CANSPY

a Platform for Auditing CAN Devices

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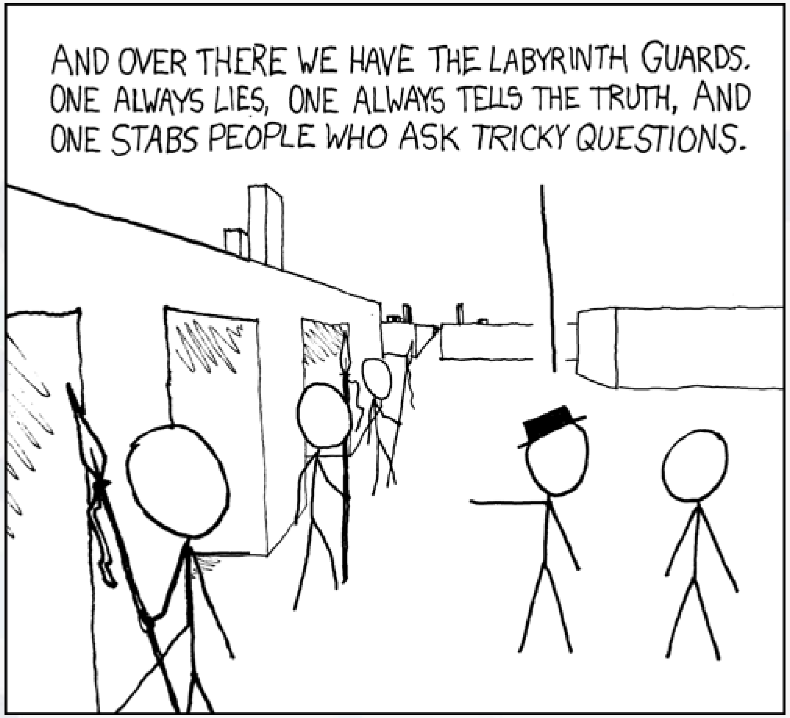
Auditing conventional IT systems

- **Penetration testing**
  - A form of security audit
  - Assess the risks of intrusion
  - Actual tests instead of a review process
  - The point of view of a real attacker (the “black-box” approach)
  - Relevant evaluation of impact and exploitability
- **Limitations**
  - Less time
  - Less resources
  - More ethics
- **Counter-measure: the “grey-box” approach**

The CISO's dilemma

- **The hand they are dealt with**
  - Huge scope of responsibility
  - Continuous changes
  - Major security threats
  - Risk of substantial damages
  - Limited budget
- **Their response**
  - They rely on penetration testing
  - They welcome the "gray-box" approach
  - They rely on risk analysis first and foremost
  - They divide perimeters accordingly



What about car manufacturer ?

- They are starting to include cyber-security along with conventional safety

- A lot of new functionalities
- Using more complex software
- Also, security researchers…

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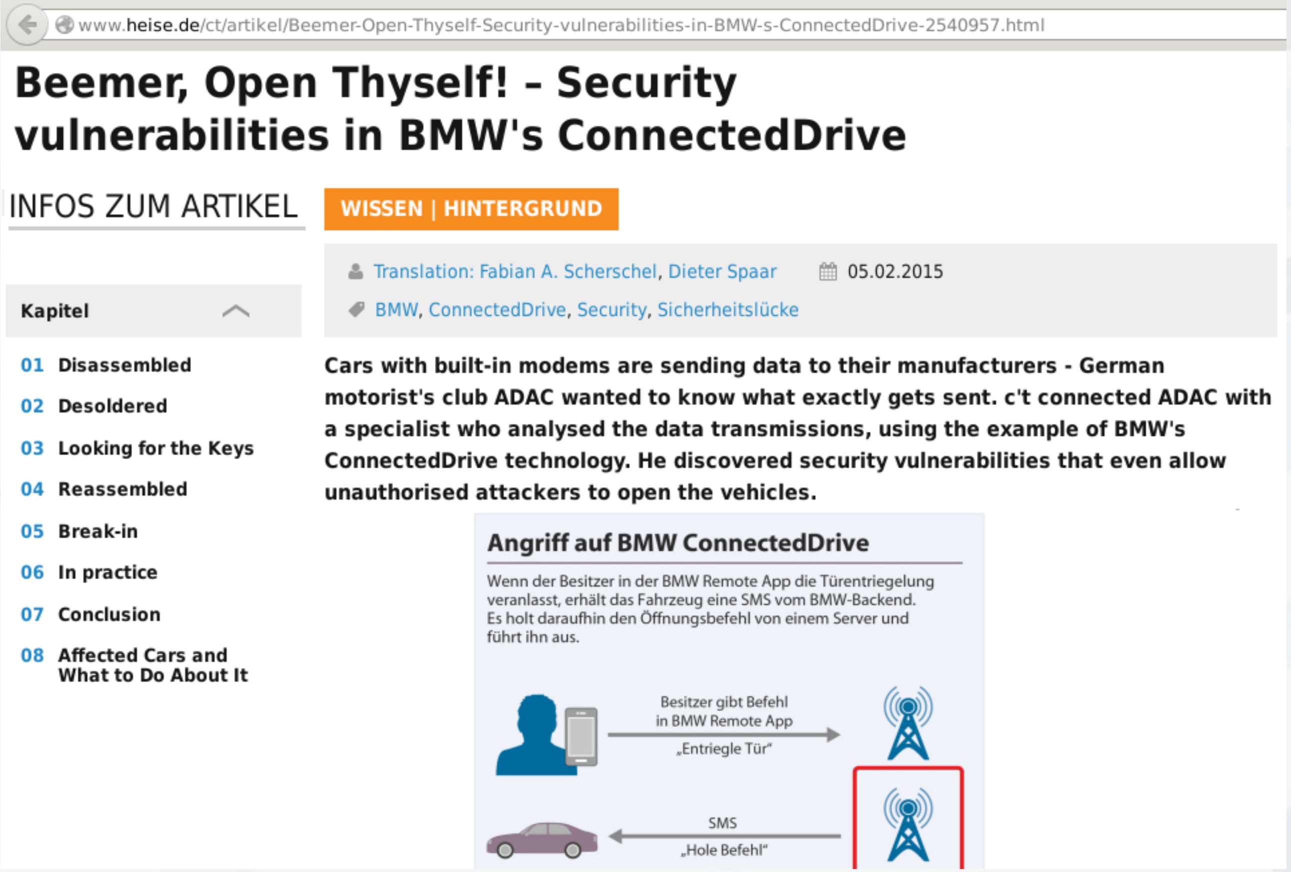

www.heise.de/ct/artikel/Beemer-Open-Thyself-Security-vulnerabilities-in-BMW-s-ConnectedDrive-2540957.html

Beemer, Open Thyself! – Security vulnerabilities in BMW's ConnectedDrive

INFOS ZUM ARTIKEL

WISSEN | HINTERGRUND

Translation: Fabian A. Scherschel, Dieter Spaar   05.02.2015

BMW, ConnectedDrive, Security, Sicherheitslücke

Kapitel

01 Disassembled
02 Desoldered
03 Looking for the Keys
04 Reassembled
05 Break-in
06 In practice
07 Conclusion
08 Affected Cars and What to Do About It

Cars with built-in modems are sending data to their manufacturers - German motorist's club ADAC wanted to know what exactly gets sent. c't connected ADAC with a specialist who analysed the data transmissions, using the example of BMW's ConnectedDrive technology. He discovered security vulnerabilities that even allow unauthorised attackers to open the vehicles.

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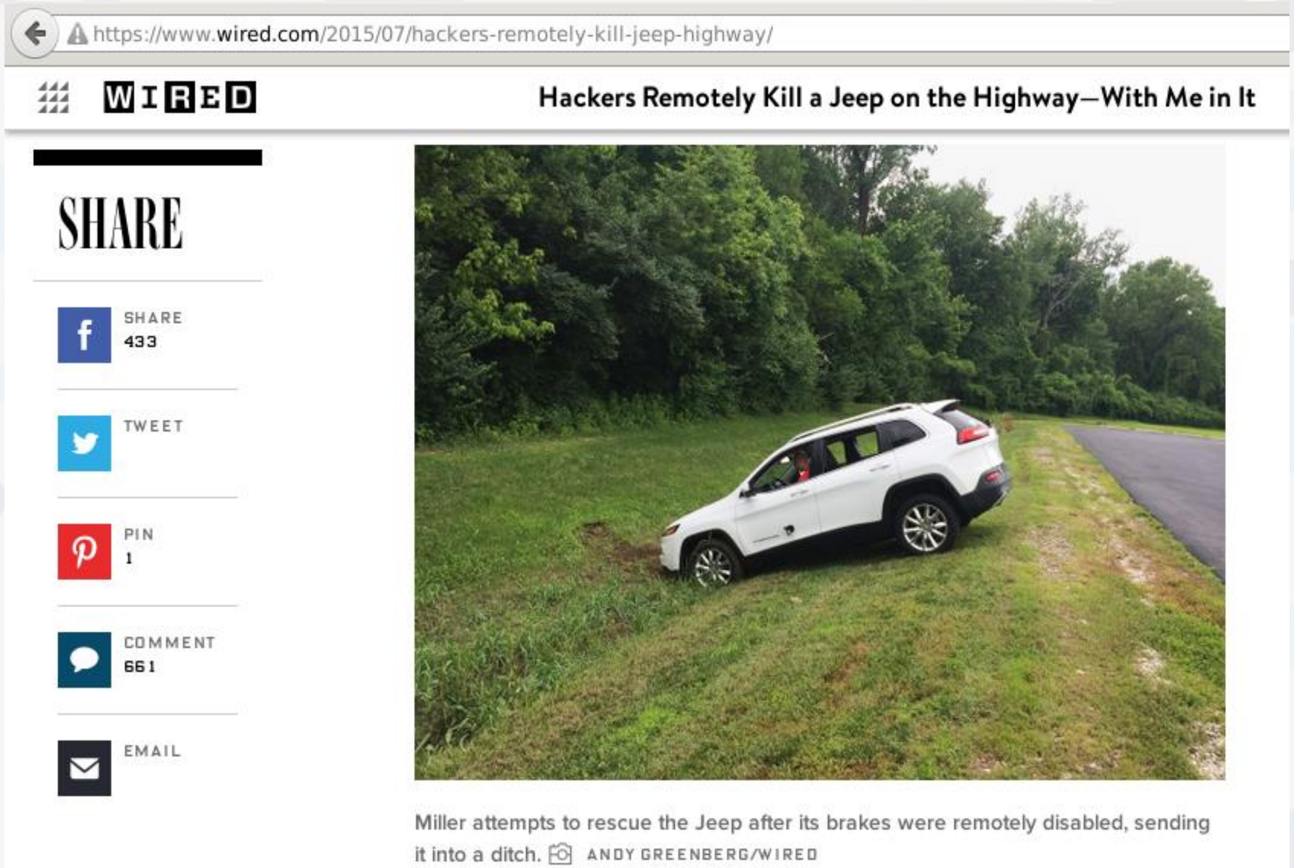

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https://www.theguardian.com/technology/2016/jun/06/mitsubishi-outlander-car-hacked-security

UK world sport football opinion culture business lifestyle fashion environment tech travel

Self-driving cars

Yet another car can be hacked - this time it's the Mitsubishi Outlander hybrid

Mitsubishi urged to recall at least 100,000 cars after hackers remotely turned off the alarm system, controlled the lights and drained the battery

Nellie Bowles in San Francisco

@NellieBowles

Tuesday 7 June 2016 02.55 BST

Shares 102

Comments 17

Save for later

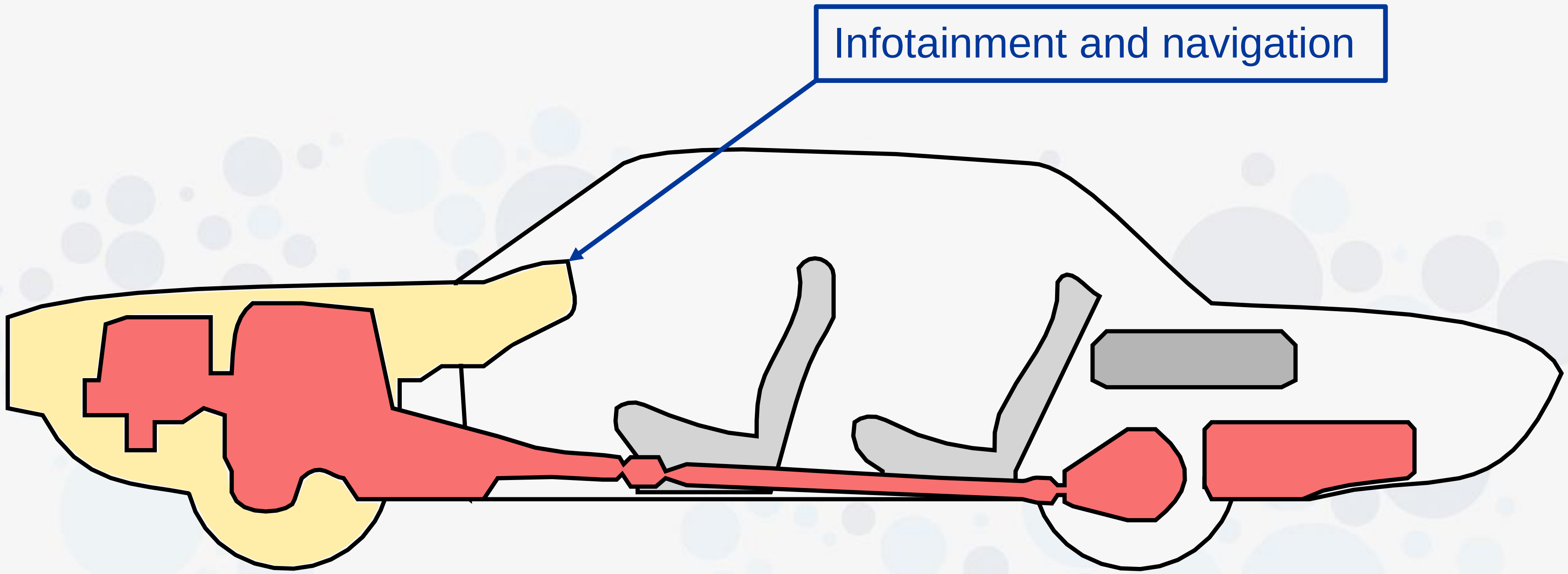
Mitsubishi joins Jeep, Nissan and Tesla on the list of cars that have had vulnerabilities highlighted. Photograph: Simon Stuart Miller (commissioned)

What about security audit for cars ?

- **The same approach can be applied**
  - While True
    - Conduct risk analysis
    - Prioritize ECUs
    - Conduct penetration tests accordingly
    - Carry out corrective actions
  - End While

- **Some ECUs can be common to several vehicles**
- **Corrective actions may be difficult to carry out**

It always begins with…



- **Consumer-grade connectivity**
  - Wi-Fi, Bluetooth and USB → Nothing new here !
  - However CAN sniffing is already useful for analysis

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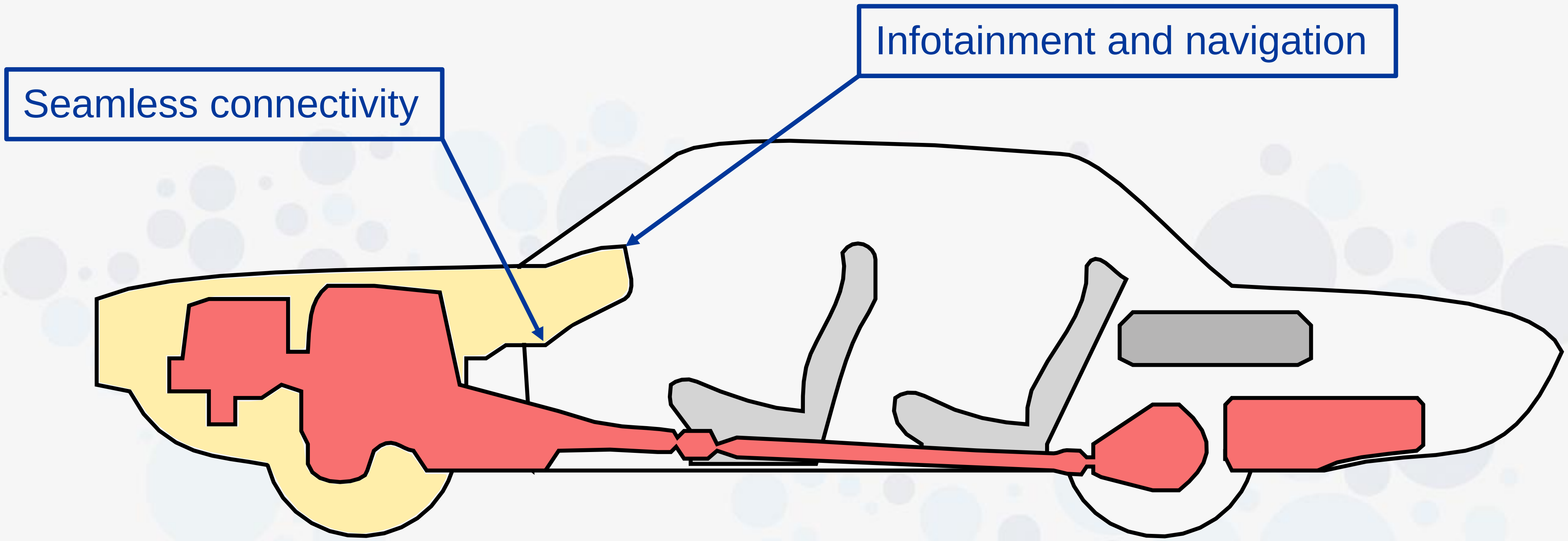

- **Mobile broadband connectivity**
  - Setting up an IMSI catcher and then…
  - Deal with conventional protocols (TCP, HTTP, …) →Again, nothing new here !

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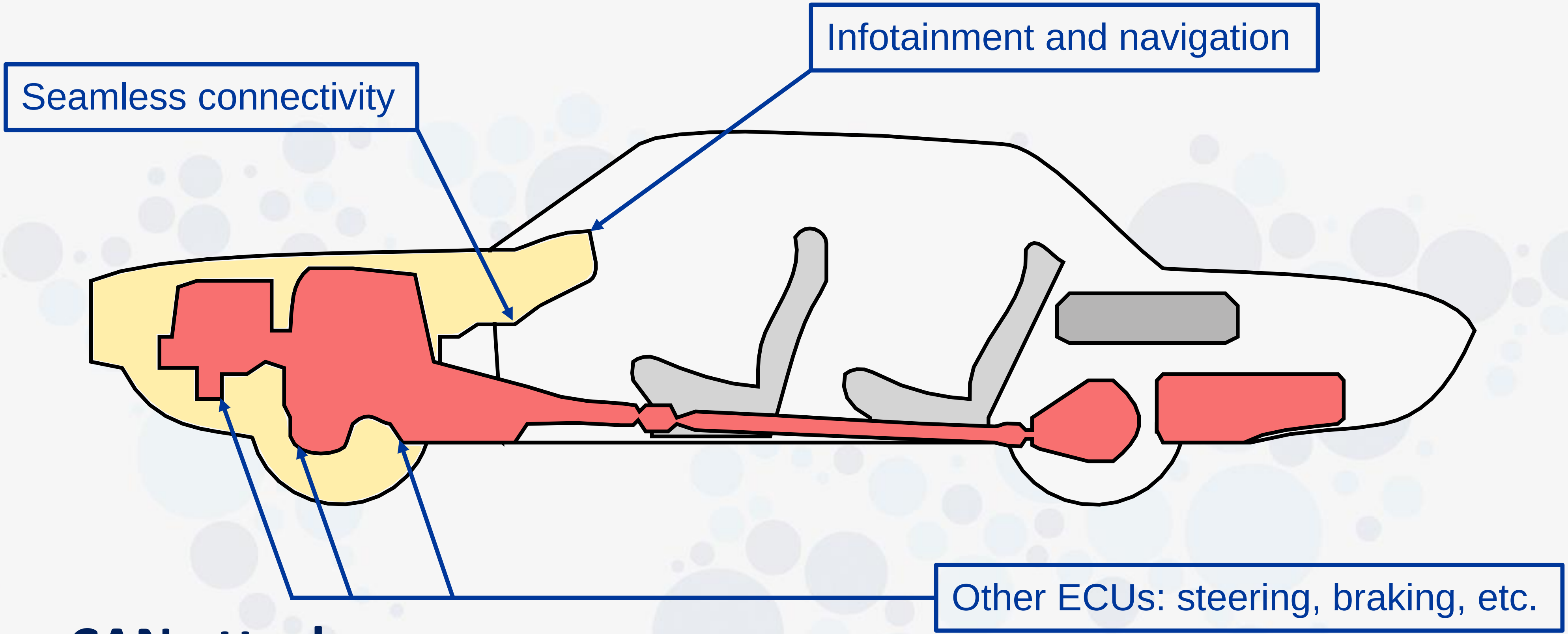
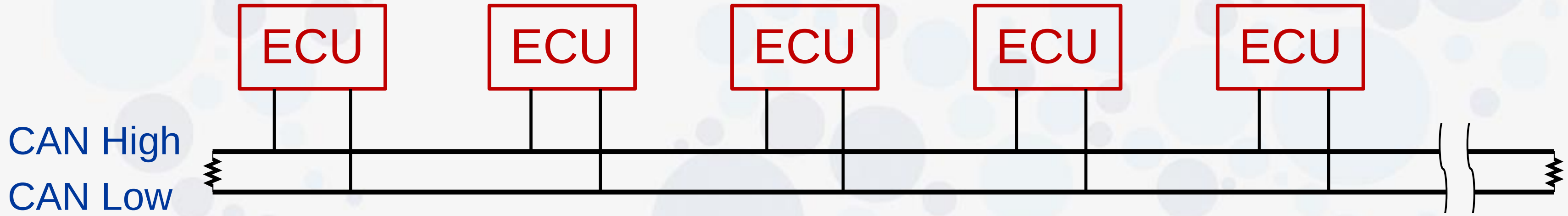


- **CAN attacks**
  - Bypass CAN bus segmentation (architecture-dependant)
  - Reverse-engineer higher-layer/custom protocols
  - Break the Security Access challenge (ISO 14229)

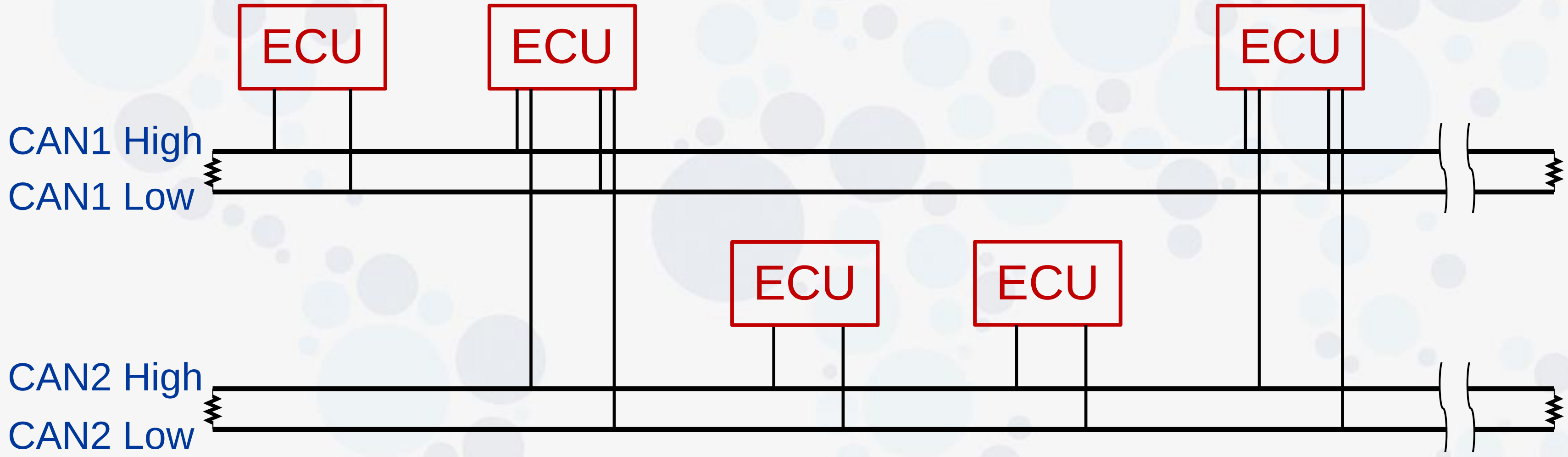
CAN architectures

- **One serial bus (to rule them all)**
  - ID-based priority mechanism
  - Congestion issues
  - Acknowledgment by anyone



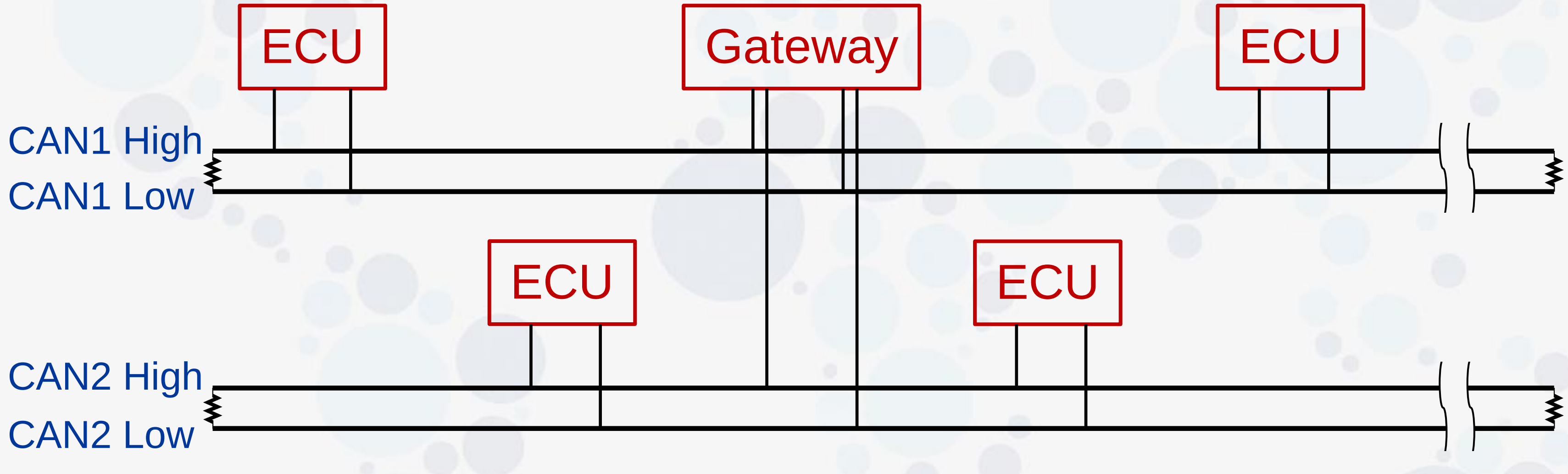
CAN architectures

- **Multiple separate buses**
  - Some ECUs have to be connected to multiple buses
  - They can be used to bypass the segmentation



CAN architectures

- **Multiple interconnected buses**
  - A gateway is routing frames between CAN buses
  - It may take into account the state of the vehicle
  - Both safety and cyber-security can be considered



Crafting CAN attacks

- **Several attack vectors**
  - Misuse of intrinsic capabilities (e.g., remote diagnostic tool)
  - Exploit a higher-level parsing vulnerability
  - Break the Security Access challenge
  - Etc.
- **This will imply a substantial amount of work**
  - Unsolder EEPROM or identify on-chip debug (JTAG/BDM) and conventional debug (UART/WDBRPC) interfaces
  - Extract the firmware
  - Reverse-engineer the aforementioned items
  - Craft actual attacks

The Man In The Middle

- **Taking advantage of the client-server model**
  - Insert yourself in-between them
  - Do not alter traffic until you see something interesting
  - Then start to drop/alter/replay/…
  - Finalize with targeted reverse-engineering
- **In theory, this is transposable to the CAN bus**
  - We are auditing one device

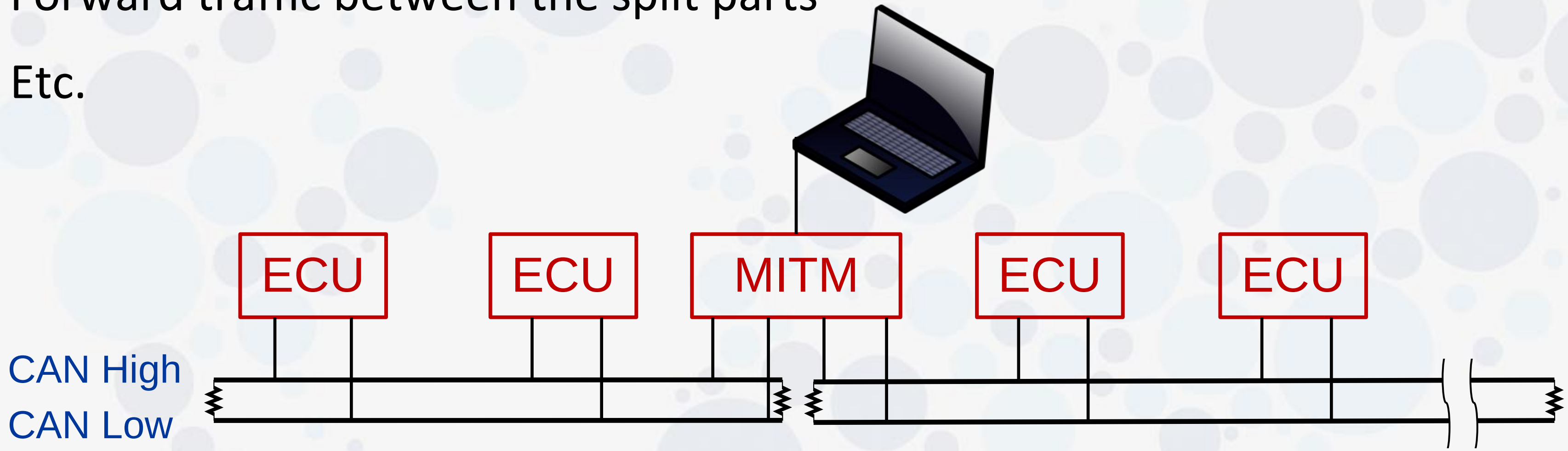
    → We could proxy the traffic from and to that device
  - We are working with the car manufacturer

    → We can ask for a restricted devices (e.g., a remote diagnostic tool)

    →This is limited by third-parties intellectual properties

However, in practice…

- **CAN is a serial bus**
  - Physically cut the bus and insert yourself in-between
  - Forward traffic between the split parts
  - Etc.



- **2 possible options (other than deep diving into the car)**
  - Emulate the car from the point of view of the audited device
  - Use an integration bench provided by the car manufacturer

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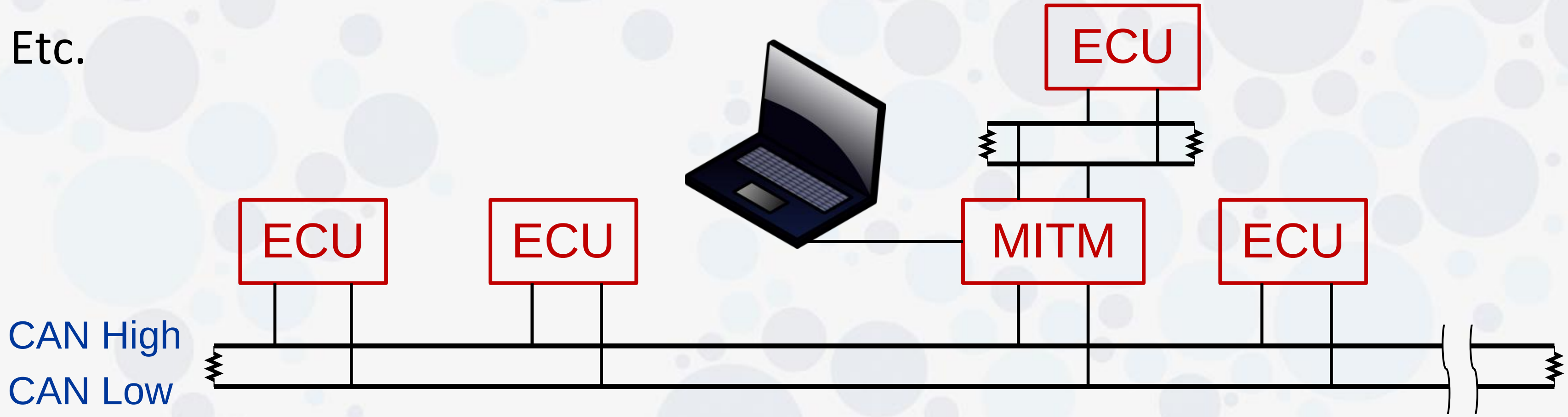

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- **CAN was designed to meet timing constraints**
  - Bridging two devices could add high latencies
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  - The default is usually 115 200 bauds (and even at max speed it is limiting)
  - CAN buses can go as far as 1Mbit/s (OBD-II is 250 or 500 Kbit/s)
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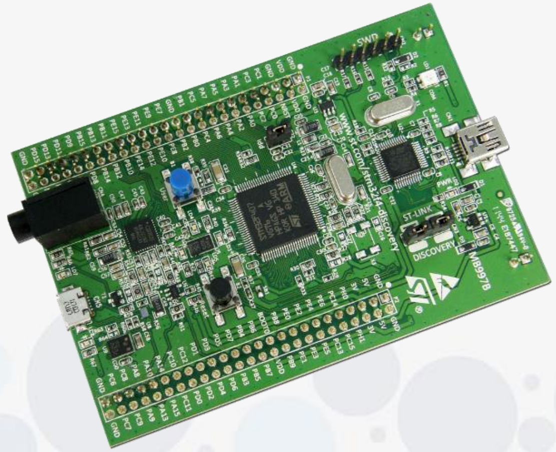
- **Lack of a mature framework**
  - We get frustrated when we cannot use Scapy
  - Federate higher-layers reverse-engineering efforts

CANSPY objectives

- **Two dedicated CAN interfaces**
  - Using independent CAN cores
  - With the ability to manipulate acknowledgments
- **Frame forwarding w/ or w/o filtering**
  - Low latencies (even with filtering)
  - At the full data rate of the CAN standard
- **Sniffing and injection capabilities**
  - CAN interfaces ←→ Ethernet (with Wireshark dissector compatibility)
  - CAN interfaces ←→ UART (mostly for setting/debugging purposes)
- **PCAP and settings read/write from SD card (autonomous mode)**
- **Configurable settings via Ethernet (fully scriptable)**

CANSPY hardware

- **STM32F4DISCOVERY board**
  - 168 MHz 32bit ARM Cortex M4
  - COTS ($20)



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- **STM32F4DIS-BB extension board**
  - 1 RS232 interface
  - 1 Ethernet port
  - 1 SD card drive
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  - 1 RS232 interface
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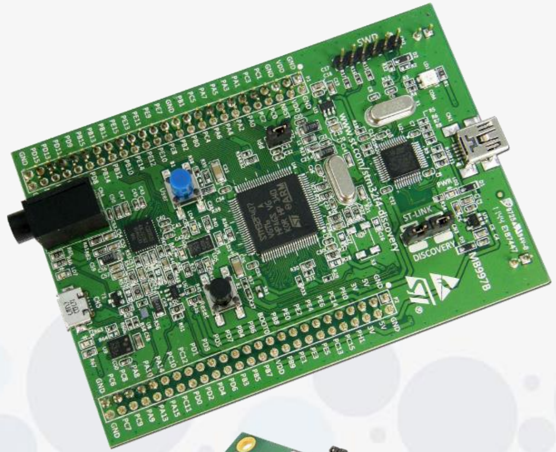
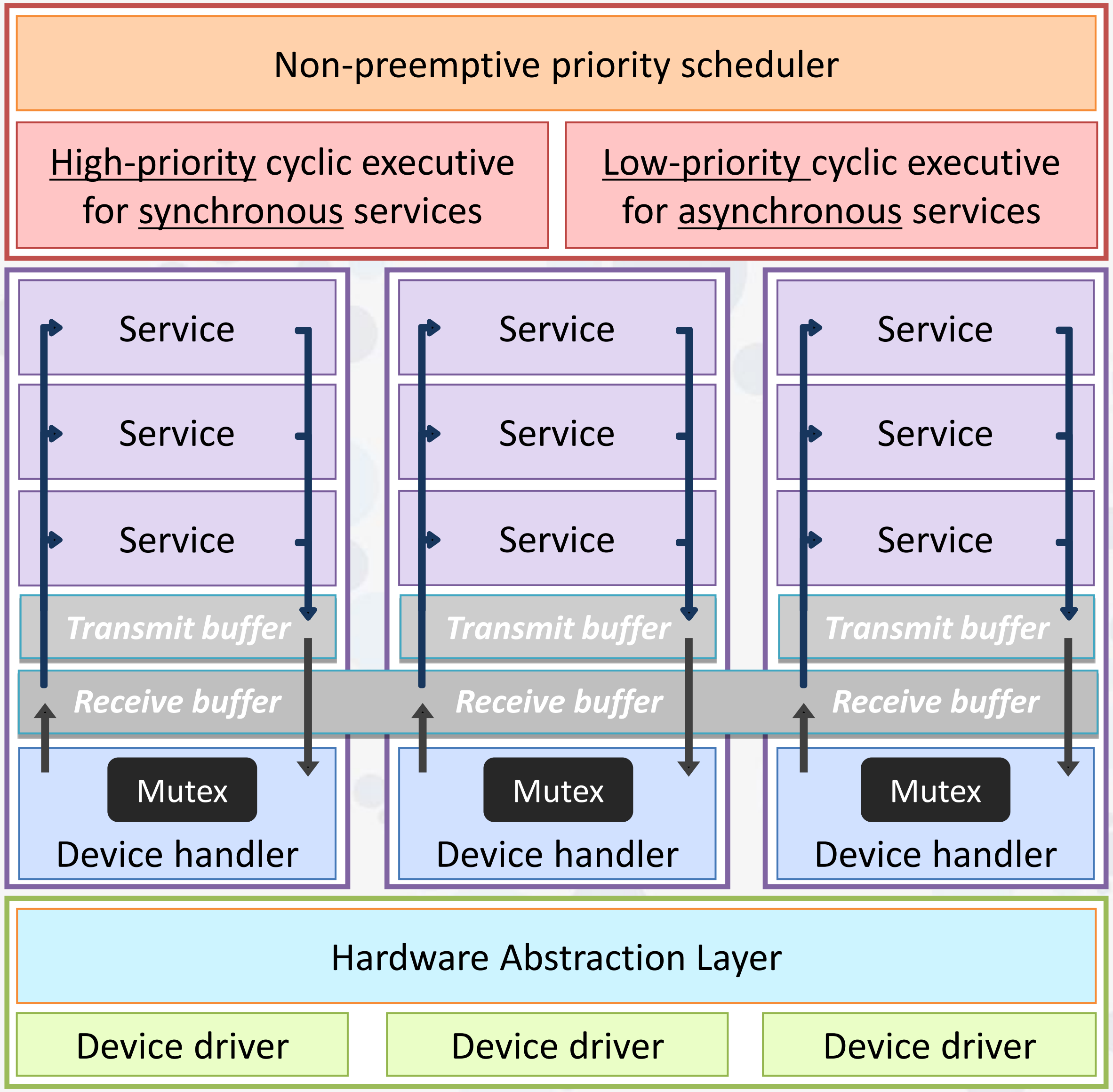
  - COTS ($40)
- **DUAL-CAN extension board**
  - Configurable resistors, power supplies and circuit grounds
  - 2 CAN interfaces and easy to build
  - Custom-made ($30 worth of PCB and components)



CANSPY firmware



https://bitbucket.org/jcdemay/canspy

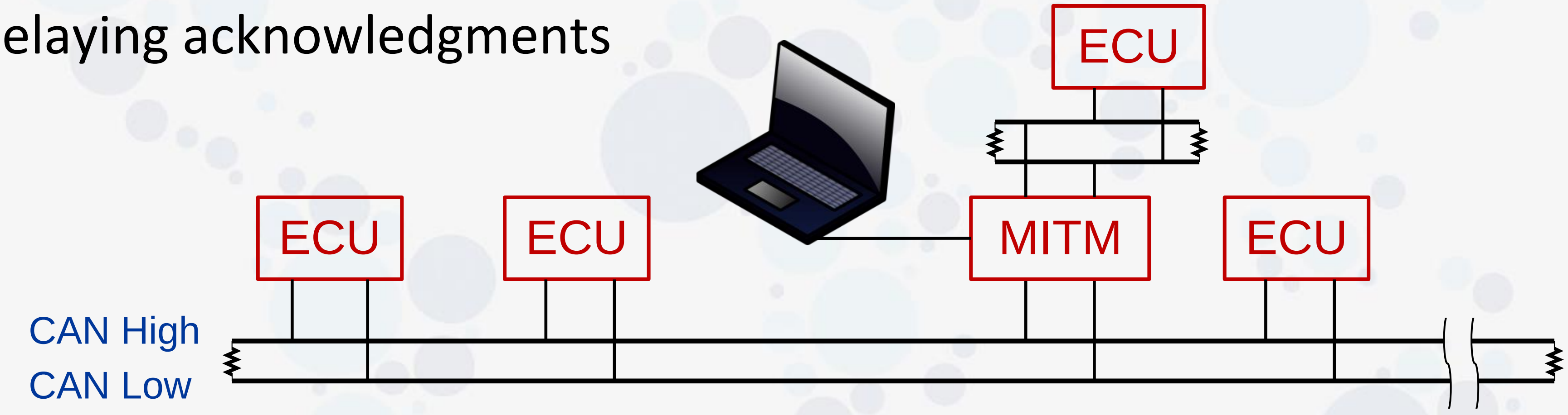
CANSPY firmware

- **Event-driven scheduler**
  - Asynchronous I/O operations
  - Low latency processing
- **1 functionality == 1 service**
  - Start only what you need
  - Read from all devices, write to only one
  - Mutual exclusion is possible
- **Autonomous mode**
  - In-built filtering/altering engine
  - SD card for read or write operations
  - Power supply from the car battery

- **Real-time approach**
- **Open source licensed**
- **Built-in services**
  - CAN: Forward/Filter/Inject
  - Ethernet: Wiretap/Bridge
  - SDCard: Capture/Replay/Logdump
  - UART: Monitor/Logview/Shell
- **CAN devices**
  - Two independent handlers
  - Support all standard speeds
  - Throttling mechanisms

Handling congestion issues

- **MITM setups can tamper with congestion**
  - Filtering or dropping will modify the available bandwidth
  - ECUs behavior may thus be impacted
- **Two possible throttling mechanisms**
  - Dummy frame injection
  - Delaying acknowledgments



CAN over Ethernet

- The SocketCAN format
- Ethertype 0x88b5
- Different MAC addresses
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class SocketCAN(Packet):
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    BitEnumField("RTR", 0, 1, {0:"Disabled", 1:"Enabled"}),
    BitEnumField("ERR", 0, 1, {0:"Disabled", 1:"Enabled"}),
    XBitField("id", 1, 29),
    FieldLenField("dlc", None, length_of="data", fmt="B"),
    ByteField("__pad", 0),
    ByteField("__res0", 0),
    ByteField("__res1", 0),
    StrLenField("data", "", length_from = lambda pkt: pkt.dlc),
  ]
  def extract_padding(self, p):
    return "",p

bind_layers(Ether, SocketCAN, type=0x88b5)
```

CAN over Ethernet

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- Ethertype 0x88b5
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```
#wireshark -X lua_script:ethcan.lua

local sll_tab =
DissectorTable.get("sll.ltype")
local can_hdl =
sll_tab:get_dissector(0x000C)
local eth_tab =
DissectorTable.get("ethertype")
eth_tab:add(0x88b5, can_hdl)
```

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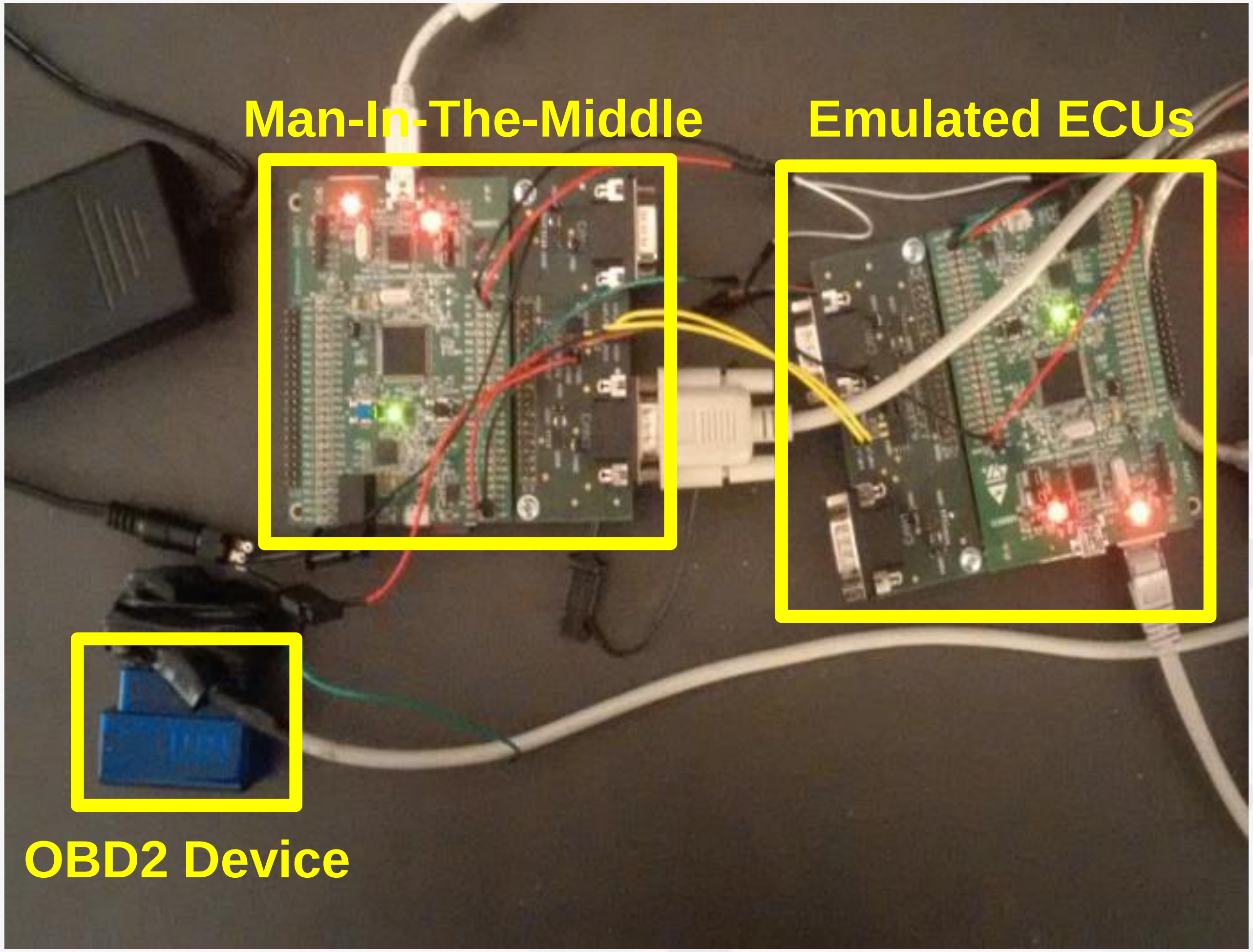
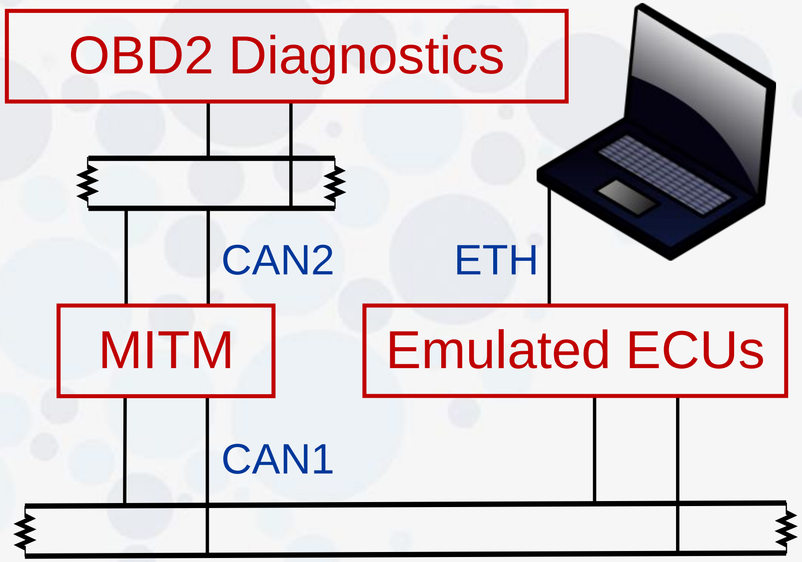
The OBD-II use case

- **No need to physically cut anything**
  - Buy a Goodthopter-compatible OBDII-to-DB9 cable
  - Build its female counterpart ($10 worth of components)
  - Setup the DUAL-CAN extension properly
  - Have fun
- **Several interesting cases**
  - Professional/consumer car diagnostic tools
  - Usage-based policies from insurance companies
  - Air-pollution control from law enforcement
- **They expose sensitive networks/hosts**

Demonstration bench





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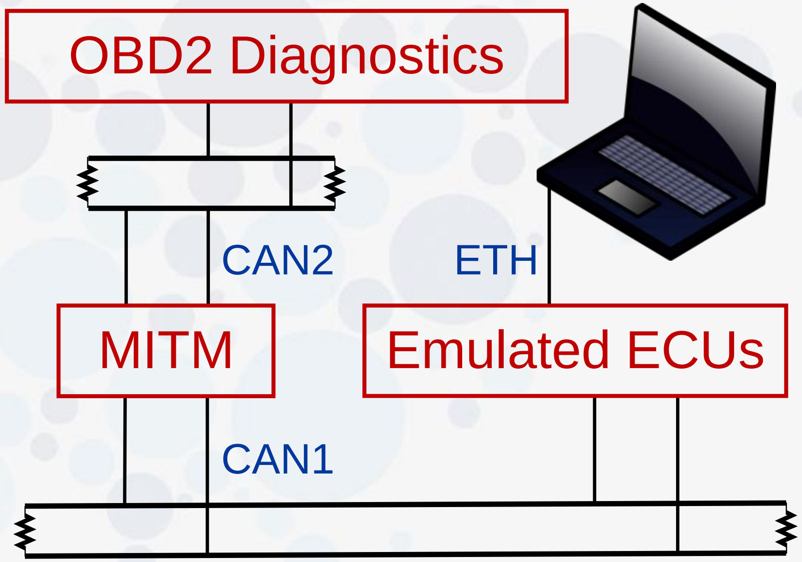
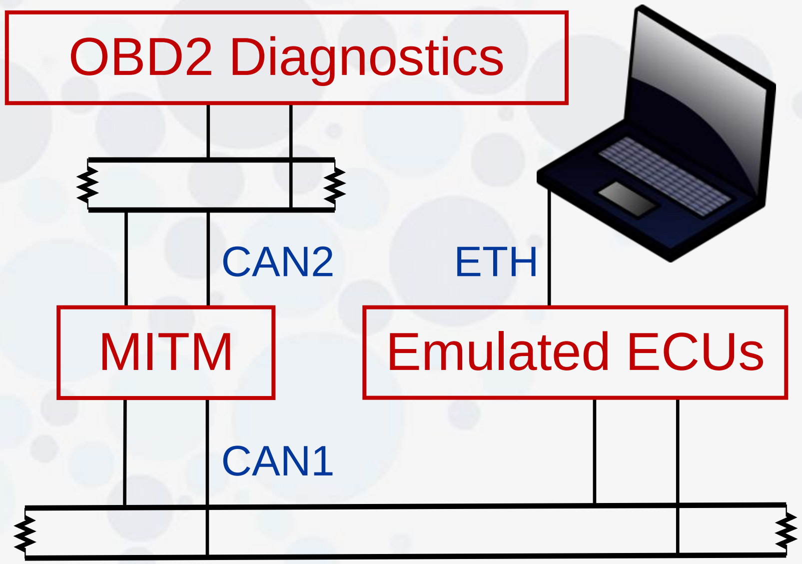


Start of emulation

Start of filtering (frame modification)

Demonstration bench

- **What about buffer overflows ?**
  - ISO-TP layer provided for Scapy
  - Identify fragmented responses
  - E.g., VIN request (17 ASCII characters)
  - Increase response length
  - Debug and exploit
- **We need more Scapy layers !**
  - For documented standards (e.g., SAE J1939)
  - For proprietary standards (i.e., reversing…)



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