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REVISITING BLUETOOTH VULNERABILITIES IN AUTOMOTIVE INFOTAINMENT SYSTEMS

A Remote Code Execution Case Study

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https://cyber.gouv.fr

Increasingly Connected Vehicles

(image generated by ChatGPT-4o)

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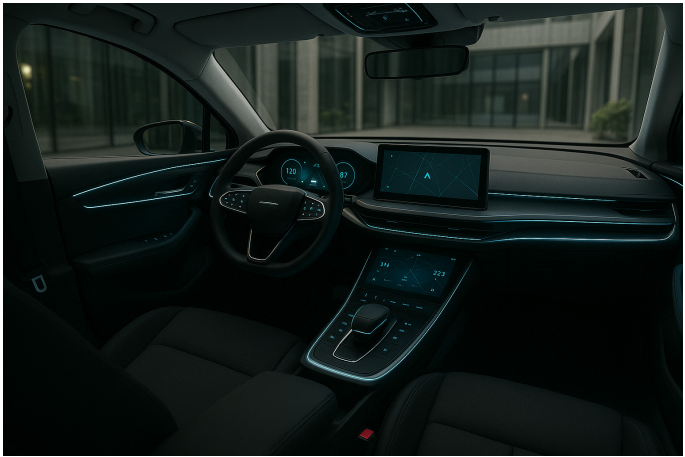
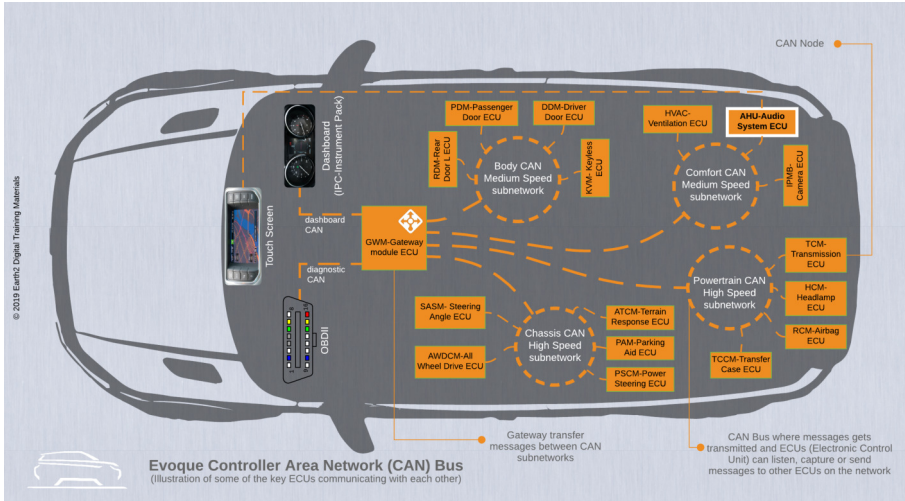


An ever-expanding attack surface!

(image generated by ChatGPT-4o)

Example of an IT Architecture for Connected Vehicles



(Source: `https://www.earth2.digital/blog/what-is-vehicle-can-bus-ecu-evoque-adam-ali.html`)

Attacker Model

Local attacker:

- Present inside the vehicle
- Physical access to internal vehicle buses

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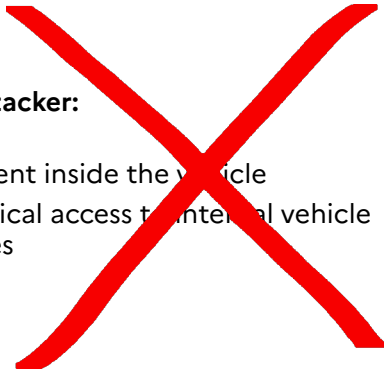

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Interfaces

- Wi-Fi
- GSM
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- **ASLR (*Address Space Layout Randomization*)**
  - randomizes memory locations (code, stack, libraries)
  - makes ROP/JOP attacks more difficult
  - strongly depends on available entropy
- **W⊕X (*Write XOR Execute* – DEP)**
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In-Vehicle Infotainment Software Architecture

Interfaces

- Wi-Fi: disabled by default.
- GSM: uncontrolled traffic.
- **Bluetooth** moved outside kernel: `BluegoService` (Java service)
  - JNI and `libbluego.so`.
  - single public CVE for this library (`CVE-2018-20378`).

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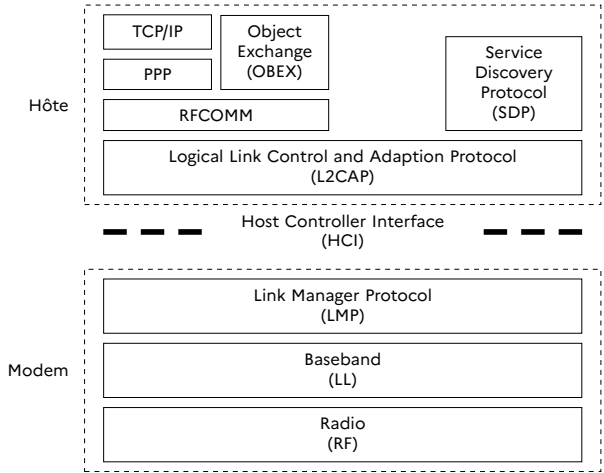
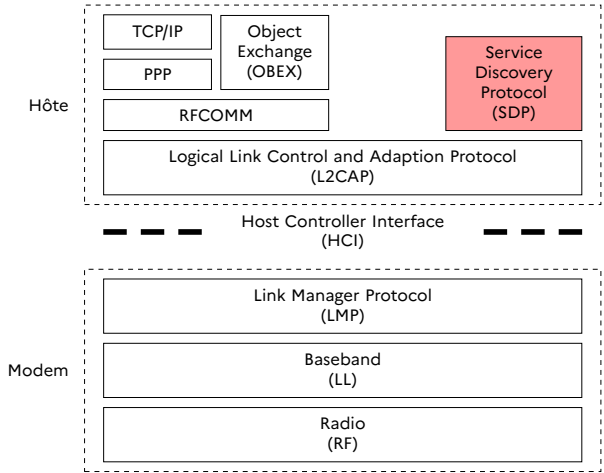
The Bluetooth Stack



[a part of] # The Bluetooth Stack



Protocol usable before pairing

Libbluego: CVE-2018-20378

`libbluego` version 2.X (`2.6.0-rc1`) is found in the studied ECU.

- CVE published on 03/29/2019 under reference `CVE-2018-20378`
- Invalid MTU in the L2CAP layer.
- Targets: OpenSynergy Blue SDK[a] versions **3.2** to 6.0.
- Closed-source library (explaining the relatively low CVSS score)

[a] **See: `https://www.opensynergy.com/blue-sdk/`**

"The L2CAP signaling channel implementation and SDP server implementation in OpenSynergy Blue SDK 3.2 through 6.0 allow remote, unauthenticated attackers to execute arbitrary code or cause a denial of service via malicious L2CAP configuration requests, in conjunction with crafted SDP communication over maliciously configured L2CAP channels. The attacker must have connectivity over the Bluetooth physical layer, and must be able to send raw L2CAP frames."

CVSS scores for CVE-2018-20378

Base Score	Base Severity	CVSS Vector	Exploitability Score	Impact Score	Source
5.4	MEDIUM	AV:A/AC:M/Au:N/C:P/I:P/A:P	5.5	6.4	nvd@nist.gov
7.5	HIGH	CVSS:3.0/AV:A/AC:H/PR:N/UI:N/S:U/C:H/I:H/A:H	1.6	5.9	nvd@nist.gov

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- **Can this CVE be transposed to the target vehicle? Yes!**
  - … but it's far from straightforward
  - … **the CVE details do not apply to the target!**
    - (since the target embeds a version older than the oldest vulnerable version)

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  - … but it's far from straightforward
  - … **the CVE details do not apply to the target!**
    - (since the target embeds a version older than the oldest vulnerable version)
  - **the actual exploitation turns out to be completely different** from the one **suggested** by the authors

General view of the retained attack scenario

L2CAP Misconfiguration ⇢ Arbitrary Code Execution

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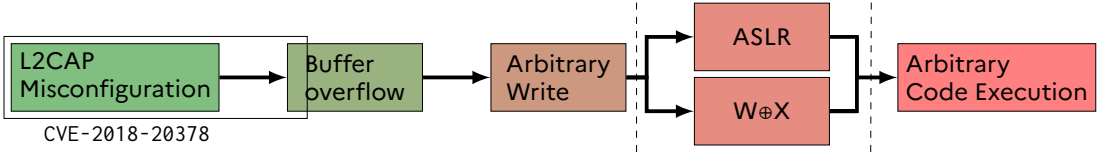
Step 1
Buffer overflow exploitation

Step 2
Bypassing security mechanisms

Step 3
Arbitrary code execution



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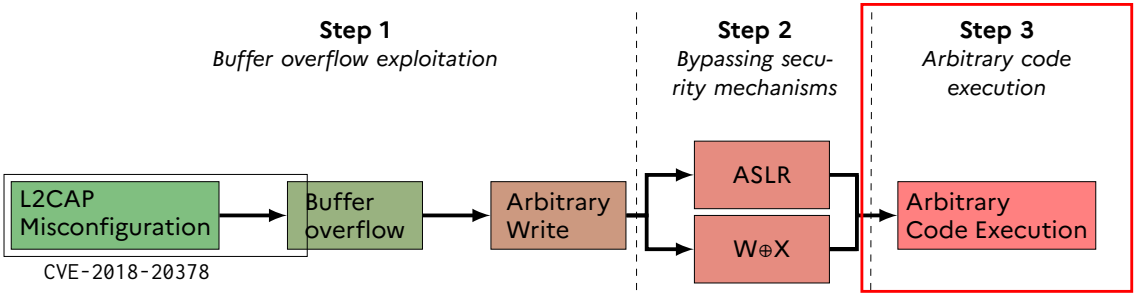
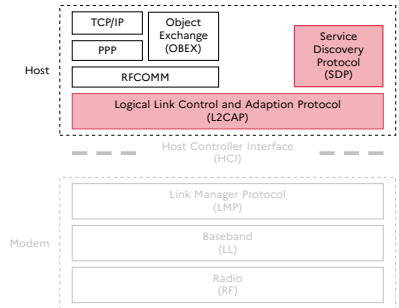


Unsecured Channel Management *(SDP only)*

Host

Device



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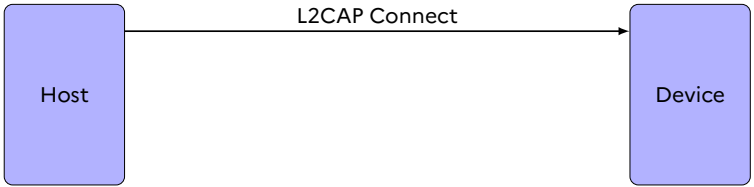

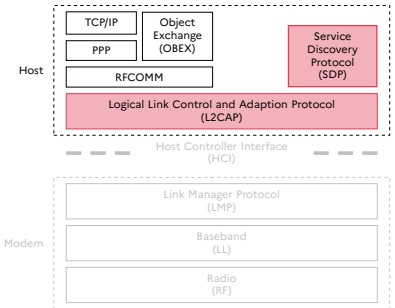

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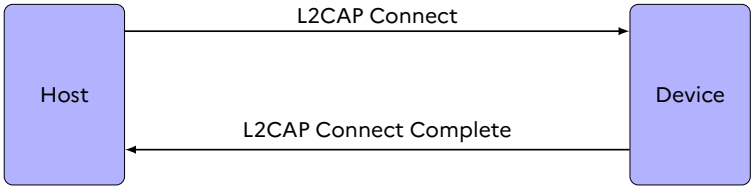

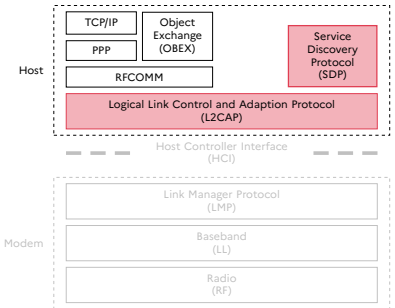

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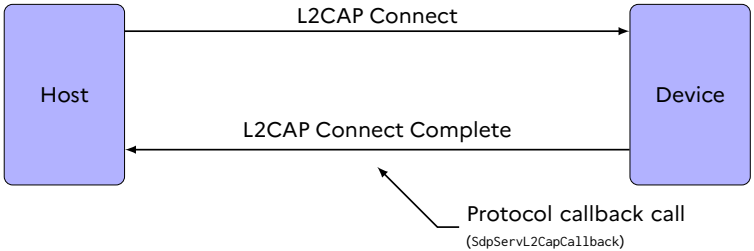

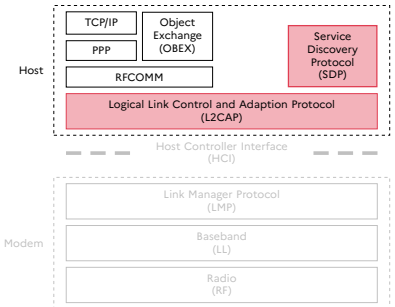

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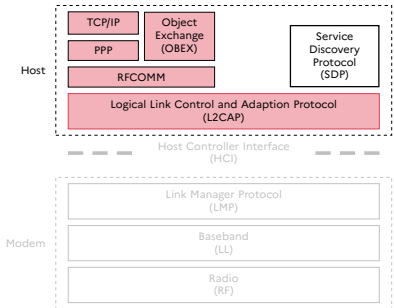

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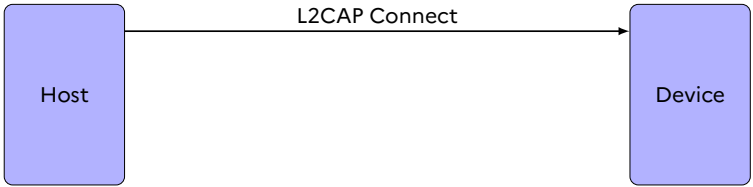

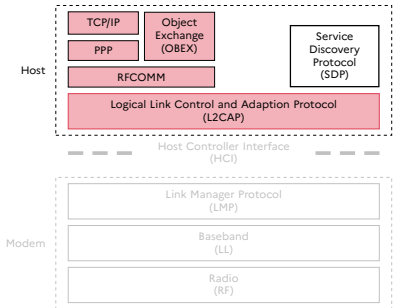

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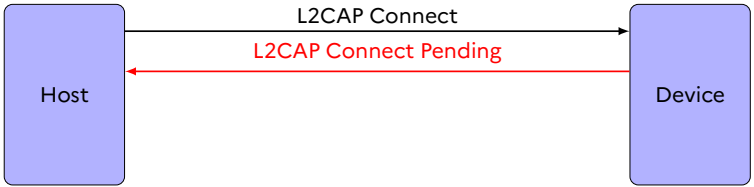

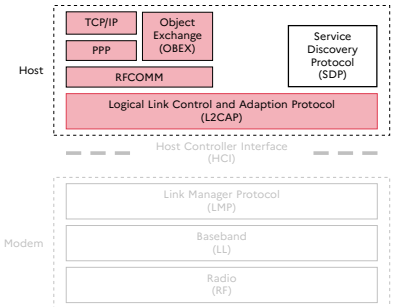

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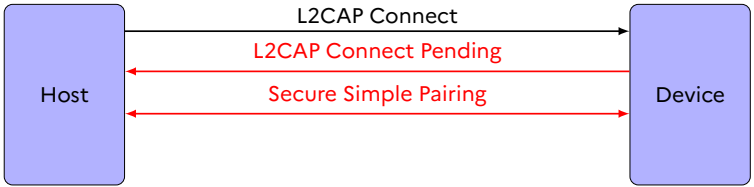

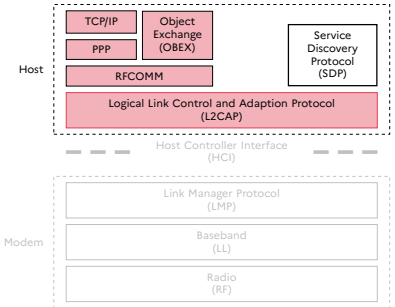

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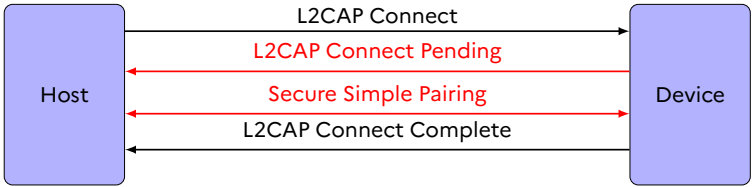

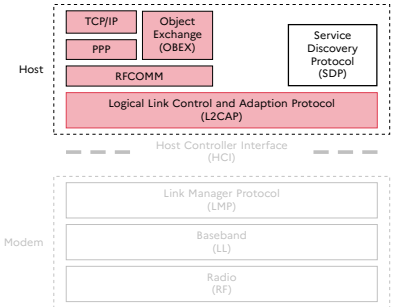

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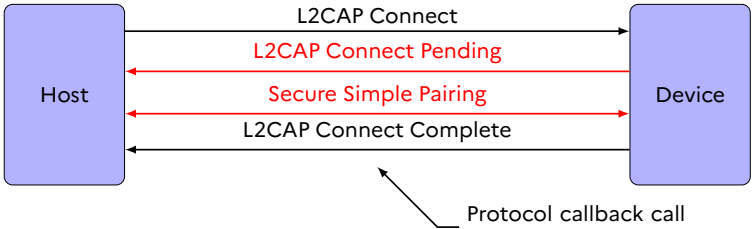

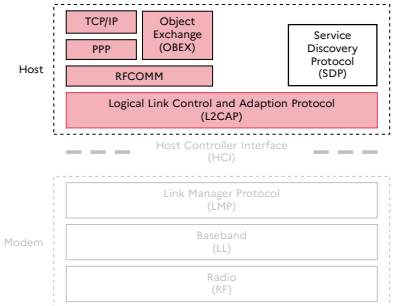

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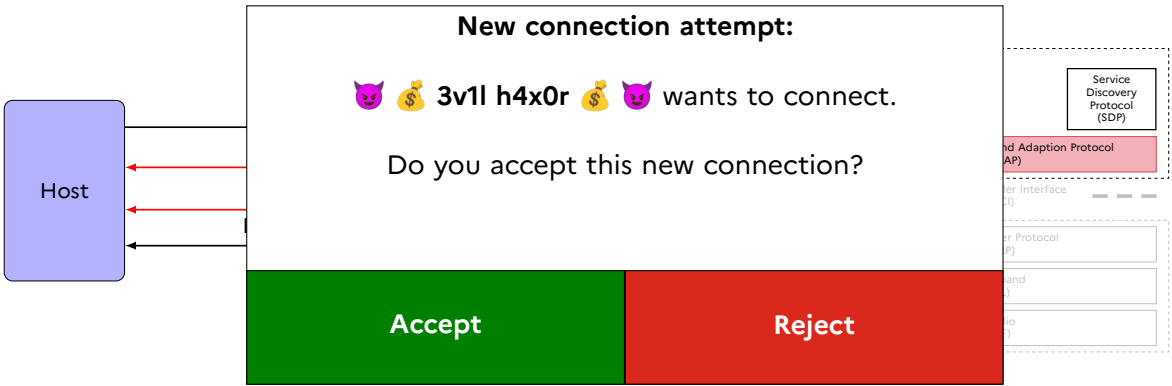

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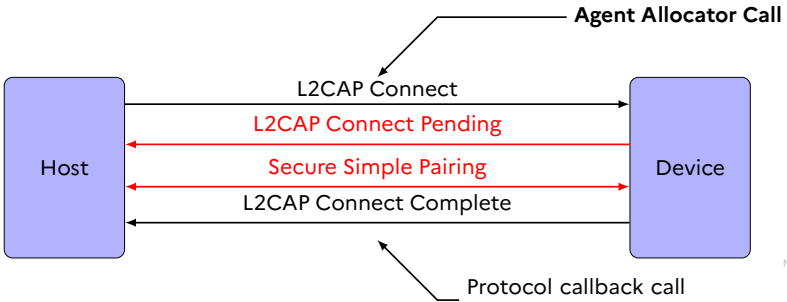

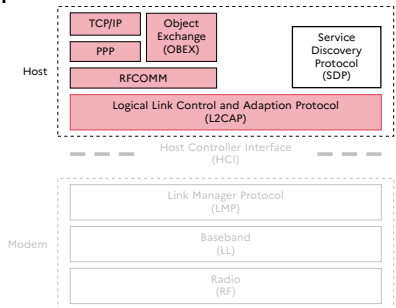

Triggering Execution

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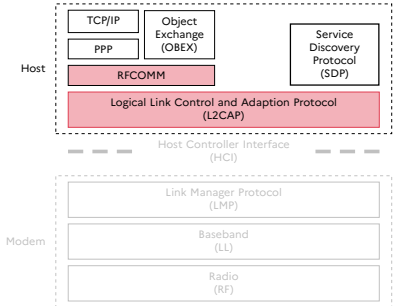

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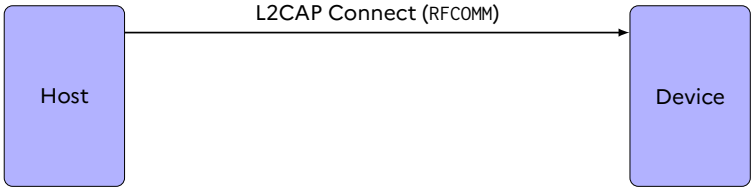

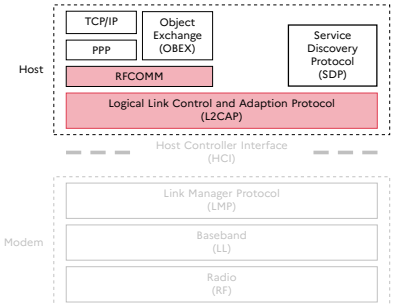

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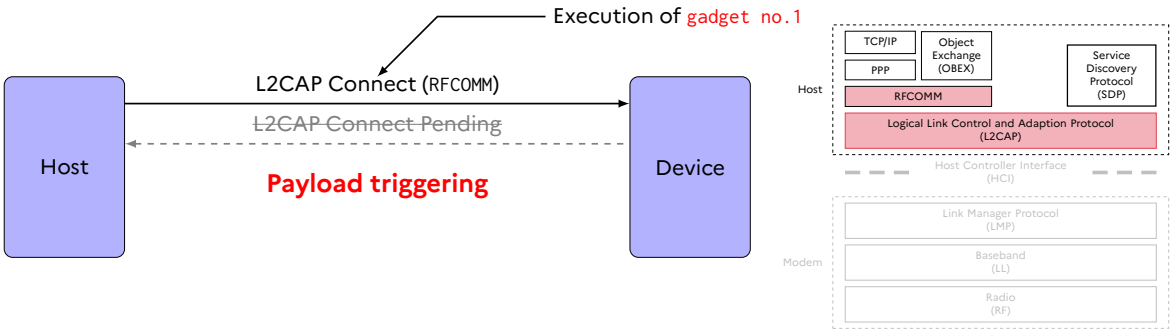

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Responsible Disclosure

- Work conducted between September 2023 and April 2024.
- The manufacturer was notified in **September 2024**.
- Positive reception and very rapid response from them.
- The manufacturer states that critical CAN commands are filtered.

This vulnerability was patched by the target vehicle manufacturer.

Conclusion

- Analysis of an embedded Bluetooth stack:
  - vehicle representative of 2020 models and **still in circulation**.
- Presence of a vulnerability referenced by `CVE-2018-20378`:
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- [illegible]
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[Much] more detail in the associated ACSW 2026 paper!

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Questions?

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Hardware and Software Architectures Lab
Paris, France

1 Introduction
2 Firmware Security Analysis
3 Remote Code Execution
4 Conclusion and Future Work