Busting Rogue Base Stations using CellGuard and the Apple Cell Location Database

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Open6GHub

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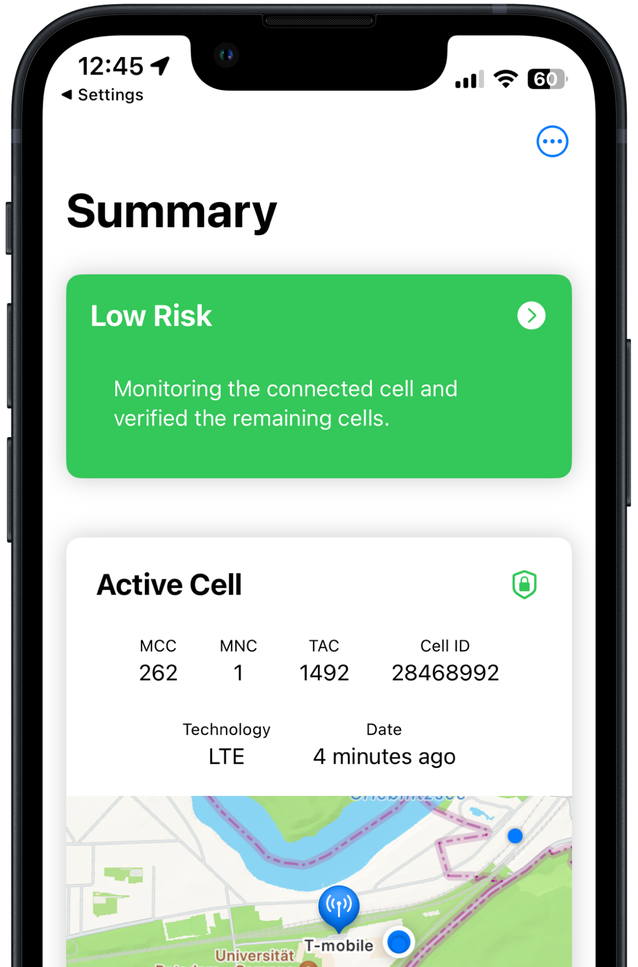


RAID 2024

Cellular Security

Attacker Goals

Personal Information &
Location Tracking

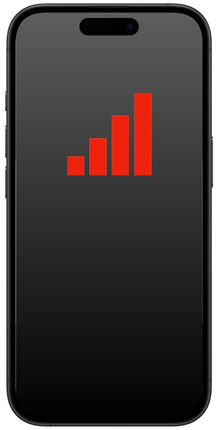
Traffic Interception &
Manipulation

Baseband Vulnerability
Exploitation

Attacker Model

Adversaries can **block**, **intercept**, and **modify** over-the-air signals

Rouge Base Station



Genuine Base Station

Cellular Security

Attack Vectors

2G

Downgrade attacks

Missing mutual authentication

3G & 4G

Missing integrity protection

Identity information leakage

5G

Improves security

Targeted information leakge

General

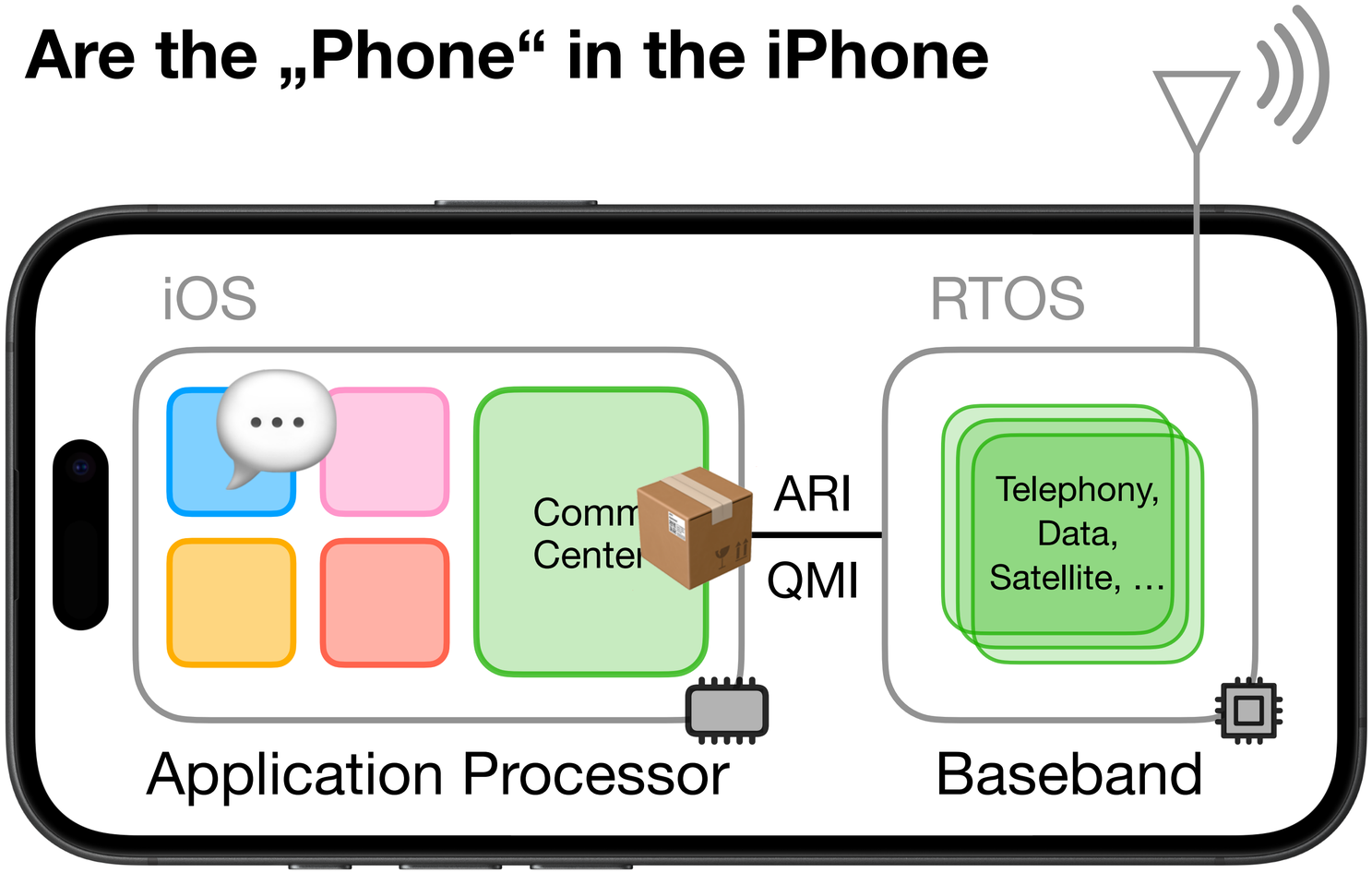
Roaming abuse

Baseband exploits

Protect yourself by disabling 2G

iPhone Basebands

Are the „Phone“ in the iPhone



Manufacturers

intel
Protocol
Apple Remote Invocation

Qualcomm
Protocol
Qualcomm MSM Interface

5
6
7
8
X
XR
XS
11
12
13
14
15
16

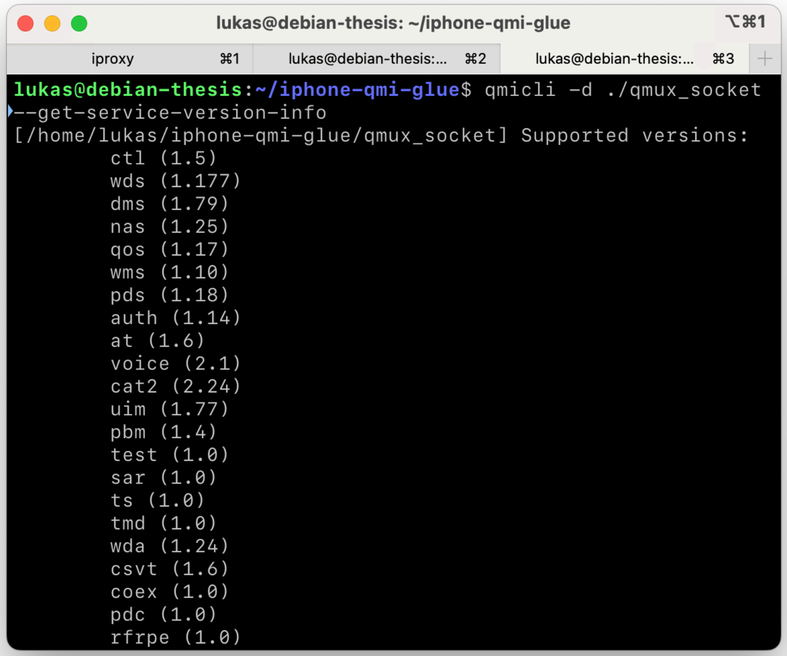
Basebands provide a **packet-based interface** for the OS

BaseTrace

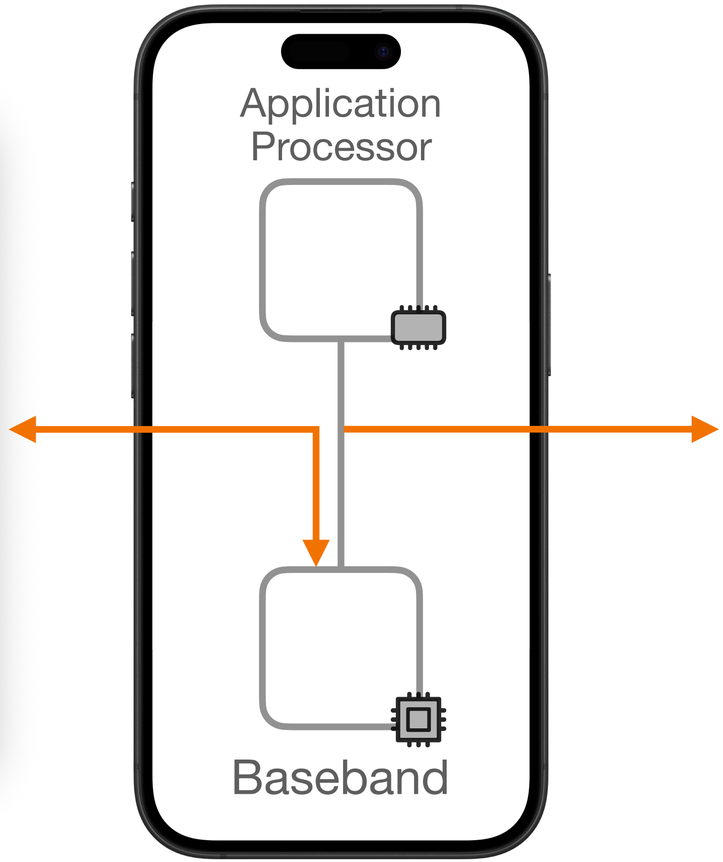
iPhone Baseband Security Analysis Framework

libqmi

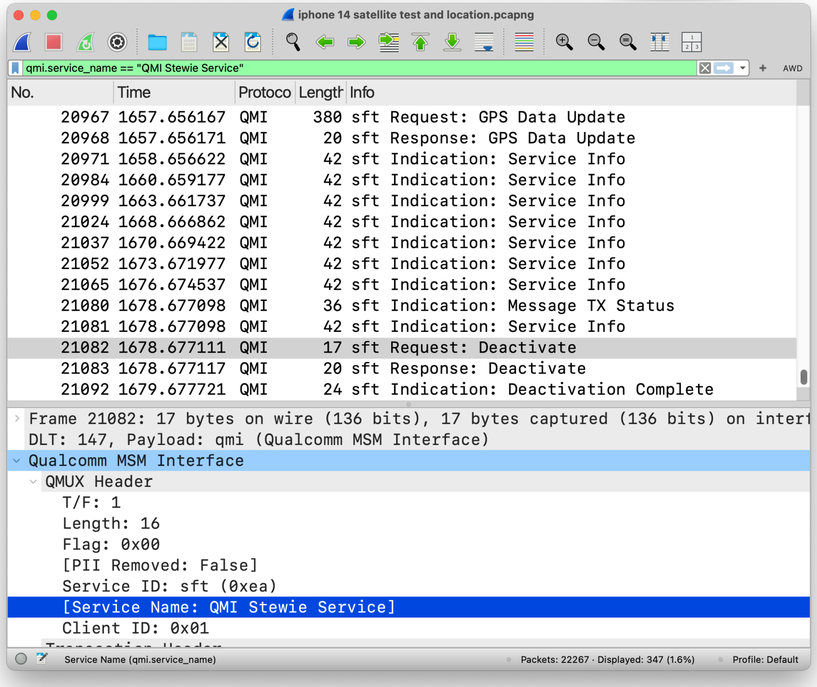
Packet Injection



Requires Jailbroken iPhone



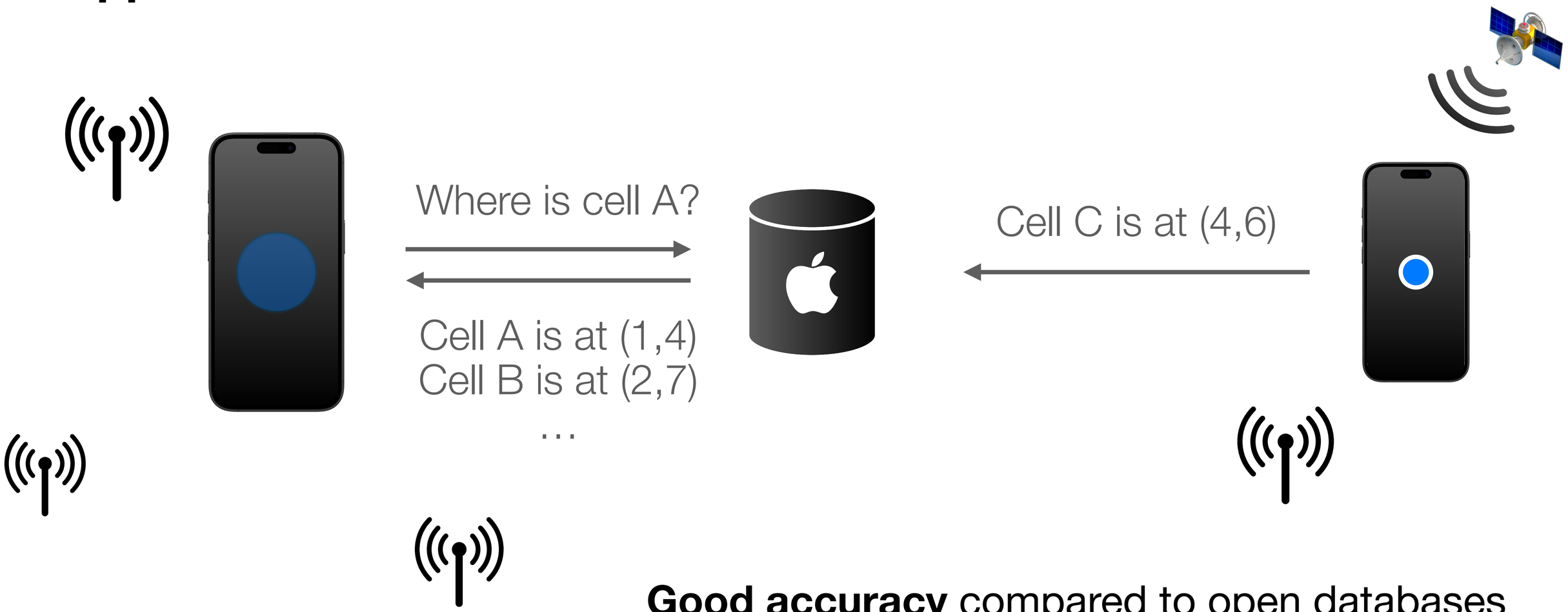
Packet Dissection



Works with all iPhones

Apple Location Services

Is Apple's Closed-Source Location Database

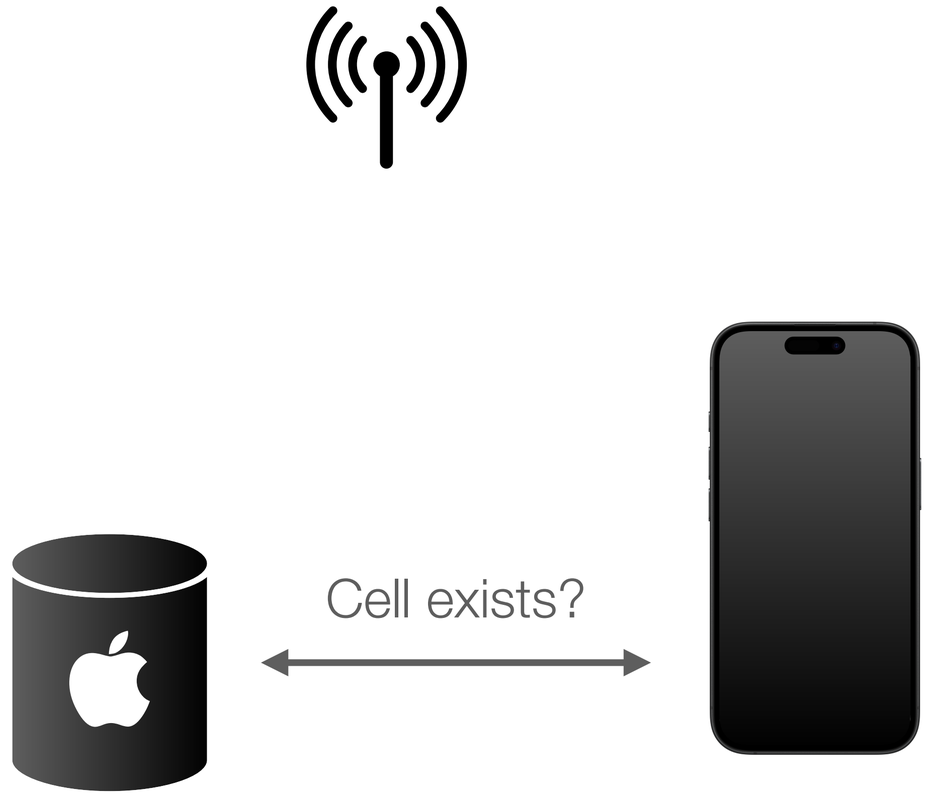


Good accuracy compared to open databases
OpenCelliD and Mozilla Location Services

Rouge Base Station Detection

With Apple Location Services (ALS)

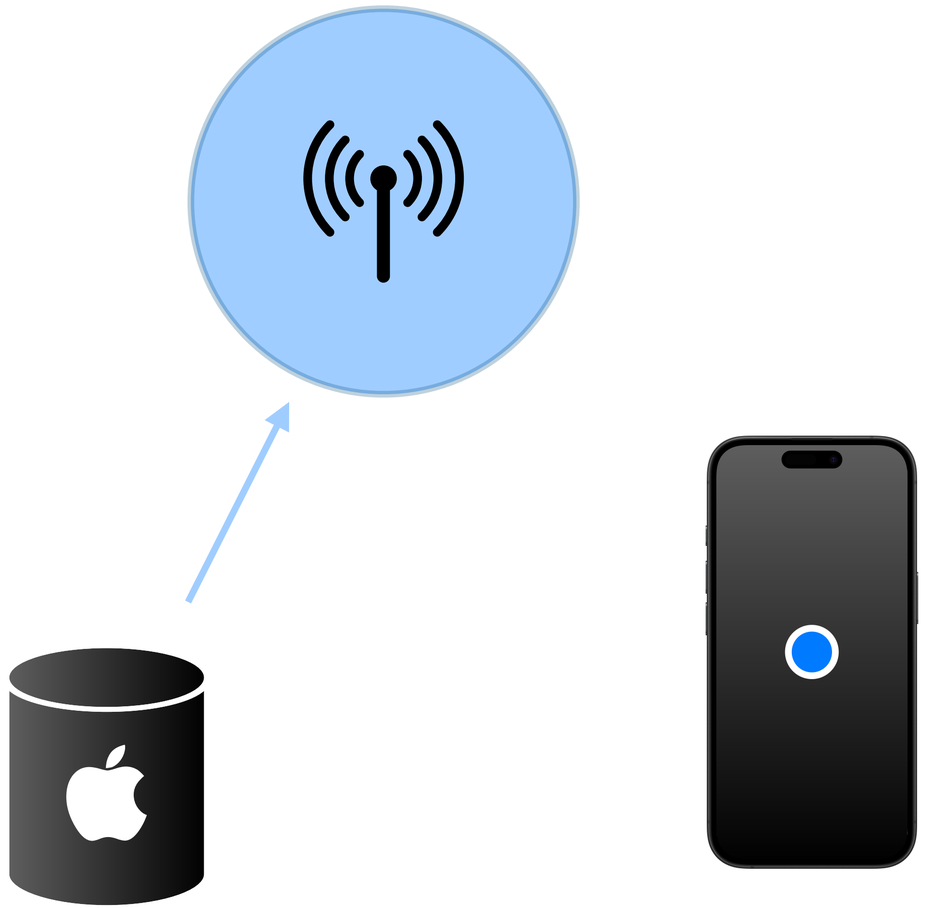
1. Confirm existence of cell with ALS (20P)



Rouge Base Station Detection

With Apple Location Services (ALS)

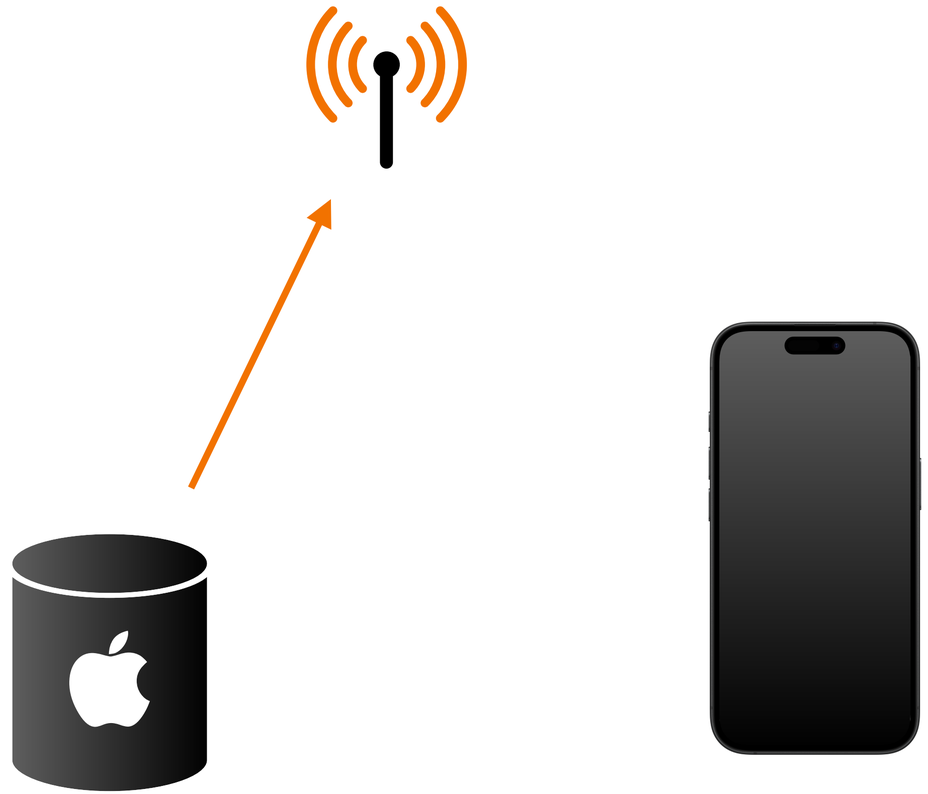
1. Confirm existence of cell with ALS (20P)
2. Calculate distance between recorded and ALS location (20P)



Rouge Base Station Detection

With Apple Location Services (ALS)

1. Confirm existence of cell with ALS (20P)
2. Calculate distance between recorded and ALS location (20P)
3. Check if frequency and physical cell identity match ALS (8P)



Rouge Base Station Detection

With Apple Location Services (ALS)

1. Confirm existence of cell with ALS (20P)
2. Calculate distance between recorded and ALS location (20P)
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4. Low Bandwidth (2P)

Rouge Base Station Detection

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5. High Signal Strength (30P)

Rouge Base Station Detection

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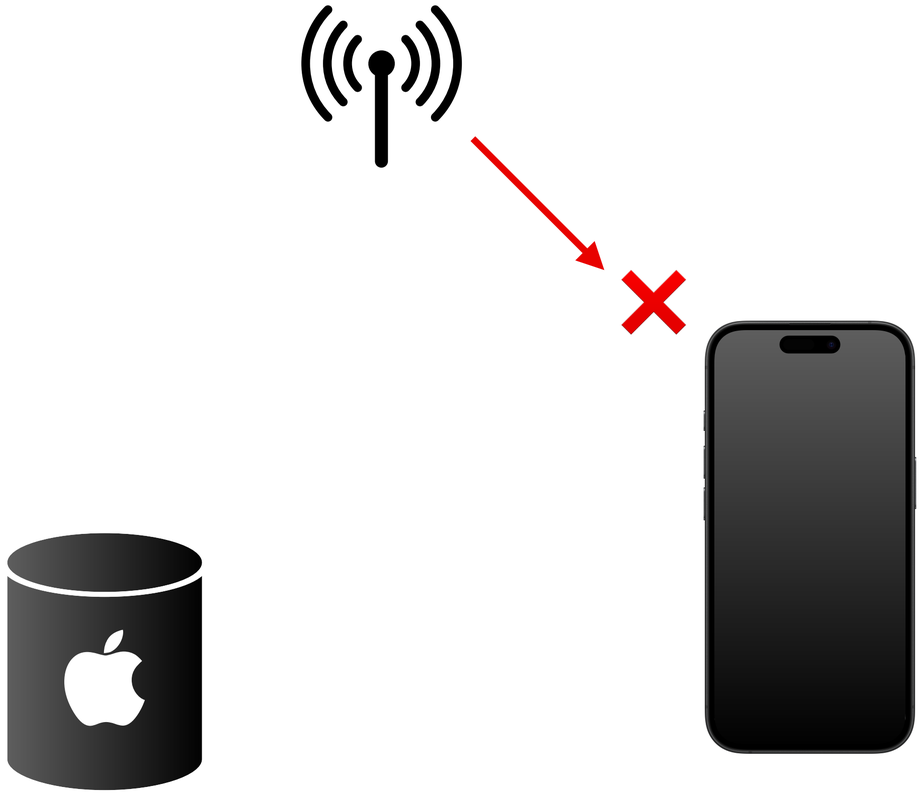
4. Low Bandwidth (2P)
5. High Signal Strength (30P)
6. Unexpected Network Reject (30P)



Rouge Base Station Detection

With Apple Location Services (ALS)

1. Confirm existence of cell with ALS (20P)
2. Calculate distance between recorded and ALS location (20P)
3. Check if frequency and physical cell identity match ALS (8P)
4. Low Bandwidth (2P)
5. High Signal Strength (30P)
6. Unexpected Network Reject (30P)

Verdict

Trusted (100P - 95P)

Anomalous (50P - 94P)

Suspicious (45P - 0P)

CellGuard

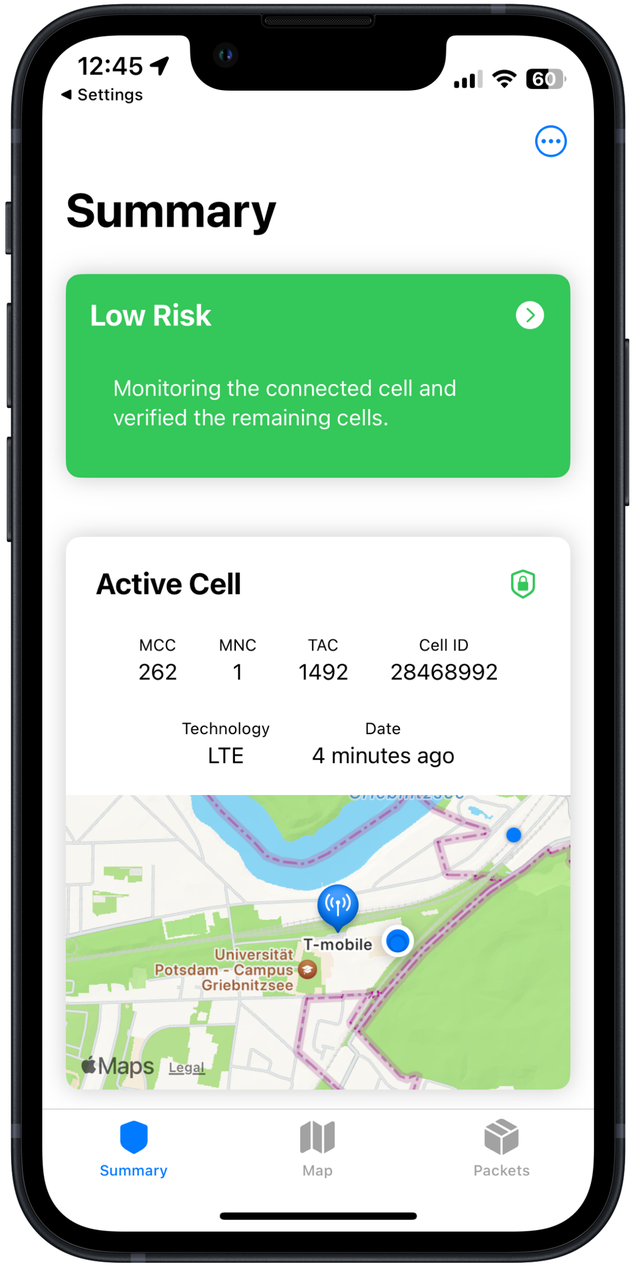
iOS App for RBS Detection

Supports iOS 14 - 18

Standard iPhone

Install debug profile and import diagsnotics snapshot

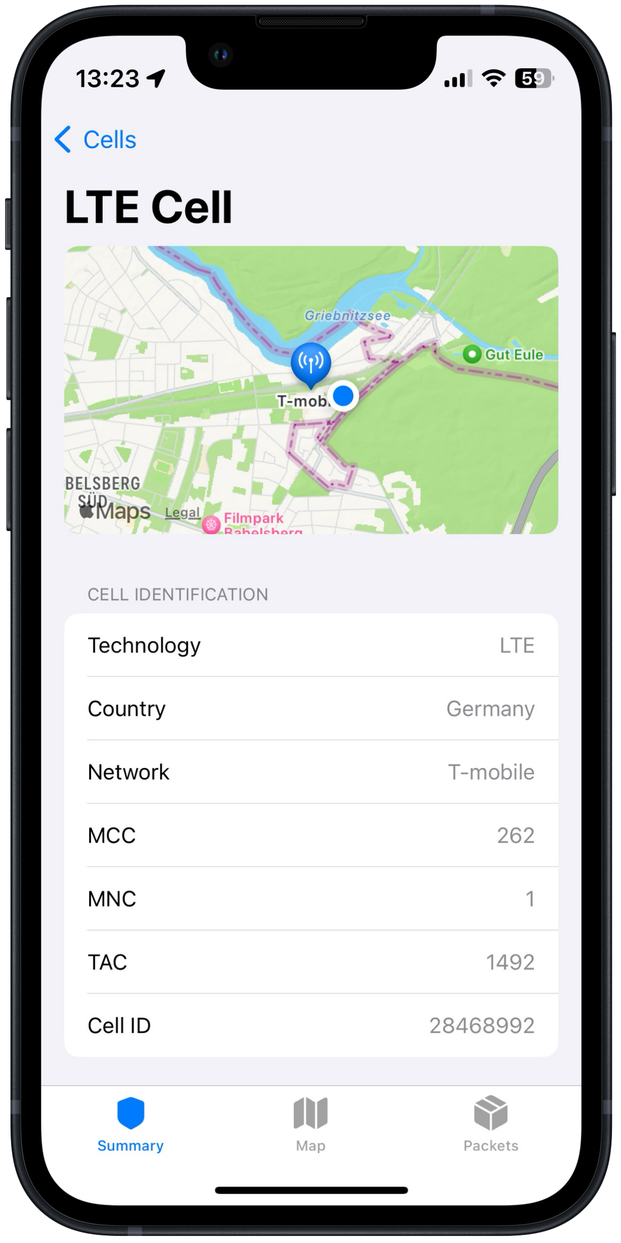
Use on primary device with Lockdown mode



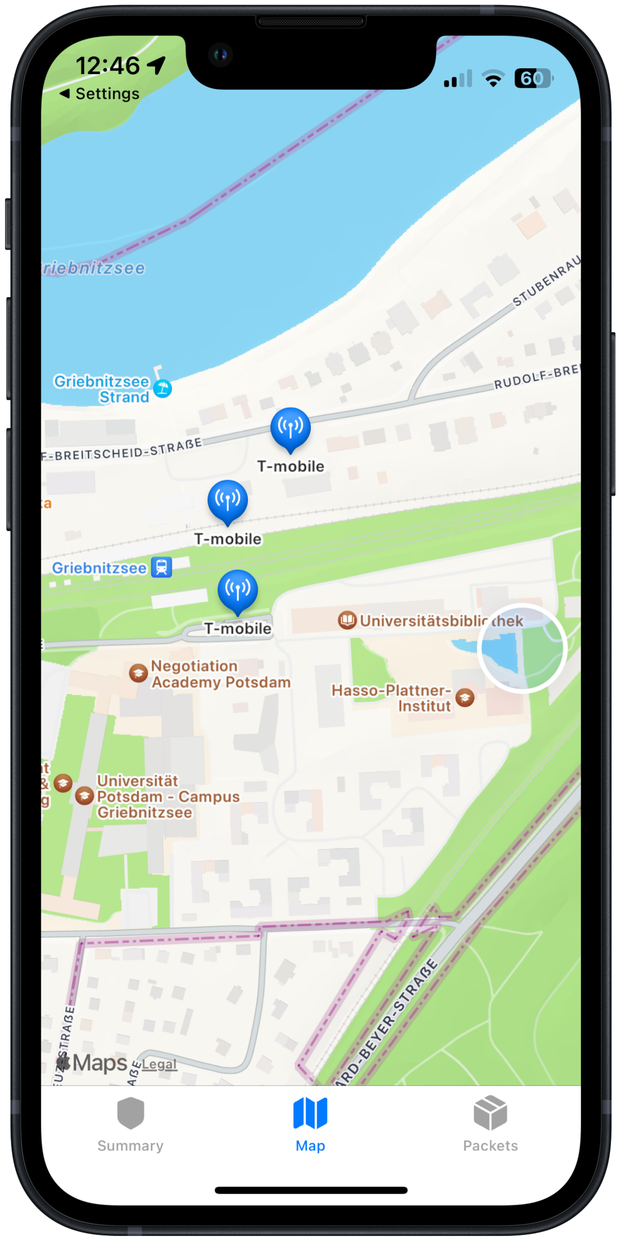
Jailbroken iPhone

Install components for con-tinous background verification

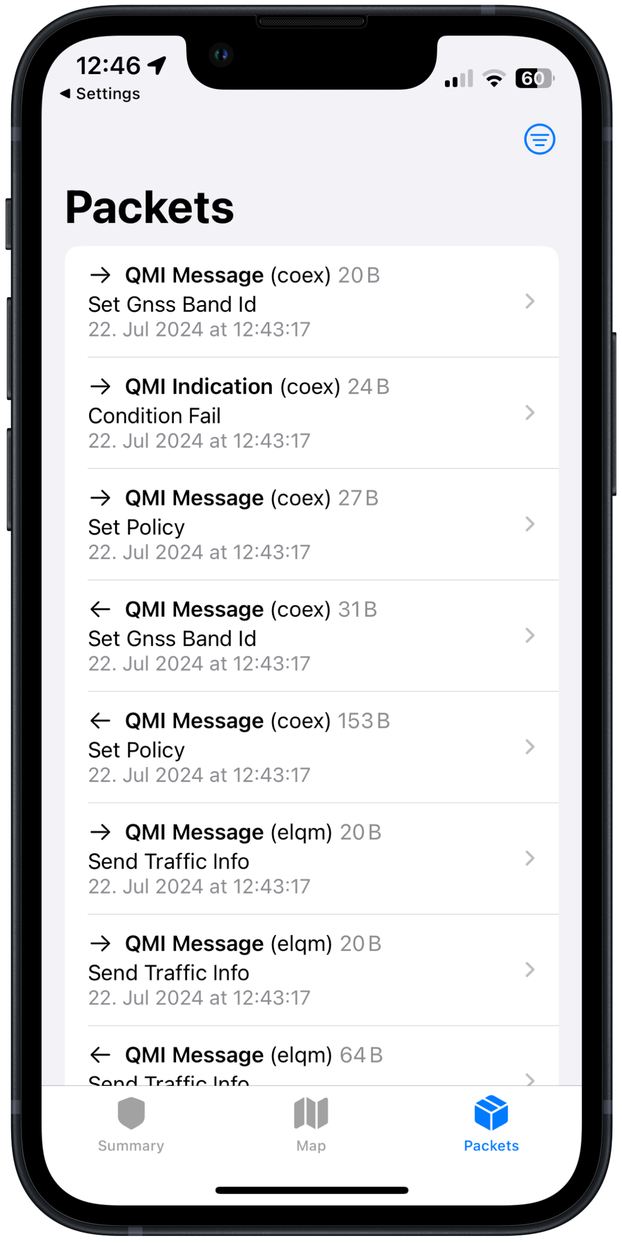
Use on secondary device functioning as sensor



Dive into Details



Explore Nearby Cells



Dissect Packets

Evaluation of CellGuard

In our lab and in the wild

Datasets from across Europe collected over multiple months

1.6% anomalous
0.0% suspicious

Excellent coverage of Apple Location Services

Detection of anomalous activity but confirmation difficult

Lab setup with evil twin rogue base stations

CellGuard is Public

Join the beta and contribute to our large-scale study

Continuous development of CellGuard & tooling

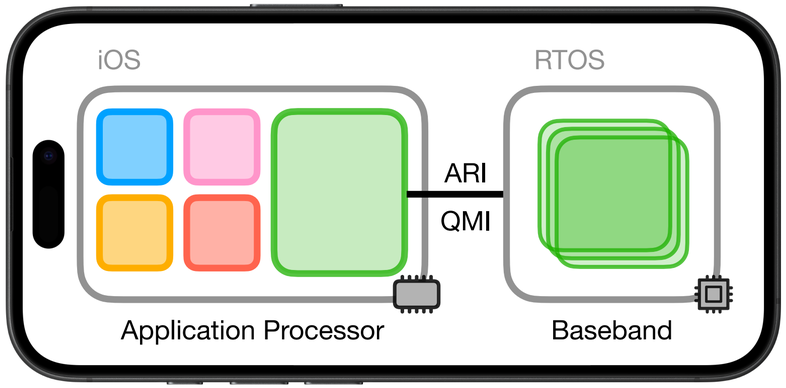
Download CellGuard at cellguard.seemoo.de

Open-source release next week

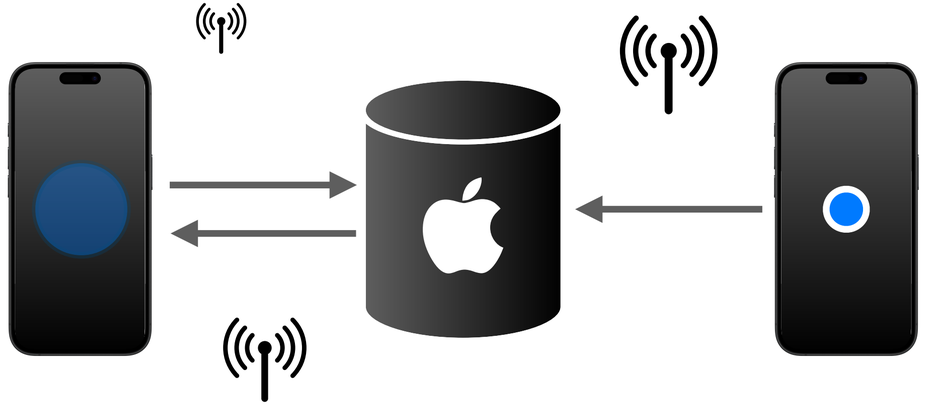
Conclusion

Busting Rogue Base Stations using CellGuard and ALS

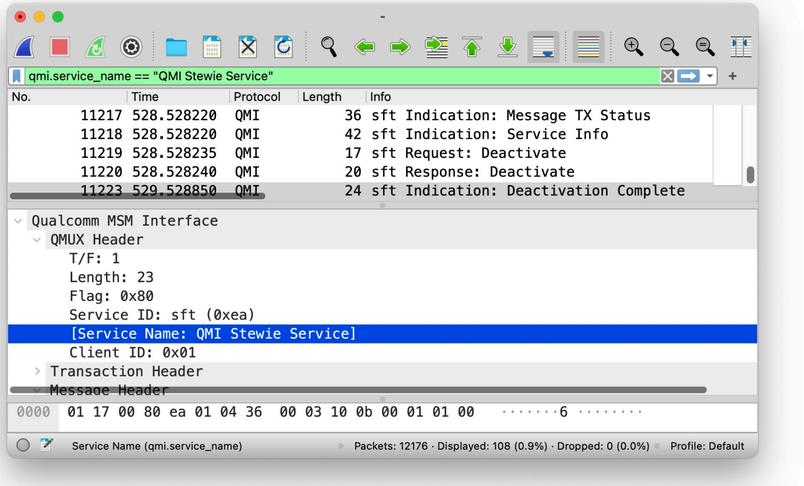
Reversing of iOS baseband architecture



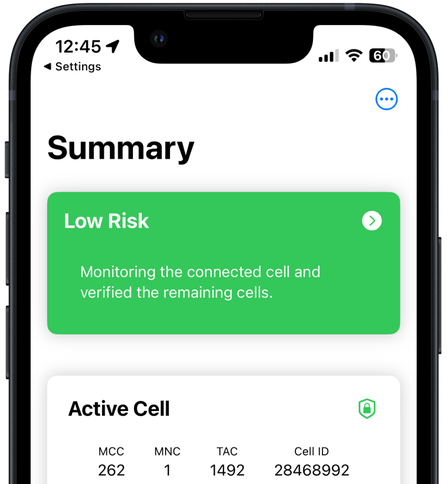
Evaluation of Apple Location Services



BaseTrace: Framework for baseband anaylsis



CellGuard with RBS detection algorithm



Q&A

Read our Paper

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