Handling Top Security Threats for Connected Embedded Devices

OpenIoT Summit, San Diego, 2016

Jeep Cherokee hacked in July 2015

- Presented at Black Hat USA 2015
  - Charlie Miller
  - Chris Valasek
- Remote exploit giving full control of the car
- Clearly demonstrates physical safety risk
- No way to fix remotely
- 1.4 million cars recalled

About me

- Eystein Stenberg
  - CS/Crypto master's
  - 7 years in systems, security management
  - eystein@mender.io

- Mender.io
  - Over-the-air updater project for Linux/Yocto
  - Under active development
  - Open Source

- Reach me after on email or exhibitor hall

Jeep Cherokee Head Unit with Wifi

Wifi hotspot offered as a service

"Head unit", "IVI"

- Cherokee customers can buy wifi subscription as an add-on (~$40/month)
- Connect devices in the car to the car's wifi to get online (phones, tablets, …)
- Wifi is password protected

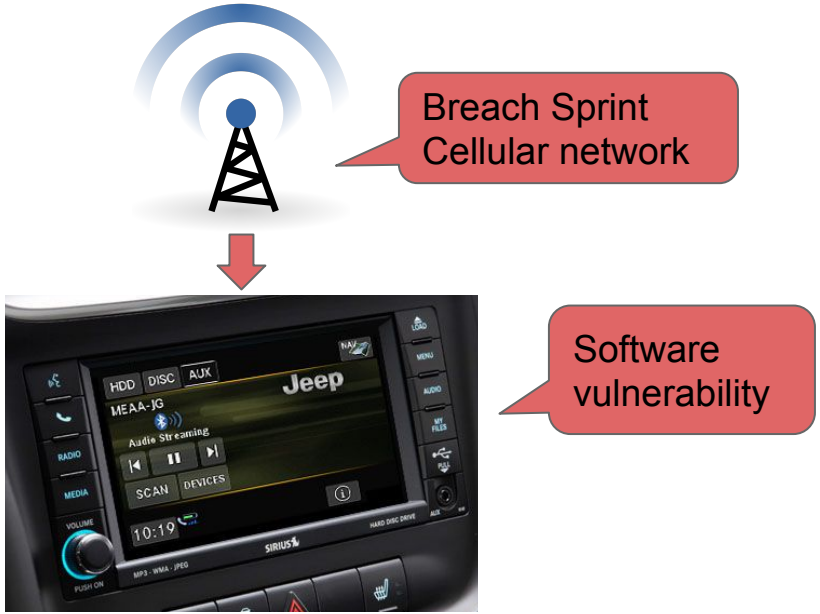
Wifi-based Breach: Short-range

Guessable password

Software vulnerability

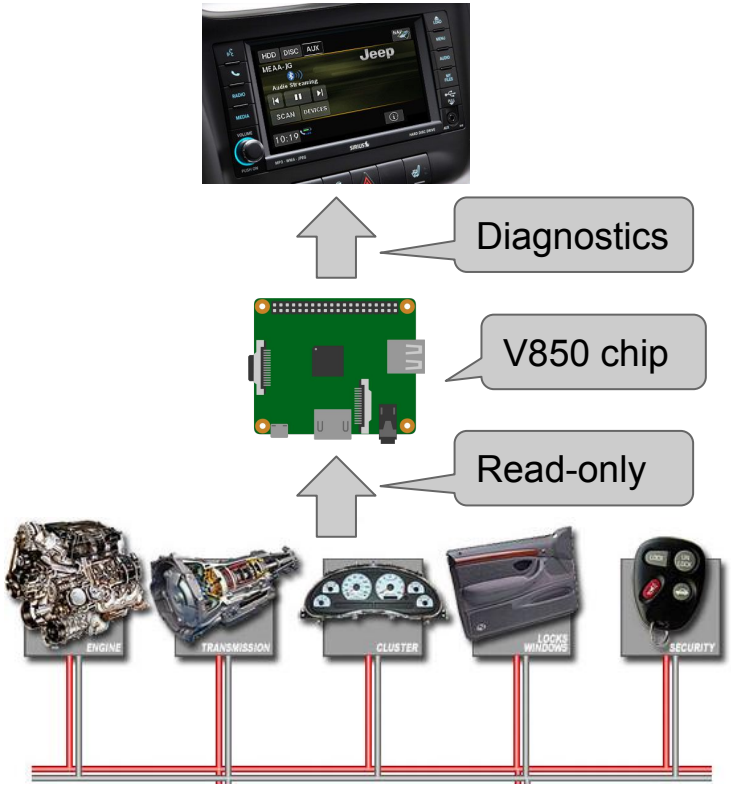
- Wifi **password** based on **system time after provisioning**
- January 01 2013 00:00 GMT +- 1 minute
- Multimedia system breached due to software vulnerability
- Scope: Control music player/radio/volume and track GPS coordinates when **within wifi range**

Cellular-based Breach: Country-wide



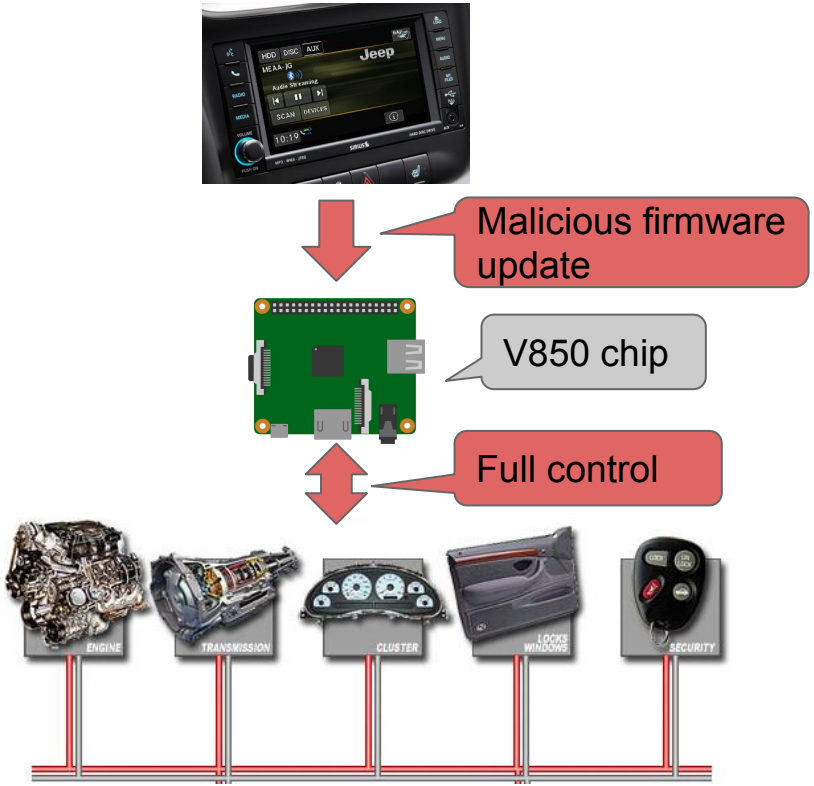
- Scope: Control music player/radio/volume and track GPS coordinates **countrywide**
- Can also select a specific Jeep based on its GPS-coordinates

The Controller Area Network (CAN) bus



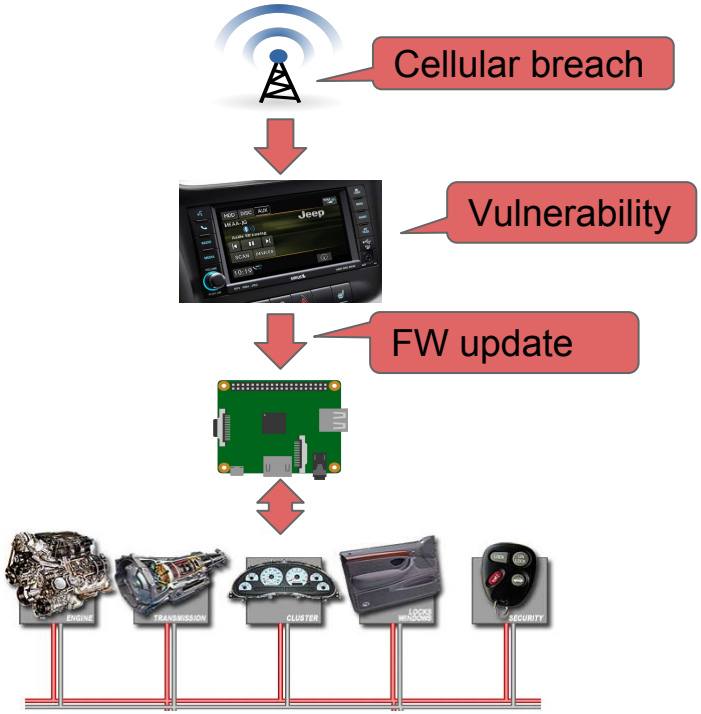
- The CAN bus connects ~70 electronic control units (ECUs), including *engine control*, *transmission*, *airbags*, *braking*
- V850 chip is designed to **only read** from the CAN bus, to isolate components

CAN bus



- The head unit can **update the firmware** of the V850
- Firmware **update authenticity not checked** properly

Putting it together



Lessons

- Wifi hotspot password was predictable
- Remotely accessible service (in head unit) was vulnerable (and not updated)
- Firmware update (for V850) did not have proper authenticity checks
- The only way to fix the vulnerabilities is through a manual update (by customer or dealership)

Security basics protects against most attacks

- Devices more software-defined & connected (IoT)
- Consider which types of attacks your products can be vulnerable to
- Reduce risk of your products being compromised

Session overview

- Our goals
- Anatomy of an attack
- Security strategies
- The patching problem
- Strategies for patching embedded devices

Attacker motivation

- Why would someone attack your product?
- Can someone *make money* from a compromise? How much?
- All crime starts with *a motive*

Your goal is to *lower attacker Return on Investment*

- It is always *possible* to compromise
- Lower Return on Investment (ROI) for attacker
  - **Decrease value** of successful attack
  - **Increase cost** of successful attack
- Focus on increasing cost of attack in this session

Decreasing value of attack can be effective too

Anatomy of an attack

Action	Desired outcome
1. Reconnaissance	➔ Discover vulnerabilities
2. Intrusion	➔ Initial access
3. Insert backdoor	➔ Ongoing access
4. Clean up	➔ Avoid detection

Remote-access services helping attacker with 1 & 2

1. Port scan to discover
   - Which services are running
   - Versions

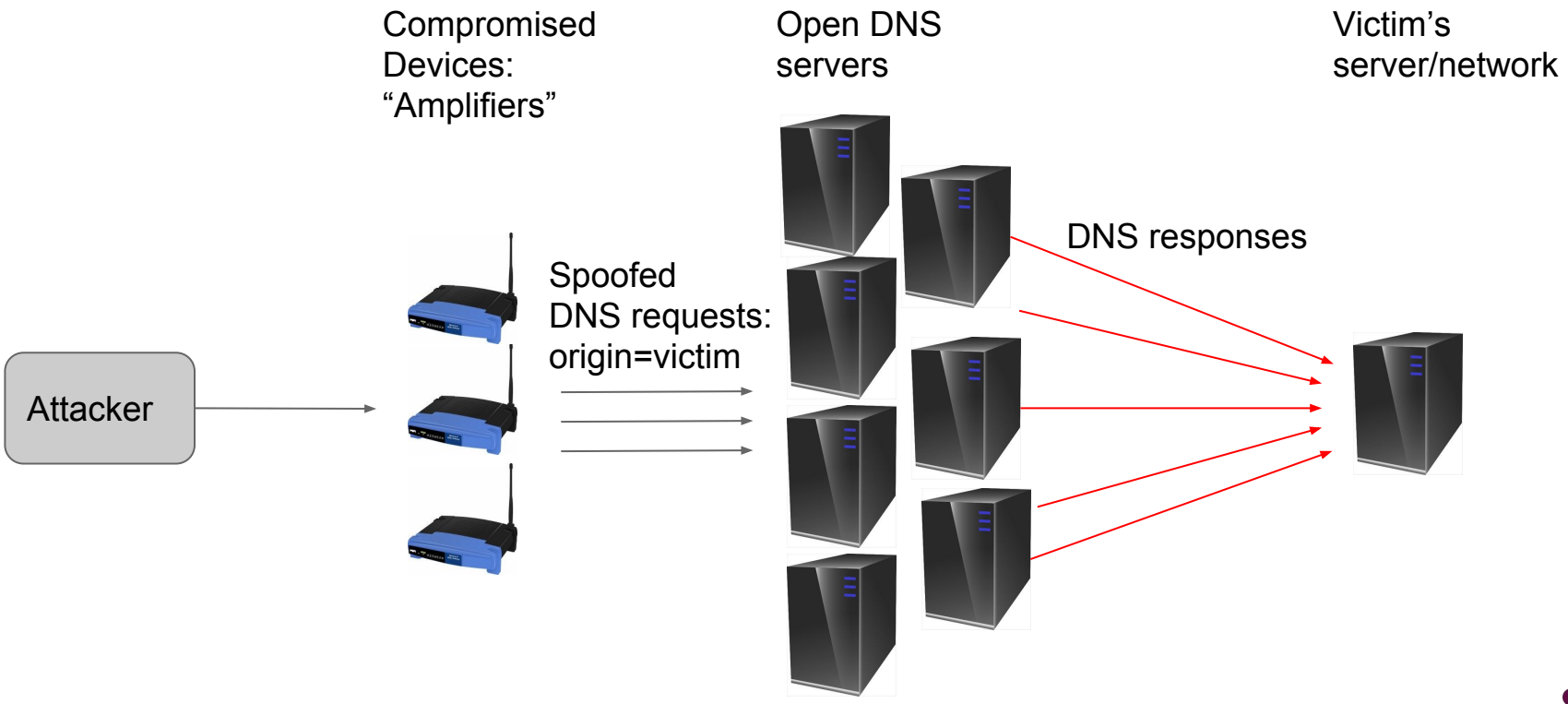
2. Match versions against known vulnerabilities/defaults

Pro tip: ***disable remote-access services that you don't need***

Devices are also susceptible to physical attacks

- In potentially hostile environments
- Device firmware/software can likely be analyzed
  - Access to device storage
- Compromise one device = compromise all?
- Pro tip: ***Don't share secrets (keys, passwords) between devices***

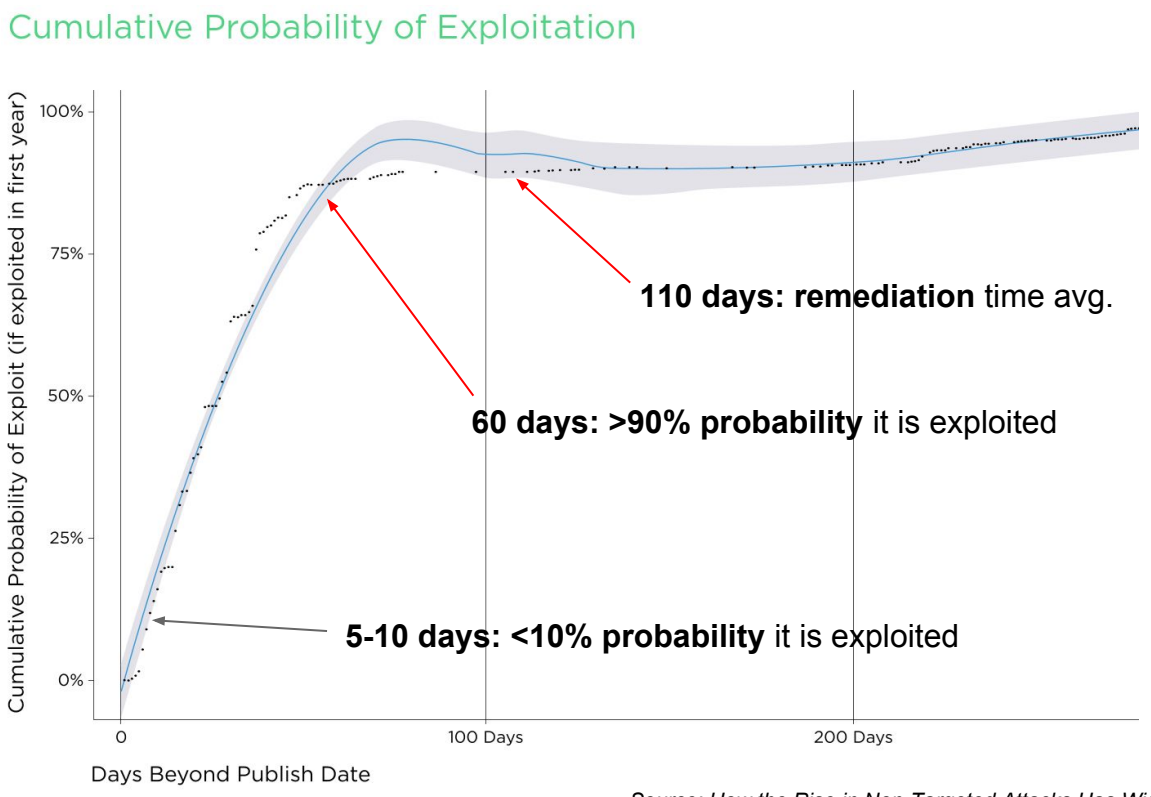
DNS Amplification attack (DDoS) enabled by IoT



Security design principles

- Principle of least privilege
  - Does component need to run as root?
- Separation of privilege
  - Does component need access to network?
  - Does it also need access to sensitive data?
  - Pro tip: ***Don't share keys between devices***
  - Pro tip: ***Network segmentation*** *(between customers/internal/...)*
- Kerckhoff's principle
  - Assume only keys are secret, not designs/algorithms
  - Pro tip: ***Only rely on industry-standard communication/crypto protocols***

Security patching is done too late



Source: How the Rise in Non-Targeted Attacks Has Widened the Remediation Gap, Kenna Security

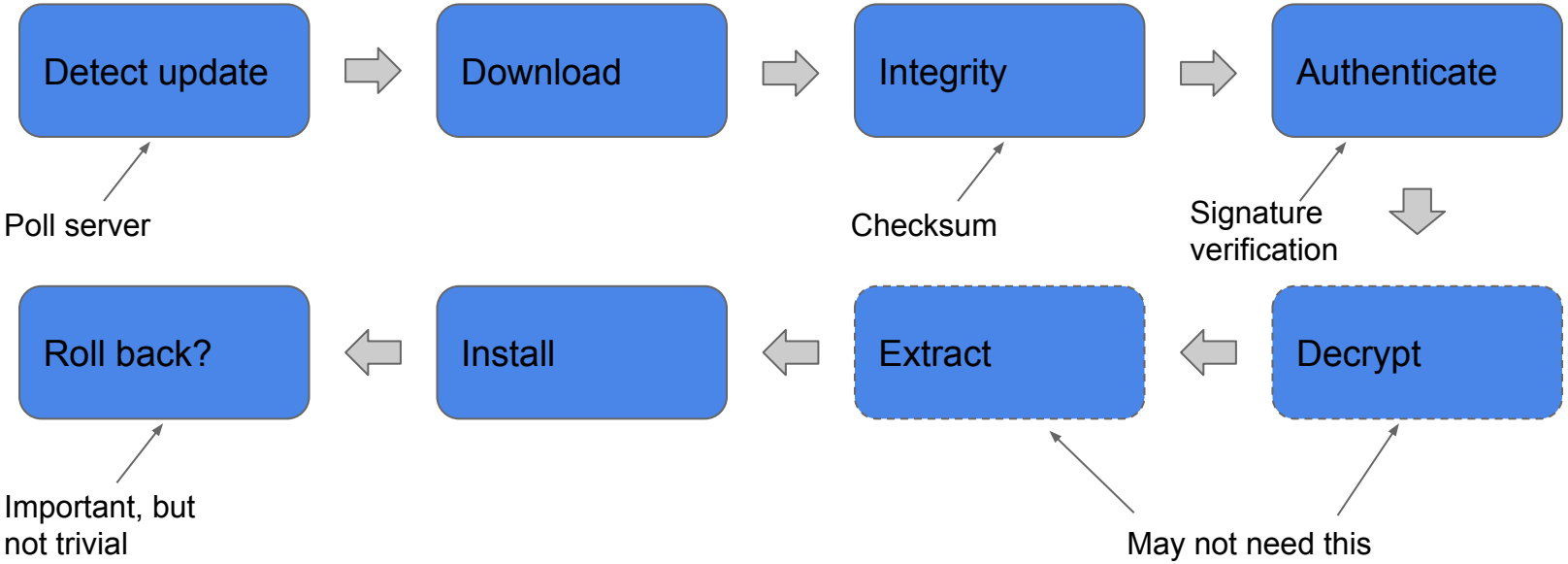
Why security patching happens too late

- Invisible until too late
- Too costly/risky
  - Manual
  - Requires downtime of production?
  - Risk of breaking production?
- Politics
- How often do *you* patch?
  - Do you have a way to do it? A process?
  - Often not a core competence and not a priority to develop updater

Patching connected devices is harder

- No/expensive physical access
  - Need failure management
- Unreliable power
  - What if power disappears in the middle of patching?
- Unreliable (wireless) network connectivity
  - Handle partial downloads
  - Ideally resume downloads in expensive networks like 3G
- Public and insecure (wireless) networks
  - Can someone inject arbitrary code during the update process?
  - Verify authenticity of update

Embedded client patching process overview



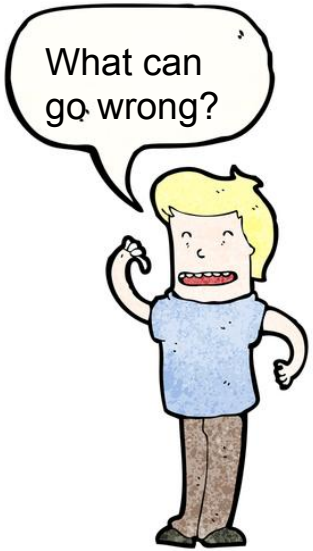
Choice of update type has tradeoffs

	Full image	Package (opkg, …)	tar.gz	Docker/Containers
Download size	Large*	Small	Small	Medium
Installation time	Long*	Short	Short	Short
Rollback	Yes (dual partition)	Hard	Hard	Yes
Consistency	Yes	Medium	Hard	Yes
Design impact	Bootloader, Partition layout	Package manager	tar, ...	Kernel, docker

* Can mitigate with compression or binary diffs

Strategies to reduce the risk of bricking

- Integrity checking
  - This must be done
  - Easy to implement
- Rollback support
  - This should be a requirement: power loss, installation error, etc.
  - Could be hard depending on update type (tarball, package)
- Phased rollout
  - I.e. don't deploy update to all devices in one go
  - Most do this to some extent: test & production environments
  - Can be more granular on device population (1%, 10%, 25%, 50%, …)
  - Used in most large infrastructures



Security basics protects against most attacks

- Segment the network
- Disable remote-access services
- Don’t share keys between devices
- Patch software vulnerabilities quickly and securely
- “80-90% of security breaches can be prevented”
  - Center of Internet Security

Many possible ways in, but let’s fix the obvious