Securing the Connected Car

MENDER.io

Deploy Software Updates for Linux Devices

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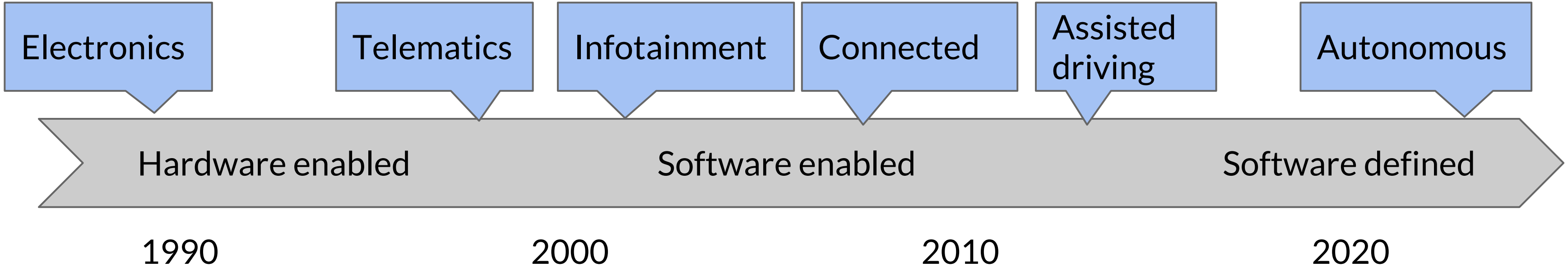
The software defined car



Electronics

Telematics

Infotainment

Connected

Assisted driving

Autonomous

Hardware enabled

Software enabled

Software defined

1990

2000

2010

2020

About me

- Eystein Stenberg
  - 7 years in systems security management
  - M. Sc., Computer Science, Cryptography
  - eystein@mender.io

- Mender.io
  - Over-the-air updater for Linux, Yocto Project
  - Open source (Apache License, v2)
  - Dual A/B rootfs layout (client)
  - Remote deployment management (server)
  - Under active development

Session overview

- Opportunities with the software defined car

- Anatomy of an attack: security risks of the connected car

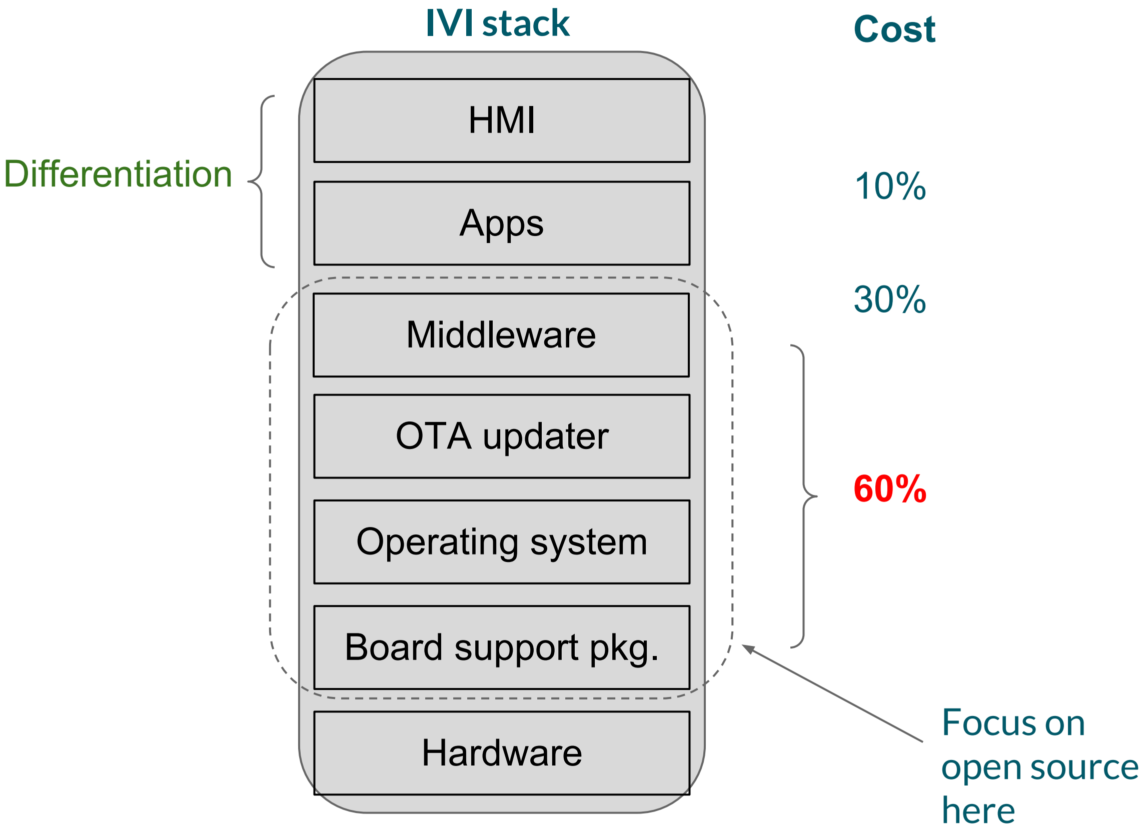
- The patching problem & solution designs

Software defined car: New revenue streams

- "Automakers could add up to **$27.1B annually** from services such as car sharing and more" - Navigant Research

- Tesla
    - An OTA update system allows for easy additional software purchases **after** buyers drive their cars off the lot
    - Semi-autonomous Autopilot feature allows current Model S owners to add the feature for $2,500 USD when they order the vehicle or they can pay $3,000 USD to upgrade later

Cost savings by using open source platforms



IVI stack

Cost

Differentiation

HMI

Apps

10%

30%

Middleware

OTA updater

Operating system

Board support pkg.

60%

Hardware

Focus on open source here

- Lower layers are *expensive* and provides *no differentiation*
- Use open source here to
  - Shorten time-to-market
  - Lower cost
  - Reallocate development to differentiating features

The software defined car requires OTA updates

- Increased software complexity requires more frequent improvements
- “**33% of current recalls** are for problems that could be fixed OTA” - ABI Research
- “OTA updates will **save carmakers $35B** in 2022” - IHS Automotive
- Fiat Chrysler hack (next up) required a **recall of 1.4 million vehicles** that could have been avoided with an OTA update

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
- August 2016: Extended to unauthorized ECU update via CAN

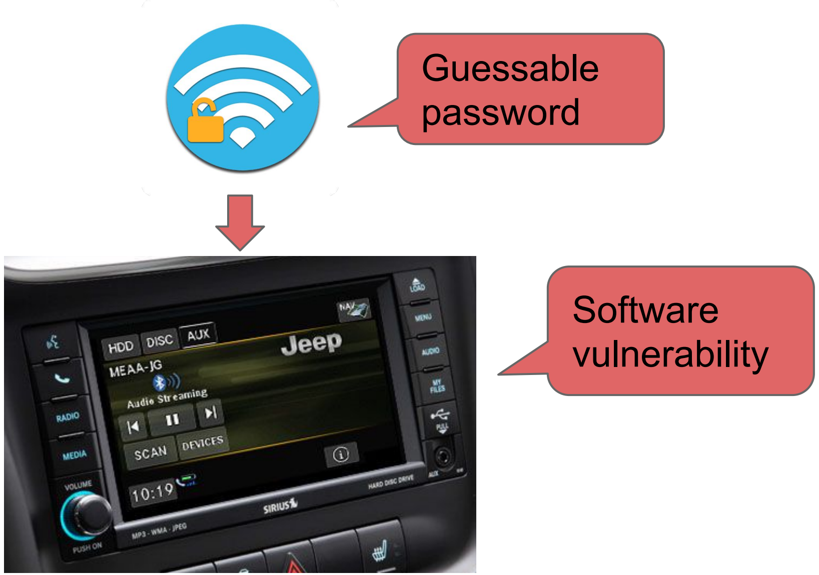
Jeep Cherokee Head Unit with Wifi

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

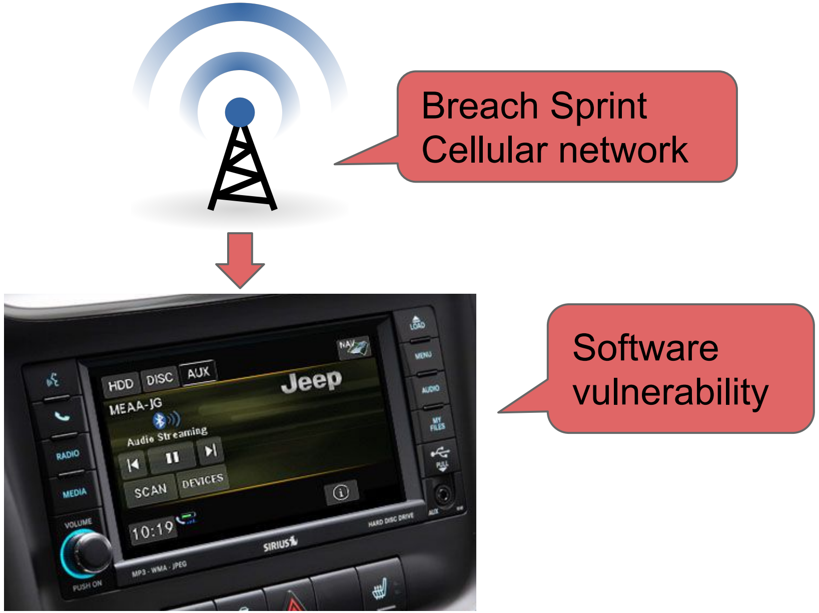


Guessable password

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

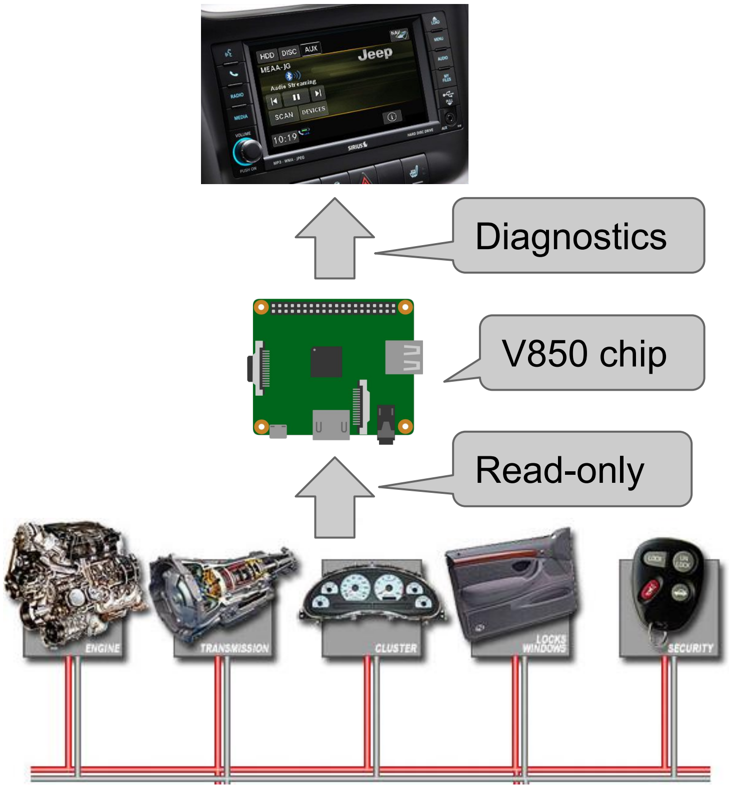


Breach Sprint Cellular network

Software vulnerability

- 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


Diagnostics

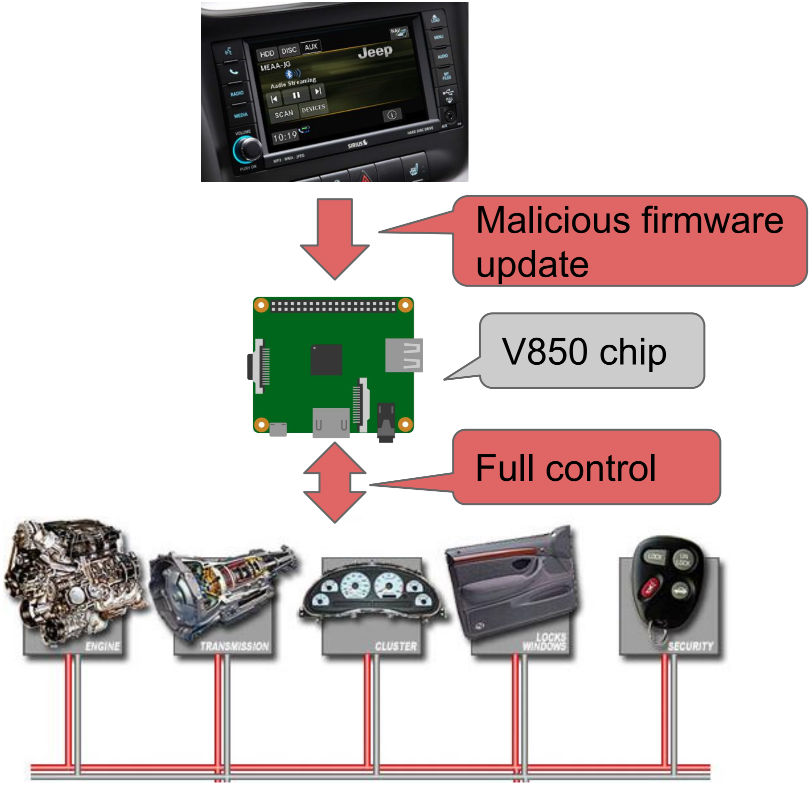
V850 chip

Read-only

- 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



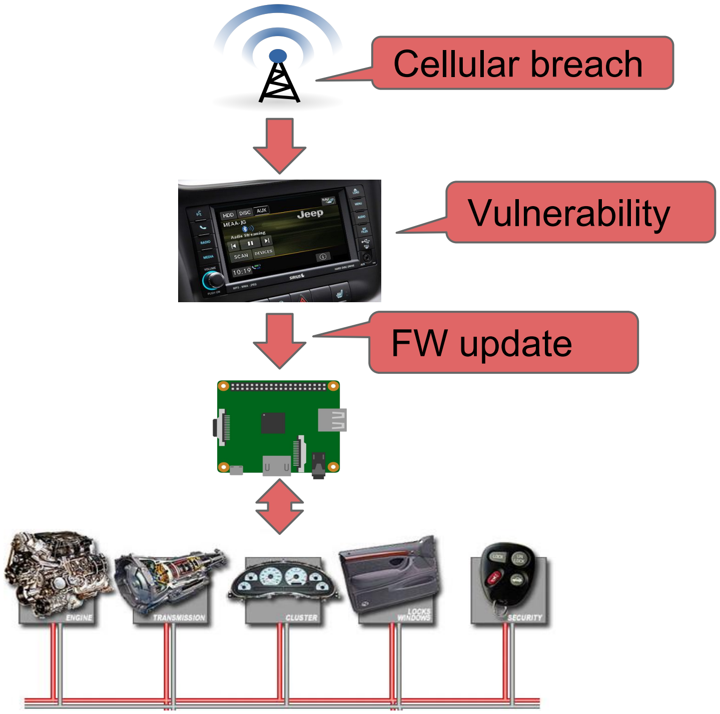
Malicious firmware update

V850 chip

Full control

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

Putting it together



Lessons

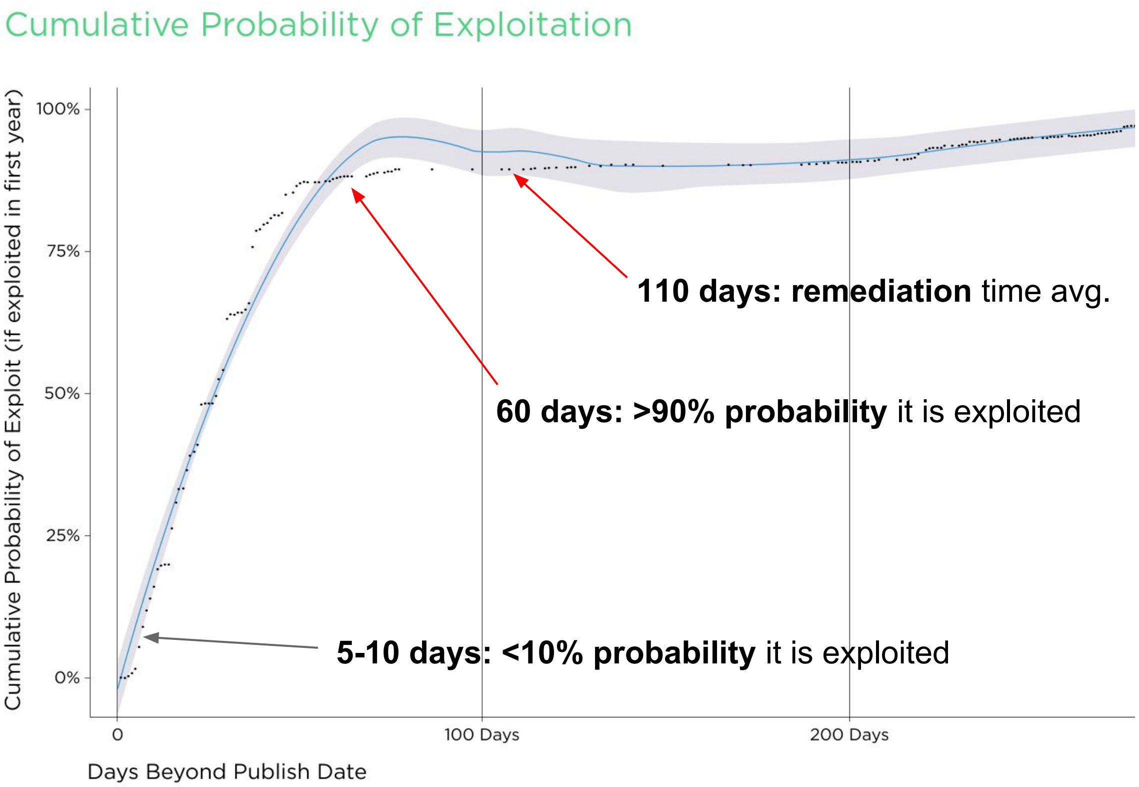
- Wifi hotspot password was predictable
- Remotely accessible service (in head unit) was vulnerable (and not updated)
- Firmware update (for V850) did not have proper authenticity checks
- The only way to fix the vulnerabilities is through a manual update (by customer or dealership)

More complexity leads to larger attack surface

- 1-25 bugs per 1000 lines of code*
  - Assume that all software components have vulnerabilities
- Rely on well-maintained software and keep it updated
  - Open source vs. proprietary is a red herring
  - Do not build all the software in-house
- Principle of least privilege
- Separation of privilege
- Kerckhoff’s principle

**Source: Steve McConnell, Code Complete*

Security patching is done too late



110 days: remediation time avg.

60 days: >90% probability it is exploited

5-10 days: <10% probability it is exploited

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

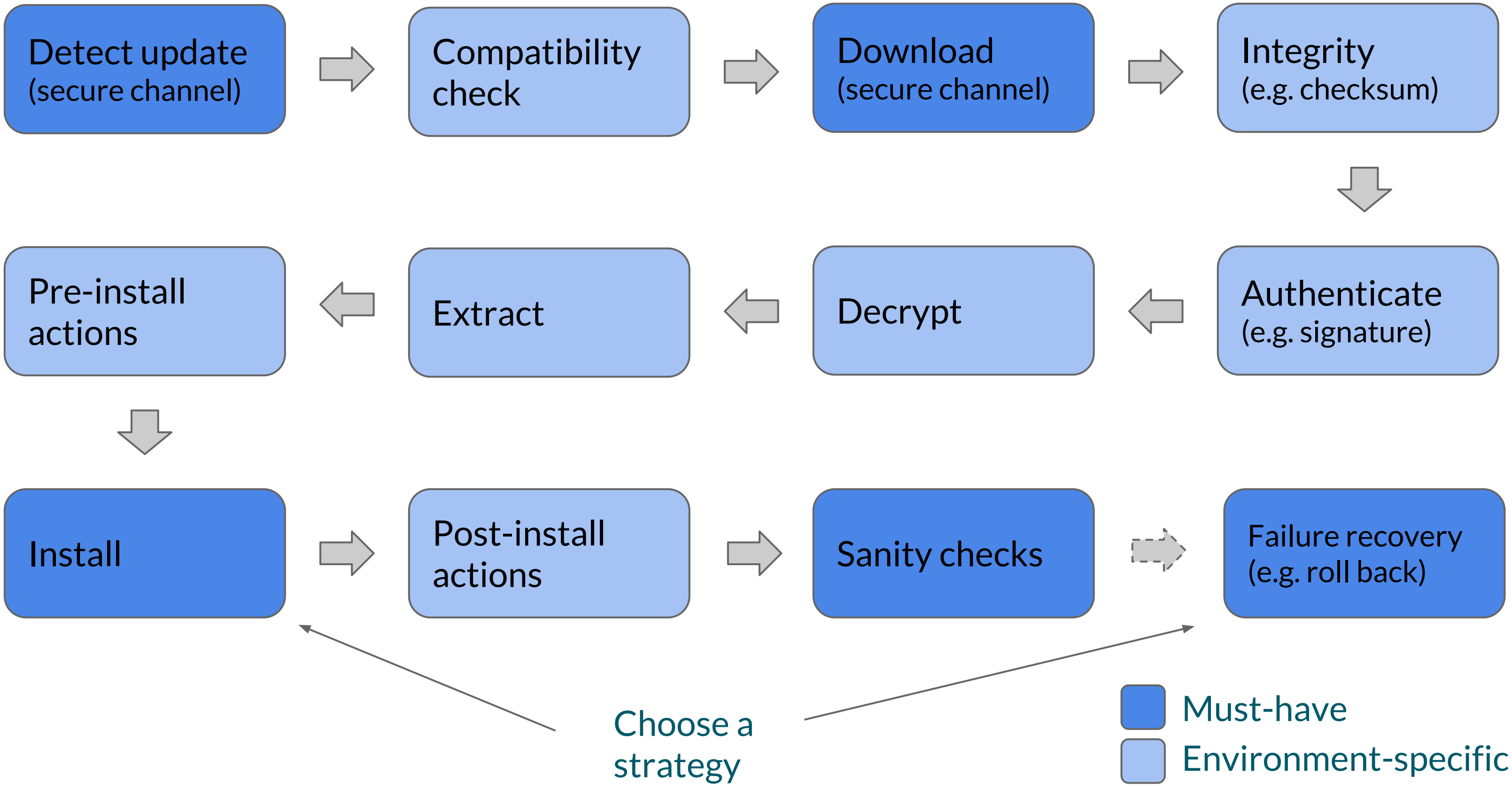
Why security patching happens too late

- The value is invisible until too late
- Too costly or risky
  - Manual? Too expensive to integrate updater?
  - 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

Generic embedded updater workflow



Detect update (secure channel)

Compatibility check

Download (secure channel)

Integrity (e.g. checksum)

Authenticate (e.g. signature)

Decrypt

Extract

Pre-install actions

Install

Post-install actions

Sanity checks

Failure recovery (e.g. roll back)

Choose a strategy

🟦 Must-have

▨ Environment-specific

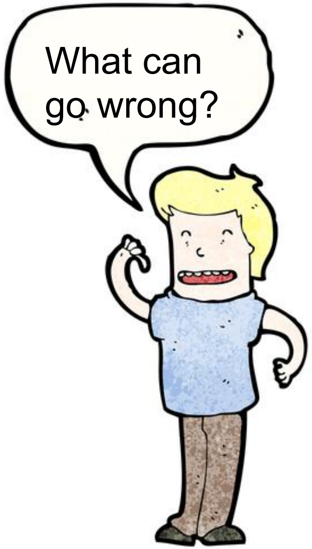
Choice of update type has tradeoffs

	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

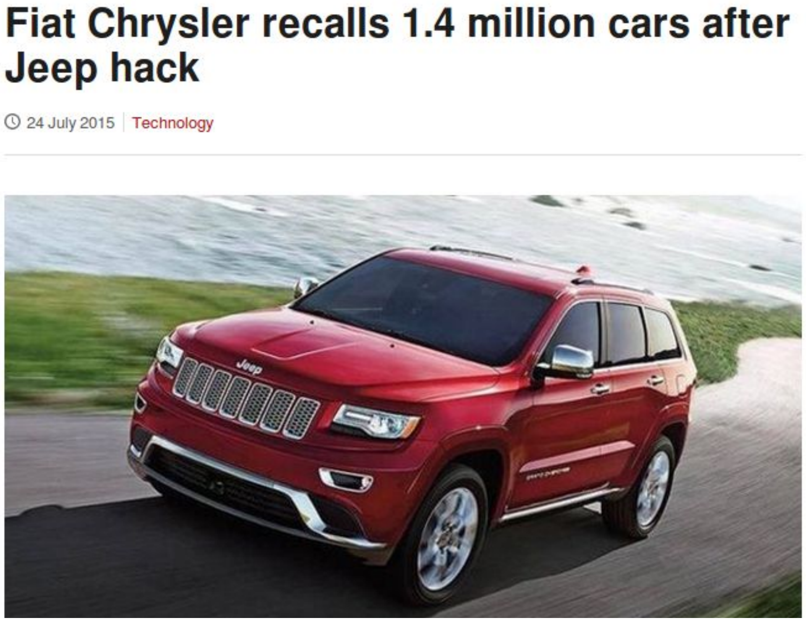
- Integrity checking
  - This must be done
  - Easy to implement
- Rollback support
  - This should be a requirement: power loss, installation error, etc.
  - Could be hard depending on update type (tarball, package)
- Phased rollout
  - I.e. don't deploy update to all devices in one go
  - Most do this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



Prepare for securing the software defined car

- Open source software where no differentiation
- Well-maintained software
- Over-the-air updates
- Apply well-known security design principles

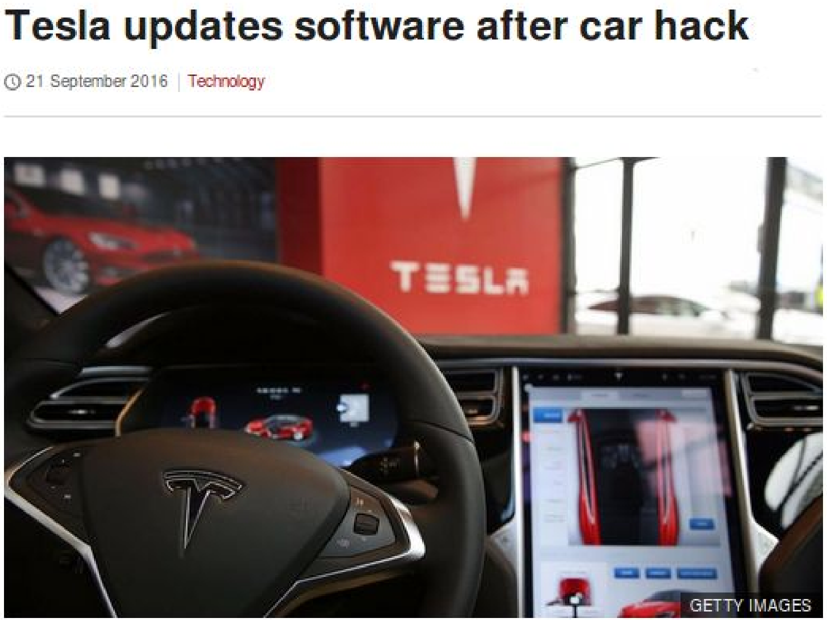
The best way to respond to hacking?



Fiat Chrysler recalls 1.4 million cars after Jeep hack

24 July 2015 | Technology

Fiat Chrysler said exploiting the flaw "**required unique and extensive technical knowledge**, prolonged physical access to a subject vehicle and extended periods of time to write code" and added **manipulating its software "constitutes criminal action"**.



Tesla updates software after car hack

21 September 2016 | Technology

Straubel [Tesla CTO] **credits KeenLabs' researchers** [...] says Tesla **will pay** KeenLabs' team a **monetary reward for its work** [...] "They did good work," Straubel says. "They **helped us find something that's a problem** we needed to fix. And that's what we did."

Sources: BBC News, Wired