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Attacking AUTOSAR using Software and Hardware Attacks

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Riscure

Introduction

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  - Principal Security Analyst @ Riscure

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Please visit Riscure's booth for more information! ☺

Today’s Agenda

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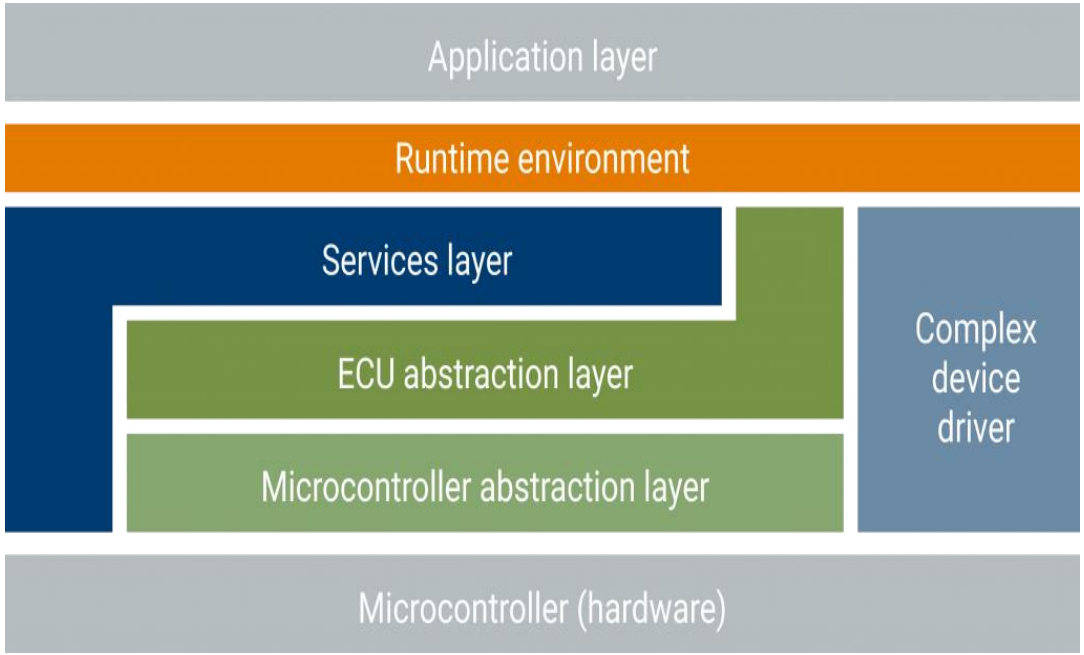
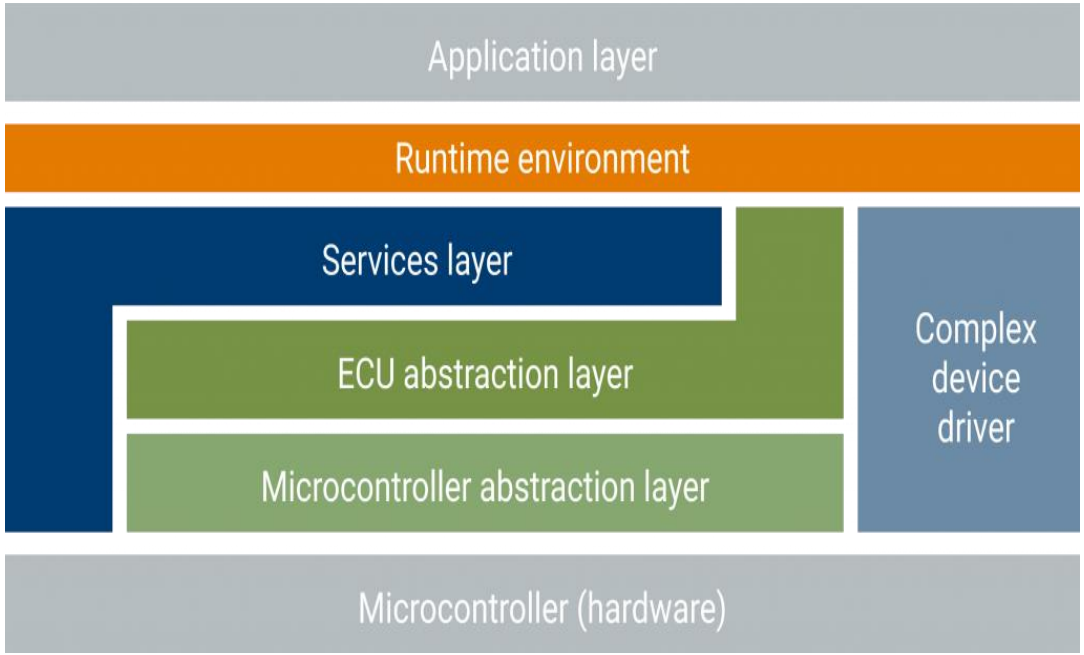
AUTOSAR Classic



AUTOSAR Classic

- Layered software architecture



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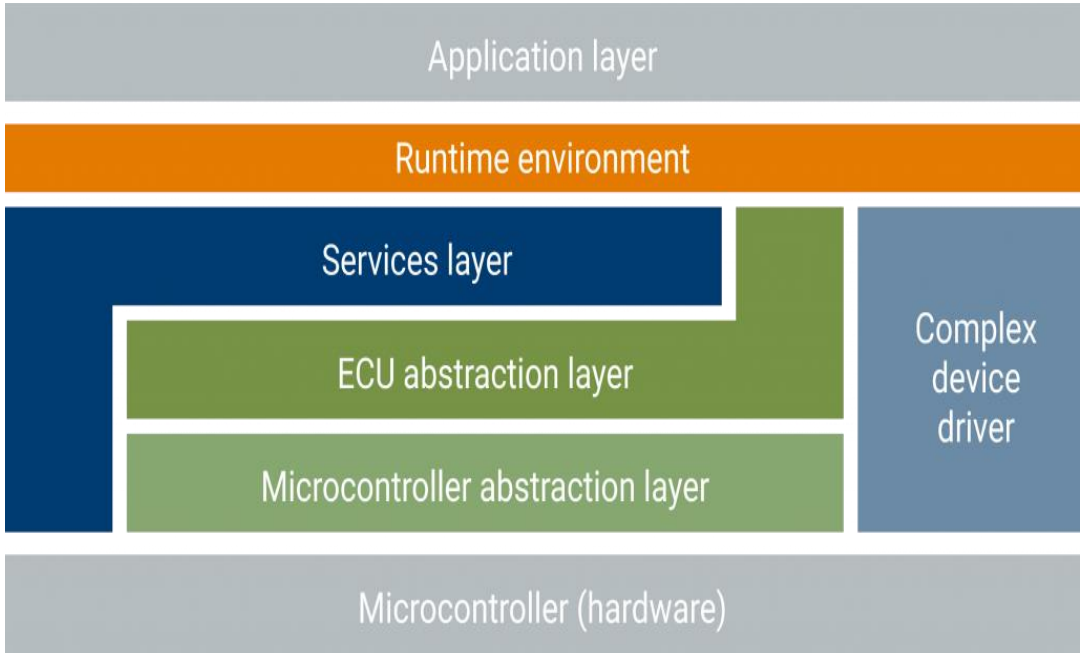
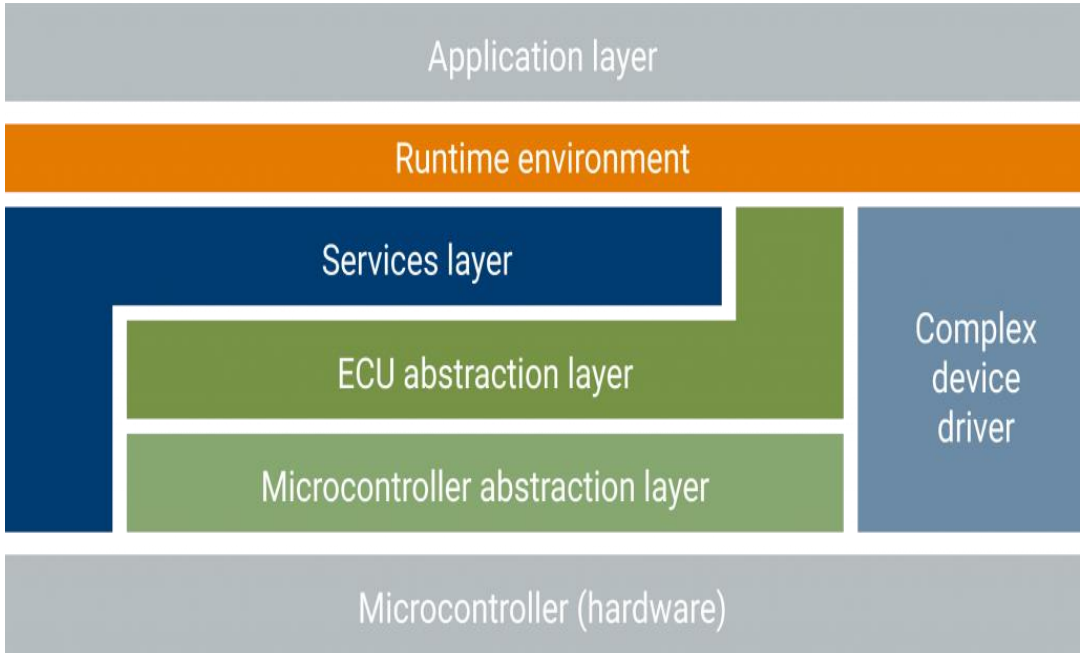


AUTOSAR Classic

- Layered software architecture
- Most layers are independent from the Microcontroller
- Improve software reusability



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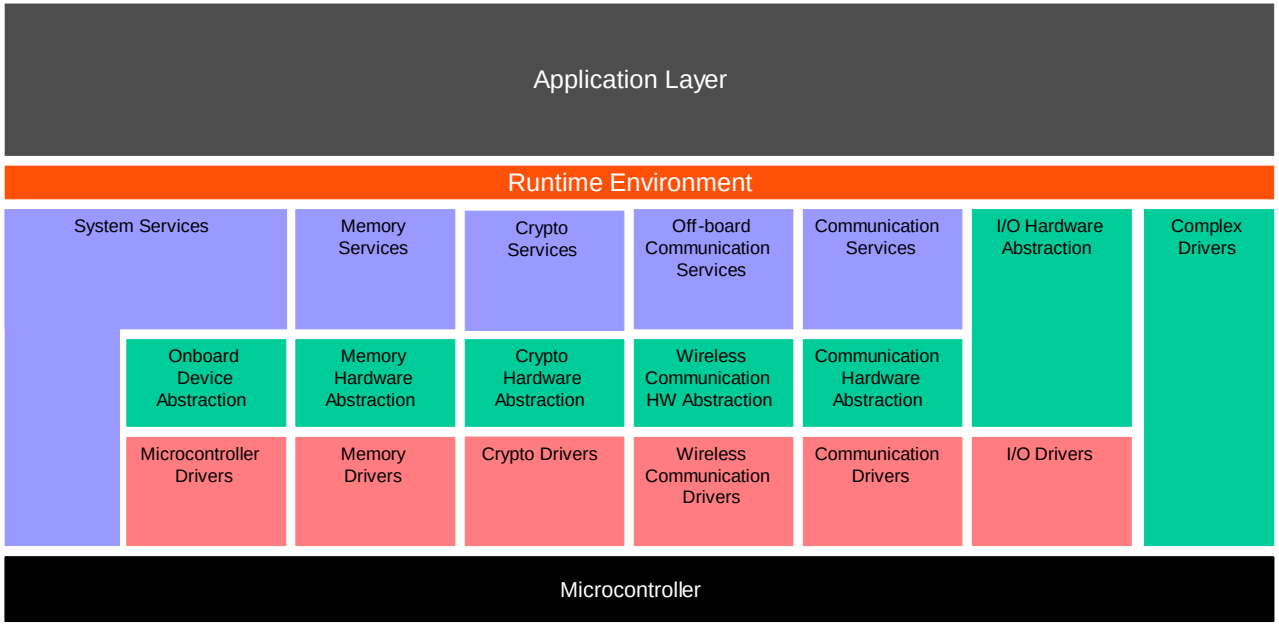

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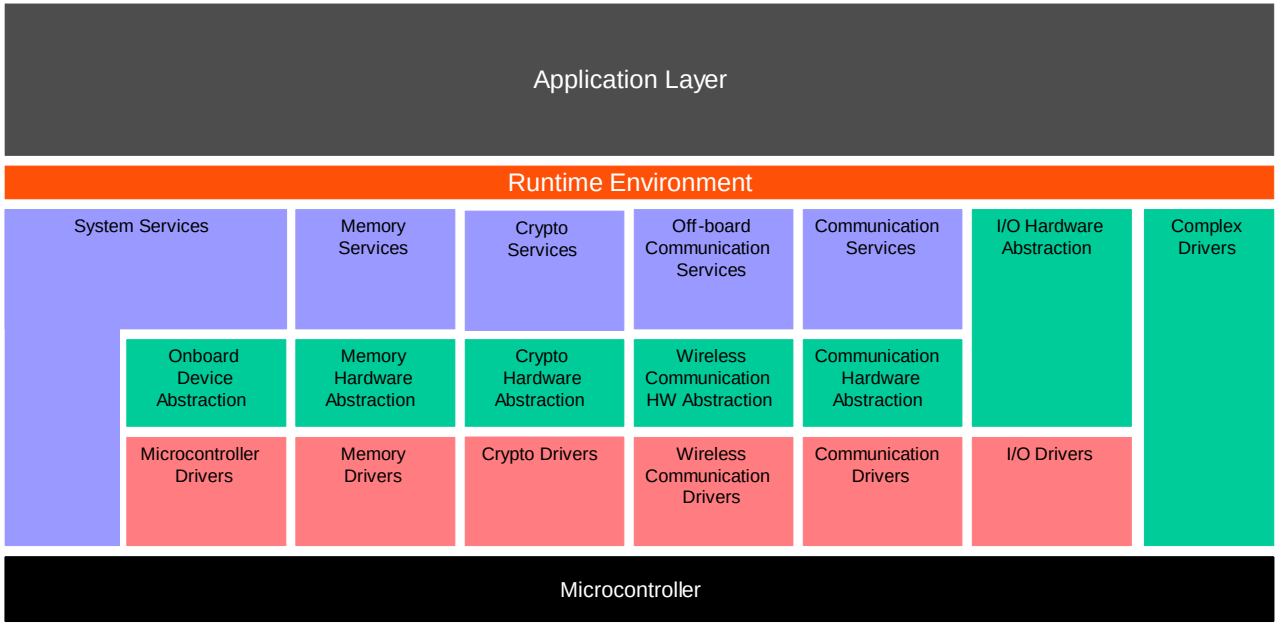

Vulnerabilities can be introduced in any layer!

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Mature! But not guaranteed secure...

What can go wrong?

Potential MCAL vulnerabilities

```
Std_ReturnType Fls_Read(    Fls_AddressType SourceAddress,
                            uint8 *TargetAddressPtr,
                            Fls_LengthType Length)
{
    if(SourceAddress == NULL || TargetAddressPtr == NULL || SourceAddress >= FLS_SIZE) {
        return E_NOT_OK;
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    /* potential integer overflow */
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Who verifies your MCAL for vulnerabilities?

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Dir 4.1	Run-time failures shall be minimized
	C90 [Undefined 15, 19, 26, 30, 31, 32, 94] C99 [Undefined 15, 16, 33, 40, 43–45, 48, 49, 113]
Category	Required
Applies to	C90, C99

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What about MISRA-C?!

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Category Required
Applies to C90, C99

A directive is a guideline for which it is not possible to provide the full description necessary to perform a check for compliance. Additional information, such as might be provided in design documents or requirements specifications, is required in order to be able to perform the check. Static analysis tools may be able to assist in checking compliance with directives but different tools may place widely different interpretations on what constitutes a non-compliance.

You cannot conform to directives automagically...

What else?

Vulnerabilities in complex software

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Who verifies your communication stack?

Mitigating software vulnerabilities

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  - *Secure coding standard, code checkers, …*
- Find vulnerabilities yourself before attackers do
  - *Continuous security code reviews, …*
- Make it harder to exploit software vulnerabilities
  - *Software exploitation mitigations, …*

Sufficiently complex software has vulnerabilities.

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Finding them is not always trivial...

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What if an attacker cannot find any
or they are too difficult to exploit?

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- Attacker needs physcial access the ECU
- Attacker often needs to open the ECU
- Different types of HW attacks:
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- Often a stepping stone for more scalable attacks

Case study: FI on AUTOSAR

“Using FI to take control of an AUTOSAR-based ECU.”

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Fault Injection? Fault model?

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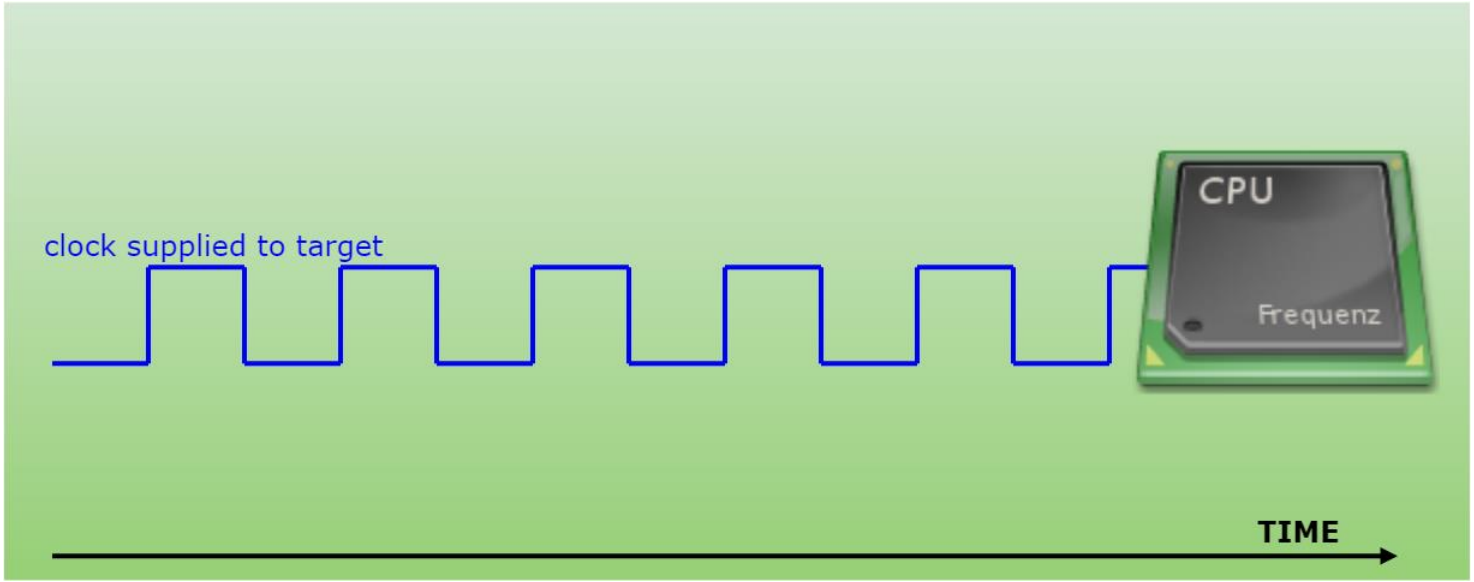

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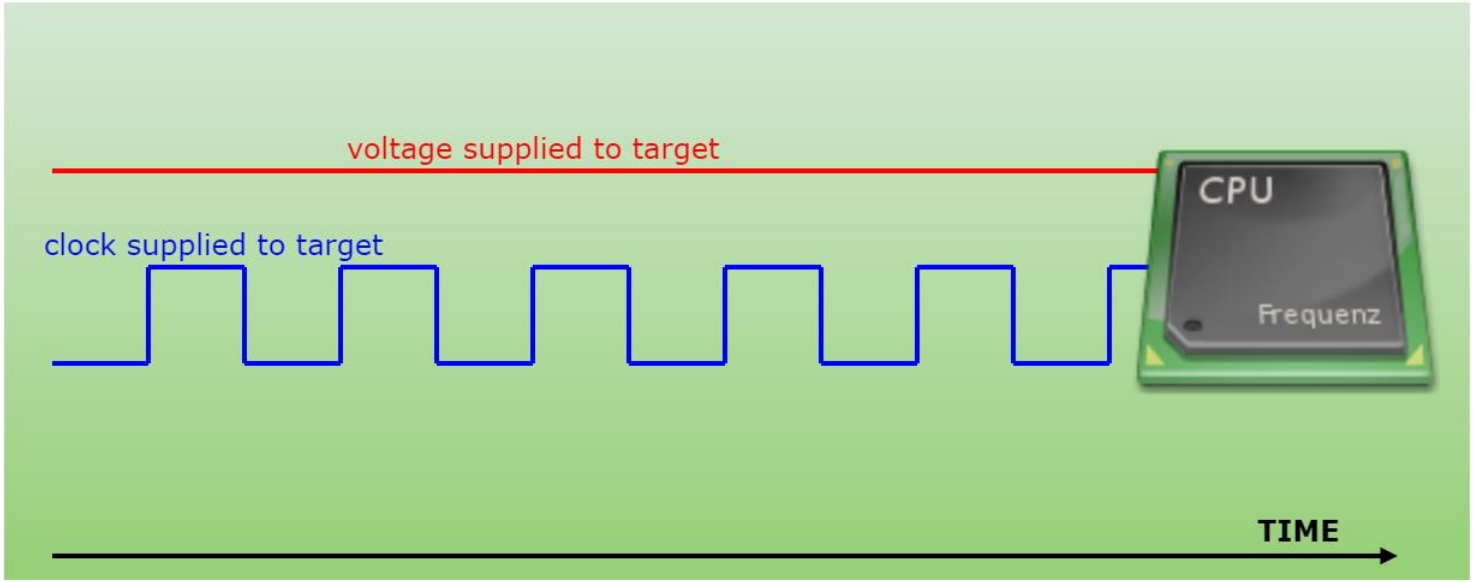

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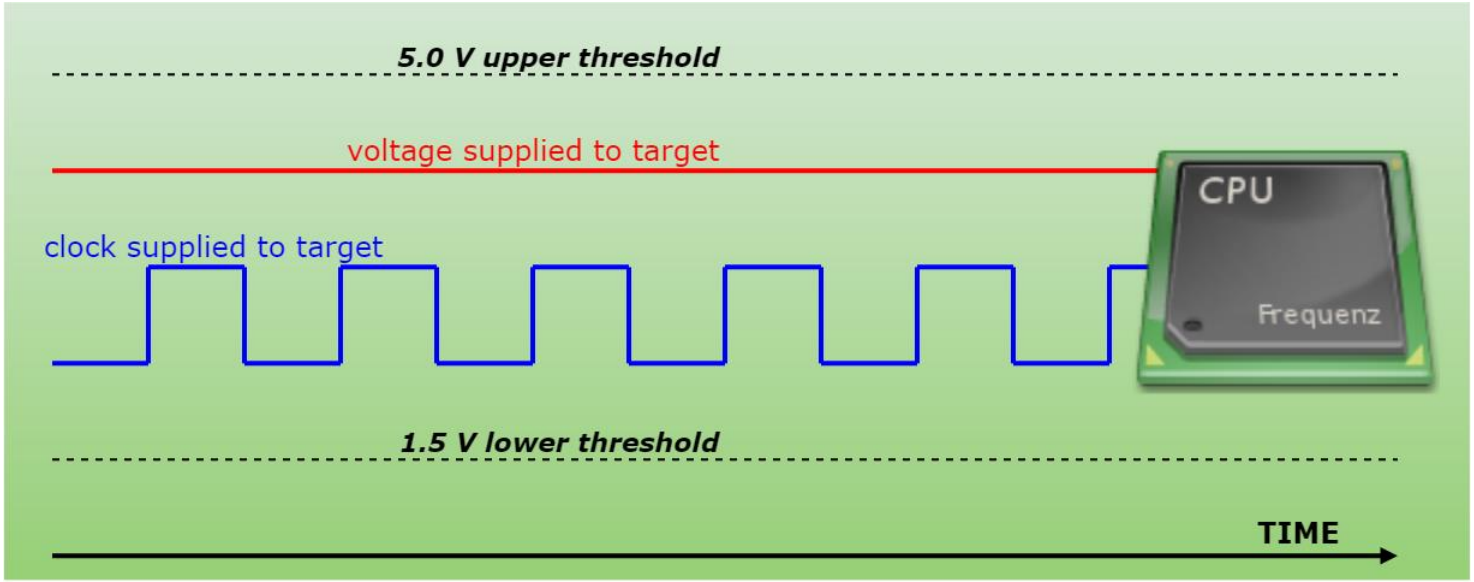

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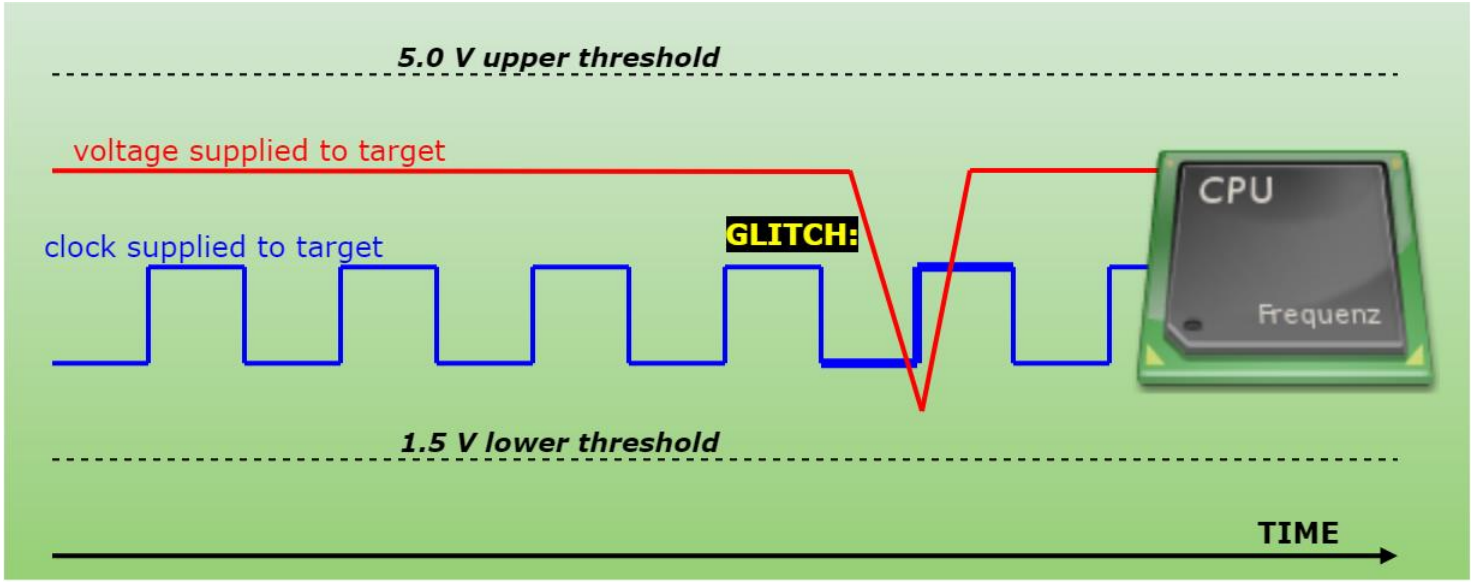

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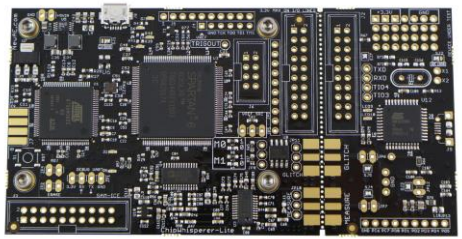

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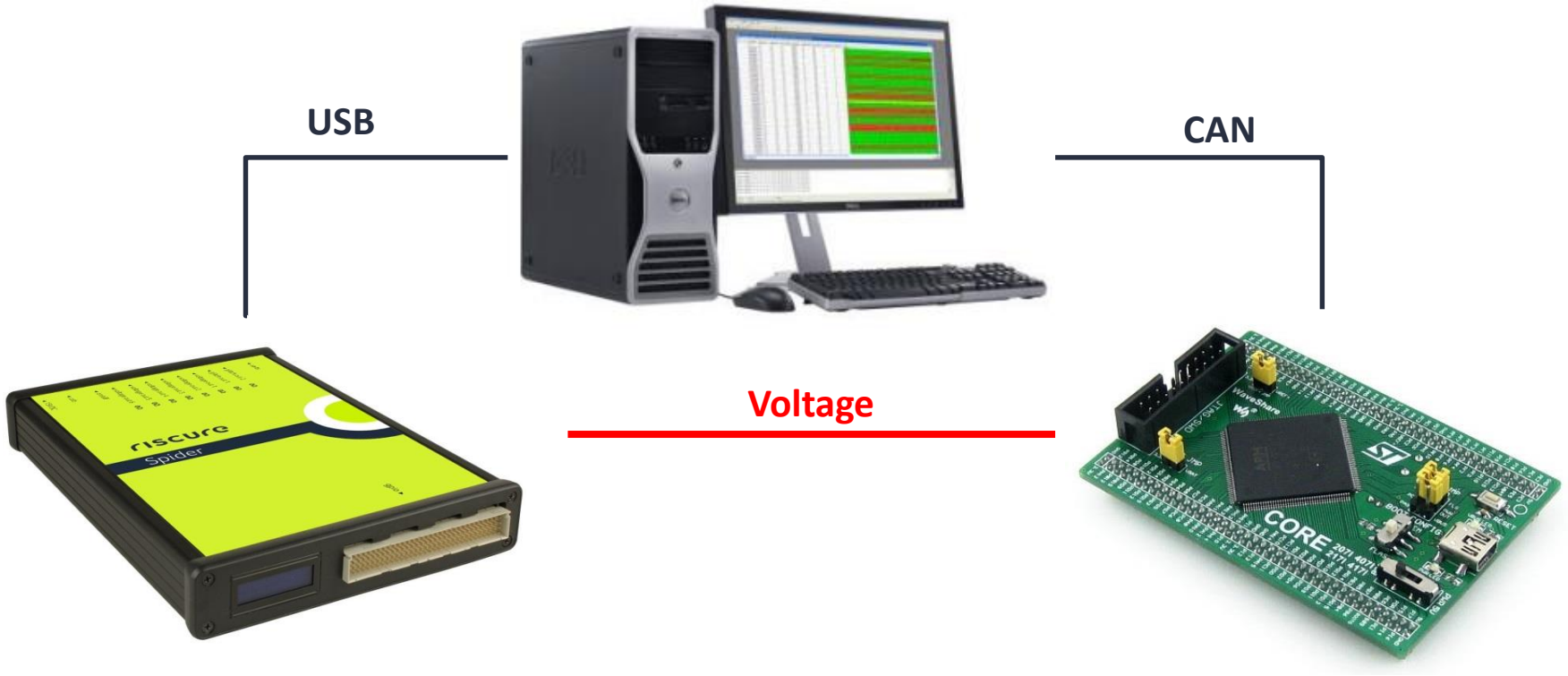


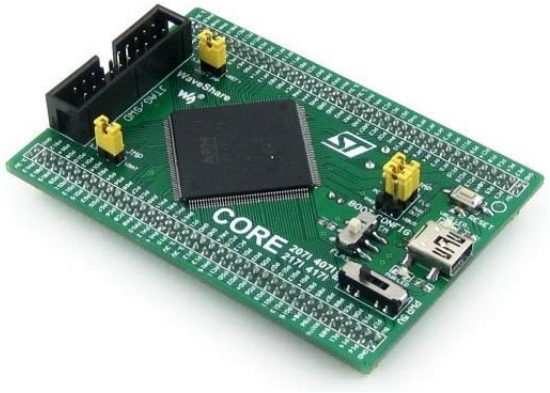
Fault Injection Setup

USB

CAN

Voltage

Reset



What can we do with fault injection?

Fault Injection Fault Model

“Instruction corruption.”

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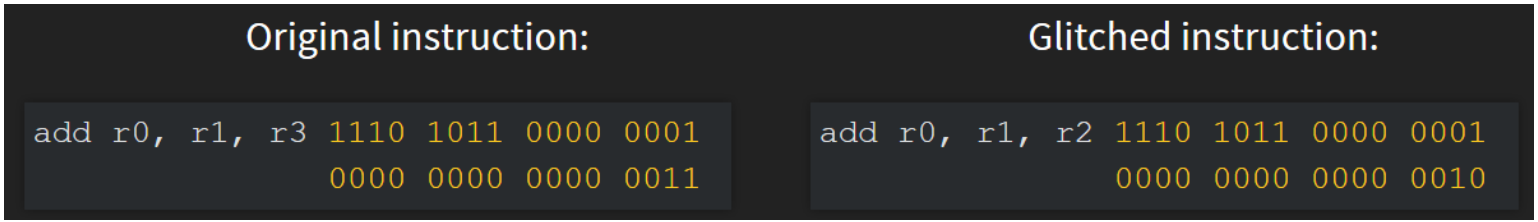

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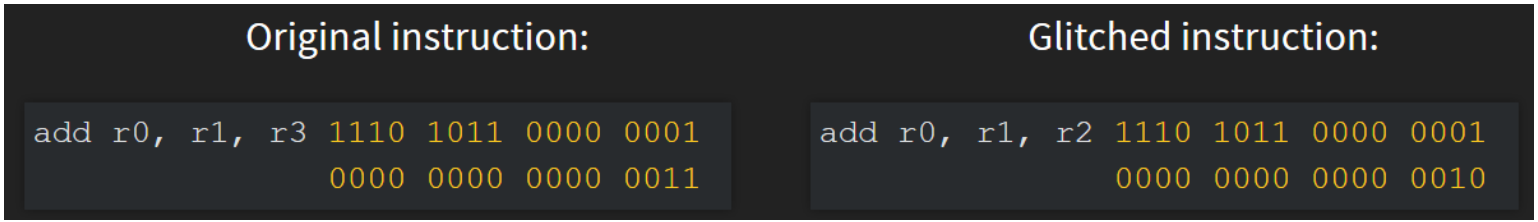

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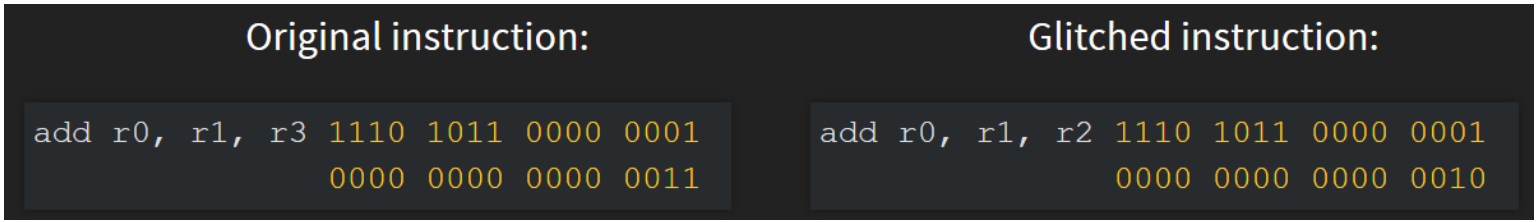

- In other words, we can modify software
- Fault injection breaks any software security model

How can we use this to attack AUTOSAR-based ECUs?

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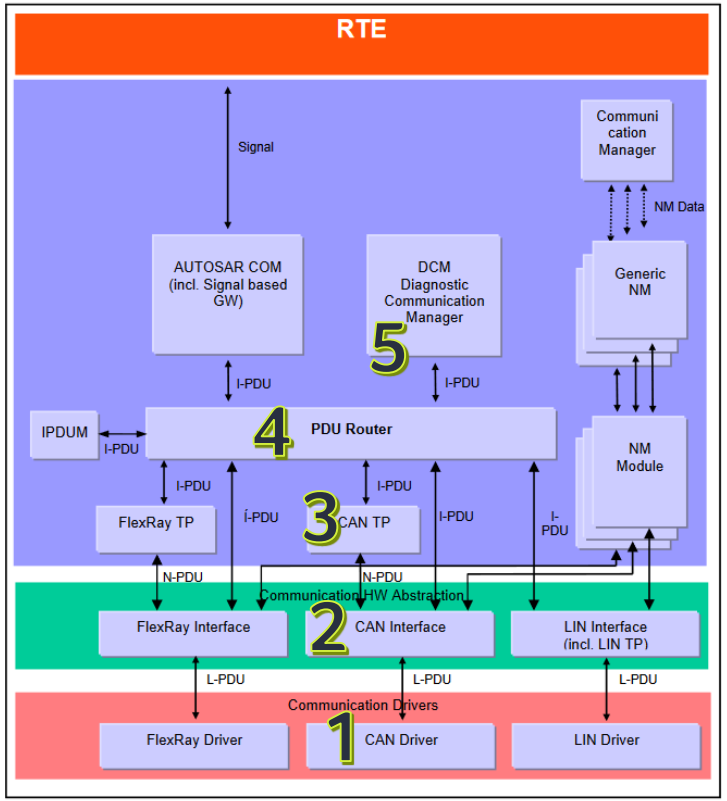
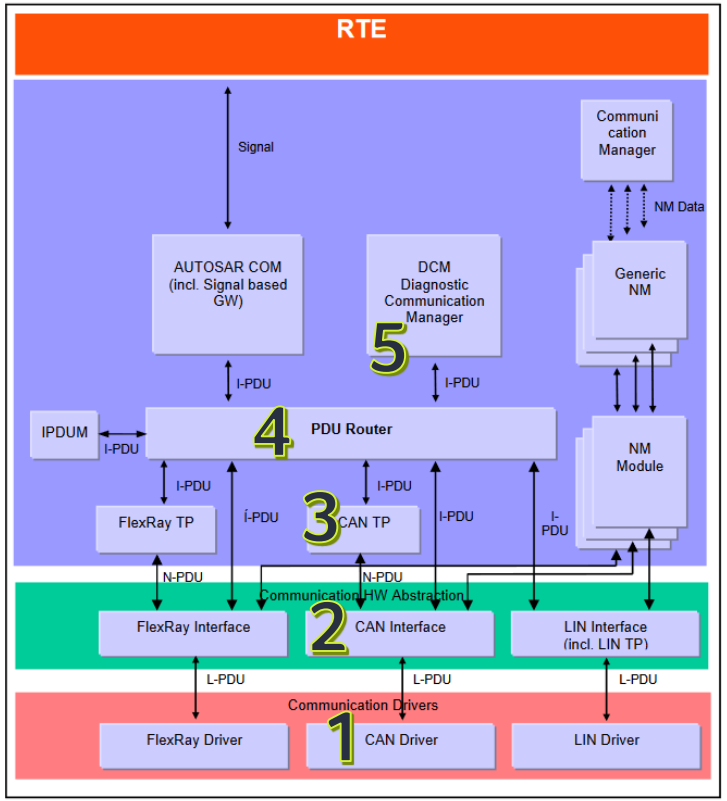
- Of course, we have physical access...

AUTOSAR's PDU Router



AUTOSAR's PDU Router

1. CAN driver receives 8-byte CAN frame



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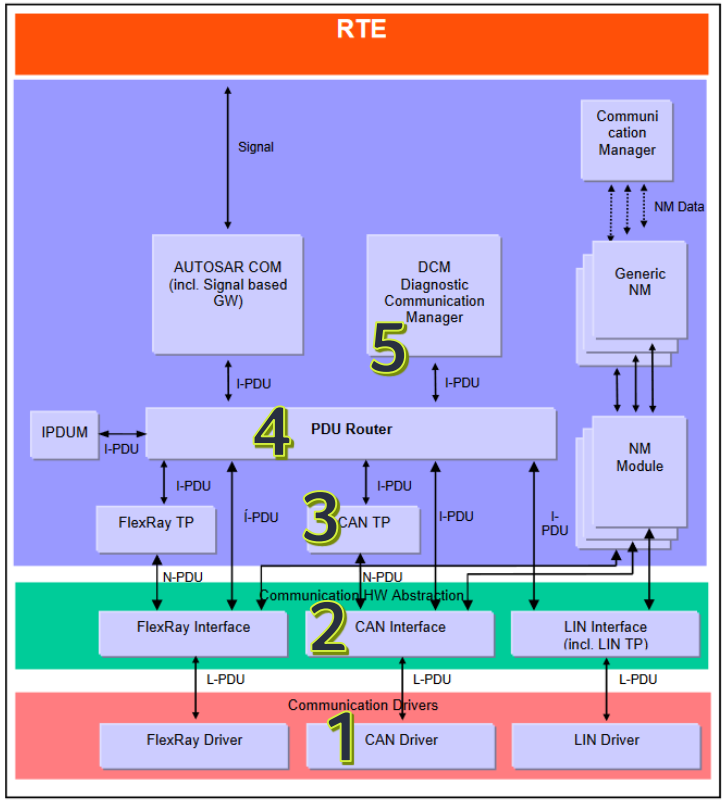

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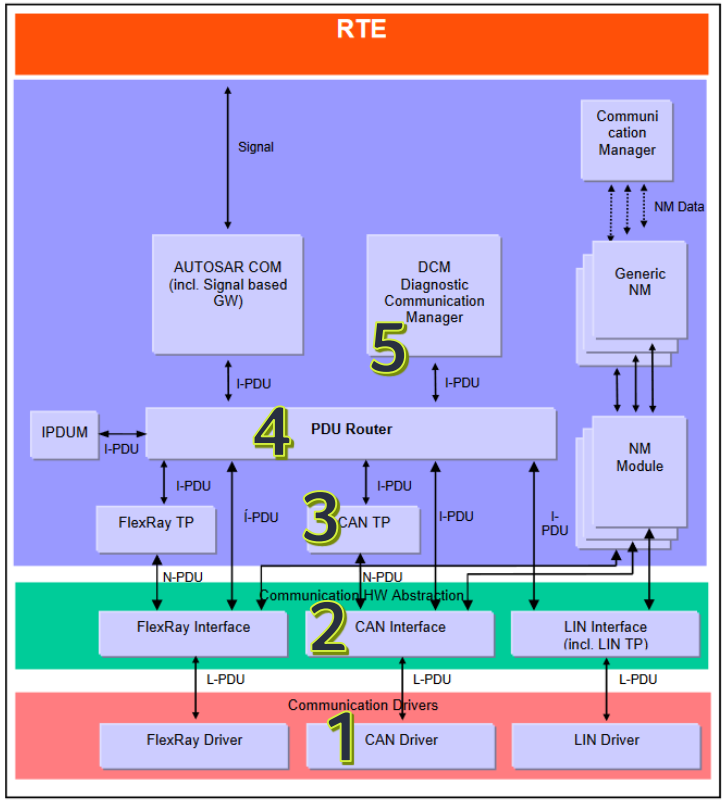

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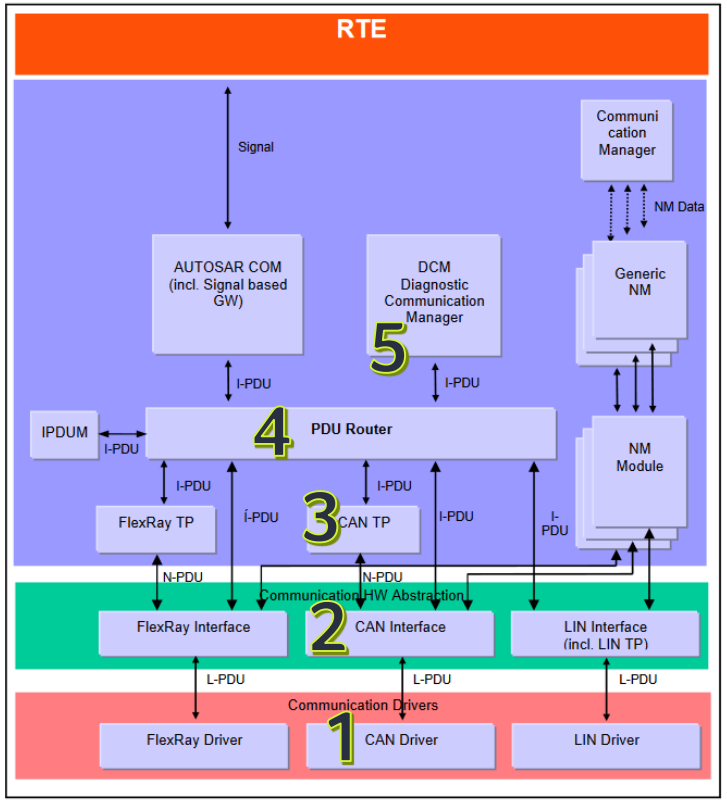

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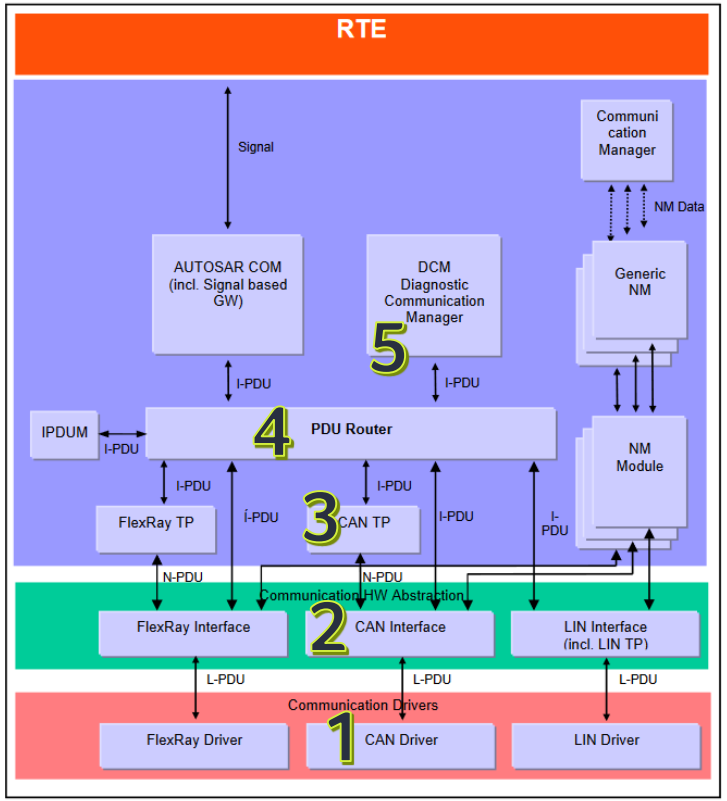

Where do we attack?!

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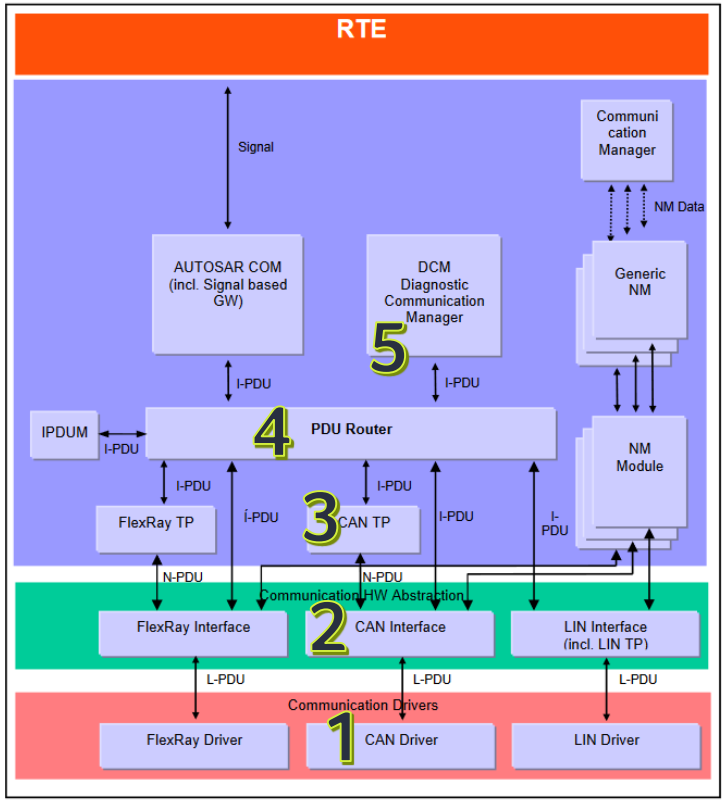

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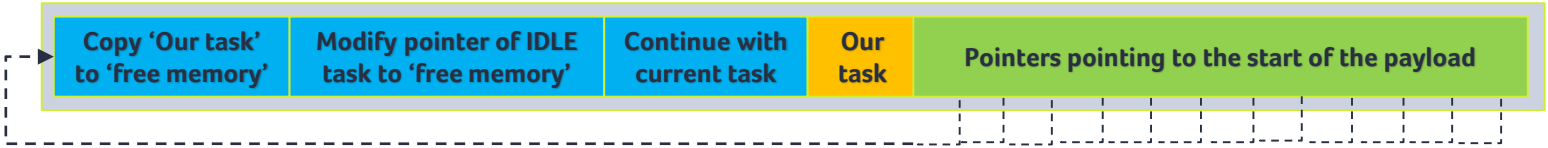

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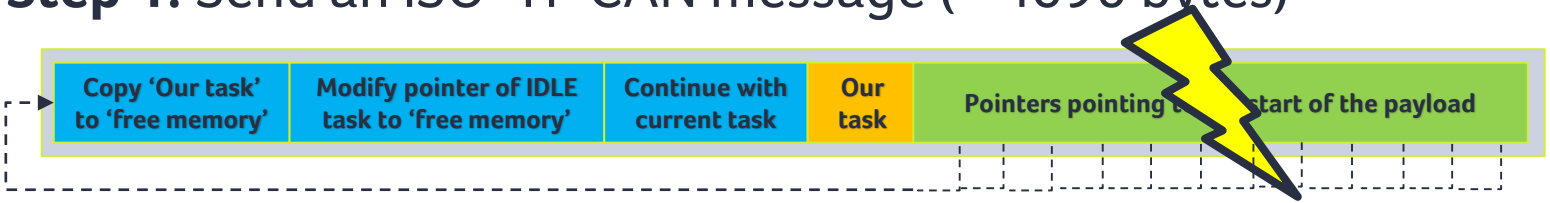

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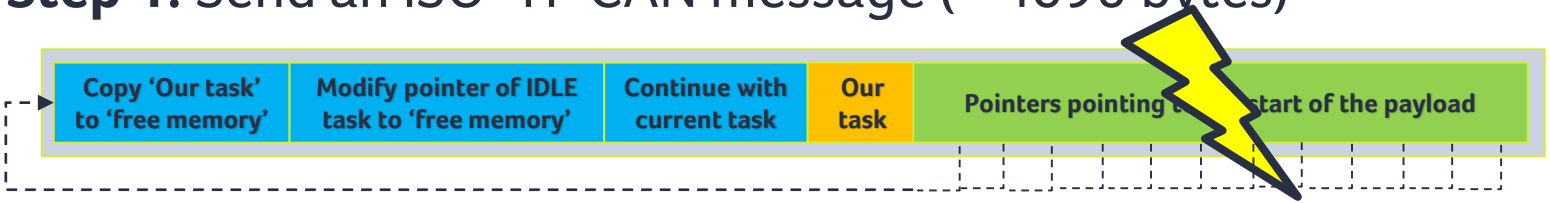

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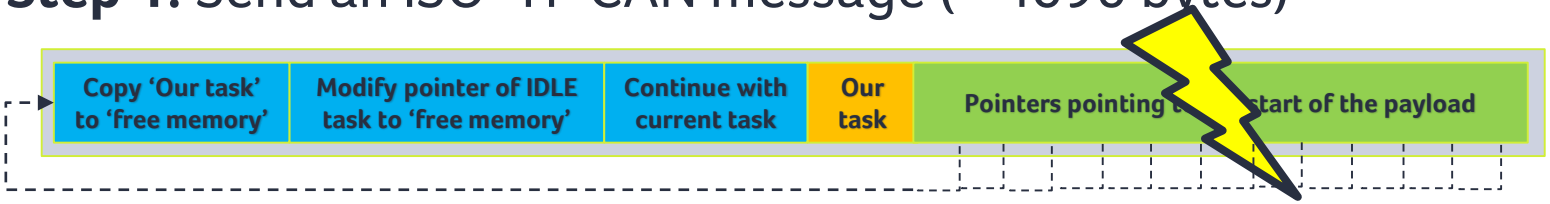

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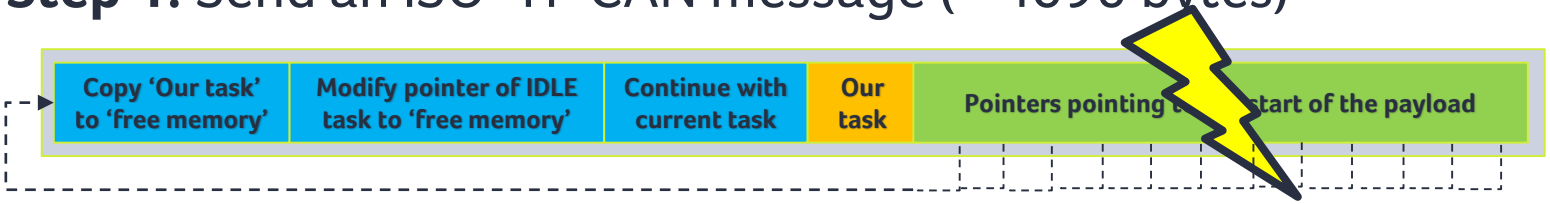

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- **Step 5:** Wait for IDLE task to be scheduled and execute our task

Why does this work?

Attacking AUTOSAR's PDU Router

```
BufReq_ReturnType PduR_CanTpCopyRxData(..., PduInfoType* p, ...) {
    ...
    memcpy(p->SduDataPtr, source, p->SduLength);
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Disassembled memcpy()

```
<memcpy>:
  mov     ip, r0
  orr.w   r3, r1, r0
  ands.w  r3, r3, #3
  bne.n   8008300 <memcpy+0xe8>
  subs    r2, #64 ; 0x40
  bcc.n   80082ac <memcpy+0x94>
  ldr.w   r3, [r1], #4
  str.w   r3, [r0], #4
  subs    r2, #64 ; 0x40
  bcs.n   8008228 <memcpy+0x10>
  adds    r2, #48 ; 0x30
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  mov     ip, r0
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  ands.w  r3, r3, #3
  bne.n   8008300 <memcpy+0xe8>
  subs    r2, #64 ; 0x40
  bcc.n   80082ac <memcpy+0x94>
  ldr.w   r3, [r1], #4
  str.w   r3, [r0], #4
  subs    r2, #64 ; 0x40
  bcs.n   8008228 <memcpy+0x10>
  adds    r2, #48 ; 0x30
  bcc.n   80082d4 <memcpy+0xbc>
```



```
<memcpy>:
  mov     ip, r0
  orr.w   r3, r1, r0
  ands.w  r3, r3, #3
  bne.n   8008300 <memcpy+0xe8>
  subs    r2, #64 ; 0x40
  bcc.n   80082ac <memcpy+0x94>
  ldr.w   pc, [r1], #4
  str.w   r3, [r0], #4
  subs    r2, #64 ; 0x40
  bcs.n   8008228 <memcpy+0x10>
  adds    r2, #48 ; 0x30
  bcc.n   80082d4 <memcpy+0xbc>
```

We take control of the Program Counter (PC) during the copy!

We have our own task. Now what?!

Post Exploitation

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- Extract information (secrets)

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- Extract information (secrets)
- Analyze firmware dynamically
- Perform additional attacks (e.g. side channel attack)
- Add (malicious) and/or change functionality

Is all hope lost?

Hardening AUTOSAR-based ECUs

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- Adhere to (automotive) security guidelines/standards

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Hardening AUTOSAR-based ECUs

- Adhere to (automotive) security guidelines/standards
- Make use of strong (hardware-based) security
- Minimize attack surface and increase attack complexity
- Consult internal/external embedded security experts

To wrap up...

Takeaways

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- Devices (incl. AUTOSAR-based ECUs) will be hacked

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- Devices (incl. AUTOSAR-based ECUs) will be hacked
  - Not AUTOSAR's fault!
- No (known) software vulnerabilities ≠ secure
- Hardware attacks are efficient and do scale

Thank you. Questions?

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Challenge your security