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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 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 Mills (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

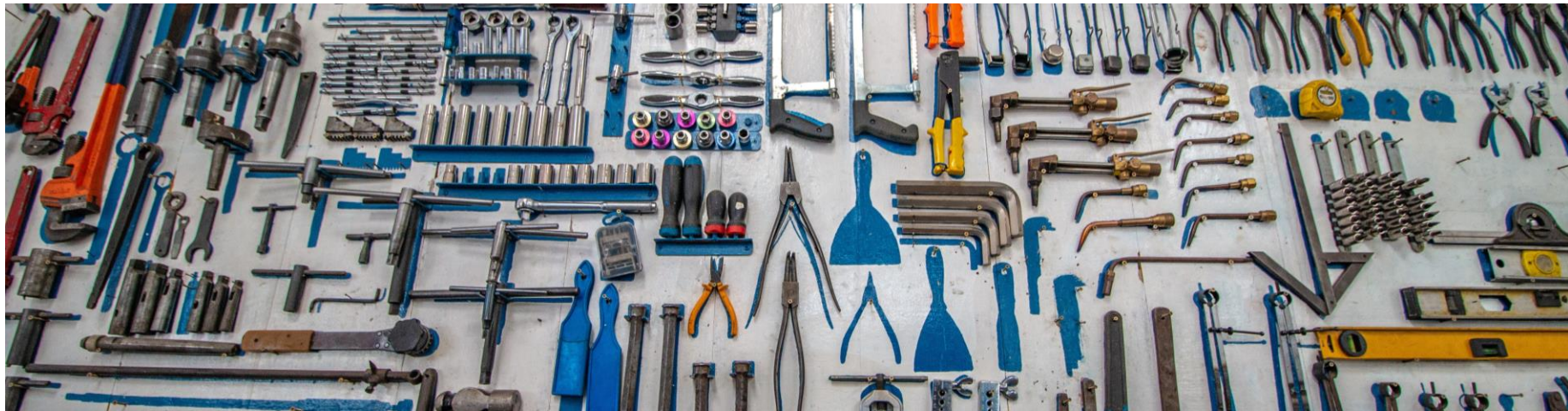


Image: Cesar Carlevarino Aragon (Unsplash license)

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

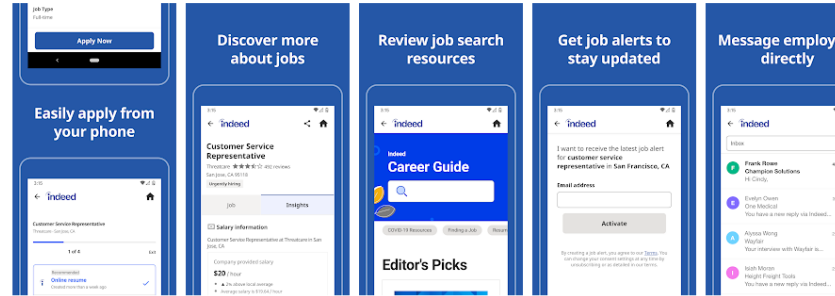
USK: All ages

Contains Ads

Editors' Choice

★★★★★ 1,236,827

Install



Find jobs on Indeed, the job search app built to help you every step of the way. Get free access to millions of job postings, personalize your search, connect with employers and submit job applications—all from the Indeed app.

READ MORE

ADDITIONAL INFORMATION

Updated

March 4, 2021

Size

Varies with device

Installs

100,000,000+

Current Version

Varies with device

Requires Android

Varies with device

Content Rating

USK: All ages

Interactive Elements

Unrestricted Internet

Permissions

View details

Report

Flag as inappropriate

Offered By

Google Commerce Ltd

Learn more

<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


```
"af_timestamp": "1611209035694",
"appsflyerKey": "ExLocXqS6j9TGyNebHQHrG",
"operator": "T-Mobile",
"network": "MOBILE",
"timepassedsinclastlaunch": "-1",
"open_referrer": "android-app://android",
"af_v2": "e1089f09b150658adadbacd6f807c1947d072cb2",
"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 Indexed

```
"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"
```





Audible: audiobooks, podcasts & audio stories

Audible, Inc Books & Reference

★★★★★ 1,125,633

USK: Ages 12+

Install

Find a listen for every moment. Choose binge-worthy audiobooks, exclusive podcasts, bite-sized audio content and genre-bending Audible Originals. Listen to captivating storytelling, and make Audible a part of your daily listening routine.

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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	
Violence Sex/Drugs					

<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": "d45c5-1-47dfae35-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,
  "inserttime": 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

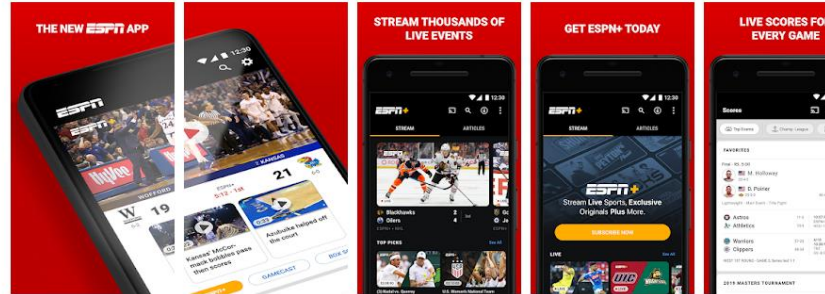
USK: Ages 6+

Contains Ads · Offers in-app purchases

Editors' Choice

★★★★★ 628,431

Install



Watch thousands of live events and shows from the ESPN networks plus get scores, on-demand news, highlights, and expert analysis. Subscribe to the ESPN+ streaming service for live events, exclusive originals, premium athletes, fantasy tools, and more.

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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
Learn more				

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

```
"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


Bitstrips Entertainment

USK: Ages 6+


★★★★★ 3,359,020

Install


Bitmoji
Your Personal Emoji



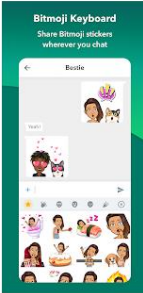
Create Your Avatar
Use your camera to instantly create an avatar that looks like you




Bitmoji Fashion
Dress your avatar to match your real-world style




Bitmoji Keyboard
Share Bitmoji stickers wherever you chat



Bitmoji Stickers
Say anything from romantic to ridiculous



Shop
Rep your style



Bitmoji is your own personal emoji.

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ADDITIONAL INFORMATION

Updated	Size	Installs	Current Version	Requires Android
March 1, 2021	Varies with device	100,000,000+	Varies with device	Varies with device
Content Rating	Interactive Elements	Permissions	Report	Offered By
USK: Ages 6+	Digital Purchases	View details	Flag as inappropriate	Google Commerce Ltd

Alcohol Use: Occasional

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

```
"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"  
} ]
```



Audiomack: Download New Music Offline Free

Audiomack Music & Audio

★★★★★ 1,236,898

USK: Ages 12+

Contains Ads · Offers in-app purchases

Install



Stream and download the best new songs, albums, and playlists for free and play them offline data-free! Browse music from top categories like Hip-Hop, Rap, R&B, EDM, African, and more on the Audiomack free music app. Download songs and even listen

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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

Report

Flag as inappropriate

Offered By

Google Commerce Ltd

Contents for Different

<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"]
  }
],
"mraid": ["1.0", "2.0"],
"appId": "fd370098318b45e083cd9826735e3f3d",
"adfa": "827d8162-0e1c-48cd-892e-4abd3df95ba8",
"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" }
```



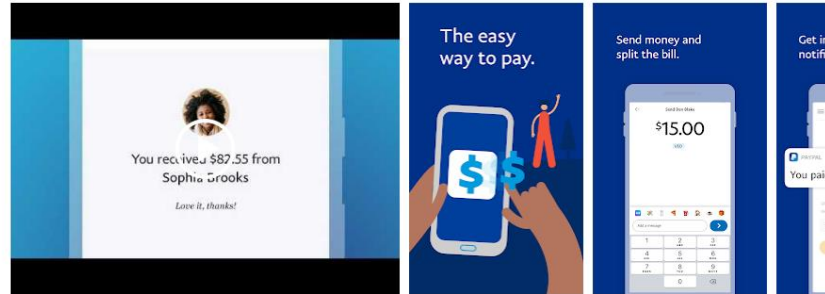
PayPal Mobile Cash: Send and Request Money Fast

PayPal Mobile Finance

USK: All ages

★★★★★ 1,836,125

Installed



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 status, choose currencies to send around the world and more. Plus, we've added some new features too.

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

Learn more

<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_addr": "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_addr": "10.0.2.16",
"ip_addresses": [
  "10.0.2.16",
  "10.0.2.15",
  "fe80::bcd3:53ff:feaf:89f2%dummy0",
  "fe80::31ec:f660:1191:9dc8%wlan0",
  "fec0::247d:2fcb:c2c5:25a6",
  "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



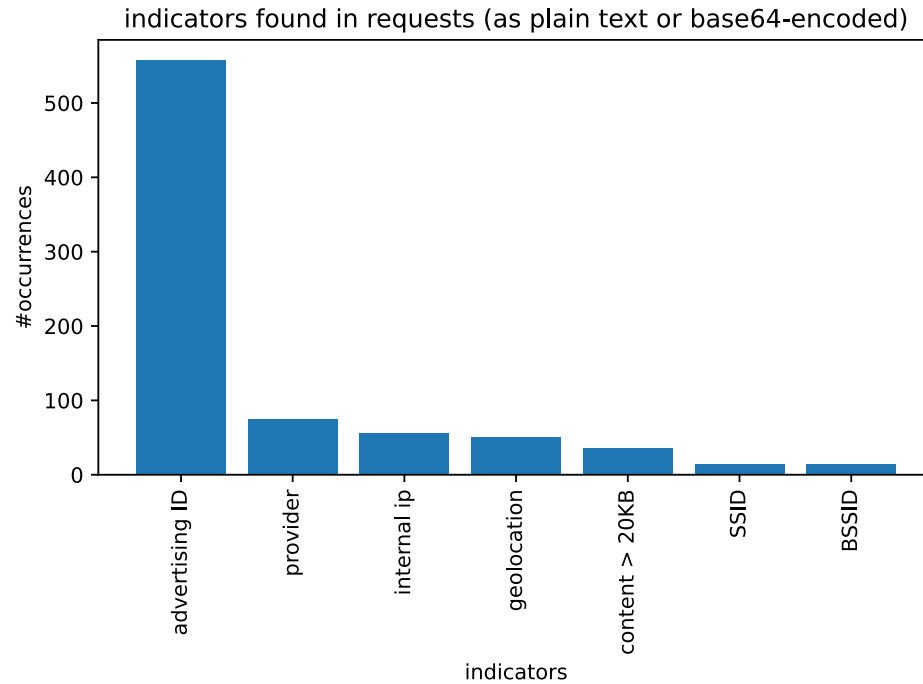
Image: William Iven (Unsplash license)

Results

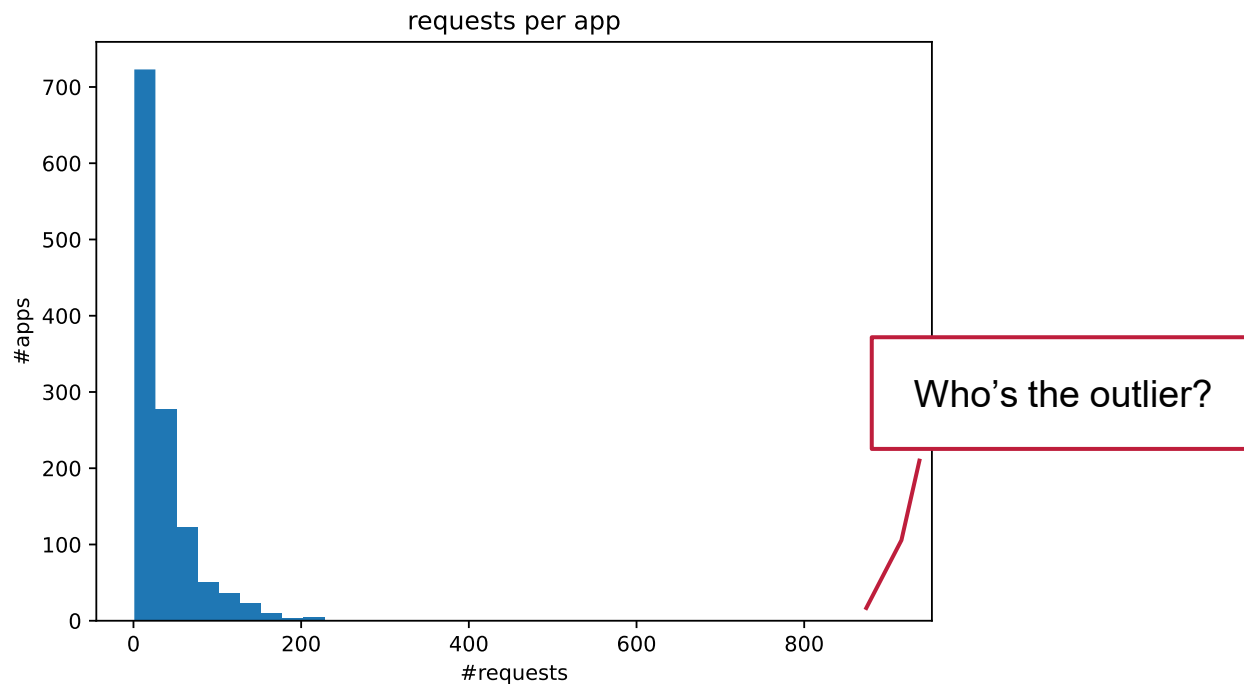
Statistics

- 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: Keto Diet App Tracker, Planner & Recipes

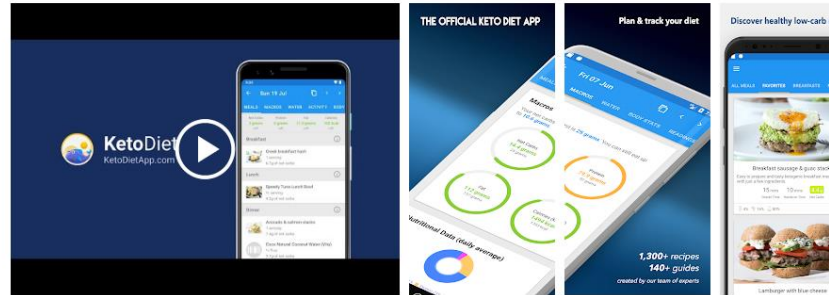
Compumaster Ltd Health & Fitness

★★★★★ 920

USK: All ages

Offers in-app purchases

Install



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

READ MORE

ADDITIONAL INFORMATION

Updated

February 22, 2021

Size

132M

Installs

100,000+

Current Version

3.42

Requires Android

6.0 and up

Content Rating

USK: All ages

Interactive Elements

Digital Purchases

In-app Products

€6.49 - €31.99 per item

Permissions

View details

Report

Flag as inappropriate

Learn more

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

	start_time	1	host	path	content
1	2021-01-19 16:07:14.280531	POST	infinitedata-pa.googleapis.com	/mdi.InfiniteData/Lookup	<null>
2	2021-01-19 16:07:35.487393	POST	firebaseinstallations.googleapis.com	/v1/projects/ketodiet-8dbca/installations	{"fid":"fzrzj-U9QlMahkL6001cg5","appId":"1
3	2021-01-19 16:07:37.456264	POST	mobile.ketodietapp.com	/KDApp.ashx?_xid=1	{"appInstallId":"3437396436383932203365393
4	2021-01-19 16:07:38.722329	GET	firebase-settings.crashlytics.com	/spi/v2/platforms/android/gmp/1:310369947550:android:26ead4e99afe332/settings?instance=6606ba809517b08492...	
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
7	2021-01-19 16:07:42.826298	POST	firebaseasemoteconfig.googleapis.com	/v1/projects/310369947550/namespaces/firebase:fetch	{"appInstanceId":"fzrzj-U9QlMahkL6001cg5",
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-4d0a-8d2b-4c7560980c8d?rev=2-012ab8dc9b3ef2f4b72e59b4240a11...	
10	2021-01-19 16:07:43.701453	GET	mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_4a1c139f-4778-43f8-96bb-12b5c472a37e?rev=2-2ad8b16852a229eb96e297d9f9ec11...	
11	2021-01-19 16:07:43.701792	GET	mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_00935fbb-32a3-45de-926a-048d1fd01531?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-ceb550fbcea8?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=2-3eafbf096d2c3dce743ea6ad54769e...	
15	2021-01-19 16:07:44.436633	GET	mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_504573e6-d772-465d-81ce-d6ab37e637e2?rev=2-645daddf6a9a07e5397d90ceafec...	
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 16:07:44.609806	GET	mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_4a9d922a-ad60-47a3-8c7d-4c3845eb142b?rev=2-07f73d7350aa8ba1b8e671d2700017...	
19	2021-01-19 16:07:44.783351	GET	mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_59f4610d-ad95-4ce2-ba7e-4f085d4fd292?rev=2-d964aded942a735030fb17970e1cf8...	
20	2021-01-19 16:07:44.821032	GET	mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_cb1eacd3-2019-4492-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-ae55-55f8832506fa?rev=2-76dd49e908ee535691cad7145e40bf...	
22	2021-01-19 16:07:45.361309	GET	mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_879c5556-0d8a-4b81-bee9-37323259f422?rev=2-710f03c41f7ae0bb05a15393d719f2...	
23	2021-01-19 16:07:45.381960	GET	mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_dd011532-16c5-4382-b4bd-5e3e21f3932c?rev=2-9a8fe1688ddeede90c2fd5e97b5524...	
24	2021-01-19 16:07:45.383622	GET	mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_1b31f930-76f5-4360-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-a8a2-29e11cdd70f5?rev=2-6fc75dd703cf71bcab62435e089be...	
26	2021-01-19 16:07:45.652492	GET	mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_c5d61e1f-e115-46aa-bac1-cbe3048eba3d?rev=2-f6afea6b1f8b2bdfce76790831dc2b...	
27	2021-01-19 16:07:45.659029	GET	mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_243f1f30-1095-4ee3-a1b8-e4bd9db2beb2?rev=2-a895693292587c2064c5f3f31e3225...	
28	2021-01-19 16:07:45.660323	GET	mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_025b2b35-ca1c-4fbd-80c8-35d17534ec12?rev=2-c5996af29b3931e2df7b16cf535a88...	
29	2021-01-19 16:07:45.660834	GET	mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_28d33003-42ab-4f76-97fb-03917791b90c?rev=2-8ab5c2e62ea073cd1277e408607c6a...	
30	2021-01-19 16:07:45.660834	GET	mobile.ketodietapp.com	/Sync.ashx/ketodiet-public/IBPCS_86c1a285-e943-45d7-b674-dbac33ea2ba1?rev=2-46552b31e49cd2ec02adfd9cc013c4...	


Inefficient design? A bug?

```
> curl -I "https://mobile.ketodietapp.com/Sync.ashx/ketodiet-  
public/IBPCS_c5d61e1f-e115-46aa-bac1-cbe3048eba3d?rev=2-  
f6afea6b1f8b2bdfef76790831dc2b02&revs=true&attachments=true"  
HTTP/1.1 500 Internal Server Error
```

Cache-Control: private

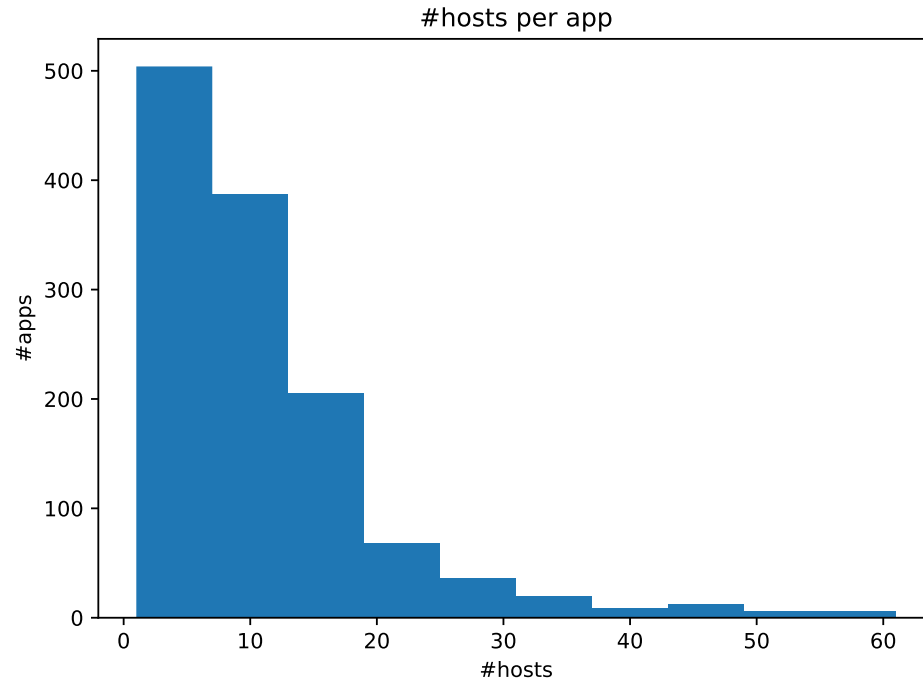
Transfer-Encoding: chunked

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

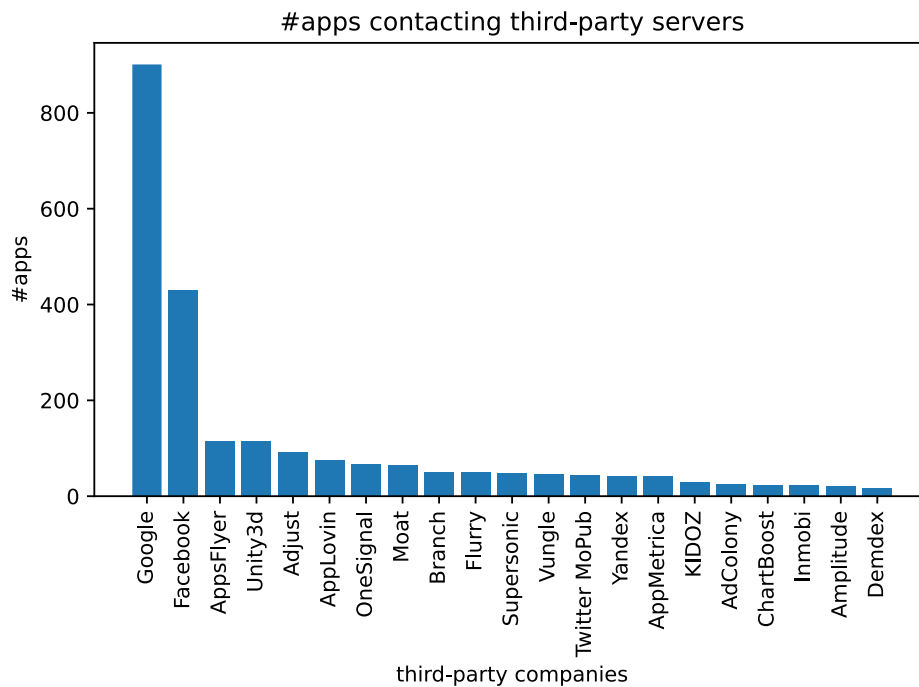


Takes 30s to respond, though.
Maybe they are DDoS-ing
their own server?

Hosts per app



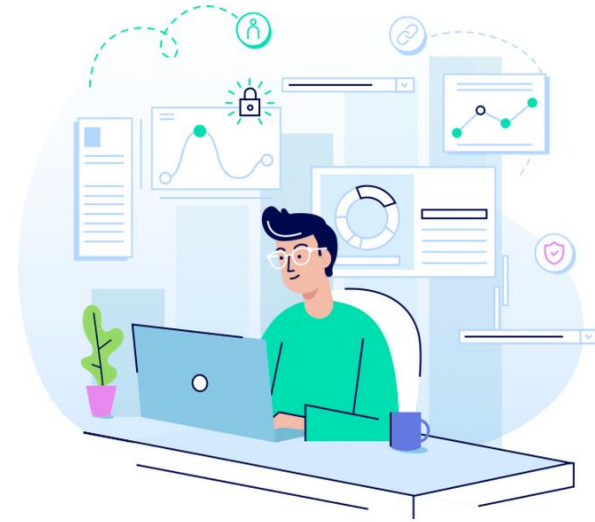
Requests to third-party tracking servers



based on Exodus tracker database [1]

Attribution data you can trust

Accurate data, an unbiased customer-centric approach, and privacy by design make AppsFlyer the attribution platform of choice for the world's leading brands

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Measure consumer attention across channels, devices, and platforms

Get in touch

Moat Ad Search

Search by brand



Recent ads: [AT&T](#), [Taxslayer.com](#), [Lladro](#)



WATCH YOUR BRAND TAKE OFF

Join the World's Largest Mobile Network for Kids

PUBLISHERS

Safely Monetize
Kids' Apps

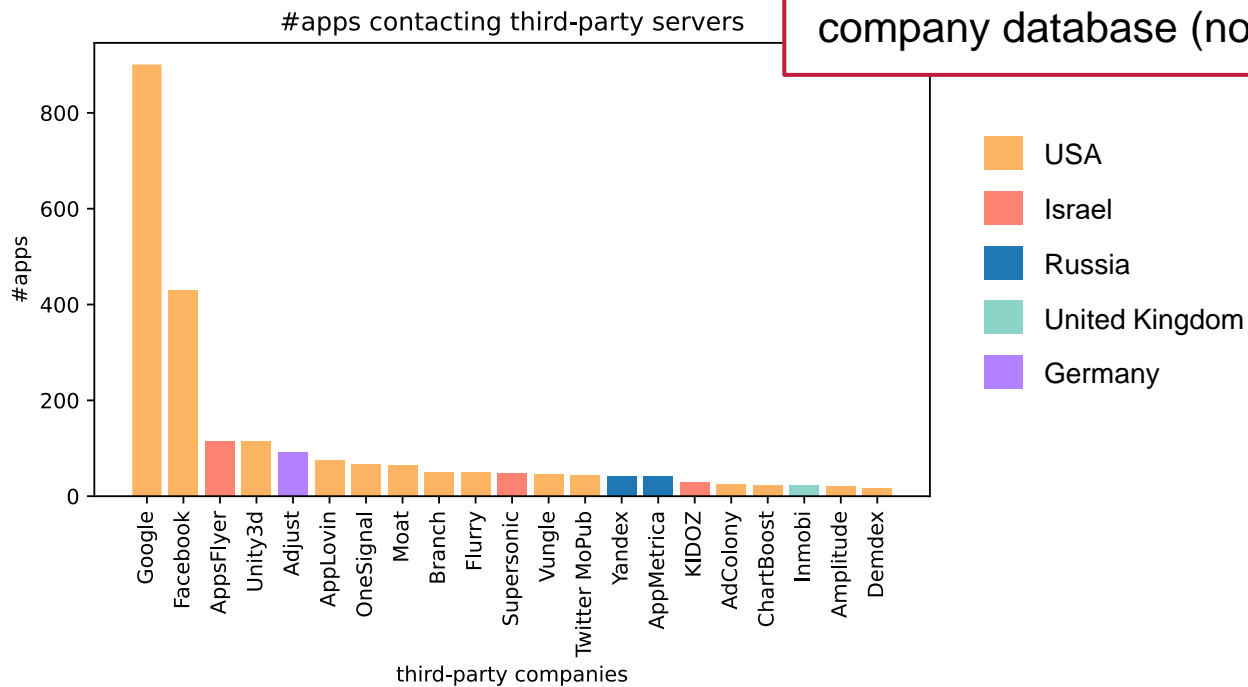
BRANDS

Reach &
Engage kids



<https://kidoz.net/>

Where are the trackers based?



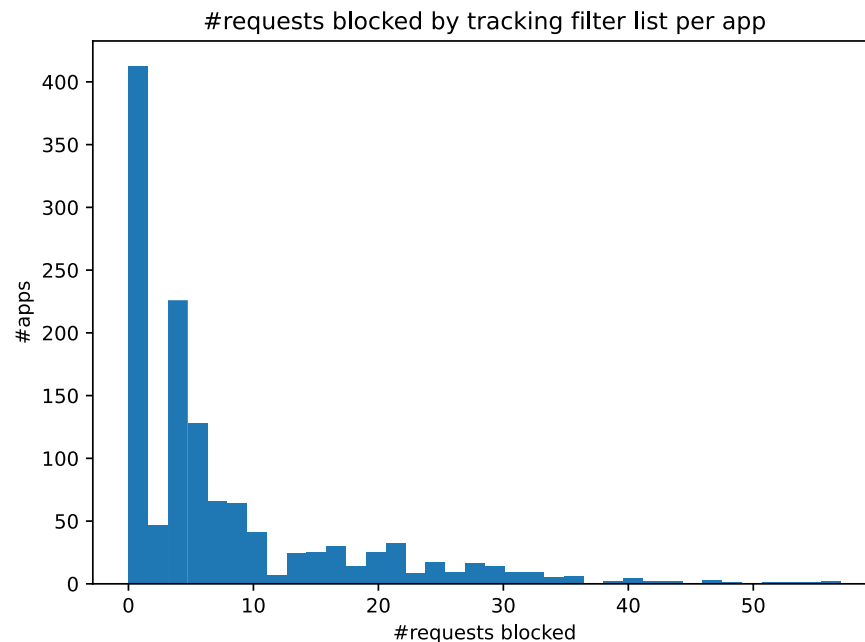
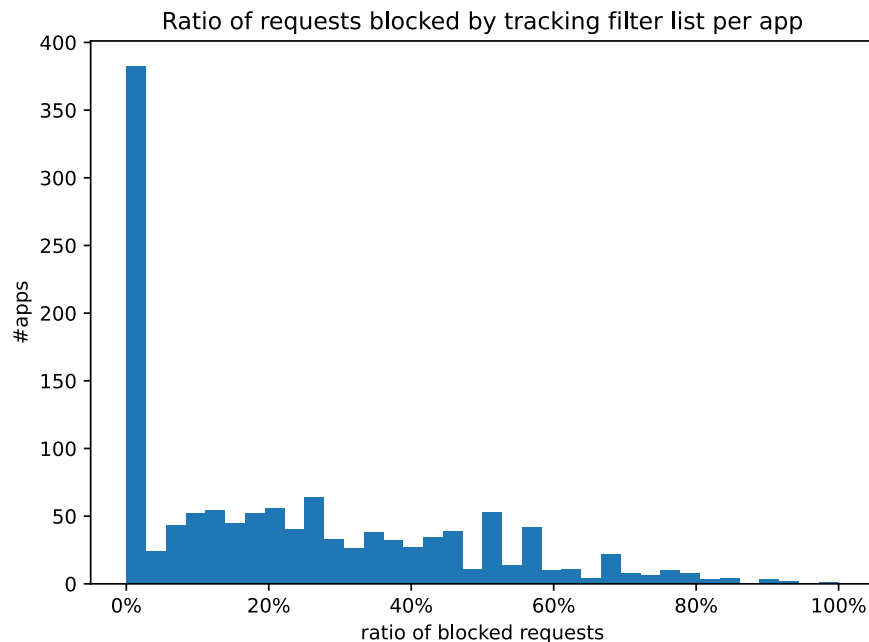
based on Exodus tracker database [1]

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

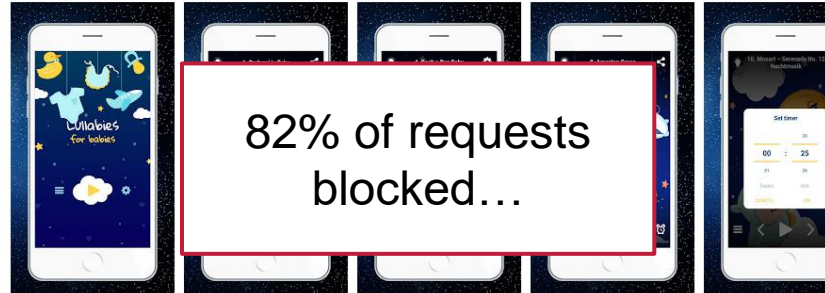
OLD CALEDONIAN INVESTMENTS LTD Music & Audio Music & Video

★★★★★ 1,511

USK: All ages **Family Friendly**

Contains Ads · Offers in-app purchases

Install



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

READ MORE

ADDITIONAL INFORMATION

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

<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 07:56:24.417786	GET	googleads.g.doubleclick.net	/favicon.ico
5	35244	2021-01-19 07:56:24.426344	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=sdm_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&riv=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~kk3pehia&c=1660031470899&slotId=830015735449.5&qqid=CN73i-nCp-4CFVOPGAodt48Pzw6e...
16	35257	2021-01-19 07:56:35.825608	GET	app-measurement.com	/config/app/1%3A738882303123%3AAndroid%3Ae4d661fe12335414?app_instance_id=8dd4baa15aaf4c34af8734859773a81f&p...
17	35258	2021-01-19 07:56:35.997879	GET	googleads.g.doubleclick.net	/pagead/interaction/?ai=Cbb83arZAGYI7PND0eYrefvvgMAPv3sLT_CbKVpamvCRABILTYw1glfQxgqwhIAEBoAGbhr3A48gBBakCHYH...
18	35259	2021-01-19 07:56:36.328194	GET	r5---sn-i5h7lner.googlevideo.com	/videoplayback?expire=1611071790&ei=rpAGYKTC0oWH7ATNvZaQDA&ip=134.169.32.95&id=50eadb372860f49a&itag=18&sour...
19	35260	2021-01-19 07:56:36.579186	GET	yt3.ggpht.com	/ytc/AUAvnnhLHxp9uxhrJE4j33s2YpbNk4ghM1bHQH-aKcC=s48-c-k-c0x00ffffff-no-rj
20	35261	2021-01-19 07:56:36.639442	POST	csi.gstatic.com	/csi?v=2&s=ima&dmc=2&puid=2~kk3pei4k&c=1660031470899&slotId=830015735449.5&qqid=CN73i-nCp-4CFVOPGAodt48Pzw6e...
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 07:56:38.129047	POST	app-measurement.com	/a
24	35266	2021-01-19 07:56:39.630895	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...
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

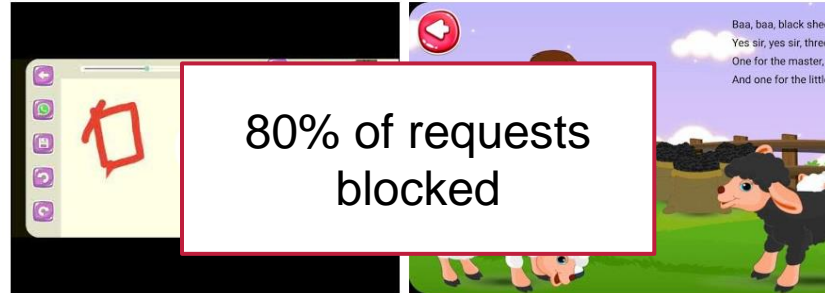
Early Learn Education Education

★★★★★ 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 assets in an interactive and fun way. It is an educational learning game for kids. It is the best pre-school

READ MORE

ADDITIONAL INFORMATION

Updated	Size	Installs	Current Version	Requires Android
January 31, 2021	8.5M	500,000+	5.1	5.0 and up
Content Rating	Permissions	Report	Offered By	Developer
USK: All ages	View details	Flag as inappropriate	Google Commerce Ltd	Visit website
Learn more				

<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 19:50:10.274767	POST	firebaseinstallations.googleapis.com	/v1/projects/easyearlylearn/installations
3	74010 2021-01-21 19:50:18.026587	GET	raw.githubusercontent.com	/jiteshdugan/random/master/abc-kids.gif
4	74013 2021-01-21 19:50:18.923604	POST	firebaseinstallations.googleapis.com	/v1/projects/27655582681/namespaces/firebase:fetch
5	74017 2021-01-21 19:50:26.941818	GET	googleads.g.doubleclick.net	/mads/static/mad/sdk/native/production/sdk-core-v40-impl.html
6	74019 2021-01-21 19:50:33.931597	GET	googleads.g.doubleclick.net	/favicon.ico
7	74021 2021-01-21 19:50:34.580709	GET	googleads.g.doubleclick.net	/getConfig/pubsetting?app_name=earlylearn.kidslearningworld&client=ca-app-pub-3255149968514506:admob_appcc=...
8	74022 2021-01-21 19:50:34.584906	GET	googleads.g.doubleclick.net	/getConfig/pubsetting?app_name=earlylearn.kidslearningworld&client=ca-app-pub-3255149968514506:admob_appcc=...
9	74024 2021-01-21 19:50:40.101841	GET	googleads.g.doubleclick.net	/mads/static/mad/sdk/native/sdk-core-v40-loader.html
10	74025 2021-01-21 19:50:40.514811	GET	googleads.g.doubleclick.net	/mads/static/mad/sdk/native/sdk-core-v40-loader.js
11	74026 2021-01-21 19:50:41.901395	GET	googleads.g.doubleclick.net	/mads/static/mad/sdk/native/production/sdk-core-v40-impl.js?n=true&v=sdm_20190107_RC02
12	74027 2021-01-21 19:50:41.916148	GET	googleads.g.doubleclick.net	/mads/static/mad/sdk/native/sdk-core-v40-loader.appcache
13	74028 2021-01-21 19:50:42.538653	GET	googleads.g.doubleclick.net	/favicon.ico
14	74029 2021-01-21 19:50:44.395451	GET	googleads.g.doubleclick.net	/mads/gma?submodel=sdm_gphone_x86_64_arm64&android_app_volume=1&disable_ml=false&format=interstitial_mb&omi...
15	74031 2021-01-21 19:50:44.579810	GET	googleads.g.doubleclick.net	/mads/gma?submodel=sdm_gphone_x86_64_arm64&android_app_volume=1&disable_ml=false&format=interstitial_mb&omi...
16	74030 2021-01-21 19:50:44.584675	GET	googleads.g.doubleclick.net	/mads/gma?submodel=sdm_gphone_x86_64_arm64&android_app_volume=1&disable_ml=false&format=interstitial_mb&omi...
17	74032 2021-01-21 19:50:44.845425	GET	googleads.g.doubleclick.net	/mads/gma?submodel=sdm_gphone_x86_64_arm64&android_app_volume=1&disable_ml=false&format=interstitial_mb&omi...
18	74033 2021-01-21 19:50:47.278059	GET	app-measurement.com	/config/app/1k3A27655582681k3AAndroidIdk3Af28806842a55c85f?app_instance_id=5b69b8a3ec48f391ebe7d64c959c2596p...
19	74034 2021-01-21 19:50:50.202617	GET	imasdk.googleapis.com	/admob/sdkloader/production/video_en.js
20	74035 2021-01-21 19:50:50.207908	GET	tpc.googlesyndication.com	/pagead/js/r2010120/r2010914/abg_lite_fy2019.js
21	74036 2021-01-21 19:50:50.630372	POST	app-measurement.com	/a
22	74038 2021-01-21 19:50:54.208092	GET	googleads.g.doubleclick.net	/pagead/images/gmob/video_loading.svg
23	74039 2021-01-21 19:50:54.738668	POST	csi.gstatic.com	/csi?v=2&s=ima&dmc=2&puid=1-kk79ssof&c=8298122799477&slotId=4149861399738.5&qqid=CLCck5nmre4CFc66Aodk-8Dzw...
24	74040 2021-01-21 19:50:54.733719	POST	csi.gstatic.com	/csi?v=2&s=ima&dmc=2&puid=1-kk79sua6&c=2735640002105&slotId=1367820001052.5&qqid=CIDsoJnmre4CFQIPGAdQY7EEGw...
25	74041 2021-01-21 19:50:55.257729	POST	app-measurement.com	/a
26	74042 2021-01-21 19:50:55.510626	POST	csi.gstatic.com	/csi?v=2&s=ima&dmc=2&puid=1-kk79sua6&c=7376535050652&slotId=3688267525326&qqid=CNuirpnme4CFVKNAGodbiwCAQ&e...
27	74044 2021-01-21 19:50:56.469921	POST	csi.gstatic.com	/csi?v=2&s=ima&dmc=2&puid=1-kk79svhd&c=6358849700451&slotId=3179424850225.5&qqid=CIQroZnmre4CFVWVGAdQdDIOSQ...
28	74043 2021-01-21 19:50:56.513680	POST	app-measurement.com	/a
29	74046 2021-01-21 19:50:57.646188	POST	app-measurement.com	/a
30	74047 2021-01-21 19:50:58.482648	POST	app-measurement.com	/a
31	74048 2021-01-21 19:51:00.526606	GET	googleads.g.doubleclick.net	/pagead/interaction/?ai=CBAYIFNsJYLDCG8f1Y5Pfj_gMAO_H700Vdc_oxrIDEBABIP-5yjlglfqXgqwHIAEBYAEFqKTJHLTKGtNPq...
32	74049 2021-01-21 19:51:00.631732	GET	yt3.ggpht.com	/ytcfAAUvnmhHShAAwINC6ajaGoE40Hpsf_i4Xo62x28jVizP=s48-c-k-c0x00ffffff-no-rj
33	74050 2021-01-21 19:51:00.835508	GET	googleads.g.doubleclick.net	/pagead/interaction/?ai=CvgrcFnsJYICSKYKeY0PiktG8AO_H700Vdc_oxrIDEBABIP-5yjlglfqXgqwHIAEBYAEFqKTJHLTKGtNPq...
34	74051 2021-01-21 19:51:01.313667	GET	googleads.g.doubleclick.net	/pagead/interaction/?ai=C8zoZFnsJYINvIntKaYuyisgGAO_H700Vdc_oxrIDEBABIP-5yjlglfqXgqwHIAEBYAEFqKTJHLTKGtNPq...
35	74052 2021-01-21 19:51:01.788408	GET	googleads.g.doubleclick.net	/pagead/interaction/?ai=CJlq0FNsJYIRKdMqYqjLuMgEAO_H700Vdc_oxrIDEBABIP-5yjlglfqXgqwHIAEBYAEFqKTJHLTKGtNPq...

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.ªÜü³ð. ....ªÜü³ð..._fot ...;´ð....ªÜü³ð..._fi ....î-ÿ³ð..._lte .  
îªÿ³ð. (ªÜü³ð.0ªÜü³ð.B.androidJ.11R.sdk_gphone_x86_64_arm64Z_en-  
us`<j.manual_installr.earlylearn.kidslearningworld...5.0..Eð...Ü"....$827d8162-0e1c-48cd-892e-4abd3df95ba8  
..ª.  
5b69b8a3ec488f391ebe7d64c959c259°.¶.âÛîîä.5...Ê.&1:27655582681:android:f28806842a55c85fà...ð..cj73krKSSEWVc4C  
BWm_A72ø.2...¬"ªðë.è.³ì..ð..  
.....1  
._o..auto  
._sid.öµ§..  
.  
._sno...._s.£¥ÿ³ð. ..B  
._o..auto  
.  
._sc.  
HomescreenNew  
.  
._si.ü°Ä|Ð;ð.¥..._vs..îÿ³ð. ....ªÜü³ð..._fot ...;´ð....ªÜü³ð..._fi ....£¥ÿ³ð..._sno ....£¥ÿ³ð..._sid  
öµ§.....â,ÿ³ð..._lte ....â,ÿ³ð..._se .  
îªÿ³ð. (£¥ÿ³ð.0.îÿ³ð.8ªÜü³ð.B.androidJ.11R.sdk_gphone_x86_64_arm64Z_en-  
us`<j.manual_installr.earlylearn.kidslearningworld...5.0..Éð...Ü"....$827d8162-0e1c-48cd-892e-4abd3df95ba8  
..ª.  
5b69b8a3ec488f391ebe7d64c959c259°.¶.âÛîîä.5...Ê.&1:27655582681:android:f28806842a55c85fð.ªÜü³ð.à...ð..cj73krK  
SSEWVc4CBWm_A72ø.2...¬"ªðë.è.³ì..ð..
```



Image: Agence Olloweb (Unsplash license)

Noteworthy examples



RegenRadar - Vorhersagen & live Wetterradar

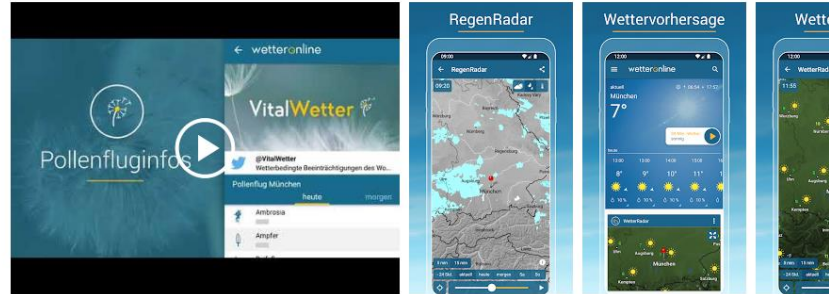
WetterOnline GmbH Weather

★★★★★ 148,075

USK: All ages

Contains Ads · Offers in-app purchases

Install



Top Funktionen der RegenRadar App:

• Aktuelles DonnenRadar für Deutschland, Österreich und die Schweiz

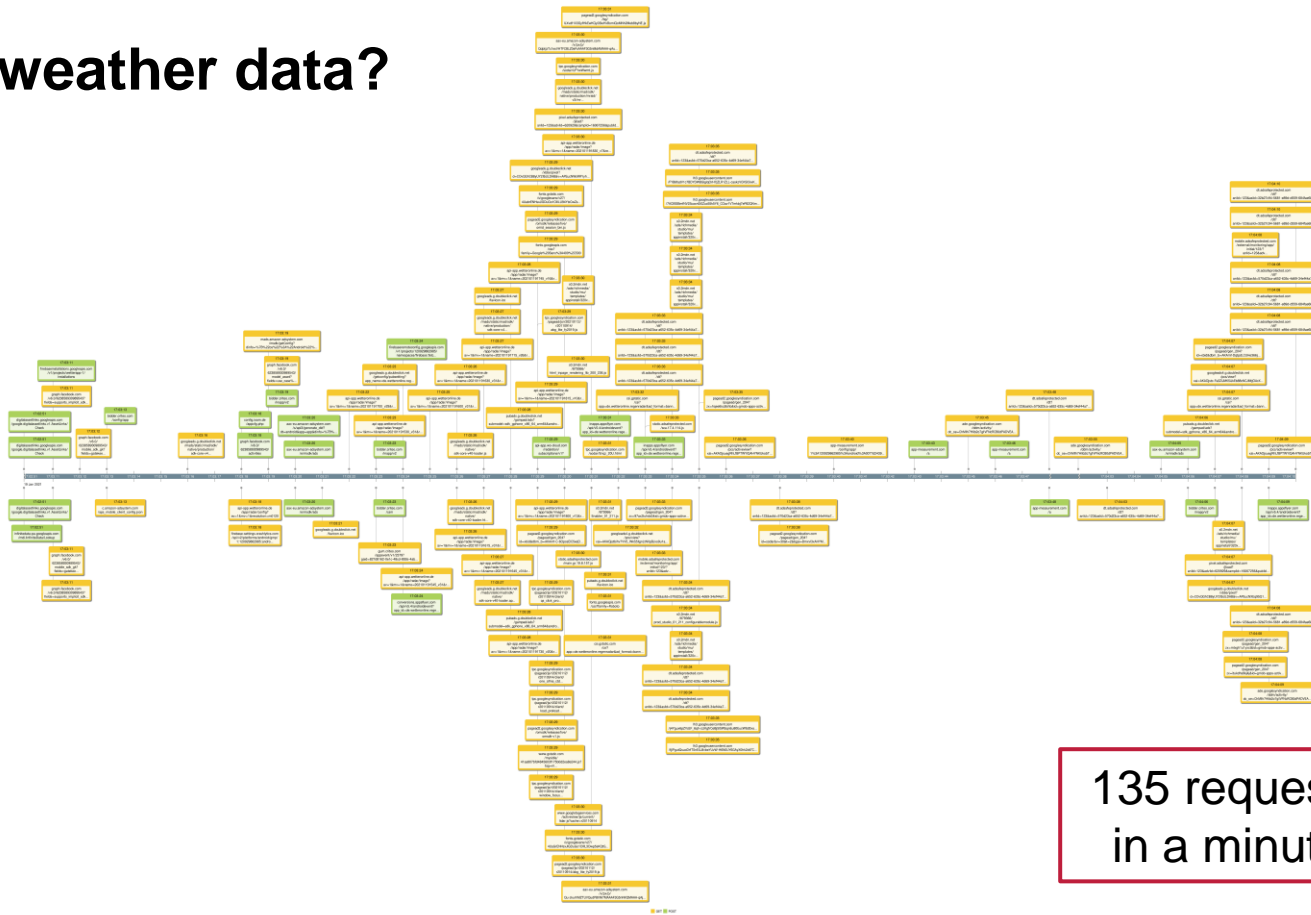
READ MORE

ADDITIONAL INFORMATION

Updated	Size	Installs	Current Version	Requires Android
February 23, 2021	22M	5,000,000+	Varies with device	Varies with device
Content Rating	Interactive Elements	In-app Products	Permissions	Report
USK: All ages	In-App Purchases	€0.99 - €6.99 per item	View details	Flag as inappropriate
Learn more				

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

Lots of weather data?

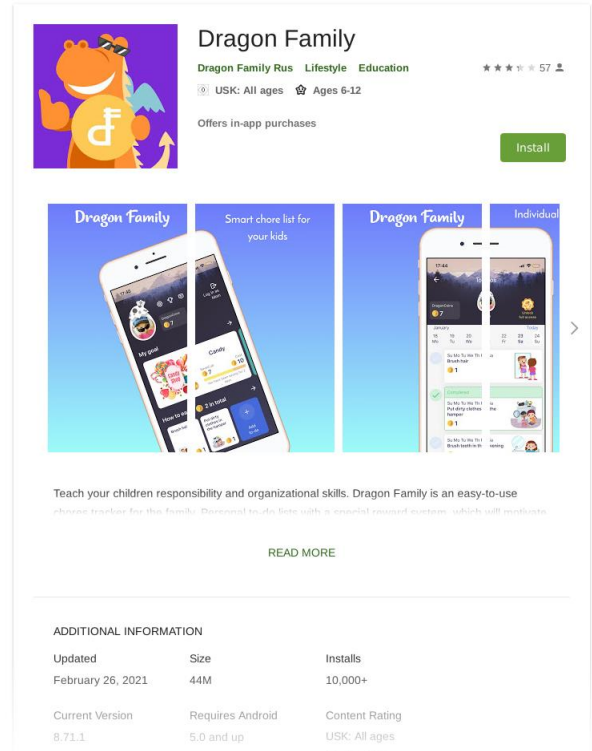


135 requests
in a minute

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




<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] [Eye Icon]

[Redacted]

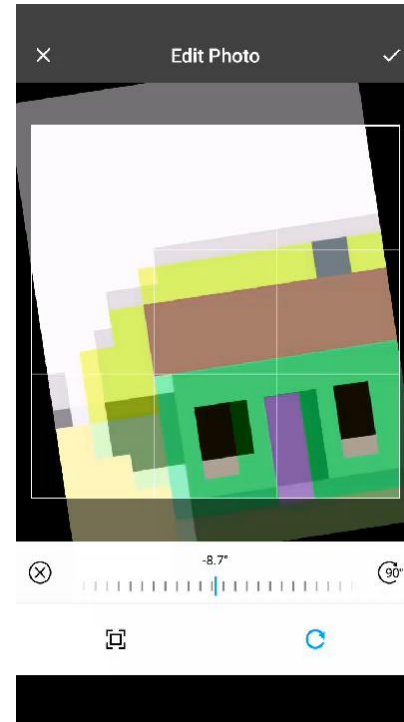
[Redacted]

Dad Mom

I agree to the privacy policy and the terms and conditions ☐

Proceed

[Redacted]





Wordscapes

PeopleFun Word

★★★★★ 933,280

USK: All ages

Contains Ads · Offers in-app purchases

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
Learn more				

<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": "appa4a89636aa0640a187",
"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	Size	Installs	Current Version	Requires Android
March 4, 2021	19M	10,000,000+	11.0.6	4.4 and up
Content Rating	Interactive Elements	In-app Products	Permissions	Report
USK: All ages	Users Interact	€0.63 - €134.99 per item	View details	Flag as inappropriate
Learn more		Learn more		

<https://play.google.com/store/apps/details?id=com.scores365>

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"
},
}
```

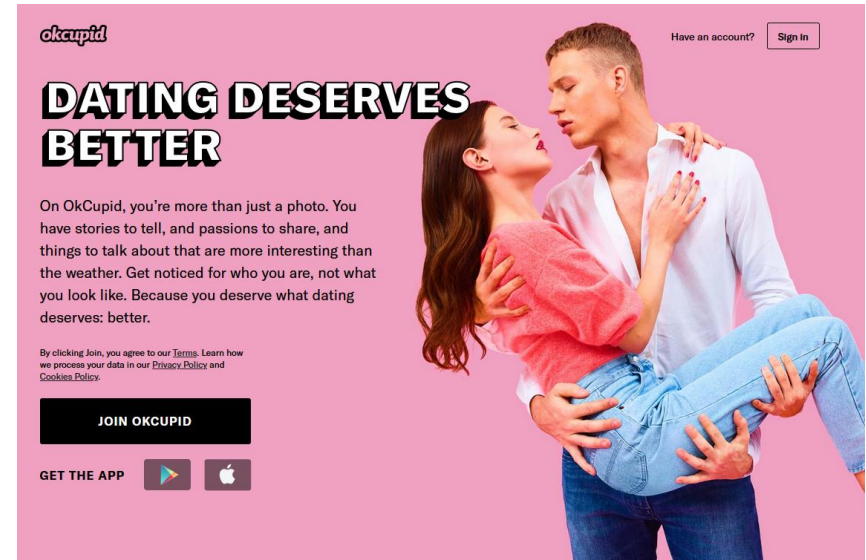
Database queries

- 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 ('[...]')`

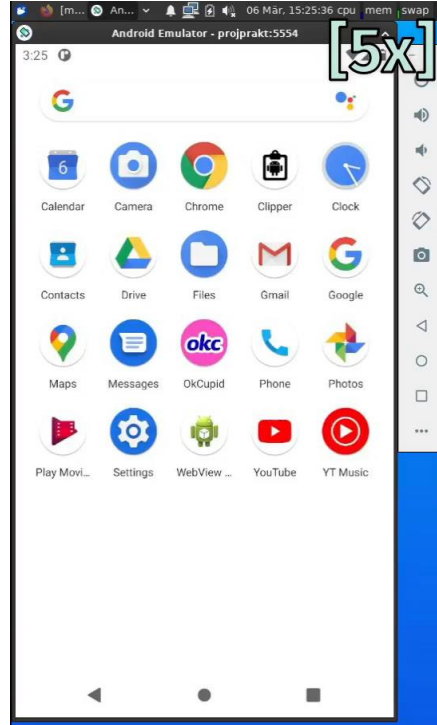
OkCupid

- 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, ...

The image shows the OkCupid app landing page. On the right, a man in a white shirt and blue jeans is lifting a woman in a pink sweater and blue jeans. They are both looking at each other. The background is a solid pink color. On the left, the text 'okcupid' is at the top. Below it, the headline 'DATING DESERVES BETTER' is in large, bold, black letters. Under the headline, there is a paragraph of text: 'On OkCupid, you're more than just a photo. You have stories to tell, and passions to share, and things to talk about that are more interesting than the weather. Get noticed for who you are, not what you look like. Because you deserve what dating deserves: better.' Below this paragraph, there is a small line of text: 'By clicking Join, you agree to our Terms. Learn how we process your data in our Privacy Policy and Cookies Policy.' At the bottom left, there is a black button with the text 'JOIN OKCUPID'. To the right of this button, there is a section titled 'GET THE APP' with icons for the Google Play Store and the Apple App Store. In the top right corner, there is a link 'Have an account? Sign In'.

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>

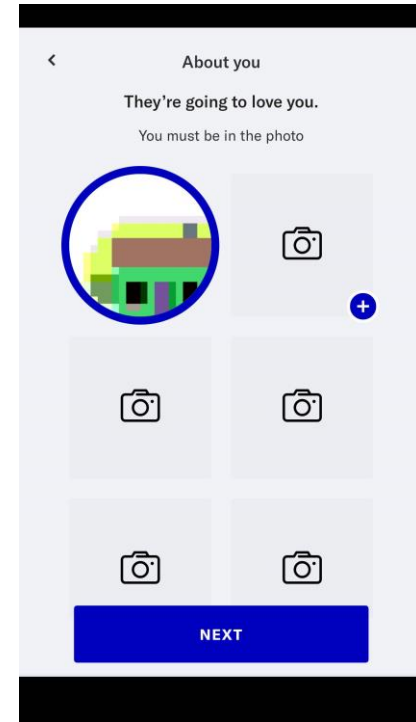
```
"he": false,  
"id": "10F16B3535B74D7CA7E6F8FED8E3AF67",  
"li": "0C49ACDC63954B608D1BDA9C21FA0913",  
"n": "billing client exception",  
"pr": {  
  "billing client exception description": "Play Store service is not connected now - potentially  
transient state.E.g. Play Store could have been updated in the background while your app was stillrunning.  
So feel free to introduce your retry policy for such use case. It should lead to acall 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.emb-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

```
{  
  "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"  
},
```

- But wait! There's even more!
- POST <https://www.facebook.com/tr/>

Form data:

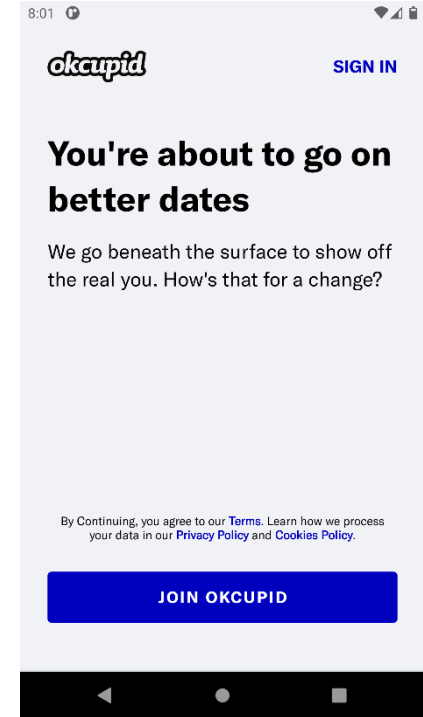
```
id: 014782201921498
ev: SubscribedButtonClick
dl: https://www.okcupid.com/onboarding?post_login=1&clear_history=1
rl:
if: false
ts: 1615040857972
cd[buttonFeatures]: {"classList":"pickmanybuttons-button checkbox-picker-pickmanybuttons-
button","destination":"","id":"","imageUrl":"","innerText":"Women","numChildButtons":0,"tag":"button","name":"","value"
:""}
cd[buttonText]: Women
cd[formFeatures]: []
cd[pageFeatures]: {"title":"OKCA App v243"}
cd[parameters]: []
sw: 412
sh: 732
udff[fn]: 61950c8964e60e152d9c194617fb9545c6f9734c8328e096a6dff8c1122c143c
udff[ct]: 215514c7719216cc237fbc96aaddbd8c409f13b65db7f69db1b2c4f1e83649a
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.

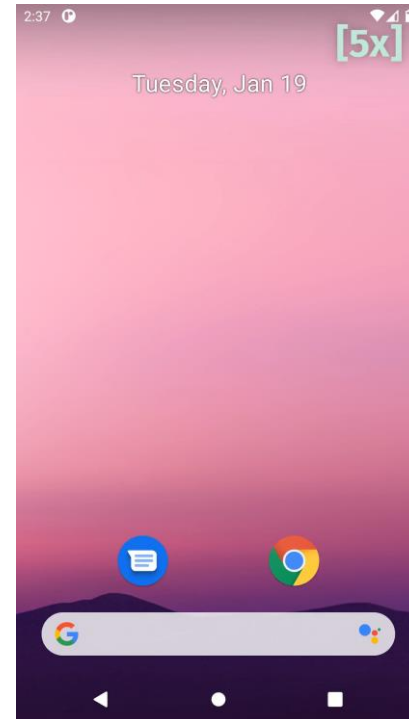


Grindr

- 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:APA91bH68o5tRxpewJV6k2rYLIhH
ZHbBRXtggy33jdRrznU2TL3K46VItBmBVIUmXL9GdQz35unVZLsf
euZfZFMx46XJ0c_atSLQzpDFIrnW5T7PyPlcO-
1YOMRj4PT9phFiO286Qm2"
}
```



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...