50 Ways to Leak Your Data

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Introduction

Research paper in focus:

50 Ways to Leak Your Data: An Exploration of Apps' Circumvention of the Android Permissions System

Reardon, J.   Feal, A.   Wijesekera, P.   On, A.,   Vallina-Rodriquez, N.,   Egelman, S.

Paper aims to:

- Boost enforcement through regulators
- Improve implementation in industry
- Educate users

Android Permission System

- Principle of least privilege
  - ‘An entity should only have the minimum capabilities it needs to perform its task.’
- Application must:
  - Ask user for permission
  - Not be able to access information without permission

Concerns:

- Access requests are not regulated
- Applications are getting around it

Main Methods of Circumvention

- Side Channel
  - Exposes path to resource outside security mechanism
    - Either flaw in design of security mechanism
    - Or flaw in the implementation of the design
  - Eg. cryptography - power usage of hardware can leak secret key

- Covert Channels
  - More intentional
  - Applications cooperate (1 has access, 1 doesn’t)
  - Eg. alternating CPU load (high/low) to send binary message

Common Targets:

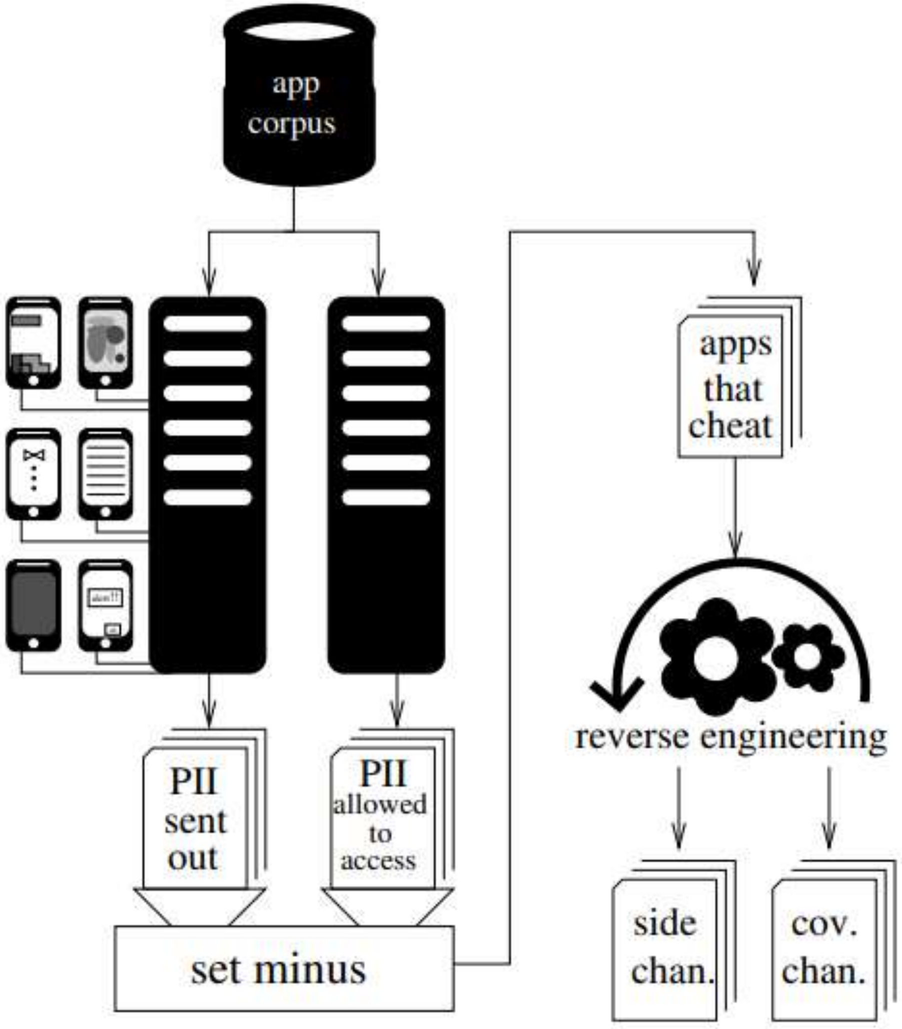
- International Mobile Equipment Identifiers (IMEI’s)
- Device Media Access Control (MAC) addresses

Examples of Circumvention

- Obtaining MAC addresses of WiFi base stations - location data
- Unity was obtaining device MAC addresses - location data
- SD cards as covert channels
- Picture metadata as location data

Testing Environment and Analysis Pipeline

- The authors of the paper set up an automated pipeline to analyse apps
- Evidence of covert- and side-channel usage in 252,864 versions of 88,113 different Android apps
- Analysed at the OS level as well as the network level by decrypting traffic



Analysis Pipeline [1]

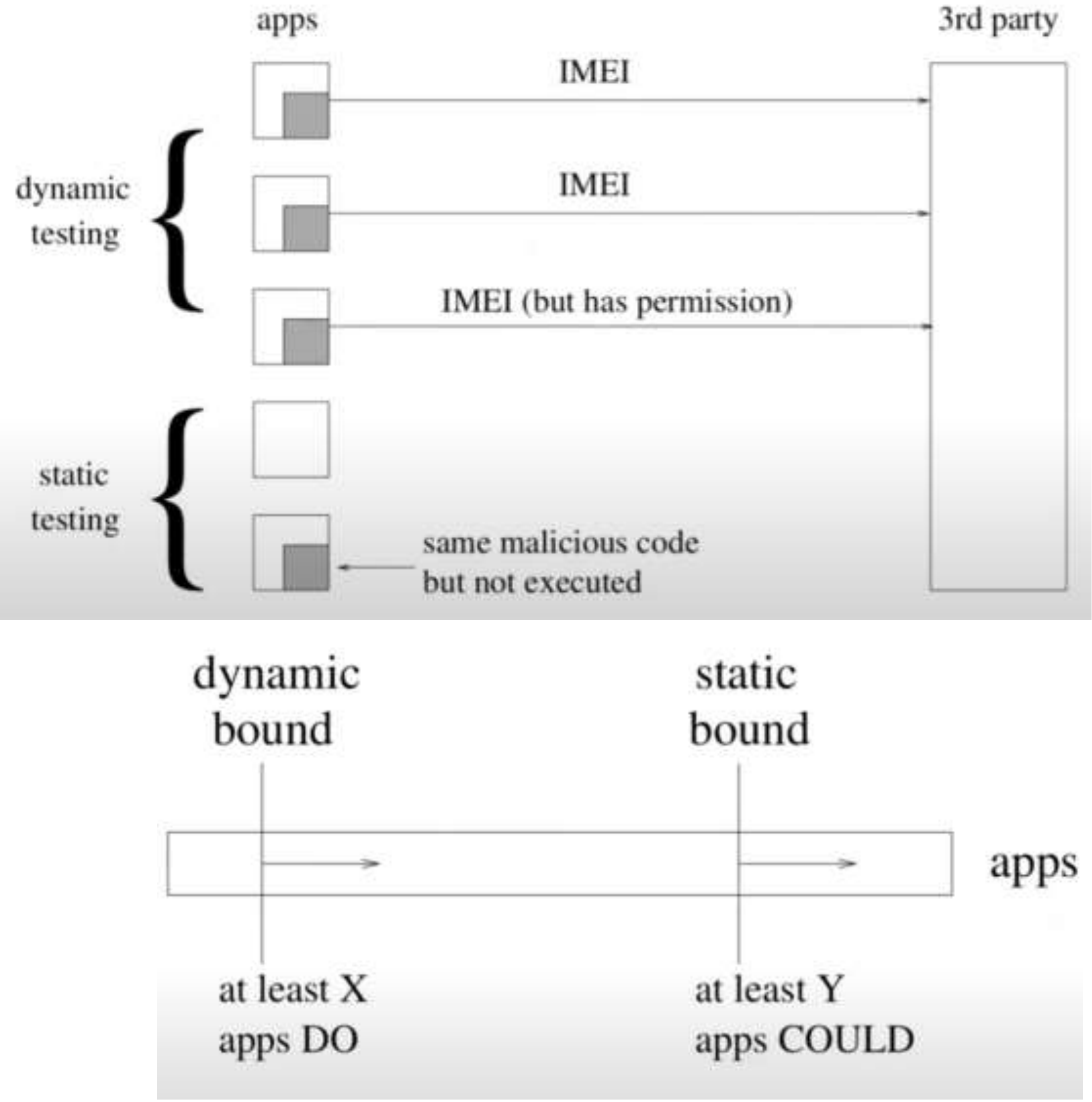
Static Analysis

- Static analysis scans for execution flows in apps' code to see where privacy might be violated
- Issues with static analysis:
  - Some apps may choose not to violate user privacy even when they could
  - Code obfuscation could cause missed instances
  - Dynamically loaded code cannot be analysed this way

Static analysis [2]

Dynamic Analysis

- Gather collection of phones
- Setup the pipeline to:
  - Automatically download the apps
  - Interact with them via the UI/Application Exerciser Monkey for 10 minutes
  - Monitor via the kernel when certain resources are Accessed
  - Intercept and decrypt network traffic



Dynamic Analysis [3]

Results

- IMEI
- Network MAC
- Router MAC
- Geolocation

IMEI (International Mobile Equipment Identity)

- Salmonads
    - 5 applications were using a covert channel to access the IMEI
    - The malicious apps were downloaded at least 17.6 million times
- Baidu
    - Stored the IMEI in an AES-encrypted json file
        - The AES key was baidu cid 2012 12 03
    - This json file was encrypted in base-64 on the SD card
    - 8 applications were using a covert channel to access the IMEI
    - The malicious apps were downloaded at least 700 million times

Device IMEI [4]

Network MAC Address

- Unity was able to obtain the MAC address of the device
- Normally protected by the ACCESS_NETWORK_STATE permission
- The exploit used the IOCTL in the native Unity library
- 42 applications were exploiting this, but 12, 408 apps had the capability to

Unity Logo [5]

Router MAC Address

- ARP table
  - /proc/net/arp was not protected properly, and anyone could read the cache file
  - OpenX is once such company, and utilised the exploit through a function called ‘getDeviceMacAddressFromArp’
    - Would first ask for the correct permission
    - If denied, it would acquire the router MAC through the aforementioned exploit
- UPnP protocol
  - Requested the igd.xml (The internet gateway device configuration) file
  - Three Peel’s smart-remote control apps utilised this

“The fact that the router is providing this information to devices hosted in the home network is not a flaw with Android per se. Rather it is a consequence of considering every app on every phone connected to a WiFi network to be on the trusted side of the firewall.”

Geolocation

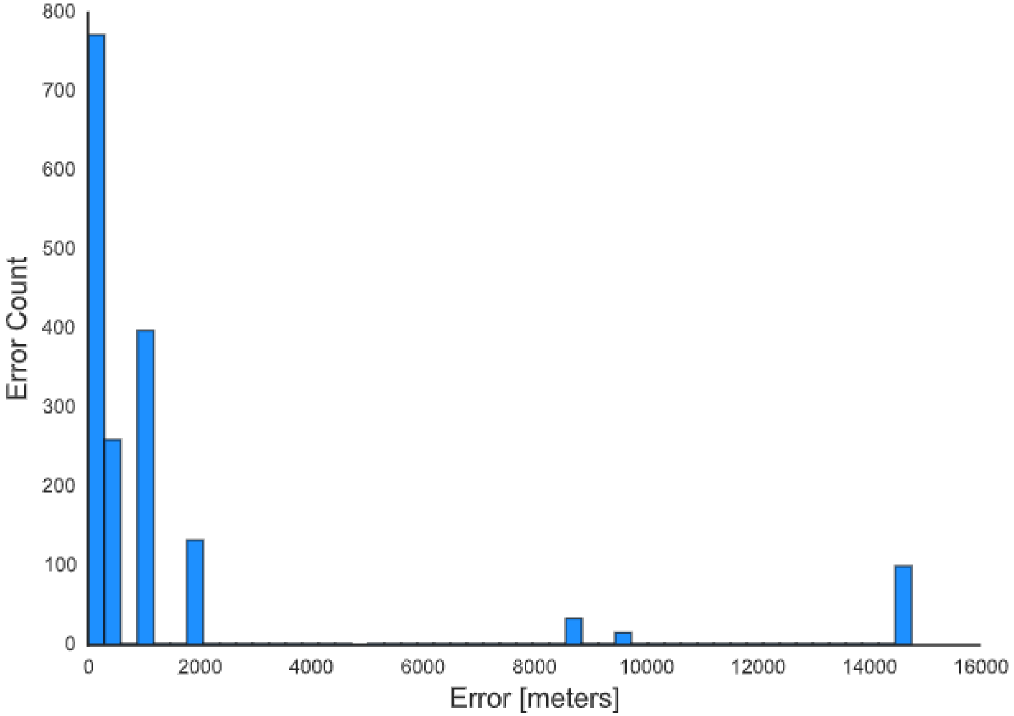
- 70 applications that would send its location to 45 different domains
  - Hypothesised that this was by ad mediation services that would provide the
  - E.g., IP geolocation
- Shutterfly
  - Would send images including the EXIF metadata to its own server
  - Metadata included the latitude and longitude of where the photo was taken
  - Any application with photo library read permissions would be able to read this metadata

Geolocation [6]

Related Work

Related works:

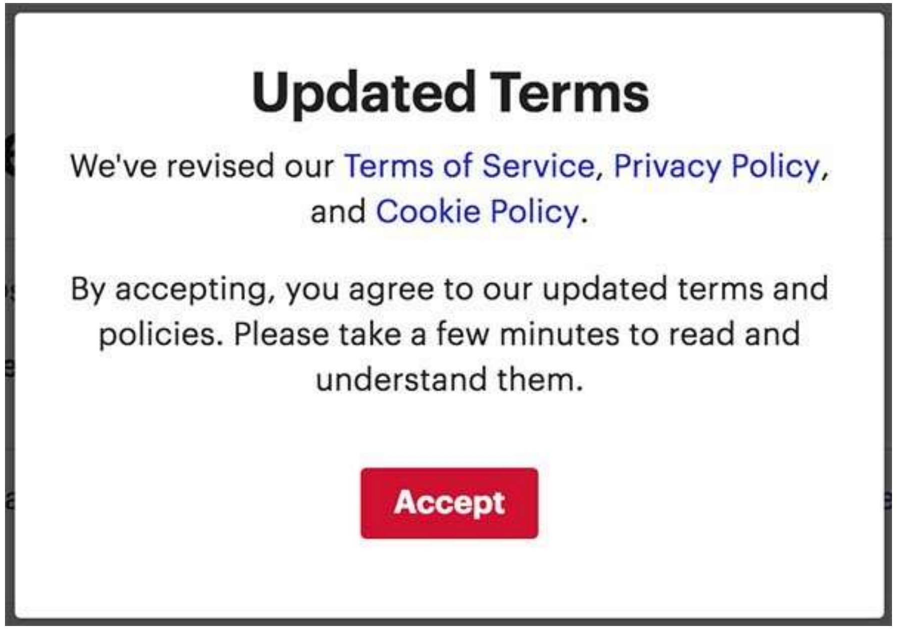
- Vibrations could be used as a covert channel between devices
- Data could be shared through UNIX sockets and external storage - demonstrated in the 50 Ways to Leak Your Data paper
- Users can be located by monitoring the power consumption of their phones
- Devices could be fingerprinted using the factory calibration of their sensors



Error showing that 90% of errors are within 1km - tracking users based on their phone's power consumption. [7]

Privacy Expectations

- The notice and consent framework governs a lot of countries' laws on privacy such as:
  - U.S law
  - The EU's General Data Protection Regulation
  - Australia's Privacy Act
- French privacy commission, CNIL, fined Google 50 million Euros for breaching the General Data Protection Regulation
- Australia's Privacy Act - companies must "manage personal information in an open and transparent way".



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We've revised our Terms of Service, Privacy Policy, and Cookie Policy.

By accepting, you agree to our updated terms and policies. Please take a few minutes to read and understand them.

Example Privacy Policy dialog box [8]

Limitations, Future Work, Recommendations

- Paper only shows the lower bound for privacy violations due to issues with:
  - Obfuscated data transmissions
  - Certificate pinning by apps
  - Android Exerciser Monkey only similar to a human 60% of the time
  - Android Exerciser Monkey could not proceed if apps required login or specific input like a CAPTCHA
- Even at the time of the paper, Google had been working on fixing some of the issues raised
- In the 3 years since, Google has likely fixed even more issues

Mobile App Testing [9]

References

[1]J. Reardon, A. Elazari Bar On, Á. Feal, N. Vallina-Rodriguez, P. Wijesekera and S. Egelman, "50 Ways to Leak Your Data: An Exploration of Apps’ Circumvention of the Android Permissions System", *USENIX*, 2019. Available: https://www.usenix.org/system/files/sec19-reardon.pdf. [Accessed 21 May 2022].

[2]R. Bellairs, *Static Analysis*. 2020.

[3]USENIX, *USENIX Security '19 - 50 Ways to Leak Your Data: An Exploration of Apps'*. 2019.

[4]Wondershare, *track-phone-using-imei-1*. 2020.

[5]1000Logos, *Unity Logo*. 2022.

[6]Ulistic, *geolocation*. 2022.

[7]Y. Michalevsky, G. Nakibly, A. Schulman, G. Arumugam Veerapandian and D. Boneh, "PowerSpy: Location Tracking using Mobile Device Power Analysis", *USENIX*, p. 9, 2015. Available: https://arxiv.org/abs/1502.03182. [Accessed 21 May 2022].

[8]Privacy Policy Generator, *Creating Agreement Checkboxes*. 2020.

[9]Freestocks, *Mobile app testing*. 2021.

[10]"Dynamic Linking vs. Dynamic Loading", *Baeldung*, 2021. [Online]. Available: https://www.baeldung.com/cs/dynamic-linking-vs-dynamic-loading#:~:text=Dynamic%20loading%20is%20the%20technique,used%20to%20implement%20software%20plugins. [Accessed: 21- May- 2022].

[11]"French Highest Administrative Court Upholds 50 Million Euro Fine against Google for Alleged GDPR Violations", *Privacy & Information Security Law Blog*, 2020. [Online]. Available: https://www.huntonprivacyblog.com/2020/06/23/french-highest-administrative-court-upholds-50-million-euro-fine-against-google-for-alleged-gdpr-violations/. [Accessed: 21- May- 2022].

[12]"Part 5: Notice and consent", *Home*, 2021. [Online]. Available: https://www.oaic.gov.au/privacy/the-privacy-act/review-of-the-privacy-act/privacy-act-review-issues-paper-submission/part-5. [Accessed: 21- May- 2022].