Automotive ECU

Secure CAN Communication

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HiPEAC

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Manchester (UK)

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SAFURE

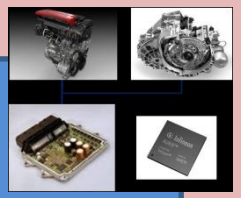
SAFety and secURity by dEsign for interconnected mixed-critical cyber-physical systems

Automotive Demonstrator

SAFURE FRAMEWORK

Modelling & integrity algorithms

SAFETY



Automotive multi-core Dem
Powertrain multicore ECU with **hard real-time**, **safety**, and **security** requirements. Function **consolidation** to reduce costs, complexity, and time-to-market

Run-time Systems

SECURITY

Powertrain Multicore ECU – technical features

- **Support mixed-critical ECU to reduce cost**
  - Engine Ctrl – Automated Manual Transmission Ctrl
- **Data Protection**
  - Compliancy with *ISO-26262*
- **OS extensions**
  - Timing and memory protection for *Infineon Aurix SW/FW multi-core Architecture and ERIKA OS*

- **Data Integrity on Inter-ECU communications**
  - Prevent attacks through ECU communication channels
- **Timing analysis**
  - Performance and CPU load calculation
  - WCET estimation

Automotive Multicore ECU – main goals

- **SAFE - Freedom of interferences**: timing protection and memory protection at firmware level – alternative to OS implementation: lower costs
- **SECURE - communication on CAN:** guarantee security requirements
- **Mixed – Criticalities** - Exploitation of Multicore to **reduce the number of control units**: reduction of complexity, costs and time-to-market

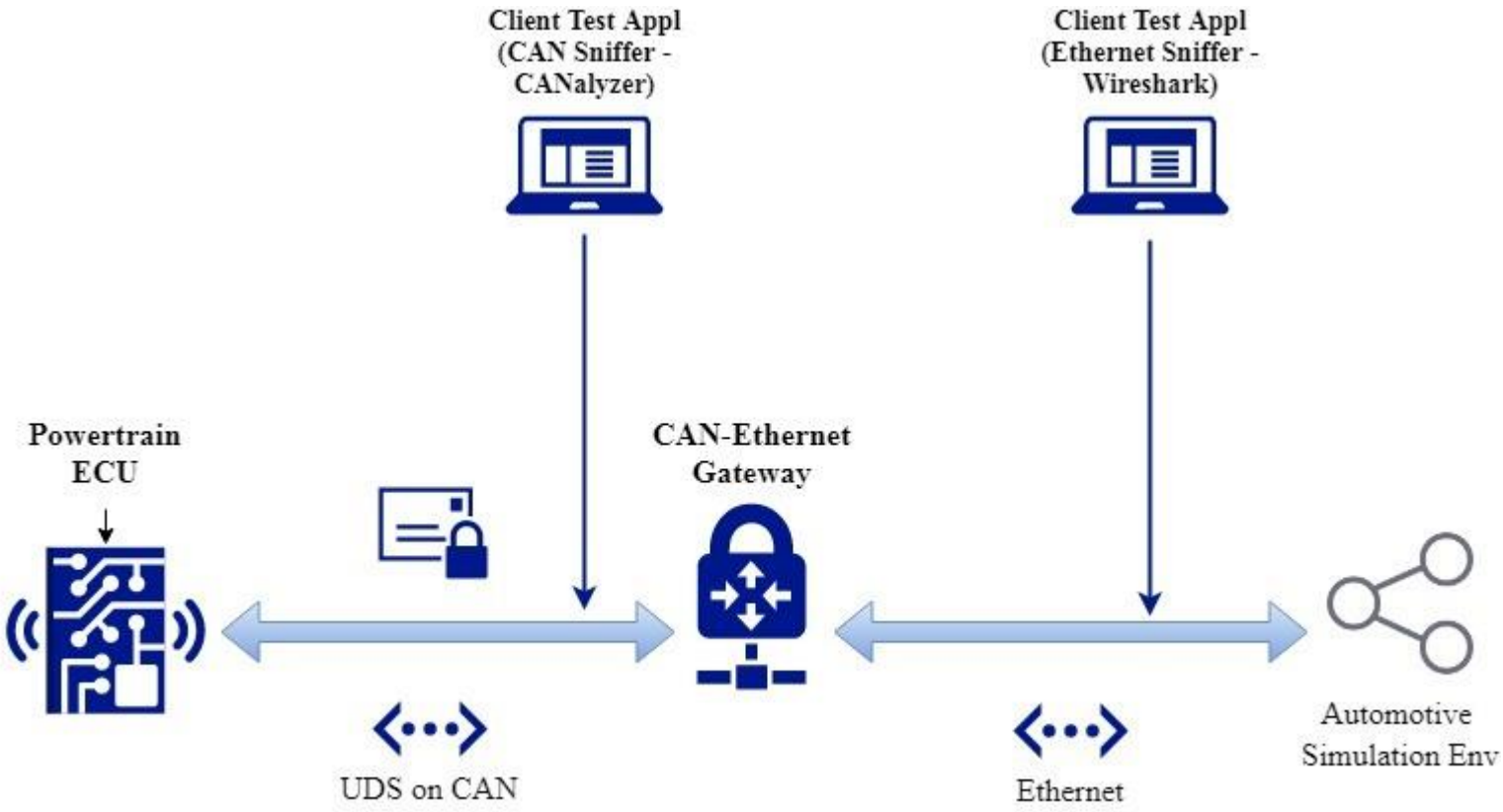
Secure communication details – ECU side

- **Functional classification of messages supported**
- **Cyclic activation (period of 10-20-100 ms)**
- **Error handling implementing**
  - **Detection of corrupted messages -> logging and diagnosis activation**

Message categories

Category A Message	Encrypted and signed message	AES-GCM	20ms
Category B Message	Signed message	HMAC-SHA256	10ms
Category C Message	Clear message		100ms

Communication scenario



Category B Massages TESTS

TEST succeeded

- Emulator view: 4 completed messages transmitted and this is last message

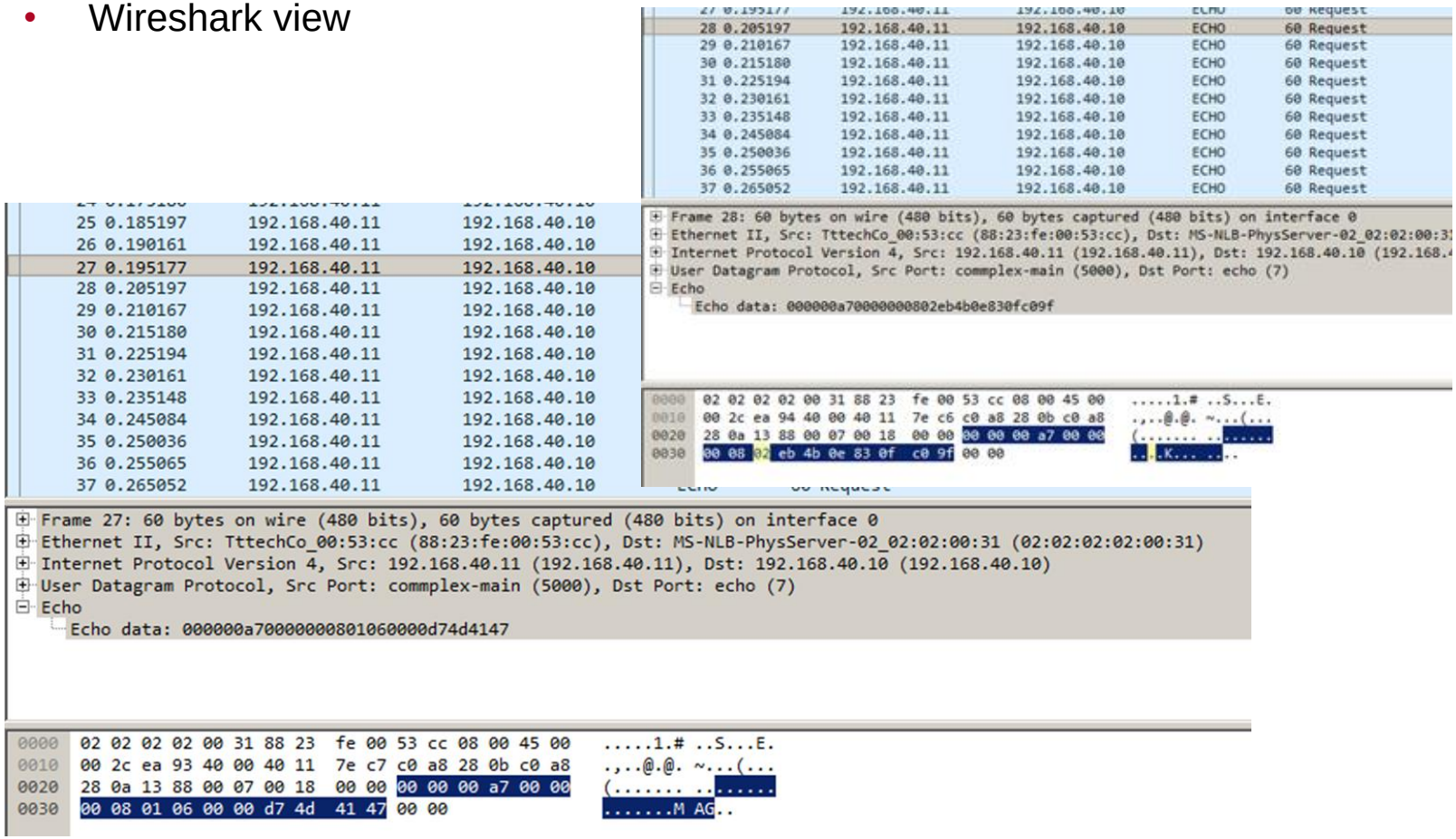
Message content on CAN

- ECU (Message ID - A7 -- RX)
- CANalyzer view (Message ID - A7 -- TX)

0.009337	CAN 1 A7	CAN Frame	Rx	8	8	01 06 00 00 FF 4D 41 47
0.000733	CAN 1 B2	CAN Frame	Tx	8	8	01 06 00 00 FF 4D 41 47
0.009260	CAN 1 A7	CAN Frame	Rx	8	8	02 F2 09 16 19 9B 1F B4
0.000678	CAN 1 B2	CAN Frame	Tx	8	8	02 F2 09 16 19 9B 1F B4
0.009327	CAN 1 A7	CAN Frame	Rx	8	8	03 6F 4A 79 80 B3 59 58
0.000709	CAN 1 B2	CAN Frame	Tx	8	8	03 6F 4A 79 80 B3 59 58
0.009295	CAN 1 A7	CAN Frame	Rx	8	8	04 36 94 55 55 55 55 55
0.000644	CAN 1 B2	CAN Frame	Tx	8	8	04 36 94 55 55 55 55 55
0.009381	CAN 1 A7	CAN Frame	Rx	8	8	01 06 00 00 00 4D 41 47
0.000735	CAN 1 B2	CAN Frame	Tx	8	8	01 06 00 00 00 4D 41 47
0.009258	CAN 1 A7	CAN Frame	Rx	8	8	02 6D 42 9A F3 EE C5 D6
0.000646	CAN 1 B2	CAN Frame	Tx	8	8	02 6D 42 9A F3 EE C5 D6
0.009363	CAN 1 A7	CAN Frame	Rx	8	8	03 DE 11 02 E2 2C 69 BA
0.000719	CAN 1 B2	CAN Frame	Tx	8	8	03 DE 11 02 E2 2C 69 BA
0.009282	CAN 1 A7	CAN Frame	Rx	8	8	04 E8 8F 55 55 55 55 55
0.000719	CAN 1 B2	CAN Frame	Tx	8	8	04 E8 8F 55 55 55 55 55
0.009303	CAN 1 A7	CAN Frame	Rx	8	8	01 06 00 00 01 4D 41 47
0.000731	CAN 1 B2	CAN Frame	Tx	8	8	01 06 00 00 01 4D 41 47
0.009262	CAN 1 A7	CAN Frame	Rx	8	8	02 BD AA D4 F1 2F BD 9D
0.000622	CAN 1 B2	CAN Frame	Tx	8	8	02 BD AA D4 F1 2F BD 9D
0.009387	CAN 1 A7	CAN Frame	Rx	8	8	03 9A 86 19 4D B1 1D FE
0.000721	CAN 1 B2	CAN Frame	Tx	8	8	03 9A 86 19 4D B1 1D FE
0.009284	CAN 1 A7	CAN Frame	Rx	8	8	04 A3 33 55 55 55 55 55
0.000606	CAN 1 B2	CAN Frame	Tx	8	8	04 A3 33 55 55 55 55 55
0.009414	CAN 1 A7	CAN Frame	Rx	8	8	01 06 00 00 02 4D 41 47
0.000721	CAN 1 B2	CAN Frame	Tx	8	8	01 06 00 00 02 4D 41 47
0.009275	CAN 1 A7	CAN Frame	Rx	8	8	02 B0 28 71 52 46 09 AE
0.000576	CAN 1 B2	CAN Frame	Tx	8	8	02 B0 28 71 52 46 09 AE
0.009429	CAN 1 A7	CAN Frame	Rx	8	8	03 7E E3 1C 67 02 1E 07
0.000723	CAN 1 B2	CAN Frame	Tx	8	8	03 7E E3 1C 67 02 1E 07
0.009280	CAN 1 A7	CAN Frame	Rx	8	8	04 25 E4 55 55 55 55 55
0.000584	CAN 1 B2	CAN Frame	Tx	8	8	04 25 E4 55 55 55 55 55

Message content on Ethernet

- Wireshark view



Can side (traces)

- ECU (Message ID - A7 -- RX)
- CANalyzer (Message ID - B2 -- TX)

0.009407	CA...	A7	CAN Frame	Rx	8	8	01 06 00 00 A4 4D 41 47
0.000731	CA...	B2	CAN Frame	Tx	8	8	01 06 00 00 A4 4D 41 47
0.009258	CA...	A7	CAN Frame	Rx	8	8	02 5B 62 57 12 81 1F C5
0.000598	CA...	B2	CAN Frame	Tx	8	8	02 5B 62 57 12 81 1F C5
0.009405	CA...	A7	CAN Frame	Rx	8	8	03 B9 EE 2E 97 DE 23 5C
0.000721	CA...	B2	CAN Frame	Tx	8	8	03 B9 EE 2E 97 DE 23 5C
0.009314	CA...	A7	CAN Frame	Rx	8	8	04 07 93 55 55 55 55 55
0.000721	CA...	B2	CAN Frame	Tx	8	8	04 07 93 55 55 55 55 55
0.009291	CA...	A7	CAN Frame	Rx	8	8	01 06 00 00 A5 4D 41 47
0.000731	CA...	B2	CAN Frame	Tx	8	8	01 06 00 00 A5 4D 41 47
0.009266	CA...	A7	CAN Frame	Rx	8	8	02 66 7C 6E A5 C9 B9 6E
0.000550	CA...	B2	CAN Frame	Tx	8	8	02 66 7C 6E A5 C9 A5 6E
0.009457	CA...	A7	CAN Frame	Rx	8	8	03 B9 EF 77 60 6C 17 9A
0.000721	CA...	B2	CAN Frame	Tx	8	8	03 B9 EF 77 60 6C 17 9A
0.009286	CA...	A7	CAN Frame	Rx	8	8	04 6F FD 55 55 55 55 55
0.000514	CA...	B2	CAN Frame	Tx	8	8	04 6F FD 55 55 55 55 55

Man in the middle attack

- **Corrupted signature**
- **Wrong «Error counter» ------→**

B::Var.Watch (on ibol1u18)

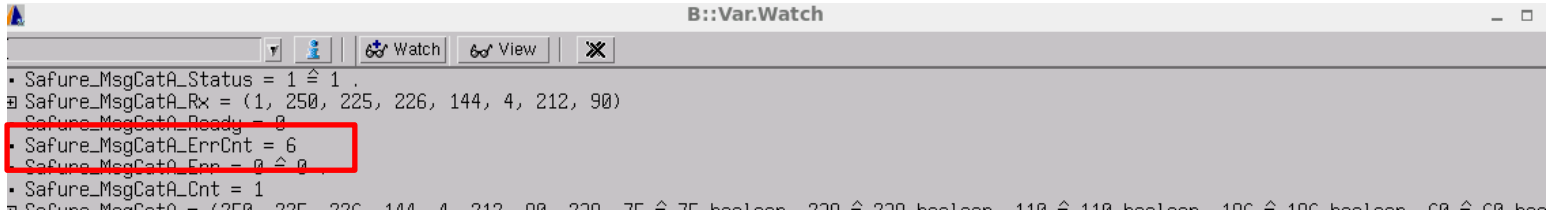
Watch View

```
⊞ Safure_Motor_11_Buffer = (0x6, 0x0, 0x0, 0xA6, 0x4D, 0x41, 0x47, 0x3D, 0xC5, 0x98, 0x25, 0xD6, 0x74, 0x7C, 0x89, 0xAD, 0x
⊞ Safure_Sign_Buffer = (0x66, 0x7C, 0x6E, 0xA5, 0xC9, 0xB9, 0x6E, 0xB9, 0xEF, 0x77, 0x60, 0x6C, 0x17, 0x9A, 0x6F, 0xFD)
▪ Safure_MsgCatB_Status = 1 ^ 1 .
⊞ Safure_MsgCatB_Rx = (0x4, 0x6F, 0xFD, 0x55, 0x55, 0x55, 0x55, 0x55)
▪ Safure_MsgCatB_Ready = 0
▪ Safure_MsgCatB_ErrCnt = 104
▪ Safure_MsgCatB_Err = 0 ^ 0 .
▪ Safure_MsgCatB_Cnt = 0
⊞ Safure_MsgCatB = (0x6, 0x0, 0x0, 0xA5, 0x4D, 0x41, 0x47, 0x66, 0x7C, 0x6E, 0xA5, 0xC9, 0xA5, 0x6E, 0xB9, 0xEF, 0x77, 0x60
▪ Safure_Motor_11_FrameCnt = 0
▪ Safure_CntMsg11 = 167
```

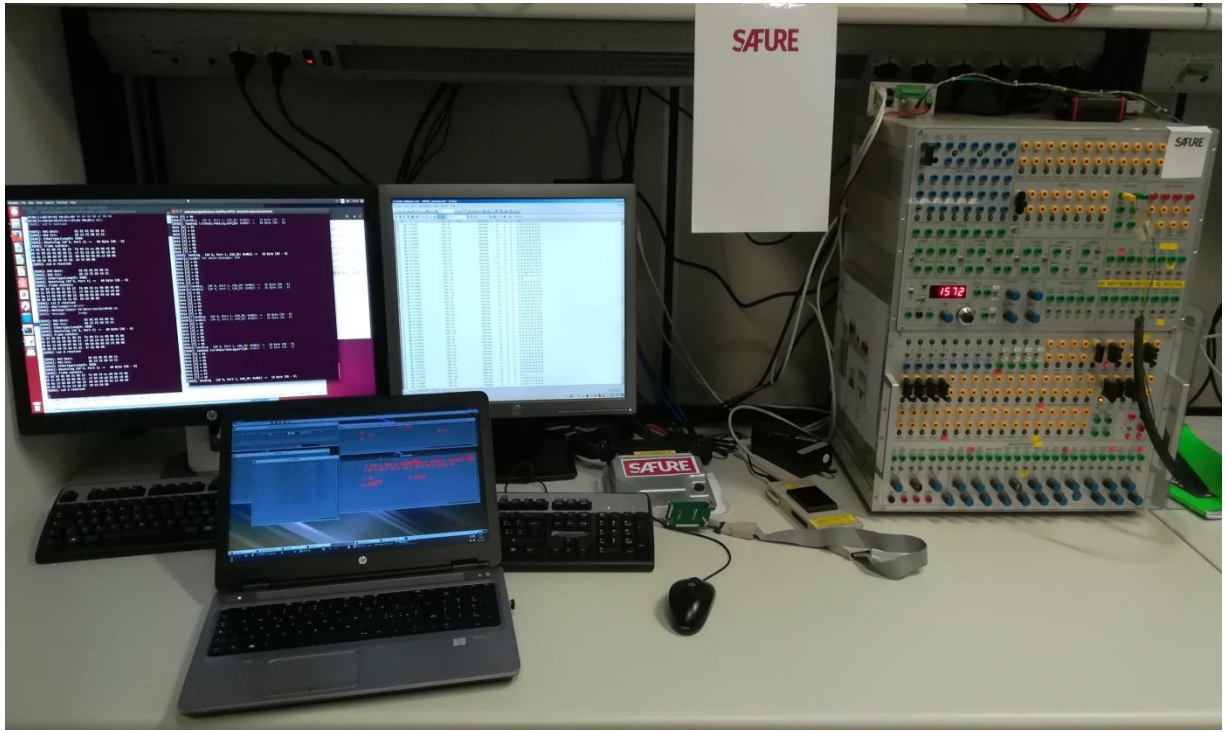
Category A Massages TESTS

Man in the middle attack

- **6 corrupted messages sent**
- **Error counter increased!** ---------→



Full Equipment



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