ZEBRA

Google Data Collection on Android

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Google Data Collection on Android
Who am I?

- Developer advocate / Software architect for Zebra Technologies
  - Android OEM developing task specific devices

- Feature owner for "GMS Restricted"

Google Data Collection on Android

2 Schools of Thought…

Google Data Collection on Android
2 Schools of Thought…

elections. Here's how we
helped do it
Nick Lowles

Google knows where you've been

Google stores your location (if you have location tracking turned on) every time you turn on your phone. You can see a timeline of where you've been from the very first day you started using Google on your phone.

Click on this link to see your own data: google.com/maps/timeline?...

Here is every place I have been in the last 12 months in Ireland. You can see the time of day that I was in the location and how long it took me to get to that location from my previous one.

▲ 'A Google map of every place I've been in Ireland this year.' Photograph: Dylan Curran

Google knows everything you've ever searched – and deleted

Google stores search history across all your devices. That can mean that,

Google Data Collection on Android
2 Schools of Thought…

ZEBRA TECHNOLOGIES

Google Data Collection on Android
Performing your own tests

Deciding on a Test Methodology:

Google Data Collection on Android
Performing your own tests

Deciding on a Test Methodology:

- What version of Android?

- What device hardware?

- Enable Location Services?

- High accuracy vs Battery Saving location?

- Perform Google searches?

- Use the Google Assistant?

Google Data Collection on Android
Performing your own tests

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- Use the Google Assistant?

- Use Google Now?

- SUW: Agree to share diagnostics?

- Sign in with a Google Account?

- Managed Android device?

- Multiple users?

- Should my test subjects move?

Google Data Collection on Android
Performing your own tests

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- Use the Google Assistant?
- Use Google Now?
- SUW: Agree to share diagnostics?
- Sign in with a Google Account?
- Managed Android device?
- Multiple users?

- Should my test subjects move?
- Should I move the device?
- Run / Walk / Cycle with the device?
- Should I actively use the device?
- Use a device with a SIM?
- Enable Bluetooth?
- Enable Chrome Diagnostics?
- Sign-in to Chrome?
- Enable Keyboard diagnostics?
- Enable apps to access location?

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Performing your own tests

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- Use a device with a SIM?
- Enable Bluetooth?
- Enable Chrome Diagnostics?
- Sign-in to Chrome?
- Enable Keyboard diagnostics?
- Enable apps to access location?
- Install 3rd party apps?
- Browse the web?
- Which websites??
- Check email with Gmail?

- Send SMS with the messaging app?
- Make an appointment with Google Calendar?
- Use Google Maps to navigate?
- Sign into Google Maps?
- Enable Location History?
- Enable Google Backup?
- Enable BLE / WiFi scanning?
- Go near BLE beacons?
- Use linked Google Home?
- Browse content on YouTube?
- Enable Play Protect?
- Disable Play Services?

Google Data Collection on Android
Performing your own tests

- Can tell how much data but not WHAT data is sent

- Quantitate Analysis:
  - Use the Network Stats API
  - Thousands of such apps – here's one I wrote (Source code).

Google Data Collection on Android
Performing your own tests

- Qualitative Analysis (<u>What</u> is being sent?):
  - http://www.darryncampbell.co.uk/2017/12/29/android-traffic-analysis-to-google-servers-methodology/

Google Data Collection on Android
Performing your own tests

- Qualitative Analysis:

Wireshark

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

tcp.stream eq 59

No.	Time	Source	Destination	Protocol	Length
7418	126.561852636	10.8.0.6	216.58.210.35	TCP	
7420	126.561953533	10.8.0.6	216.58.210.35	TCP	
7423	126.652822823	10.8.0.6	216.58.210.35	HTTP	105
7424	126.652866572	216.58.210.35	10.8.0.6	HTTP	
7430	126.702787260	216.58.210.35	10.8.0.6	HTTP	79
7433	126.734832915	10.8.0.6	216.58.210.35	HTTP	105
7434	126.734880791	216.58.210.35	10.8.0.6	TCP	
7443	126.789823685	216.58.210.35	10.8.0.6	TCP	139
7444	126.789831052	216.58.210.35	10.8.0.6	TLSv1.2	15
7447	126.792430095	10.8.0.6	216.58.210.35	TCP	139
7449	126.795795415	216.58.210.35	10.8.0.6	TLSv1.2	139
7452	126.796679520	10.8.0.6	216.58.210.35	TCP	
7453	126.796702384	216.58.210.35	10.8.0.6	HTTP	60
7456	126.802378967	10.8.0.6	216.58.210.35	TCP	
7458	126.824913362	10.8.0.6	216.58.210.35	HTTP	106
7459	126.824976909	216.58.210.35	10.8.0.6	TCP	
7466	126.871595488	216.58.210.35	10.8.0.6	TCP	139
7467	126.871602223	216.58.210.35	10.8.0.6	TLSv1.2	15
7471	126.881785837	10.8.0.6	216.58.210.35	TCP	
7472	126.881819611	216.58.210.35	10.8.0.6	HTTP	109
7475	126.937688228	10.8.0.6	216.58.210.35	TCP	

[Calculated window size: 57216]
[Window size scaling factor: 128]
Checksum: 0x4bf8 [unverified]
[Checksum Status: Unverified]
Urgent pointer: 0
▷ Options: (12 bytes), No-Operation (NOP), No-Operation (NOP), Timestamps
▷ [SEQ/ACK analysis]
▽ Secure Sockets Layer
  ▽ TLSv1.2 Record Layer: Application Data Protocol: http-over-tls
       Content Type: Application Data (23)
       Version: TLS 1.2 (0x0303)
       Length: 1021
       Encrypted Application Data: c95b2ea4ddf92a0c9e15a43b2ad4b57960fe1a301eea89a5...
    SSL segment data (997 bytes)
▷ [2 Reassembled SSL segments (2386 bytes): #7467(1389), #7472(997)]
    [Frame: 7467, payload: 0-1388 (1389 bytes)]
    [Frame: 7472, payload: 1389-2385 (997 bytes)]
    [Segment count: 2]
    [Reassembled PDU length: 2386]
    [Reassembled PDU data: 485454502f312e3120320323030204f4b0d0a4163636570742d...]
▽ Hypertext Transfer Protocol
  ▷ HTTP/1.1 200 OK\r\n

Frame (1094 bytes) | Decrypted SSL data (997 bytes) | Reassembled SSL (2386 bytes) | Uncon

Text item (text), 17 bytes

google-cert

Wireshark · Follow HTTP Stream (tcp.stream eq 59) · wireshark_any_20171220084538_Uv9wU8

1039649/indian-potato-pie" ping="/url?sa=t&source=web&rct=j&url=https://www.bbcgoodfood.com/recipes/1039649/indian-potato-pie&ved=0ahUKEwixpqqXmpjYAhVqLsAKHbvoBk8QgII8QEoADAt&usg=AOvVaw3qH3iFMuPa7NOhT2Ywr88K" oncontextmenu="google.ctpacw.cm(this)">Indian potato pie</div></div><div class="_nkt _lKp" jsname="UXbvIb" jscontroller="zXZXD"><div jsname="jXK9ad" class="_lKp">Raised pork pie</div></div><div class="_nkt _lKp" jsname="UXbvIb" jscontroller="zXZXD"><div jsname="jXK9ad" class="_lKp">Scotch egg pie</div></div><div class="_nkt _lKp" jsname="UXbvIb" jscontroller="zXZXD"><div jsname="jXK9ad" class="_lKp"><span cla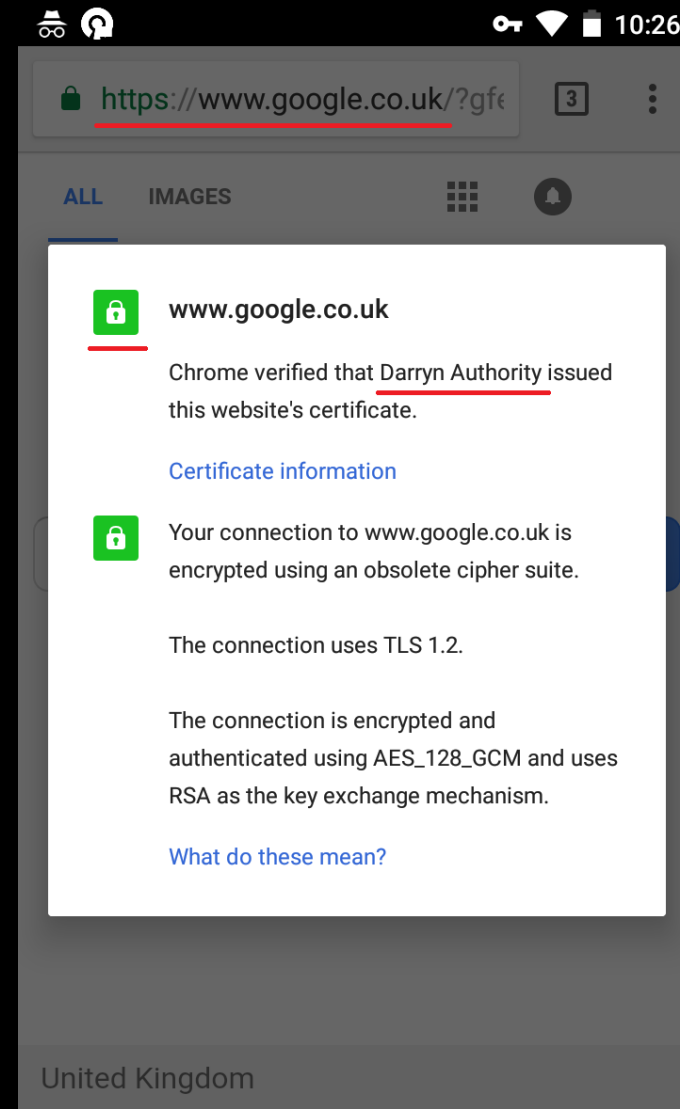ss="_H1m">Spiced pork & potato pie</div></div><div class="_nkt _lKp" jsname="UXbvIb" jscontroller="zXZXD"><div jsname="jXK9ad" class="_lKp">Green garden veg pie</div></div><div class="_nkt _lKp" jsname="UXbvIb" jscontroller="zXZXD"><div jsname="jXK9ad" class="_lKp">Grown-up banoffee pie</div></div><div class="_nkt _lKp" jsname="UXbvIb" jscontroller="zXZXD"><div jsname="jXK9ad" class="_lKp">Filo-topped fish pie</div></div></div><script>var a=function(d){var e=RegExp(d+":(\\d+)").exec(window.location.hash);e&&(d=document.querySelector('[data-id="'+d+'"]'))&&(d.scrollLeft=parseInt(e[1],10))},b=["google","fruit","sc","init"],c=this;b[0]in c||!c.execScript||c.execScript("var "+b[0]);for(var f;b.length&&(f=b.shift());){var g=c[f];b.length||void 0===a?c[f]&&c[f]!==Object.prototype[f]?c=c[f]:c=c[f]={}:c[f]=a;</script><script>(function(){var id="_rSM6WvGbMOrcqAa70Zv4BA3';google.fruit.sc.init(id);})();</script></div></div></div></div></div><div class="_tos"><div jsname="E3SGid" data-link="/search?dcr=0" class="bHXNeoCNSPo__result-pivots fexp-hide"><div jsname="G0pmF" class="_rOq" data-ved="0ahUKEwixpqqXmpjYAhVqLsAKHbvoBk8Q2Z0BCPgBMC0"><div class="_dVs _bCp">People also search for</div><div class="_SUs"><div class="_tUs _lKp"></div></div></div></div></div><div jsname="plIjzf" class="_t6r" aria-label="Dismiss suggested follow ups" role="button" tabindex="0"></div></div></div></div><div data-hveid="257"><div class="_Z1m"><div class="_a5r" jscontroller="UrRncd" data-id="_4" jsaction="rcuQ6b:npT2md"><div><div><div aria-level="3" role="heading" class="_H1m _ees">Savoury pie recipes | BBC Good Food</div><div class="_aBw _H1m _kup _J5m">https://www.bbcgoodfood.com ... collection</div></div></div><hr class="_oDv"></div><div><div class="_bCp"><div class="_Ycq"><div class="_ieo" style="width:104px;height:104px"><img id="tsuid5" src="data:image/gif;base64,R0lGODlhAQABAIAAAP//////yH5BAEKAAEALAAAAAABAAEAAAICTAEAOw==" data-deferred="1" alt="" from www.bbcgoodfood.com" class="_c0s" style="margin-left:-5px" onload="typeof google==='object'&&google.aft&&google.aft(this)"></div></div><div class="_D3n"><div class="_H1m">Delight in sensational savoury pies with crispy pastry and all kinds of fillings, including classic chicken and leek, gooey cheese and even a Christmas pie.</div></div></div></div><div class="_tos"><div jsname="E3SGid" data-link="/search?dcr=0" class="bHXNeoCNSPo__result-pivots fexp-hide"><div jsname="G0pmF" class="_rOq" data-ved="0ahUKEwixpqqXmpjYAhVqLsAKHbvoBk8Q2Z0BCPYCMC4"><div class="_dVs _bCp">People also search for</div><div class="_SUs"><div class="_tUs _lKp"></div></div></div></div><div jsname="plIjzf" class="_t6r" aria-label="Dismiss suggested follow ups" role="button" tabindex="0"></div></div></div><div data-hveid="271"><div class="_Z1m"><div class="_a5r" jscontroller="UrRncd" data-id="_6" jsaction="rcuQ6b:npT2md"><div><div><div aria-level="3" role="heading" class="_H1m _ees">Pie - Wikipedia</div><div class="_aBw _H1m _kup _J5m">https://en.m.wikipedia.org ... wiki ... Pie</div></div></div><hr class="_oDv"></div><div><div class="_bCp"><div class="_Ycq"><div class="_ieo" style="width:104px;height:104px"><img id="tsuid7" src="data:image/gif;base64,R0lGODlhAQABAIAAAP//////yH5BAEKAAEALAAAAAABAAEAAAICTAEAOw==" data-deferred="1" alt="" from en.m.wikipedia.org" class="_c0s" style="margin-left:-2px" onload="typeof google==='object'&&google.aft&&google.aft(this)"></div></div><div class="_D3n"><div class="_H1m">A pie is a baked dish which is usually made of a pastry dough casing that covers or completely contains a filling of various sweet or savoury ingredients. Pies are defined by their crusts.</div></div>

Packet 4352. 16 client pkts, 16 server pkts, 31 turns. Click to select.

Entire conversation (2422 kB) | Show and save data as ASCII

Find: baked | Find Next

Google Data Collection on Android
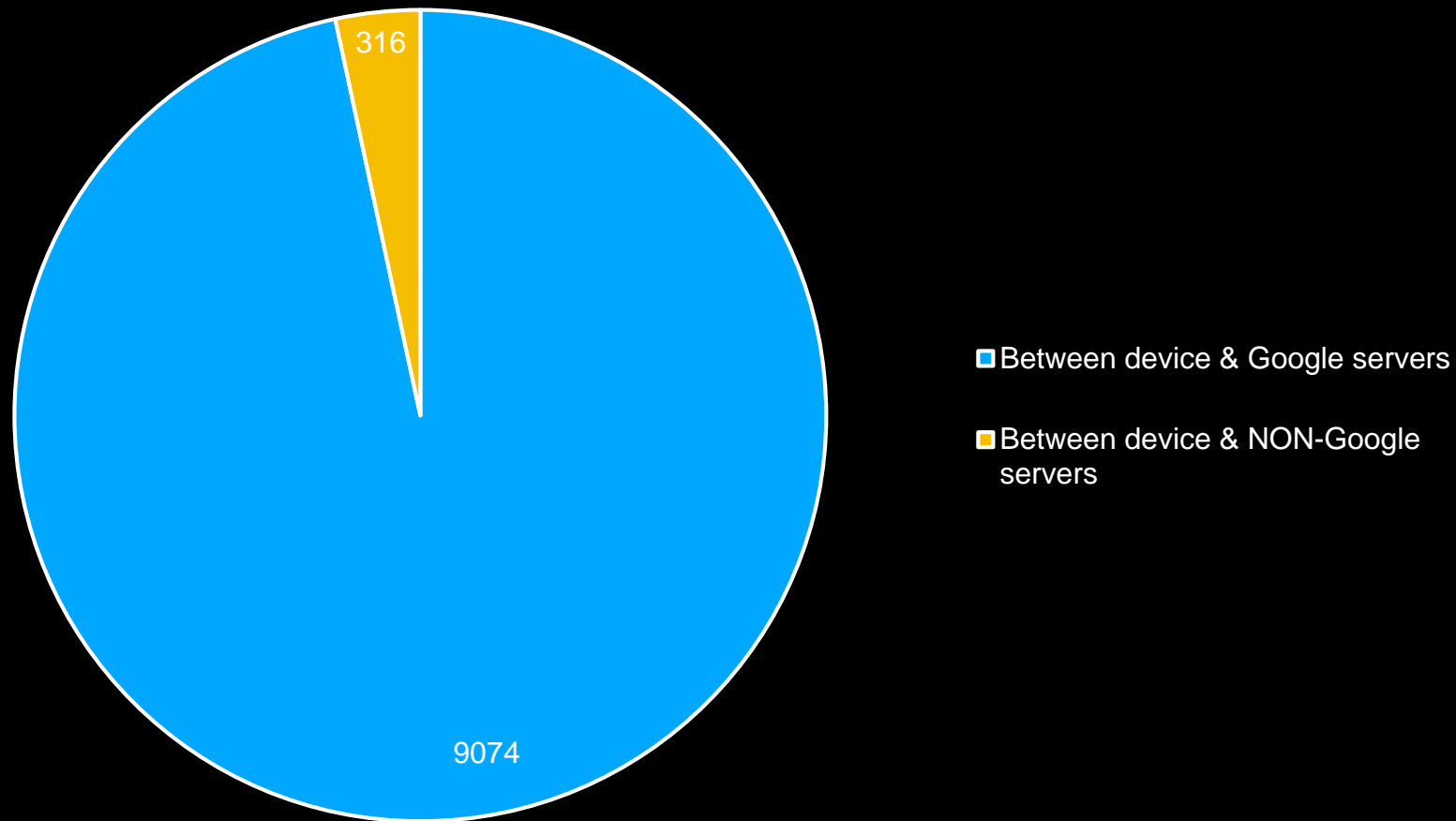## Some Data – My own analysis

- Test Conditions:
  - Android Nougat 7.1
  - Device kept:
    - Stationary
    - Untouched
    - Plugged into power
  - No applications manually launched
  - Google (@gmail) account exists on device
  - Factory Reset and run through SUW

- SUW Conditions:
  - Back up to Google Drive: <u>Enabled</u>
  - Help apps find location: <u>Enabled</u>
  - Improve location accuracy: <u>Enabled</u>
  - Send System Data (analytics): <u>Enabled</u>
  - Location History: <u>Enabled</u>

- Leave device overnight

Google Data Collection on Android
Some Data – My own analysis

Packets Exchanged per Hour

316

9074

- ■ Between device & Google servers

- ■ Between device & NON-Google servers

Google Data Collection on Android
Some Data – My own analysis

Destination of Google Bound packets (per hour)

- googleapis.l.google.com
- android.l.google.com
- pagead.l.doubleclick.net
- update.googleapis.com
- clients.l.googl.e.com
- wm-im-f188.1e100.net
- history.l.google.com
- www.gstatic.com
- anccounts.google.com
- googlemail.l.google.com
- www.google.com
- storage.l.googleusercontent.com
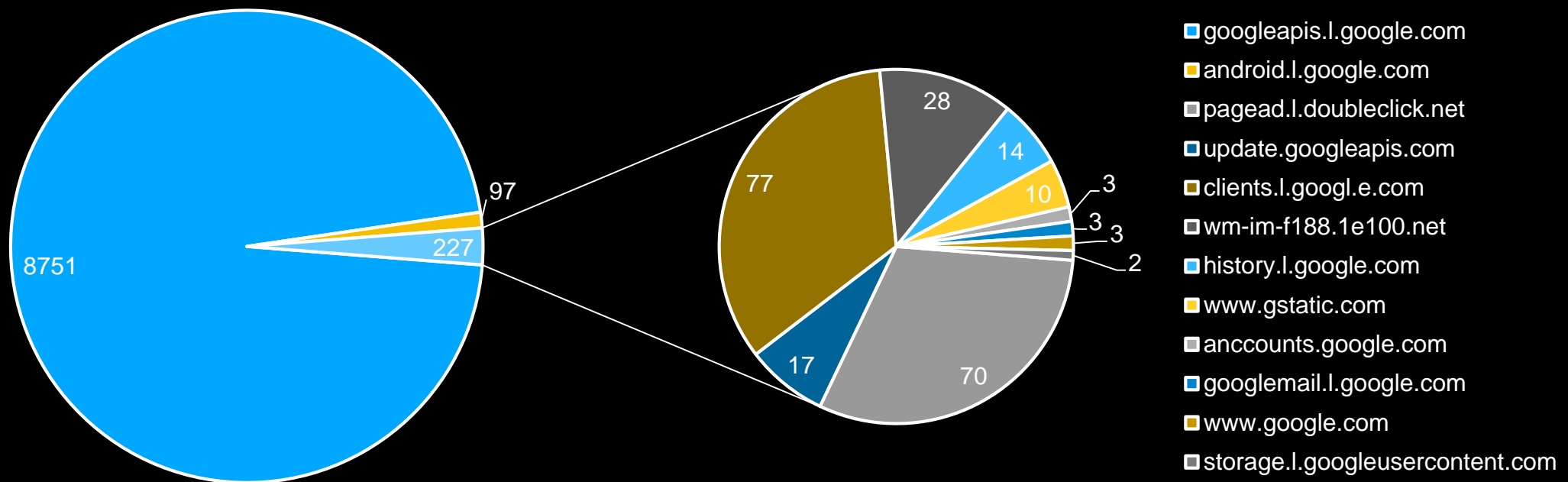
Google Data Collection on Android

Some Data – My own analysis

- HTTP Traffic: Location update:

```
Hypertext Transfer Protocol
    POST /loc/m/api HTTP/1.1\r\n
    User-Agent: GoogleMobile/1.0\r\n
    Content-Type: application/binary\r\n
    Transfer-Encoding: chunked\r\n
    Host: www.google.com\r\n
    Connection: Keep-Alive\r\n
    Accept-Encoding: gzip\r\n
    \r\n
    [Full request URI: https://www.google.com/loc/m/api]
    [HTTP request 1/1]
    [Response in frame: 30554]
    HTTP chunked response
    File Data: 315 bytes
Media Type
    Media type: application/binary (315 bytes)  ← The location object
```

Google Data Collection on Android
Some Data – My own analysis

- ## HTTP Traffic: QuickSearchBox POST:

```
HTML Form URL Encoded: application/x-www-form-urlencoded
    Form item: "androidId" = "3d4478c9dbb98ecb"
    Form item: "lang" = "en_GB"
    Form item: "google_play_services_version" = "11951446"
    Form item: "sdk_version" = "25"
    Form item: "device_country" = "gb"
    Form item: "client_sig" = "38918a453d07199354f8b19af05ec6562ced5788"
    Form item: "callerSig" = "38918a453d07199354f8b19af05ec6562ced5788"
    Form item: "Email" = "darryncampbellfake@gmail.com"
    Form item: "has_permission" = "1"
    Form item: "service" = "oauth2:https://www.googleapis.com/auth/googlenow"
    Form item: "app" = "com.google.android.googlequicksearchbox"
    Form item: "check_email" = "1"
    Form item: "token_request_options" = "CAA4AQ=="
    Form item: "system_partition" = "1"
    Form item: "callerPkg" = "com.google.android.googlequicksearchbox"
```

Google Data Collection on Android
Some Data – My own analysis

- QUIC Data
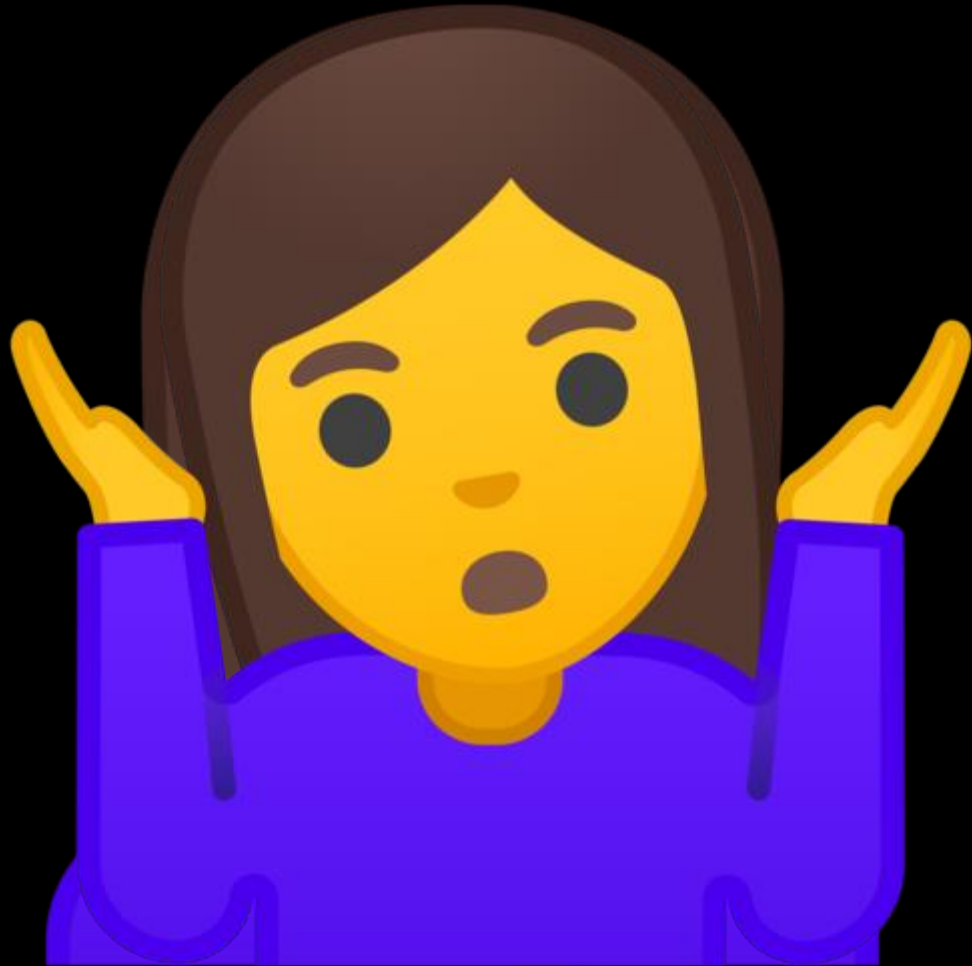
Google Data Collection on Android

Enter Academia… Previous studies

Title	Relevant findings	Author, Date, Source
AP Exclusive: Google tracks your movements, like it or not	Google is tracking users' location even when location services are disabled	Ryan Nakashima August 2018 Source Link
Australian regulator investigates Google data harvesting from Android phones	Google "harvest" about 1GB of data from Android devices per month	Oracle May 2018 *Could not find original source*
Google collects Android users' locations even when location services are disabled	Google collects Android location when location services are turned off	Quartz November 2017 Source Link
Ericsson Mobility Report	Android devices consume more data (2.2GB/month) than other smartphones	Ericsson December 2013 Source Link
Data leakage from Android smartphones	Android passes anonymous IDs along with device IDs such as Mac addresses and IMEI	Lasse Øverlier June 2012 Source Link (Mirror)

Google Data Collection on Android
Performing your own tests

Figure 23: Example VPN setup used to analyze data shared with Google

ager (Oasis)

Voice

SMS

Data

VPN

UDP / IP decryption

SIM
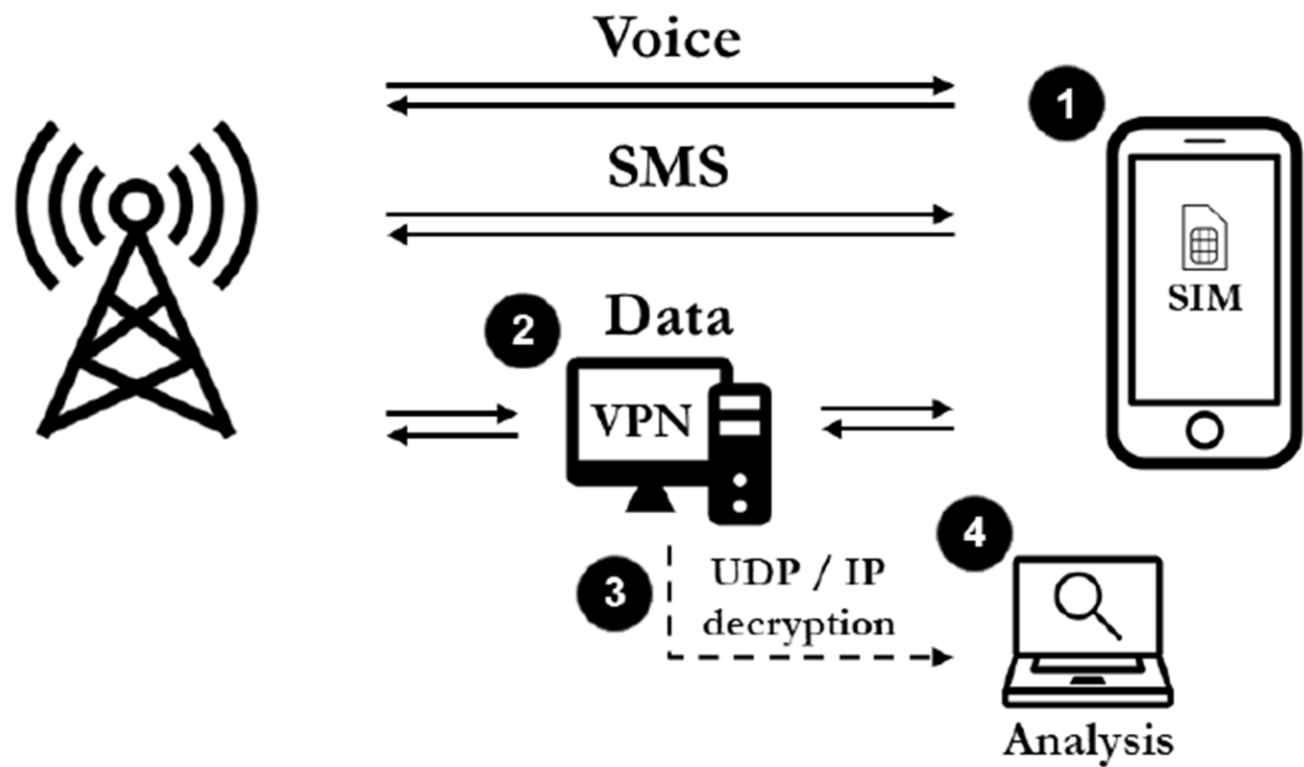
Analysis
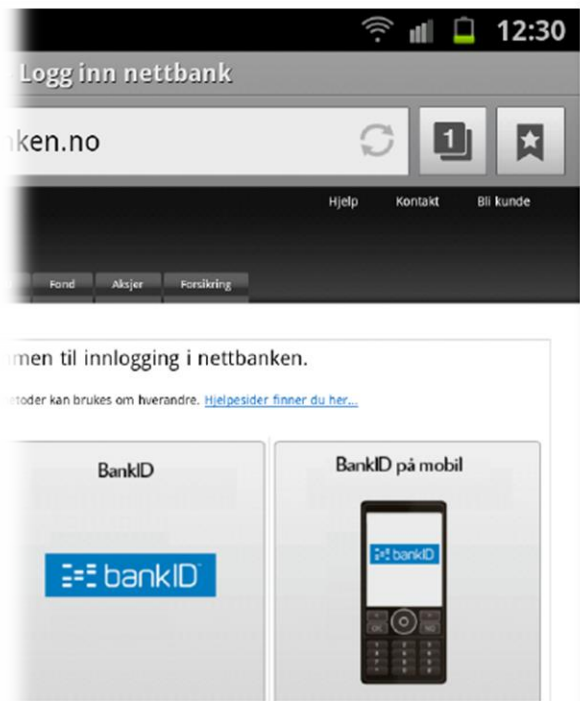
Figure 3.2   Login without warning when adding trusted certificate issuer locally

Google Data Collection on Android
Enter Academia…

- August 2018, Professor Douglas C. Schmidt, Professor of Computer Science at Vanderbilt University, and his team published, "Google Data Collection"
  - "Offered to the public"
  - https://digitalcontentnext.org/blog/2018/08/21/google-data-collection-research/
- Collected data sources :
  - Google's My Activity and Takeout tools
  - **Data intercepted as it is sent to Google server domains**
  - Google's privacy policies
  - Other 3rd party research

Google Data Collection on Android
Some Data – Academic analysis

- Paper limits itself to Android 6.0 and (strangely) does not specify which phone is used. Android 6.0 has a 16.9% market share today.

- Paper conducts a series of tests on stationary and moving devices and determines typical usage based on past studies of user behaviour

- Paper distinguishes between 'Active' data collection and 'Passive' collection

- *"Overall, our findings indicate that Google has the ability to connect the anonymous data collected through passive means with the personal information of the user"*
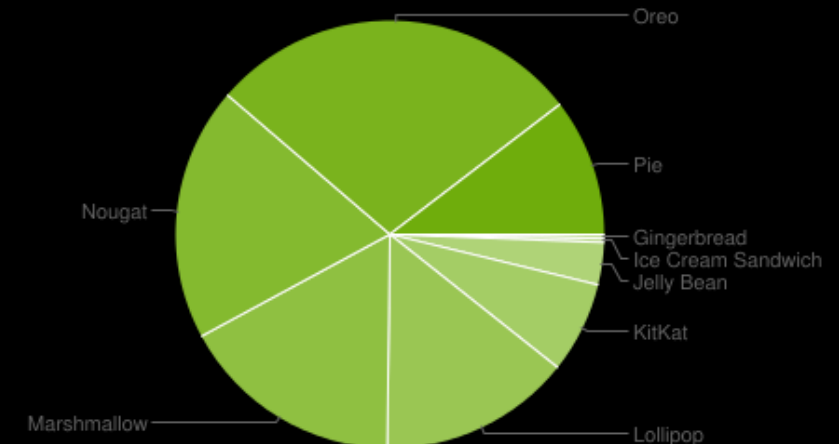
Google Data Collection on Android
Some Data – Academic analysis

- *"Analysis… during a normal day in the life of Jane [test subject] suggested that the number of 'passive' data collection events outnumbered the 'active' events by approximately 2 to 1"*

Description	Active collection	Passive collection
Listening to Google Play in the morning	Music interests	Morning location
Walks from subway to work		Commute path to work address
Uses Maps to find a new lunch spot	Destination entered into Maps	Dining interests
Takes an Uber from home to work		Commute path home & use of the Uber app
Uses Google Home to play music for her children	Google Home search query	Location of Google Home

Google Data Collection on Android
Some Data – Academic analysis

- Location
  - "*It is hard for an Android mobile user to "opt-out" of location tracking*".
    - Location mode
    - Location Services
    - Wi-Fi
    - Wi-Fi scanning (even when Wi-Fi is off)
    - BLE scanning
    - Cell tower triangulation
    - Sensor dead reckoning
    - Google Maps location history
  - See: Recent 'scare' that Google is tracking your location when you turn location off (Quartz, Nov 2017)
  - "*During a short 15-minute walk around a residential neighbourhood, an Android device sent nine location requests to Google [containing] 100 unique BSSIDs of Wi-Fi access points*"

Google Data Collection on Android
Some Data – Academic analysis

- *"Location constitutes most of the passive data sent from an idle device"*
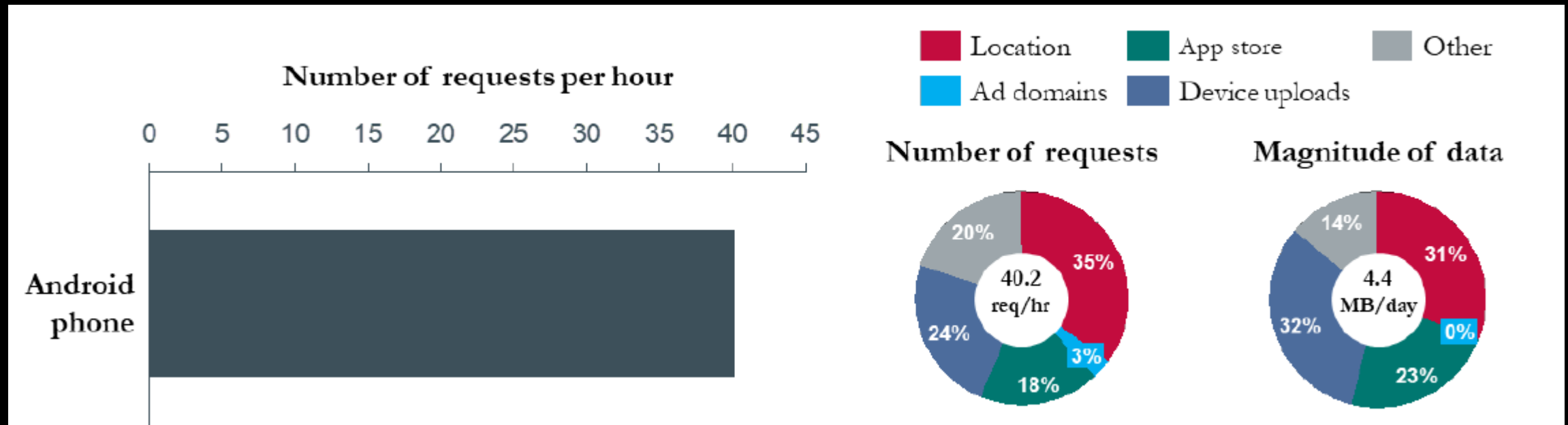
Google Data Collection on Android
Some Data – Academic analysis

- Location: Application APIs can return user activity using a combination of device sensors and on-device machine learning

- The academic analysis observed this data uploaded to Google

```
"activityReadings": [{

    "activities": [{

        "confidence": 99,

        "type": "onFoot"

    },{

        "confidence": 99,

        "type": "walking"

    }], "timestampMs": 1527095517507 },
```

Google Data Collection on Android
Some Data – Academic analysis

- Potential to de-anonymize device via data sent to Google by Android:

- The Check-in upload was observed 2 times in a 24 hour test:

```
Locale: "en-us"

macAddr: "2c598a23***"                          MAC

Meid: "35956507040***"                          IMEI

accountCookie: "[jane.gcollpro@gmail.com]"      GMAIL

accountCookie: "ya37.GokBuQWFvoYx919S7S52Hxksk-K0CZMUvVw1_hZO.."

…

serialNumber: "LGUS610b12c***"                  Serial

…
```

Google Data Collection on Android
Some Data – Academic analysis

- Potential to de-anonymize device via data sent to Google by Android:

- The <u>bulk upload</u> allows the association between the GAID (Advertising ID) with the <u>GSF ID</u> (Unique to a user of Google services):

```
User-agent: "Android-Finsky/10.1.08-all%20…"

X-dfe-device-id: "3945dee97778***"              GSF in hex

authorization: "GoogleLogin auth=lwZo4lcwvnwk8QKiuw…"

X-dfe-cookie: "CAEQARgAIjJVUygBMjxDaXNhS1FvVE5…"

X-def-device-checkin-consistency-token: "ABFEt1U16JQ5xikF9j8…"

…

X-ad-id: "83d479a5-5eb7-44f1-a2ee-14e91094"     GAID

…
```

Google Data Collection on Android
Some Data – Academic analysis

- Non-Stationary device

- "Various consumer usage studies were used to form a daily usage profile of a typical mobile phone user … any direct interactions with Google's products were omitted."

Google Data Collection on Android
Some Data – Academic analysis

- Non-Stationary device

- Over a 24 hour period Google collected user location in ~450 instances, or 1.4x the experiment on a stationary device

  - This includes collection across all Google's portfolio of services e.g. DoubleClick, Analytics etc.
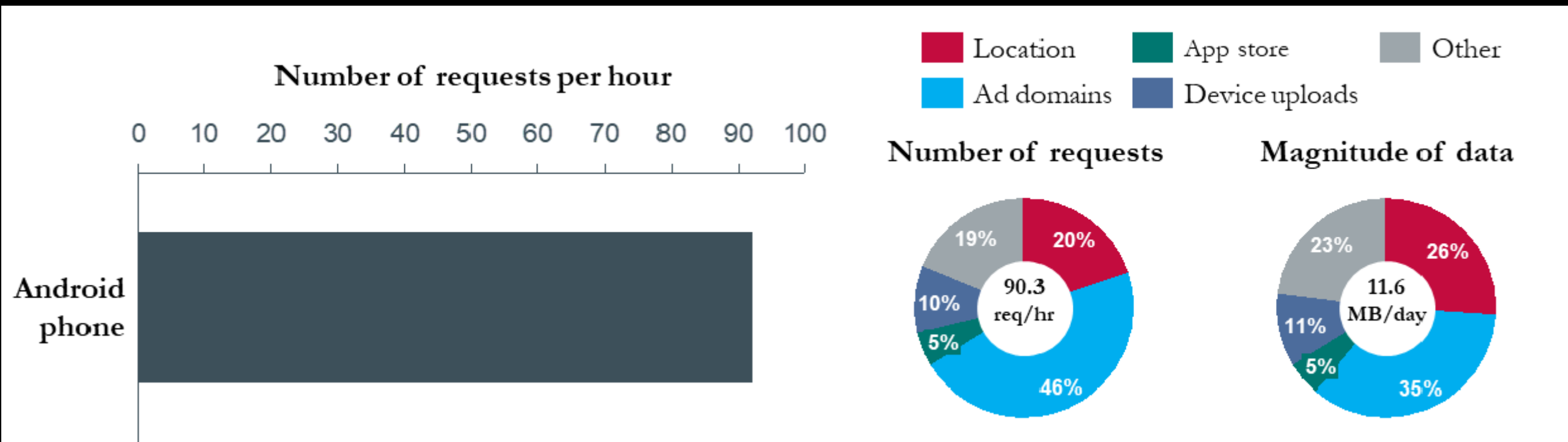
Number of requests per hour

| | 0 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 |

Android phone

Legend: Location, App store, Other, Ad domains, Device uploads

Number of requests — 40.2 req/hr
- 35% Location
- 3% Ad domains
- 18% App store
- 24% Device uploads
- 20% Other

Magnitude of data — 4.4 MB/day
- 31% Location
- 0% Ad domains
- 23% App store
- 32% Device uploads
- 14% Other
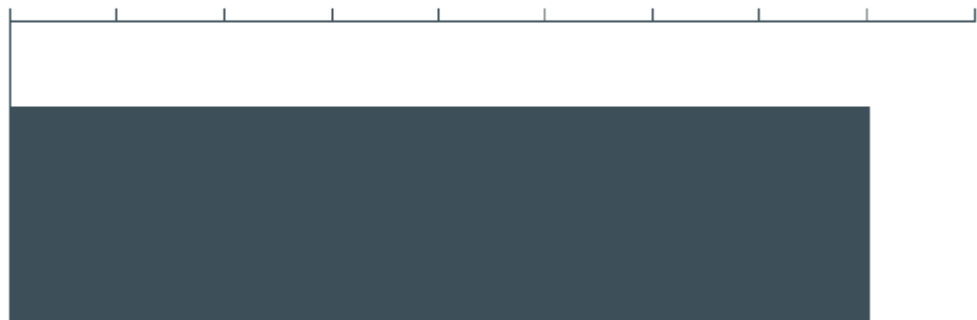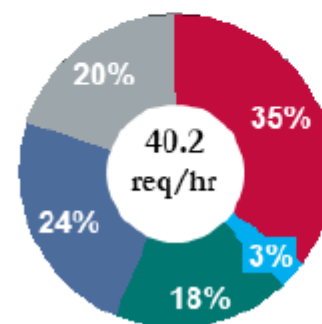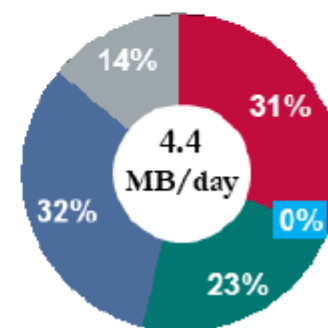
Number of requests per hour

| | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |

Android phone
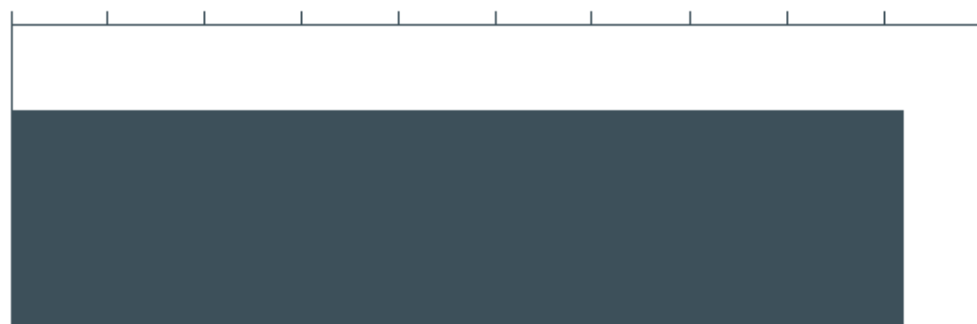
Legend: Location, App store, Other, Ad domains, Device uploads

Number of requests — 90.3 req/hr
- 20% Location
- 46% Ad domains
- 5% App store
- 10% Device uploads
- 19% Other

Magnitude of data — 11.6 MB/day
- 26% Location
- 35% Ad domains
- 5% App store
- 11% Device uploads
- 23% Other
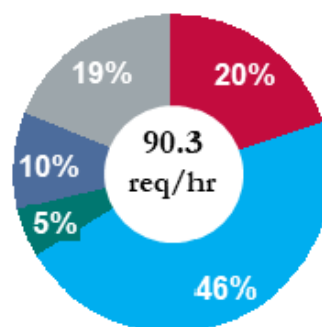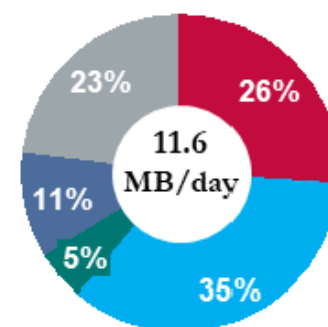
Google Data Collection on Android
Some Data – Academic analysis

- Conclusion:
  - "A major part of Google's data collection occurs while a user is not directly engaged with any of its products. The magnitude of such collection is significant, especially on Android module devices"
  - "While such information is typically collected without identifying a unique user, Google distinctively possesses the ability to utilize data collected from other sources to de-anonymize such a collection"

Google Data Collection on Android
Some Data – Academic analysis

- Counterpoints:
  - None of these studies consider the <u>value to the user</u> of Google collecting this data
    - Consider the analogy with Runtime permissions: Why does Uber want to know my location? To provide me with a service.
  - There is an inherent assumption of nefarious purposes, less so in the academic studies but still present, *in my opinion*.
  - All of the studies analysed a very specific, narrow set of behaviour

Google Data Collection on Android
Some Data – Academic analysis

- As an aside…
  - "One specific request to Google that was further decoded was the 'Google location API' designated by the /loc/m/api endpoint. The location specifications were reverse engineered by removing the message header and decoding the compressed protobuf message"

```
Media Type
    Media type: application/binary (315 bytes)  ← The location
```

Google Data Collection on Android
Controlling your data

- Some <u>dodgy websites</u> out there giving all sorts of wacky advice on this!

- Some of the <u>better</u> <u>ones</u> I could find suggest:
    - Opt out of Ads personalization
    - Change DNS Server
    - Use a VPN
    - Don't use Google Apps
    - Disable app backup
    - Turn off Data & Personalization
    - Turn off Web & App activity
    - Turn off Location History

Google Data Collection on Android
Controlling your data

- Still a lot of closed source components, requires a degree of trust

- Every new version of Android introduces new components, settings, behaviour changes etc.
  - Trying to do this manually is a losing battle
  - You lose a lot of the value of Android by turning all this off

- Two approaches:
  - Network level
  - Device level

Google Data Collection on Android
Controlling your data – Network Level

- No authoritative list of Google sites exists

- You COULD block all IP addresses listed under [AS15169](#)
  - Best source I could find for IP addresses owned by Google
  - Also includes 3rd party sites hosted by Google (about 8.7M in total)

- For 99.95% of people this approach would be a non-starter

- You COULD block named hosts based on previous traffic analysis
  - But you would need to re-analyse every time Play Store updates (not just Android)

Google Data Collection on Android
Controlling your data – Device Level

- Disable all GMS applications and services
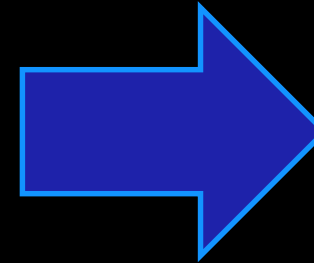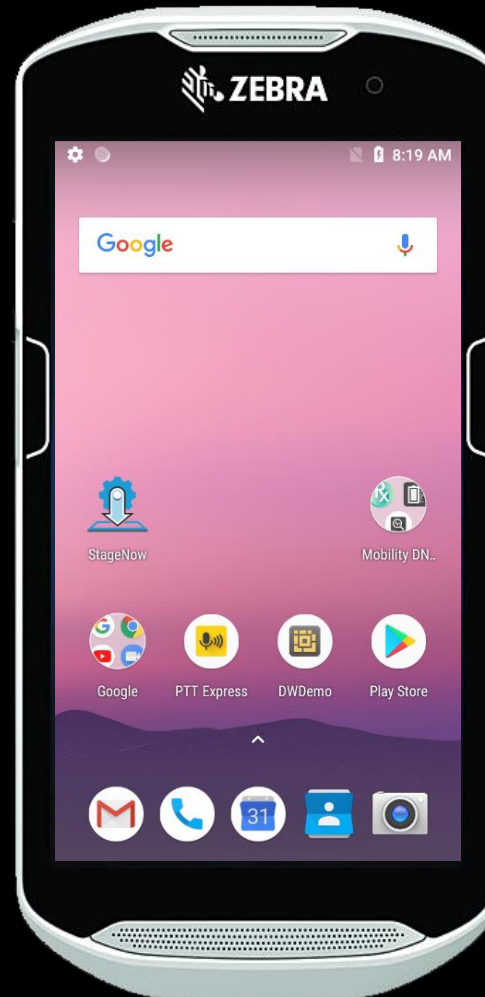
Google Data Collection on Android
Controlling your data

- Zebra's Restricted GMS provides an easy option for administrators to disable Google apps / services in a single step.

- Come talk to us at the booth!

- **DEMO**
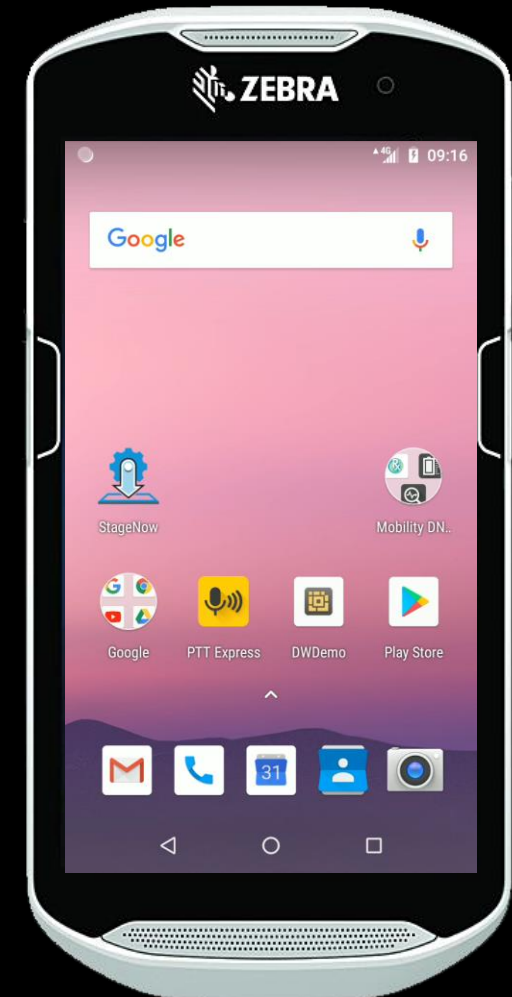
Google Data Collection on Android
Resources

- News Organization articles:
  - [Guardian article](#)
  - [AP Exclusive: Google tracks your movements, like it or not](#)
  - [Google collects Android users' locations even when location services are disabled](#)
- My Original Research
  - [Network Stats Logger](#)
  - [Test Methodology](#)
- Academic Papers:
  - [Google Data Collection](#) (Aug 2018)
  - [Data leakage from Android smartphones](#) (June 2012)
- Controlling your Data
  - [Zebra's GMS Restricted](#) ([Webinar](#))

Google Data Collection on Android

Questions?

Thank You