Android Security Workshop

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(NowSecure)

Connecting next generation talent with the heavy duty industry to keep vehicles secure

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Outline

Main ideas

- ## Introduction Android

  Android OS internals
  Automotive Android OS

- ## Android Reverse Engineering

  Static & Dynamic analysis
  Tools used for RE-ing Android apps

- ## CyberTruck Challenge CrackMe Walkthrough

  Vulnerable keyless Android app to wirelessly unlock vehicles with your mobile
  “Mobile Keyless Remote System”

- ## Takeaways

  Things learned after this workshop

$ whoami

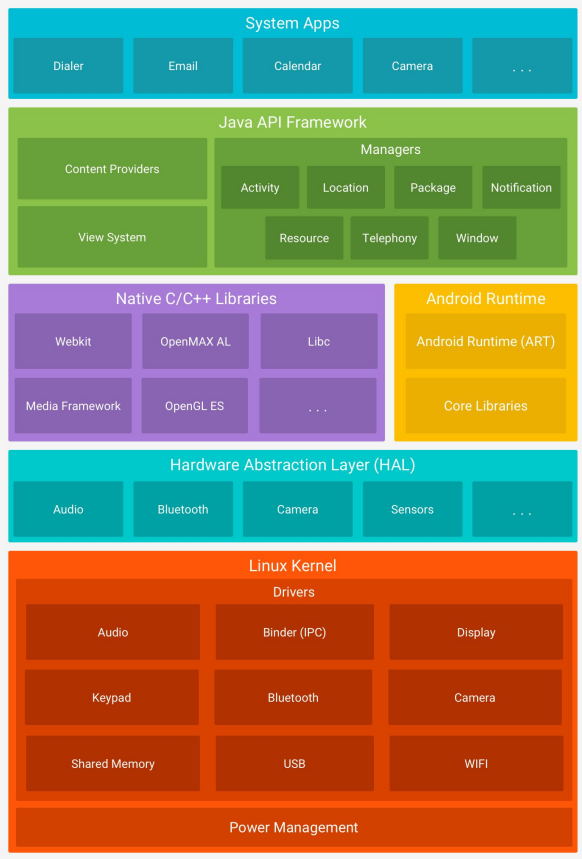
"I stay with problems longer"

- Mobile Security Research Engineer @ **NowSecure**
  - Focused on **Android** Reverse Engineering
- **Previously (**Reverse Engineering**)**
  - Android **mobile** security: cloud-based payments (HCE wallets), DRM and TEE solutions
  - **Embedded** security : smartcards, smartmeter, PayTV, HCE, routers, any hardened IoT dev
  - Crypto: side-channel & fault injection attacks (hw). Whitebox cryptography (sw)
- Personal @ enovella.github.io
  - Based in Europe
  - Chess player, swimmer and nature lover

Android OS

Architecture

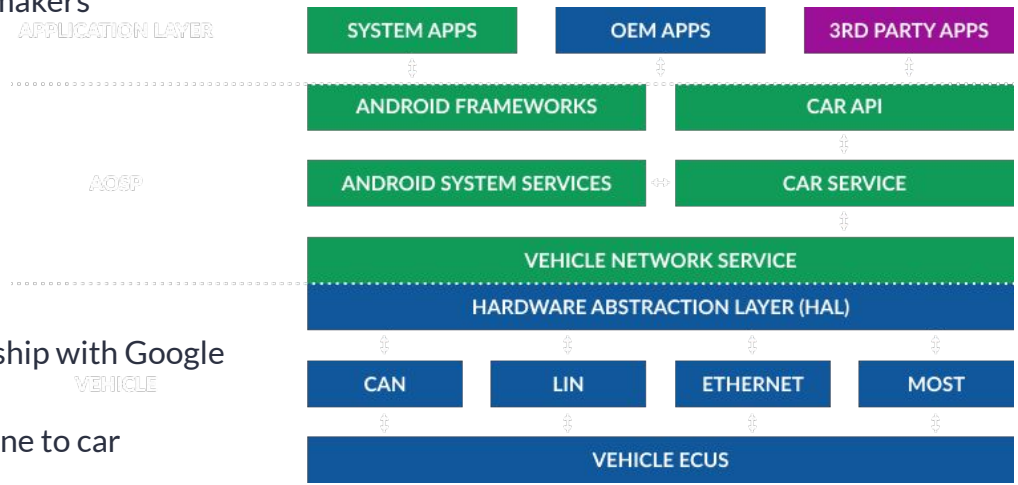
- Android OS developed by Google
  - Based on Linux (Open Source) with kernel- and user-space
  - Hardware manufacturers, app developers, AOSP contributors
  - Components:
    - Android Runtime (Dalvik VM vs ART)
    - Native core libraries (c/c++/rust), Linux Kernel, Java API
    - System apps, HAL, third-party applications
- Application Sandbox - least privilege
  - Each app operates in its own isolated environment (sandbox)
  - Unix-style permission model
  - Data directory */data/data/package-name-app/*
  - App data sharing via IPC (content providers)
  - UID - User Identity. Greater than 10000 for normal apps



Automotive Android OS (AAOS)

Architecture

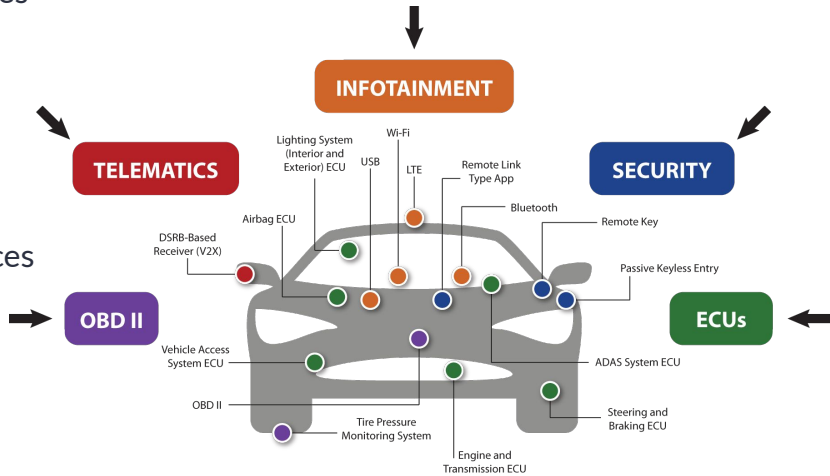
- Android Automotive OS (AAOS) - “Android for Cars”
  - Infotainment system built into cars by carmakers
  - Interface designed for car screens
  - Components
    - In-vehicle Infotainment (IVI)
    - Google Automotive Services (GAS)
    - Vehicle Map Service (VMS)
    - Exterior View System (EVS)
    - Heating, ventilation & AC (HVAC)
  - OEM receives access to GAS via a partnership with Google
- Android Auto
  - A framework to connect your Android phone to car



Android Threat Modelling

Attack Surface

- Physical access
  - USB port (ADB). Developer Options enabled
  - Hardware ports (UART, JTAG,...) for debugging purposes
  - Pull out proprietary apps from automotive vendors
  - Jailbreak from kiosk
  - ...
- Vendor's Applications
  - Identify critical assets within the app
    - IP, crypto, databases, Android shared preferences
    - Proprietary protocols and crypto
  - Network protocols (MITM), tracking, GPS spoofing
  - App security can be tampered with
  - Firmware updates for automotive components
  - ...
- Non-physical access
  - Wireless (WiFi, Bluetooth, NFC, LTE, Baseband)
  - Vulnerabilities on old Android OS
  - Web server accessible via browser
  - ...



Android Reverse Engineering

Tools

- Java/Kotlin → Dalvik Bytecode
  - **JADX**
  - Bytecode Viewer
  - JEB
  - **Apktool**
  - Baksmali/smali
- Native
  - IDA Pro
  - **Radare2**
  - **Ghidra**
  - Binary Ninja
  - Hopper
- Dynamic Binary Instrumentation
  - **Frida**
  - Xposed
- Source code
  - Android Studio + AVD emulators

Android Reverse Engineering

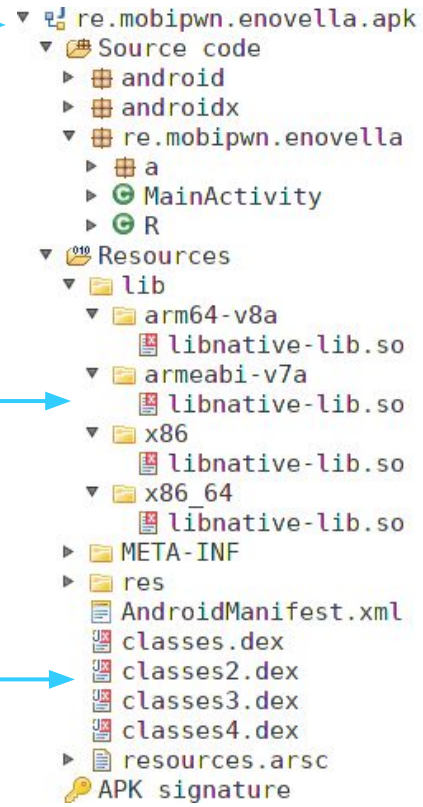
Most powerful OSS tools

- JADX
  - DEX decompiler
- Ghidra
  - Native decompiler
- Radare2
  - Unix-like reverse engineering framework
- Frida
  - Dynamic Binary Instrumentation
- R2frida
  - The ultimate static analysis on dynamic steroids

APK

Android Application Packaging (APK)

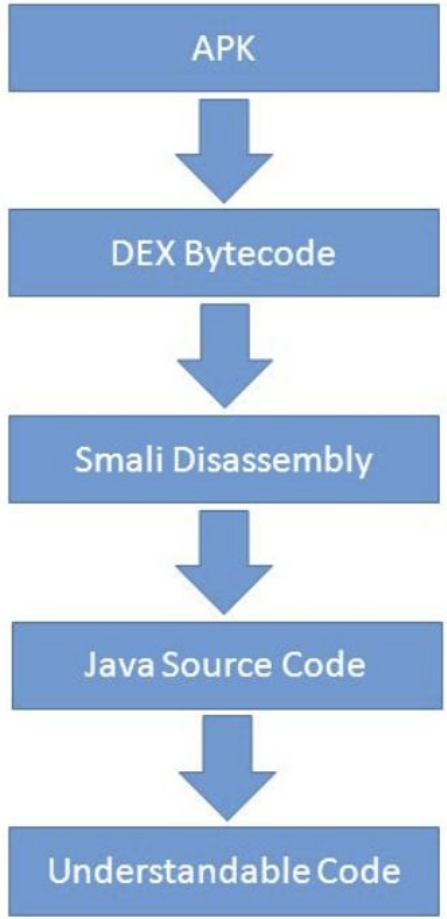
- **APK**
  - APK == ZIP
  - Manifest XML
  - Assets folder
  - Resources folder
- **Reverse Engineering**
  - APK
  - Native **code**
  - DEX byte**code**



Android RE

Static Analysis

- Static Analysis
  - Understand app logic
  - Find security bugs
  - Reveal critical assets
  - Locate places to perform dynamic analysis
- Steps
  - Decompile binary code → Pseudo code (readable)
  - Navigate codebase & search for
    - strings, crypto keys, passwords, network traffic, ..
    - obfuscation
      - Rename variables, functions (if stripped)
  - Tamper with the app integrity
    - Include your modifications
      - enable logging
      - disable checks
      - GPS locations



Android Reverse Engineering

Dynamic Analysis

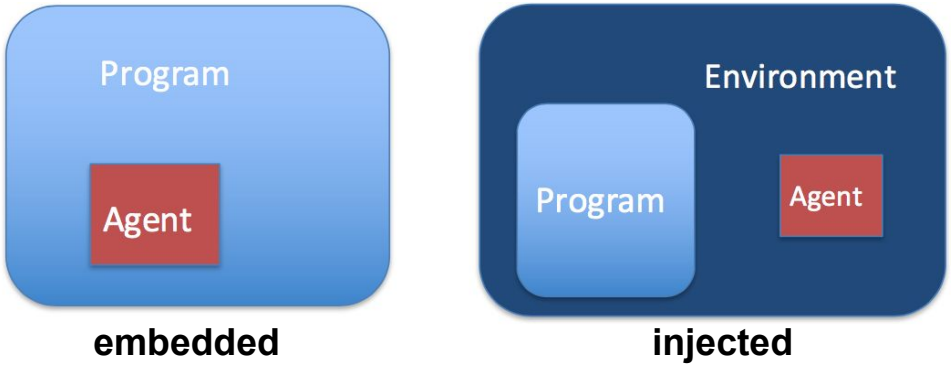
- Dynamic Binary Instrumentation (DBI)

"A method of analyzing the behavior of a binary application at runtime through the injection of instrumentation code"

  - Access process memory (stack,heap,code,...)
  - Hook, trace, intercept functions
  - Change return values, variables, globals, function args,...
  - Overwrite function implementations while app is running
  - Call arbitrary functions from imported classes
  - Find object instances on the heap
  - Bypass client-side security checks

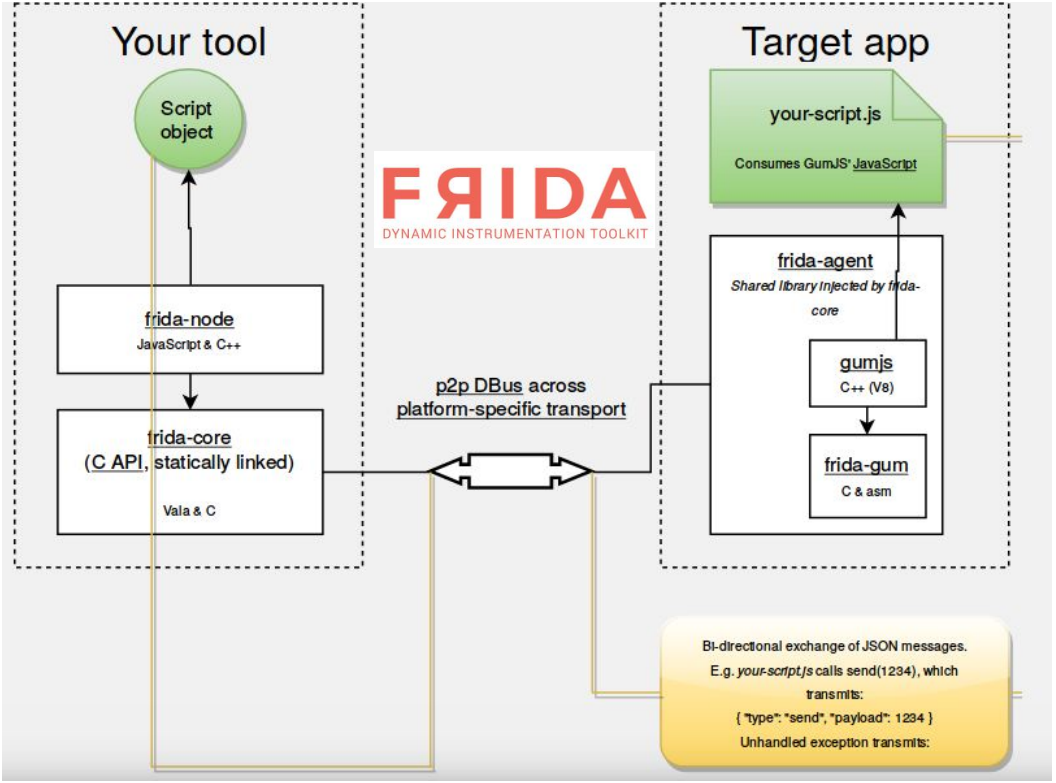
FRIDA

DYNAMIC INSTRUMENTATION TOOLKIT



Android Reverse Engineering

Process Injection via Frida



Android CyberTruck Crackme

Can you unlock this uncrackable car keyless system?

https://github.com/nowsecure/cybertruckchallenge19

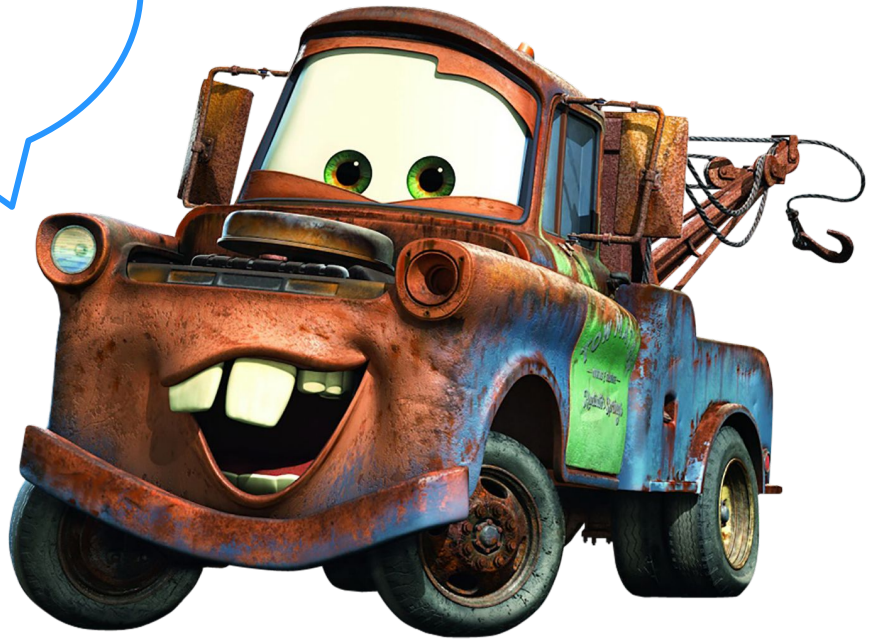
Android CyberTruck Challenge Crackme

"Unlock your truck with your Android"

- **Mobile CrackMe simulating an app capable of unlocking vehicles via bluetooth**
  - Material: https://github.com/nowsecure/cybertruckchallenge19
  - Android CTF-like challenge (3 static + 3 dynamic flags = **6 flags** in total)
  - Run it in Android emulator
  - 1h workshop + extra time
  - Enable the TamperProof switch if you're brave :-)
- **Rules**
  - Don't share flags with other mates
  - Up to you how to solve the challenges

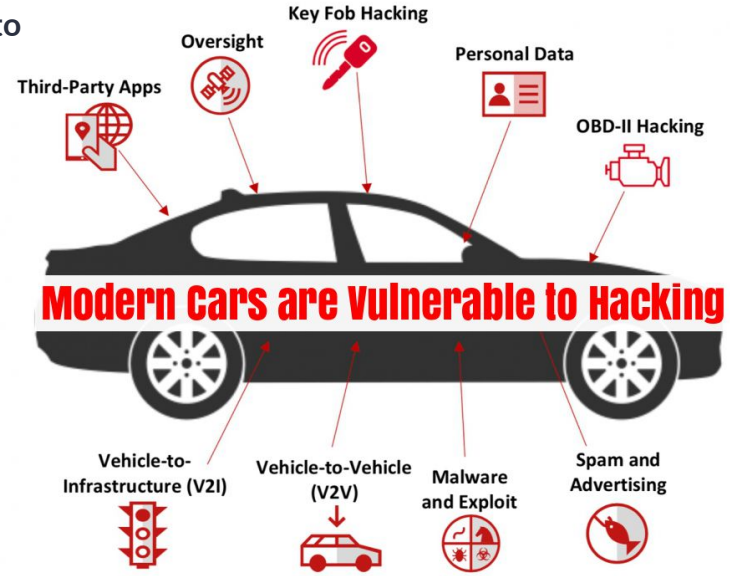
Mobile CTF

Let’s play!



Takeaways

- Secure vehicles can be hard → Security by obscurity is not the solution
- Focus on the **design** and ensure **strong** key hierarchy → Client-side apps will be eventually compromised
- Follow security **guidelines** → OWASP MSTG
- **Minimum** privilege principle → Reduce the attack surface
- Do not **hardcode** secrets within your code → Use **encryption** at rest
- Use **hardware-backed** keystore to keep secrets instead of SW-based implementations
- Protect IP → **Code hardening** (obfuscation, anti-tampering, anti-rooting, anti-debugging, ...)
- Ensure proper **randomness** source → Use strong & secure **crypto**
- Implement multi-factor authentication (MFA)
- Enforce certificate pinning to slow down MITM attacks
- Bug **bounty** your application before you got hacked
- Employ hardened OS features → **TrustZone** (TEE)
- Google security → **SafetyNet**



Links

Where to search

- Radare2 && Frida (NowSecure)
- The Mobile Security Testing Guide (MSTG)
- Awesome Mobile CTFs
- Awesome Frida && Frida CodeShare
- MOBISEC lectures
- Android App Reverse Engineering 101
- RedNaga Security
- Gio's blog
- A bunch of mobile security blog posts on the Internet

THANK YOU!
Q&A

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Special thanks to

@RomainKraft @fs0c131y @Hexploitable

for providing feedback on the crackme