GROUPE RENAULT THALES

CANANALYZE

A PYTHON FRAMEWORK

SSTIC 2020

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ABOUT US

GROUPE RENAULT

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AGENDA

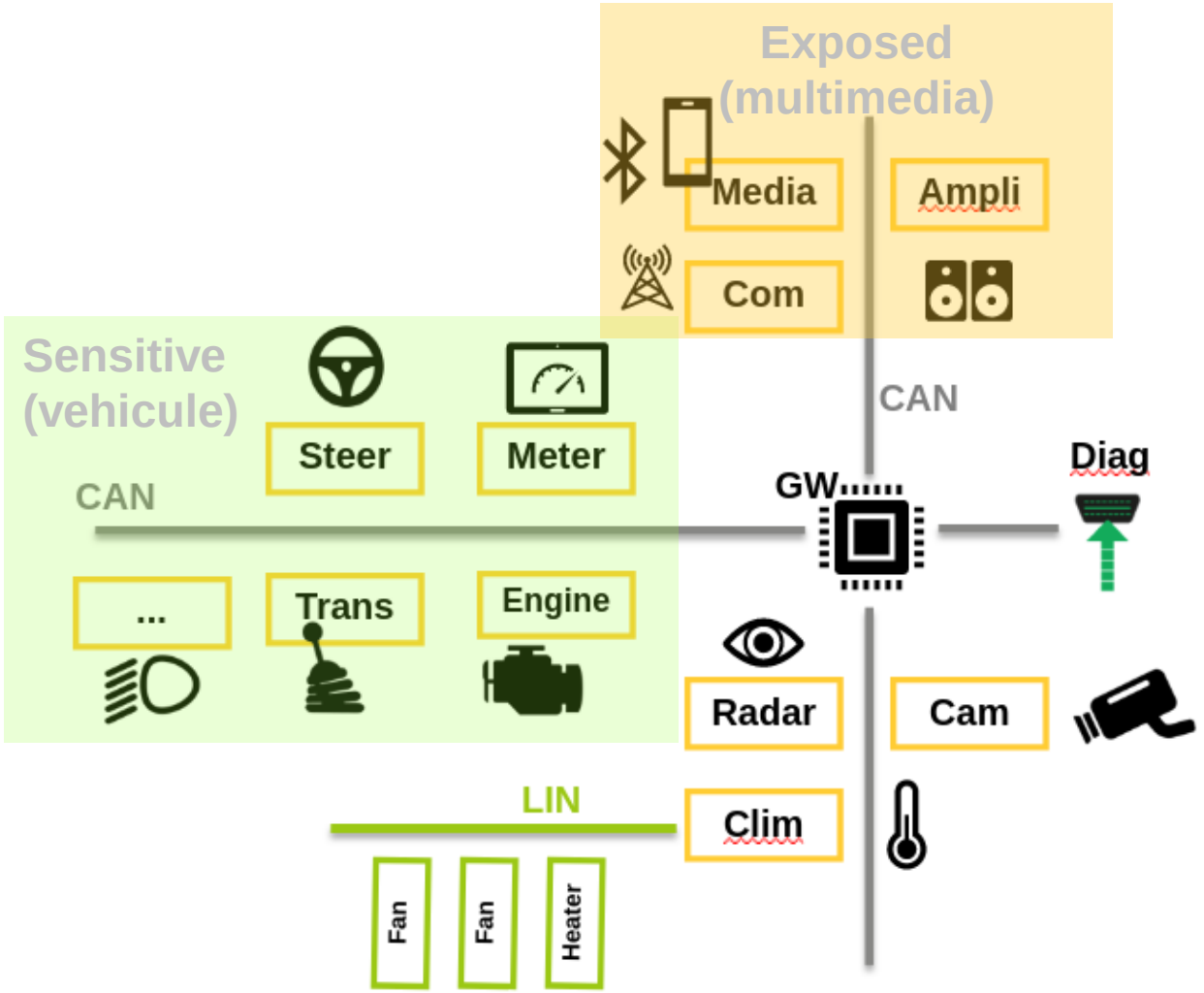
CONTEXT
FRAMEWORK
DEMO
NEXT

01

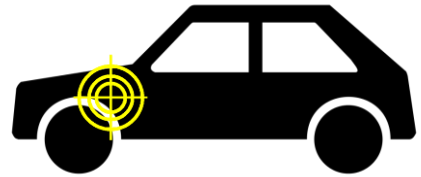
CONTEXT

ARCHITECTURE OF A CAR

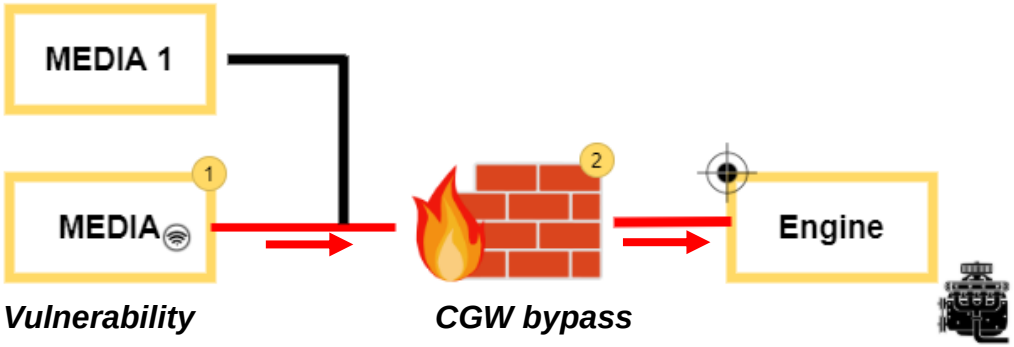
- **ECU (Electronic Control Unit)**
  - BCM (**B**rake **C**ontrol **M**odule)
  - Telematics box
  - Dashboard
  - ….
- **BUS**
  - CAN (**C**ontroller **A**rea **N**etwork)
  - I2C (**I**nter-**I**ntegrated Circuit)
  - LIN (**L**ocal **I**nterconnect **N**etwork)
  - …

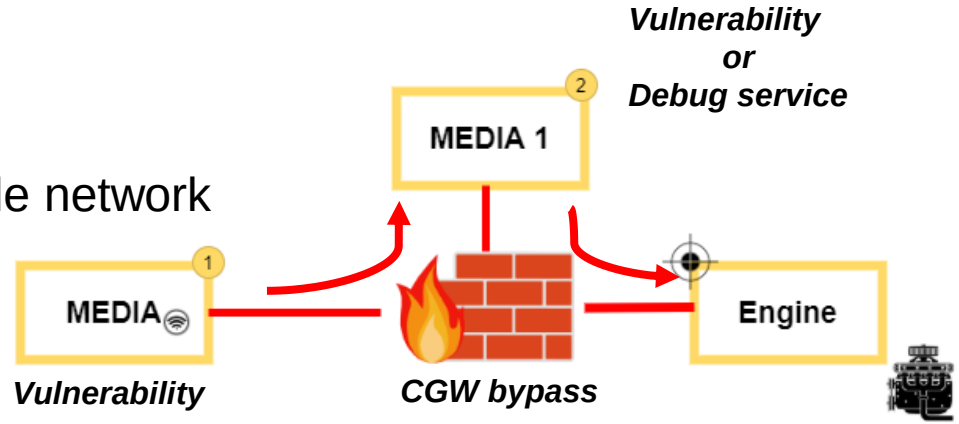


SECURITY CONCERNS



- **Cybersecurity impacts**
  - Safety (preserve passager life) *[Main concern]* ⭐
  - Data privacy (RGPD)
  - IT (Automobile knowledge)
- **Scenarios**
  - Compromise an ECU in the multimedia network
  - Bypass the CGW to send malicious frames in the vehicule network





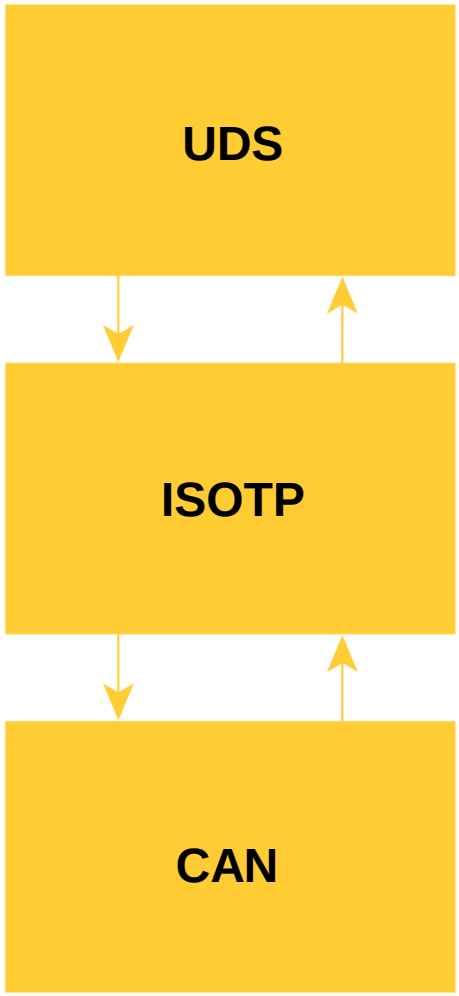
SECURITY CONCERNS

- **Verify Debug services are closed (or correctly locked by a robustness authentication)**
  - UDS services (*Unified Diagnostic Services ISO 14229-1)*
    - ReadMemoryByAddress
    - WriteMemoryByAddress
    - Transfer data

- **Verify sensitives frames are correctly filtered by CGW (CAN firewall)**

How to verify this ? … CANanalyze …

GLOBAL OVERWIEW



UDS (ReadMemoryByAddress, WriteMemoryByAddress, DataTransfer)

SERVICE_ID	PARAMATER1	VERY LONG PARAMATER2

Fragmentation

FRAG	SERVICE_ID	PARAMATER1

FRAG	VERY LONG PARAMATER2	PAD

Simple packet (CANid DATA)

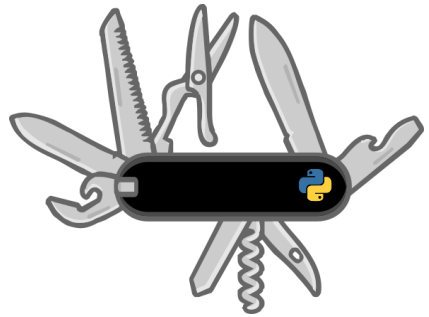
CANID	DLC	C	FRAG	SERVICE_ID	PARAMATER1	CRC

02

FRAMEWORK

WHY CREATING A NEW FRAMEWORK?

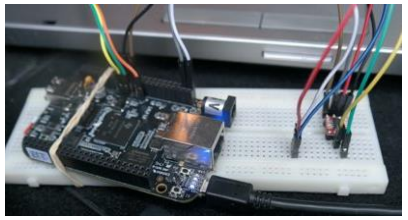
Need for a CAN Army Swiss Knife



- Existing internal code base
- Programming language accessible to everyone, very simple API
- Support several hardware dongles (KOMODO, CANUSB)
- Support the use of several interfaces at the same time
- Specific features to validate / instrument CAN Gateways (virtual ECU / GW)

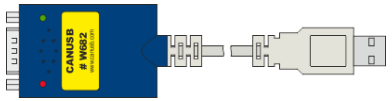
VECTOR

"Handmade"



BeagleBone Black + Tranceiver

BBB + extended CAPE



CAN USB dongle

Komodo CAN DUO

EXISTING FRAMEWORKS

	Udsoncan	CANTools	UDSim	CANanalyze
Activity (GIT)	★★★	★	★★	Too recent
Language	Python	Python	C/C++	Python
API simplicity	★★	★	★	★★★
Documentation	★★★	★★★	★★	★★★
CAN / ISOTP / UDS	★★★	★★★	★★★	★★
ECU Simulator			✔	✔
Script probing (CANid, UDS)		✔	✔	✔
Hardware compatibility	★★	★★	★★	★★★

PROVIDED SCRIPTS – VIRTUAL GATEWAY

Calibration

JSON format defines routing + filtering per interface / CANID

```
“dlc": {
  "ext": {
   "0x20": [ { "payload": "0x0000000000000000",
               "mask": "0xF0F0000000000000" },
             { "payload": "0x0040000000000000",
               "mask": "0xF0F0000000000000" } ],
   "0x21": [ { "payload": "0x0000000000000000",
               "mask": "0xF0F0000000000000" },
             { "payload": "0x0040000000000000",
               "mask": "0xF0F0000000000000" } ]},
  "v2": {
   "0x20": [ { "payload": "0x0000000000000000",
               "mask": "0xF0F0000000000000" }, ... ] },
  ...
}
```

Interface mapping

Specific mapping depending on the interfaces

```
"interfaces": {
  "v1":  { "channel" : "vcan0",
           "bustype" : "socketcan", "bitrate" : 500000},
  "v2":  { "channel" : "vcan3",
           "bustype" : "socketcan", "bitrate" : 500000},
  ...}
```

Virtual Gateway

Socket CAN Gateway : calibration.json + mapping.json

```
$ python3 scripts/gw_virtual_socketcan.py calibration.json mapping.json

Add virtual CAN interface vcan3 [physical=v1 virtual=vcan3]
Add virtual CAN interface vcan0 [physical=v2 virtual=vcan0]
Add virtual CAN interface vcan1 [physical=ext virtual=vcan1]
Add virtual CAN interface vcan2 [physical=dlc virtual=vcan2]

...
R: dlc [0x406 - 0xb'd20a38059b300e']
R: v1 [0x53f - 0xb'ae2f8f45d9e1']
R: dlc [0x200 - 0xb'df72']
R: v1 [0x7aa - 0xb'c5be5f348af39461']
R: dlc [0x405 - 0xb'67c68e0f3e093806']
R: v1 [0x7df - 0xb'6f33ee49fb21a96a']
R: v1 [0x020 - 0xb'12312333']
  R: CAN ID matches = 0x020
    F: v1 -> v2 [0x020 - 0xb'12312333']
W: v2 [0x020 - b'12312333']
R: v1 [0x021 - 0xb'aaaaaaaa']
  R: CAN ID matches = 0x021
    F: v1 -> v2 [0x021 - 0xb'aaaaaaaa']
W: v2 [0x021 - b'aaaaaaaa']
...
```

READ

FORWARD

WRITE

Send messages to virtual GW:

```
$ cangen vcan0
$ cansend vcan0 123#DEADBEEF
...
```

PROVIDED SCRIPTS – PHYSICAL GATEWAY

Calibration

Calibration depending on the hardware

Calibration only required to validate the routing and filtering configuration

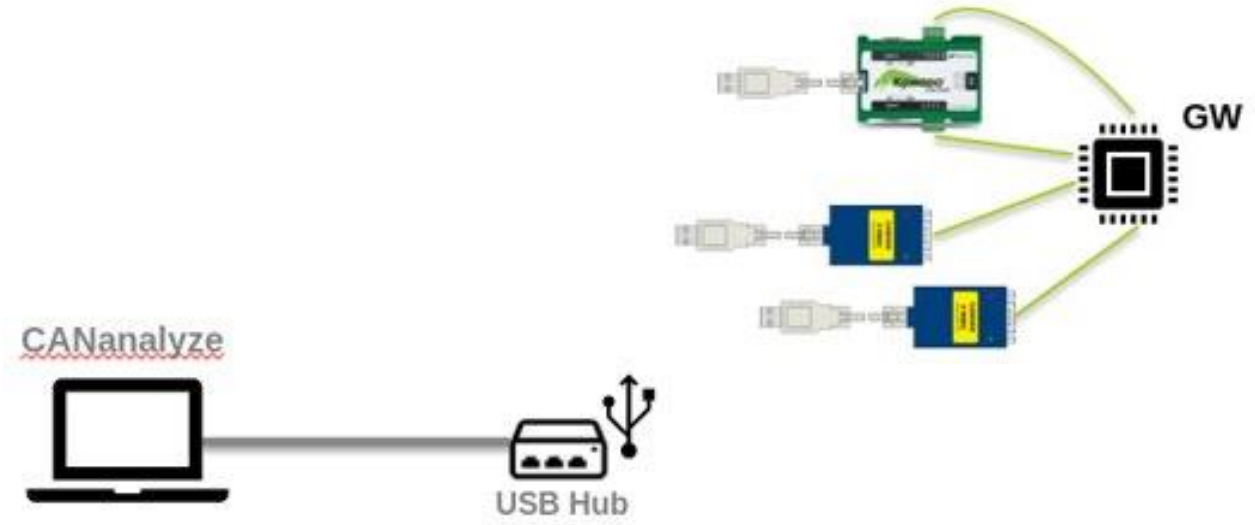
Validation script

- Listen simultaneously on all interfaces and generate trafic depending on the tests
- Discover CANID authorized on interfaces (UDS DiagSessionControl)
- Check authorized CANID and payloads from calibration

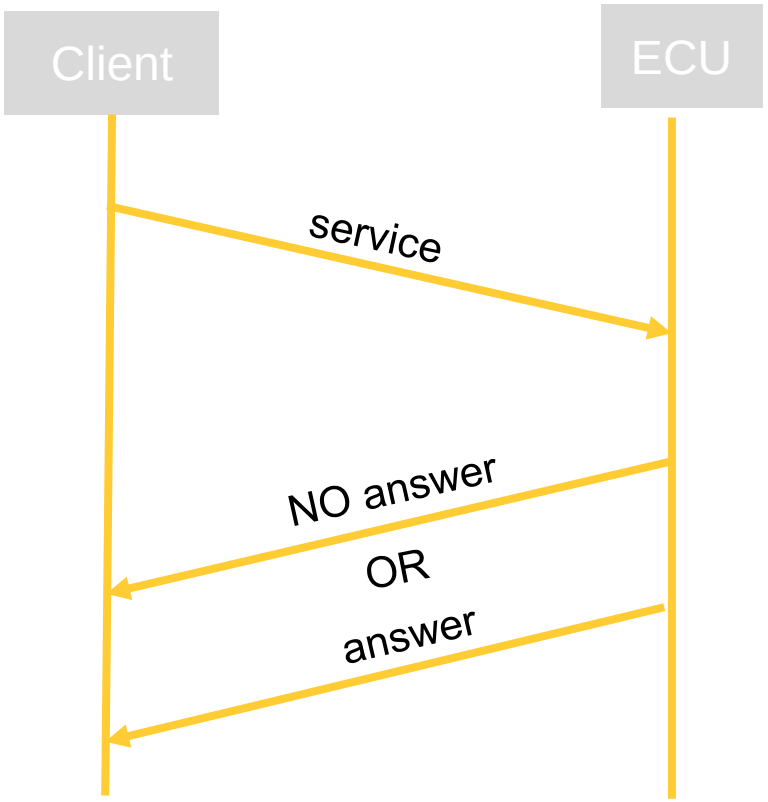
Interface mapping

Specific mapping depending on the interfaces

```
"interfaces": {
  "v1":  { "channel" : "vcan1", "bustype" : "socketcan",
           "bitrate" : 500000},
  "ext": { "channel" : "A", "bustype" : "komodo", "port_nr" : 1,
           "bitrate" : 500000},
  "dlc": { "channel" : "B", "bustype" : "komodo", "port_nr" : 0,
           "bitrate" : 500000},
}
```



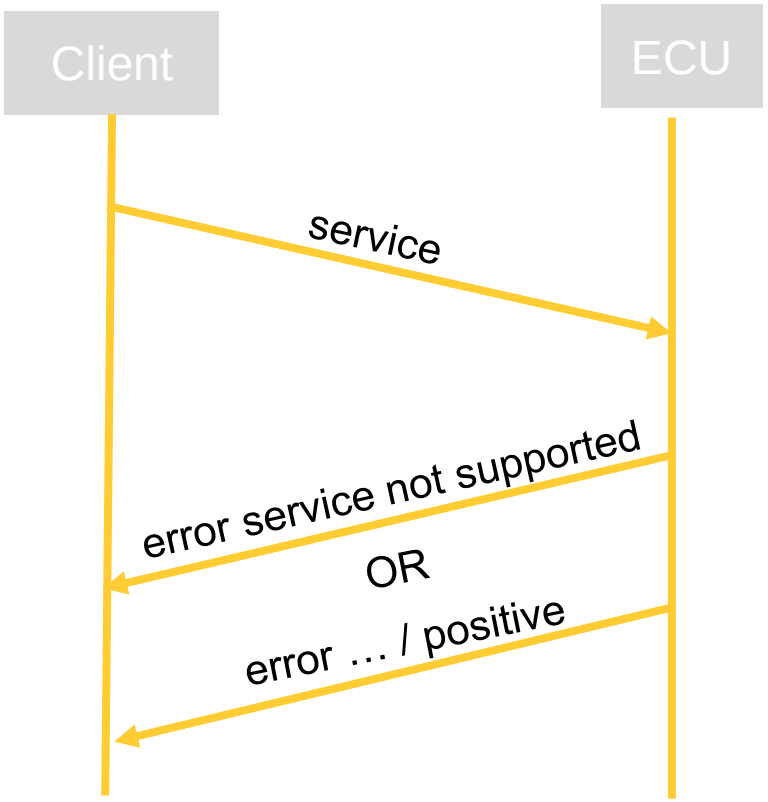
PROVIDED SCRIPTS (CANID DISCOVERY)



Goal: Discover CANid offering UDS services (needed to get the debug services list)

```
$ python scripts/id_uds.py
km_init_channel: Acquired features: 38
km_init_channel: Bitrate set to 5000000
km_init_channel: Timeout set to 1 second(s)
UDS service detected (canid_send=0x7CA, canid_receive=0x7DA)
```

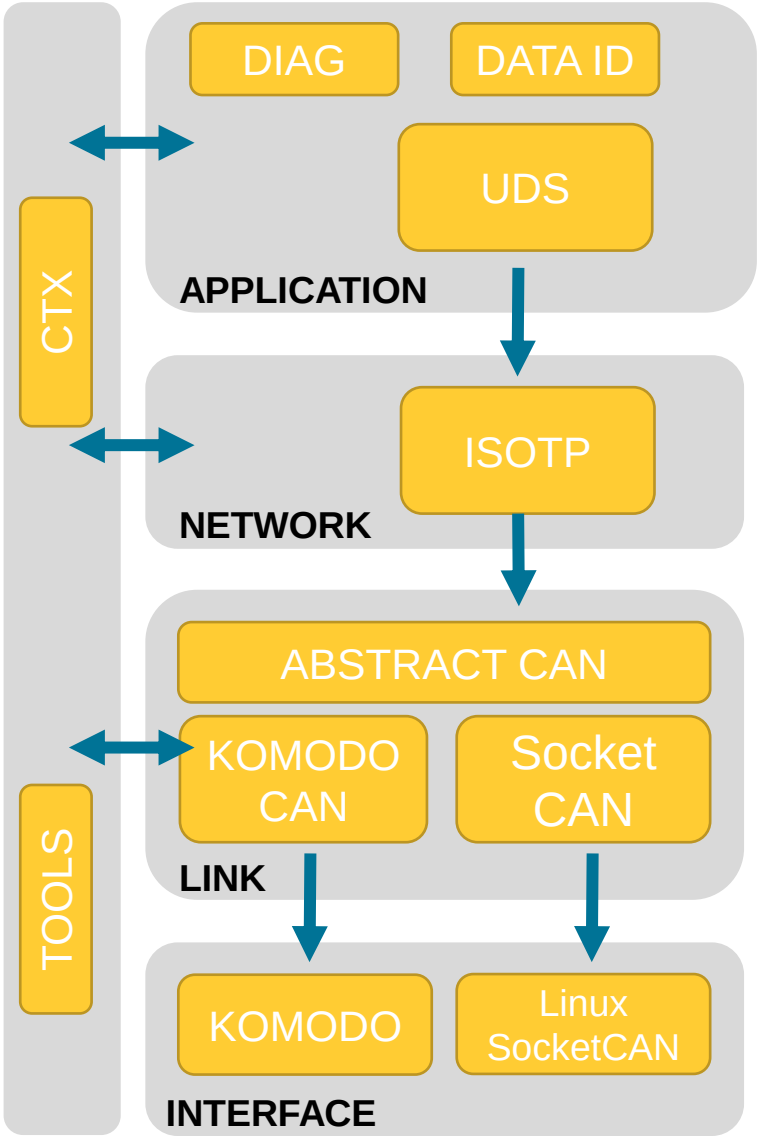
PROVIDED SCRIPT (SCAN UDS SERVICES)



Goal: list UDS services exposed by the ECU (and verify that some UDS debug services are disabled)

```
$ python scripts/nmap.py
km_init_channel: Acquired features: 38
km_init_channel: Bitrate set to 5000000
km_init_channel: Timeout set to 1 second(s)
Scan.services discovered 10 Diagnostic Session Control
Scan.services discovered 11 ECU Reset
Scan.services discovered 14 Clear Diagnostic Session Information
Scan.services discovered 19 Read DTC Information
Scan.services discovered 22 Read Data By Identifier
Scan.services discovered 27 Security Access
Scan.services discovered 2e Write Data By Identifier
Scan.services discovered 31 Routine Control
Scan.services discovered 3e Tester Present
```

ARCHITECTURE



python™ unittest
3 python-can
sphinx documentation

- **CAN abstraction interface**
  - Strong python-can adhesion: message format, socket CAN support (and more)
  - Komodo support (single and dual interfaces)
- **ISOTP and advanced UDS interfaces**
- **Context management**
  - Manage simultaneously multiple interfaces (CAN id filters, timeouts...)
  - Per-context cache (with filtering capabilities)

```
ctx = context.create_ctx (channel = 'A',
                          bustype = BusType.KOMODO,
                          port_nr = 0,
                          bitrate = 500000)

vcan.sniff (ctx, max=20)
vcan.write (ctx, can.Message(
            data = [0xD0, 0x32, 0x00, 0x09]), can_id = 0x166)
```

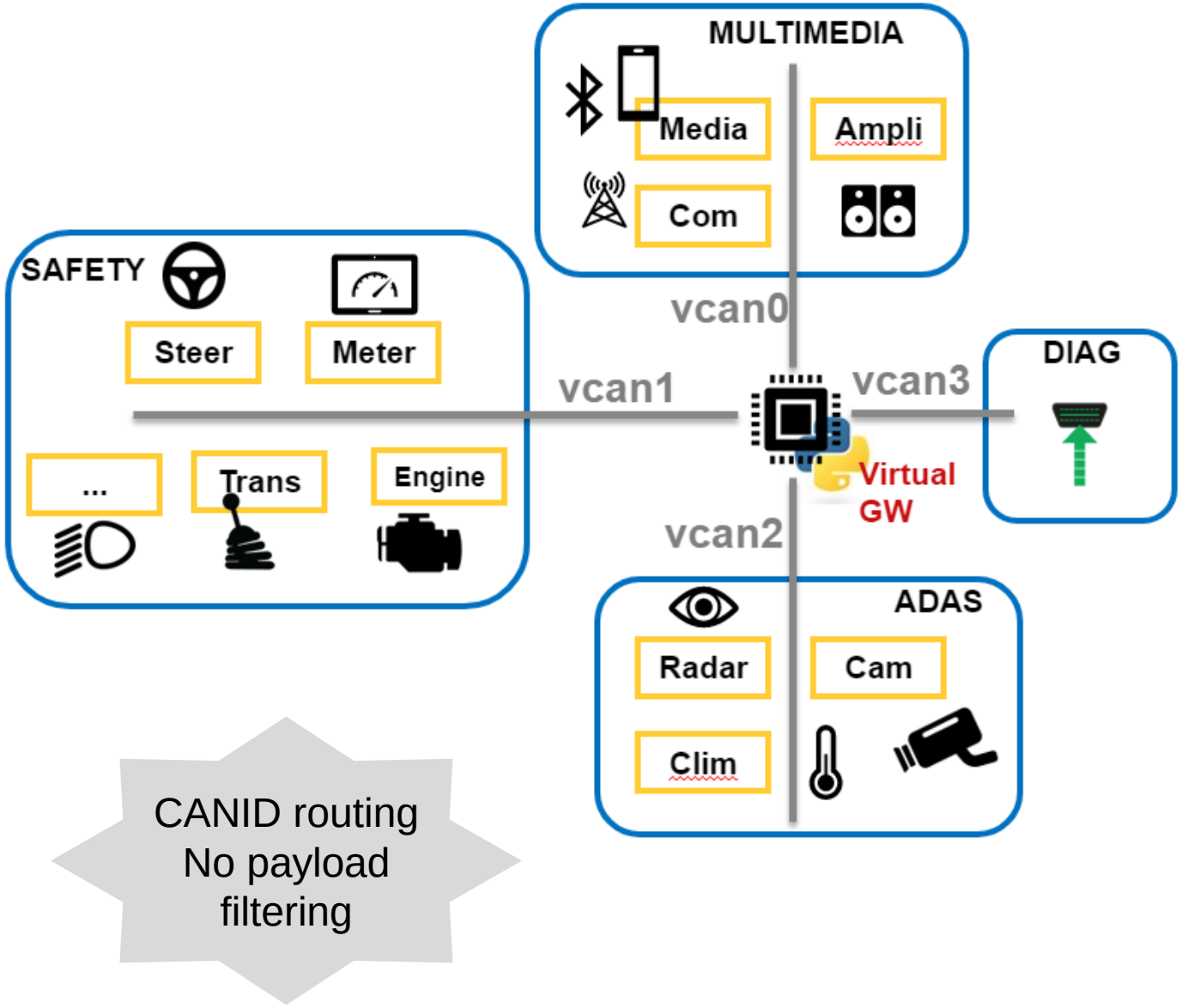
03

DEMO

DEMO SETUP

- **4 virtual CAN interfaces:**
  - vcan0 (MULTIMEDIA) : exposed services
  - vcan1 (SAFETY) : sensitive ECU
  - vcan2 (ADAS) : optional driving aids
  - vcan3 (DIAG) : ODB II diagnostic

- **Sample calibration: ALLOW**
  - SAFETY => * : ALL CAN ID
  - ADAS => MULTIMEDIA : CANID 0x01 / ACK 0x02
  - DIAG => SAFETY : CANID 0x0a / ACK 0x0b
  - DIAG => ADAS : CANID 0x0d / ACK 0x0e

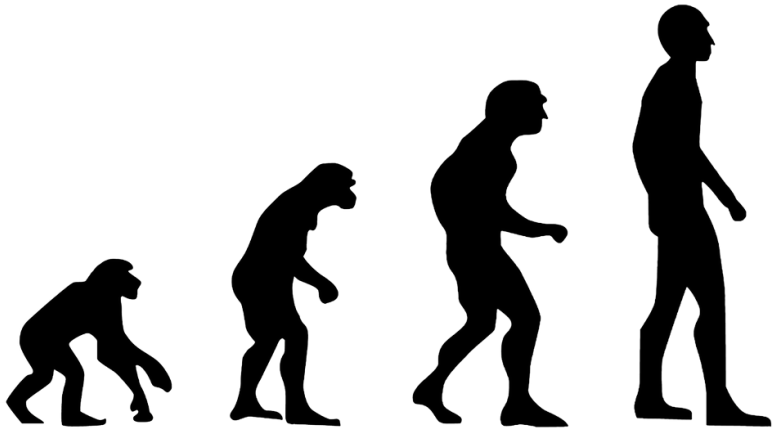


04

EVOLUTION

FUTURE EVOLUTIONS

- Probing UDS routines
- Support more hardware dongle
- Support CANFD
- Automatize some tests on Security Access
- …



THANK YOU

05

APPENDIX

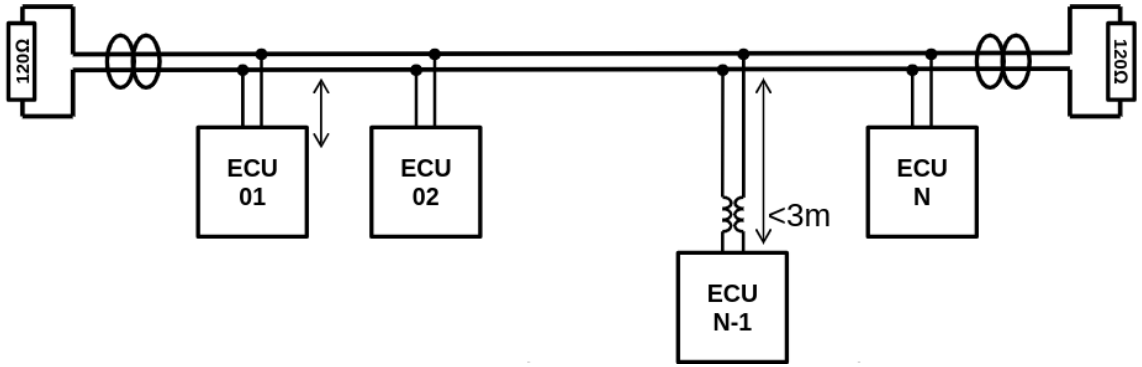
02’

COMMUNICATION WITH ECU

WHAT IS A CAN REQUEST?

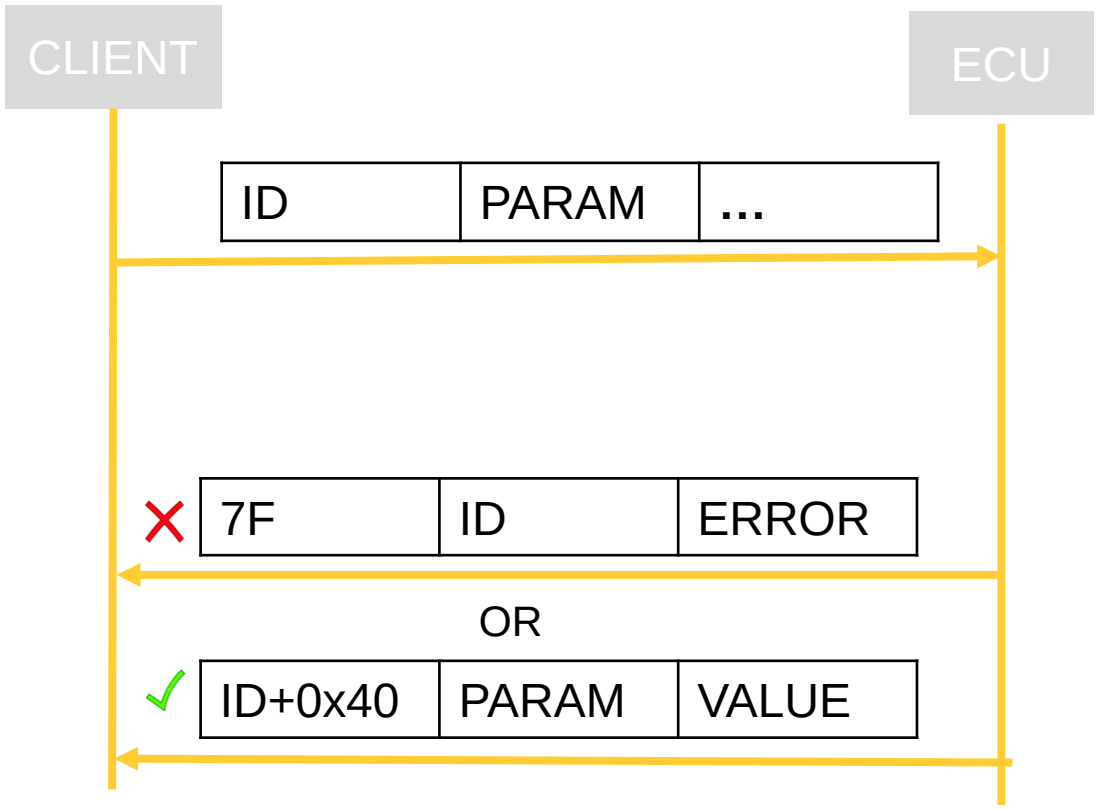
- **CAN**
  - ISO 11898-2 (2003): CAN « high-speed » (until 1Mbits/s),
  - ISO 11898-3 (2006): CAN « low-speed, fault tolerant » (until 125kbits/s).

ARBITRATION ID (11)	C	DLC (4)	DATA (0-64)	CRC (15)



"Daisy-chain" structure with twisted-pair CAN High / CAN Low

UDS SERVICES



- **Services**
  - 0x10 / DiagnosticSession
  - 0x11 / EcuReset
  - 0x27 / SecurityAccess
  - 0x23 / ReadMemoryByAddress
- **Error Code**
  - 0x10 / generalReject
  - 0x11 / serviceNotSupported
  - 0x12 / subFunctionNotSupported
  - 0x35 / invalidKey
  - 0x33 / securityAccessDenied

HOW SEND DATA BIGGER THAN 8 BYTES?

ISOTP

- 0 = Single Frame

  [0x02, 0x10, 0x02, 0xFF, 0xFF, 0xFF, 0xFF]

- 1 = First Frame

  [0x1X, 0xXX, 0xDD, 0xDD, 0xDD, 0xDD, 0xDD]

- 2 = Consecutive Frame

  [0x21, 0xDD, 0xDD, 0xDD, 0xDD, 0xDD, 0xDD]

  [0x22, 0xDD, 0xDD, 0xDD, 0xDD, 0xDD, 0xDD]

  [0x23, 0xDD, 0xDD, 0xDD, 0xDD, 0xDD, 0xDD]

- 3 = Flow Control Frame

  [0x30, 0xXX, 0xYY, 0x00, 0x00, 0x00, 0x00]

Example

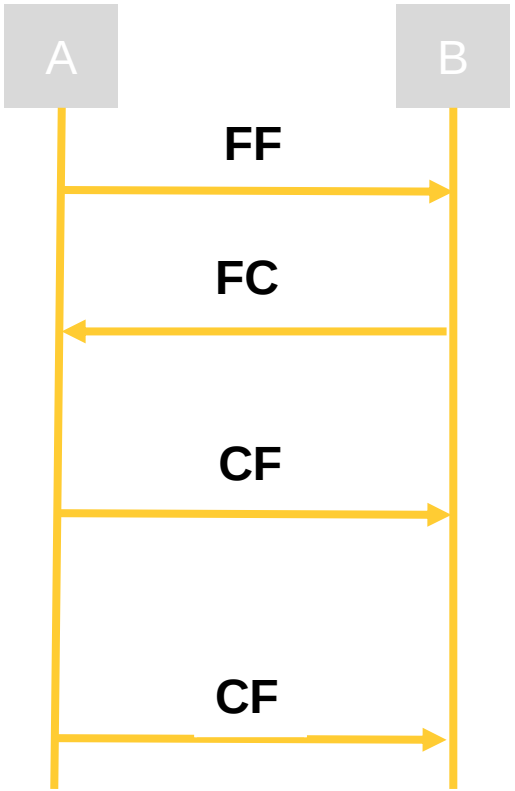
- Send the following message from ECU A to ECU B

010203040506070809 0A0B0C0D0E0F101112

CANid	C	DLC	DATA	CRC
DEB	X	8	**10** (12) 01 02 03 04 05 06	XXXX…
DEB	X	8	**20** 07 08 09 0A 0B 0C 0D	XXXX…
DEB	X	8	**21** 0E 0F 10 11 12 00 00	XXXX…

HOW SEND DATA BIGGER THAN 8 BYTES?

Exchanged frames between the ECU A and ECU B

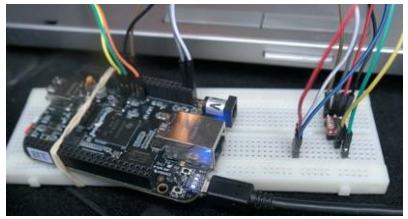


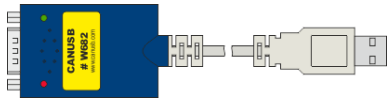
10	12	01	02	03	04	05	06
30	02	14	00	00	00	00	00
21	07	08	09	0A	0B	0C	0D
22	0E	0F	10	11	11	00	00

CAN INTERFACE

Hardware

"Handmade"





CAN interface	BeagleBone Blac k + Tranceiver	BeagleBone Black + extended CAPE	CANUSB dongle	Komodo CAN DUO	VECTOR
COST	★	★★	★★	★★★	★★★★
API	Native Linux socketcan	Native Linux socketcan	Windows Library Native Linux socketcan	Windows/Linux C library + python binding	Windows environ ment / proprietary scripting

CAN connector D-SUB9 / ODB II (termination resistor)

Software

- Limitation of character device model and drivers implementation
- Linux SocketCAN (>= 2.6.25) based on network layer
- Advanced features and abstraction for user space applications
- SocketCAN user space utilities and tools (can-utils)