba8",
"sessionId": "75220784-93da-437d-9963-03919e2a9430",
[...],
"advertiserId": "827d8162-0e1c-48cd-892e-4abd3df95ba8",
"manufacturer": "Google",
"zoneIds": ["vzc4845fb2b25e45d2bb", "vzf99f130e0baa4c0c9f"],
"osVersion": "11",
"carrierName": "Android",
"appId": "appa4a89636aaa0640a187",
"countryLocaleShort": "US",
"model": "sdk_gphone_x86_64_arm64",
[...],
"environment": "Production",
"level": "Warn",
"message": "Controller : [warn] [AppConfiguration] WARNING: TEST MODE ENABLED. PLEASE ENSURE THIS OPTION IS
NOT SET IN PRODUCTION.",
"clientTimestamp": "20210113T155457.497+0100",
"mediation_network": "AppLovin",
"mediation_network_version": "9.14.10",
"plugin": "",
"plugin_version": "",
"batteryInfo": 0.77
```



365Scores - Live Scores and Sports News

365Scores LTD · Sports

★★★★★ 1,037,281

USK: All ages

Contains Ads · Offers in-app purchases

Install



Live the Game with 365Scores - The complete sports experience!

READ MORE

ADDITIONAL INFORMATION

Updated

March 4, 2021

Size

19M

Installs

10,000,000+

Current Version

11.0.6

Requires Android

4.4 and up

Content Rating

USK: All ages

Interactive Elements

Users Interact

In-app Products

€0.63 - €134.99 per

Permissions

View details

Report

Flag as inappropriate

[Learn more](#)

[Read](#)

[View details](#)

[Report](#)

[Flag as inappropriate](#)

[View details](#)

365Scores: POST 500KB strings

```
{  
    "AliasName": "COMMENTS_BANNER_DOWN",  
    "Name": "Get the best sports app with live scores, news, videos and comments about every game!"  
,  
{  
    "AliasName": "COMMENTS_BANNER_DOWN2",  
    "Name": "3,000,000 already use the best sports app, Get it now and be part of it!"  
,  
{  
    "AliasName": "FOLLOW_TW_FOLLOW",  
    "Name": "Folge uns auf Twitter"  
,  
{  
    "AliasName": "FOLLOW_TW_POPUP",  
    "Name": "VERNETZE DICH MIT UNS UND HOL DIR DIE BESTEN SPORT-NEWS AUF TWITTER"  
,  
{  
    "AliasName": "FOLLOW_TW_LINK",  
    "Name": "365scores"  
,
```

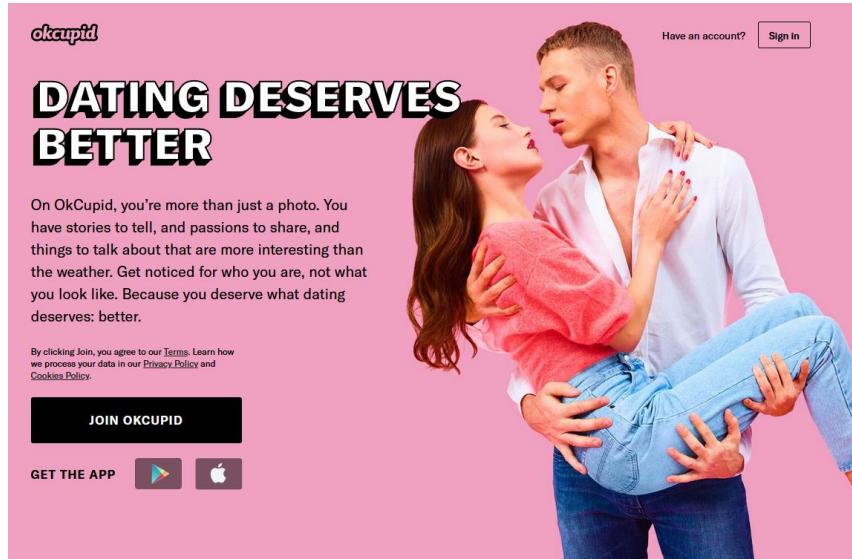
Database queries

- **Yahoo Mail:**
 - POST <https://analytics.query.yahoo.com/v1/public/yql?format=json&yhlCompressed=true&yhlClient=app&yhlBTMS=1610983165413&yhlURLEncoded=0&yhlEnv=prod&yhlVer=1&cacheAsyncByDefault=true&up=2>
 - **Content:** q=INSERT INTO data.track2 (trackdata) VALUES (' [...] ')

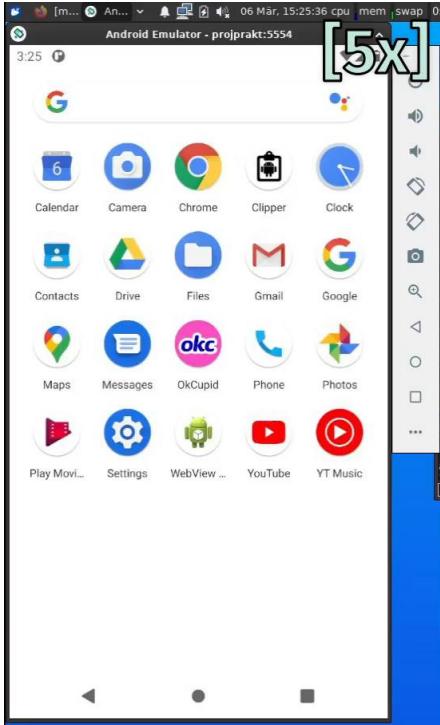
OkCupid

- Dating app OkCupid
- Match Group!

Tinder, Plenty Of Fish, OkCupid, Meetic, Matchaffinity, LoveScout24, Twoo, Neu.de, Partner.de, Amoureux, Lexamore.nl, DisonsDemain.fr, BlackPeopleMeet.com, OurTime, Pairs, ParPerfeito, LDSPlanet.com, PetPeopleMeet.com, BBPeople, InterracialPeopleMeet.com, Chemistry.com, MarriageMindedPeopleMeet.com, LatinoPeopleMeet.com, DemocraticPeopleMeet.com, RepublicanPeopleMeet.com, BabyBoomerPeopleMeet.com, singleparentmeet.com, ...



Let's take a look at the sign-up process



Let's look at the traffic

- POST <https://www.okcupid.com/1/apitun/signup/email>
 - {"email":"ok.cupid@fmail.party","password":"123456ok"}
- PUT https://www.okcupid.com/1/apitun/profile_details/relationship_type
 - {"value":3}
- POST <https://data.emb-api.com/v1/log/logging>

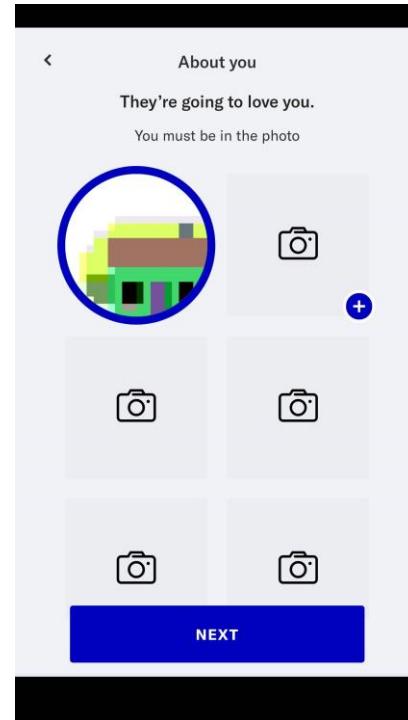
```
"he": false,  
"id": "10F16B3535B74D7CA7E6F8FED8E3AF67",  
"li": "0C49ACDC63954B608D1BDA9C21FA0913",  
"n": "billing client exception",  
"pr": {  
    "billing client exception description": "Play Store service is not connected now - potentially transient state. E.g. Play Store could have been updated in the background while your app was still running. So feel free to introduce your retry policy for such use case. It should lead to a call to {@link #startConnection} right after or in some time after you received this code.",  
    "billing client exception method": "GET_PRODUCT_DETAILS"  
},  
"sc": true,  
"si": "F297A2306E664B639F9FD0387AD3F9FE",
```

Okay, Cupid?

- POST <https://images.embed-api.com/v1/screenshot/28r9d/logs/0C49ACDC63954B608D1BDA9C21FA0913.jpg>

Indian User?

- GET https://www.okcupid.com/1/apitun/profile/me/is_indian_user
 - 28 requests in 1m04s
 - Response: false



Braze

- Logs are sent to Braze
 - "customer engagement platform"
 - Not from the recorded session
 - POST <https://sdk.iad-01.braze.com/api/v3/data>
HTTP/1.1
 - But wait! There's even more!
 - POST <https://www.facebook.com/tr/>
- ```
 {
 "data": {
 "n": "selected next on onboarding essay",
 "p": {
 "character count (no spaces)": "26",
 "debug_platform": "android",
 "essay text": "i <3 ver.di und gott (rom-kath)"
 }
 },
 "name": "ce",
 "session_id": "adaa3d49-9ee0-4e7c-b31f-6a7923aca57c",
 "time": 1614693083.997,
 "user_id": "10455379225072330509"
 },
 }
```

Form data:

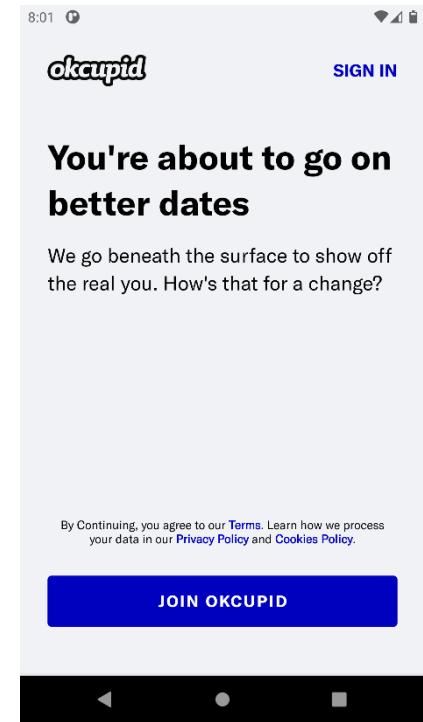
```
id: 914782201921498
ev: SubscribedButtonClick
dl: https://www.okcupid.com/onboarding?post_login=1&clear_history=1
rl:
if: false
ts: 1615040857972
cd[buttonFeatures]: {"classList":"pickmanybuttons-button checkbox-picker-pickmanybuttons-button","destination":"","id":"","imageUrl":"","innerText":"Women","numChildButtons":0,"tag":"button","name":"","value":""}
cd[buttonText]: Women
cd[formFeatures]: []
cd[pageFeatures]: {"title":"OKCA App v243"}
cd[parameters]: []
sw: 412
sh: 732
udff[fn]: 61950c8964e60e152d9c194617fb9545c6f9734c8328e096a6dff8c1122c143c
udff[ct]: 215514c7719216cc237fbcd96aaddbd8c409f13b65db7f69db1b2c4f1e83649a
v: 2.9.5
r: c2
ec: 14
o: 2078
fbp: fb.1.1615040611001.1010838334
it: 1615040780310
coo: false
es: automatic
rqm: SB
```

# Special categories of personal data

- “Processing of [special categories of personal data] shall be prohibited.” (Art. 9(1) GDPR)
- This applies to the following data:
  - racial or ethnic origin
  - political opinions
  - religious or philosophical beliefs
  - trade union membership
  - genetic data, biometric data for the purpose of uniquely identifying a natural person
  - health data
  - data on a natural person’s sex life or sexual orientation

# So, can this data not be processed at all?

- Art. 9(2)(a–j) GDPR lists exceptions under which processing of special categories is allowed; relevant in the context of an app:
  - explicit consent given for a specific purpose (lit. a)
  - concerned data is manifestly made public by the user (lit. e)
- Neither of these are applicable for OkCupid:
  - No consent at all is given, app only points out the privacy policy on the signup screen: “Learn how we process your data in our Privacy Policy and Cookies Policy”.
  - User doesn’t make their data public. Profiles are only visible for other users that are ‘matches’ and the answers to the questions are never shown to other users but only used for the matching algorithm.

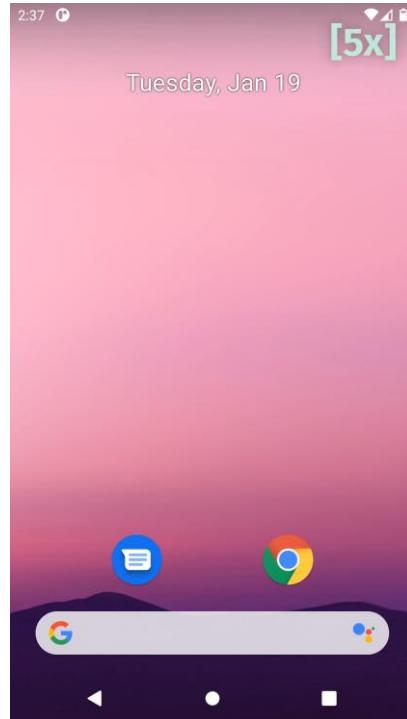


# Grindr

- In January 2021, the Norwegian DPA fined gay dating app Grindr almost 10 Mio € after complaints about the app sharing data with third-parties for advertising. [1]
- Data allegedly shared is *much* less comprehensive than what we saw with OkCupid. ‘Only’ location and the fact that person uses Grindr is transmitted.
- The decision by the DPA [2] hinges on two breaches of the GDPR:
  - No legal basis for processing. Grindr claimed to rely on consent but that did not meet the high requirements set by the law.
  - Prohibited processing of special categories of personal data without an exception. Grindr claimed to rely both on consent and the data being made public by the user through the app. DPA denies both.

# BBC

```
"channel": {
 "android_api_version": 30,
 "app_version": "1.21.4.12594",
 "device_model": "sdk_gphone_x86_64_arm64",
 "timezone": "Europe/Berlin",
 "android": { "delivery_type": "fcm" },
 "set_tags": true,
 "device_type": "android",
 "locale_country": "US",
 "tags": [],
 "carrier": "Android",
 "background": true,
 "sdk_version": "13.3.1",
 "opt_in": true,
 "locale_language": "en",
 "push_address":
 "dDc_EUGETVmemiPTJcWuy1:APA91bH68o5tRxpewJV6k2rYLIInH
 ZHbBRXtgyy33jdRrznU2TL3K46ViTBmBVIUmXL9GdQz35unVZLsf
 euZfZFMx46XJ0c_atslQzpDFIrnhW5T7PyPlcO-
 lYOMRj4PT9phFiO286Qm2"
}
```



# Strava (Snowplow)

```
1 {
2 "schema": "iglu:com.snowplowanalytics.snowplow/payload_data/jsonschema/1-0-4",
3 "data": [
4 {
5 "p": "mob",
6 "eid": "9864fb7b-fca6-4469-8924-c8ab6d252515",
7 "tv": "andr-0.6.2",
8 "e": "ue",
9 "cx": {
10 "schema": "iglu:com.snowplowanalytics.snowplow/contexts/jsonschema/1-0-1",
11 "data": [
12 {
13 "schema": "iglu:com.strava/application/jsonschema/1-1-0",
14 "data": {
15 "app_language": "en",
16 "release_stage": "production",
17 "development_settings_enabled": false,
18 "device_language": "en-US",
19 "version": "185.8 (1217210)",
20 "device_year_class": 2013,
21 "platform": "android"
22 }
23 },
24 {
25 "schema": "iglu:com.snowplowanalytics.snowplow/client_session/jsonschema/1-0-1",
26 "data": {
27 "sessionIndex": 1,
28 "storageMechanism": "SQLITE",
29 "firstEventId": "627945c9-e940-4869-b5e2-84e7963c88cf",
30 "sessionId": "41fbc79c-e2f9-4e5f-b8c1-86ac4364da39",
31 "previousSessionId": null,
32 "userId": "93e09047-f9bd-4652-97af-1d5cf87ae990"
33 }
34 }
35 }
36 }
37]
38 }
```

# Conclusion

- Android eco system pretty much broken
  - Baptiste “@fs0c131y” Robert was right
  - almost every app sends data to third parties
    - without any prior user input!
- lots of GDPR violations
  - we will file a complaint against OkCupid
- but there are alternatives..
  - Android allows other app sources like F-Droid

*Such practice is pretty standard and you can be assured that most apps you use have the same data-retrieval process.*

*– @fs0c131y in TikTok:  
Logs, Logs, Logs*

# Future Work

- other app stores
- more powerful host → more apps
- testing on actual devices instead of emulation
- sophisticated data analysis
  - clustering, ...
- analysis of privacy impact
- inspect European/German apps using offending frameworks
  - better leverage for complaints
- Is the iOS eco system better?
  - Hint: OkCupid on iOS is an offender as well...