
V2GEVIL
GHOST IN THE WIRES

whoarewe

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GOALS OF THIS TALK

- Analyze the state of cybersecurity in the automotive industry
- In-depth look at EV architectures and the emerging attack vector
- Exploration of communication protocols used in EV charging
- Introduction to V2GEvil
- Create a reference point for EV security research and evaluation

KAPITOLA 1

INTRODUCTION TO VEHICLE CYBER SECURITY

The State of Automotive Cyber Security

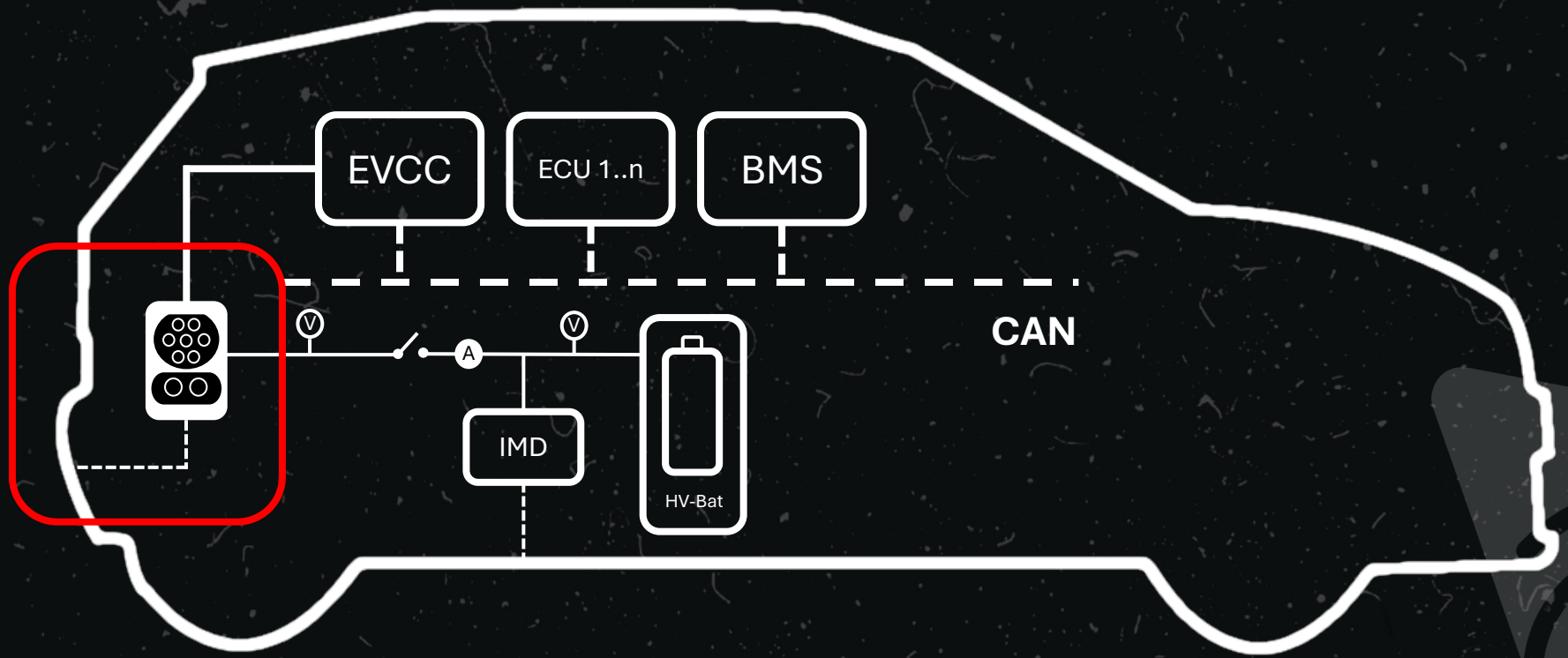
- The automotive industry cannot be considered new
- The connectivity and technological aspect of it though, is not so old
- Entertainment and constant need for connectivity, are the reasons for technological advancements and integration
- Usually, 100+ year old industries, trying to catch up with young start-ups

The State of Automotive Cyber Security

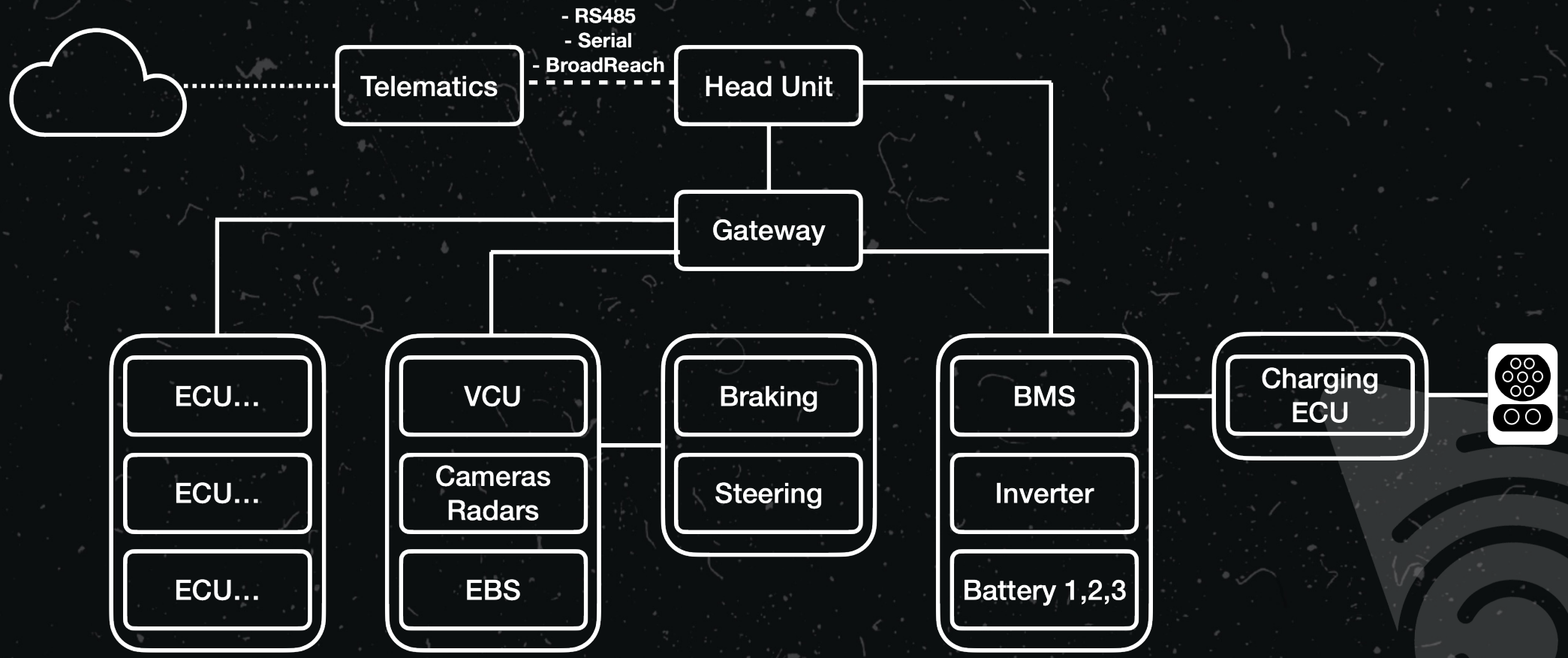
- Hybrid vehicles and EVs became more popular
  - Need for direct use of renewable energy sources
  - Direct gains on speed and efficiency
  - And more…

- While early models used basic charging, last decade charging standards are applied and enforced in many ways

INTRODUCTION TO EV



INTRODUCTION TO EV



KAPITOLA 2

CHARGING

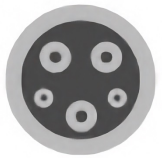
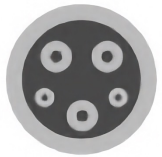
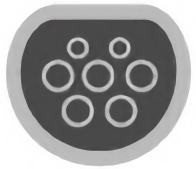
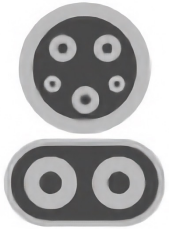
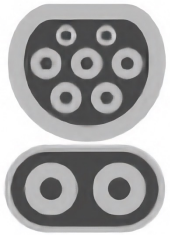
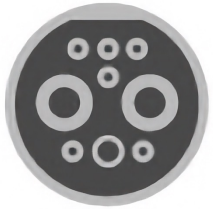
Charging Basics I

- Charging methods
  - Conductive, Wireless, Battery Swap, Bidirectional
- Charging types
  - AC vs DC
- Charging modes
  - 4 modes

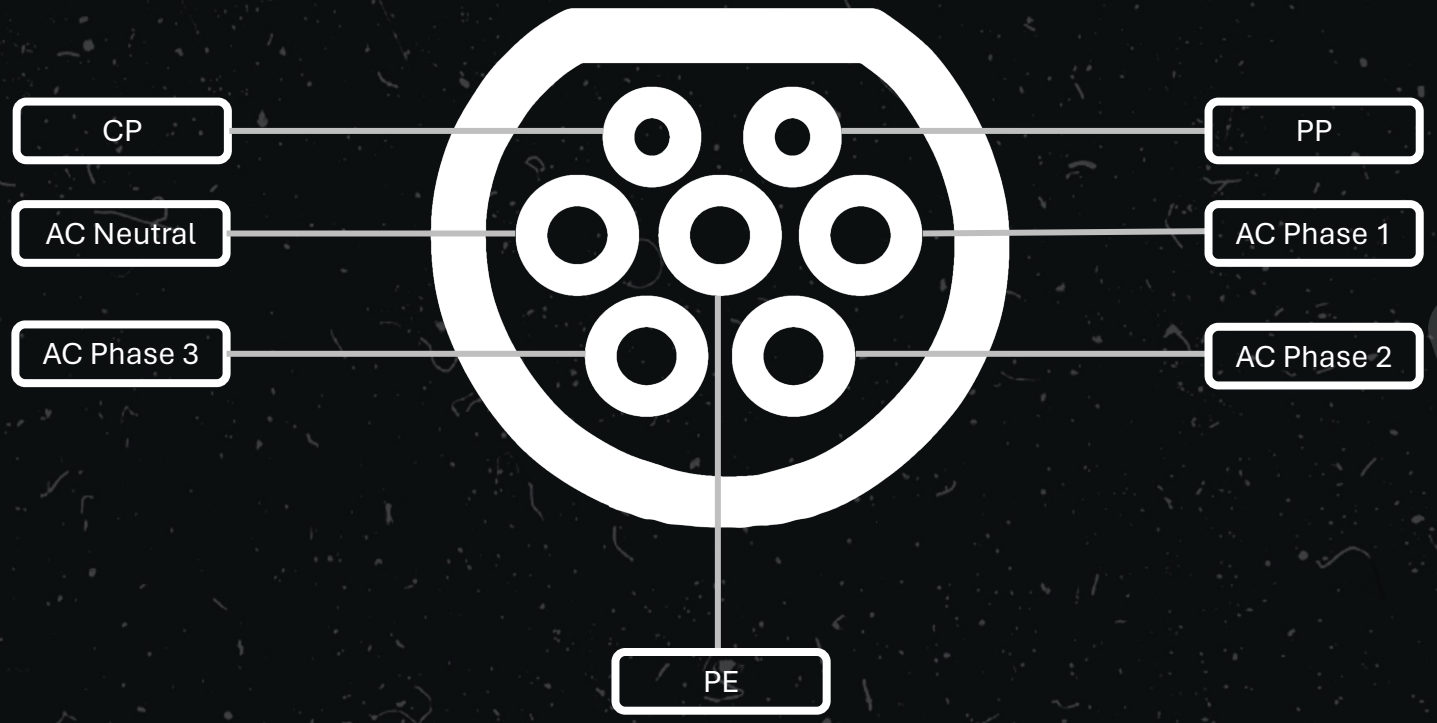
Charging Basics II

- **Many different available charging standards**
  - **We are interested only in standards used in CCS (Europe)**
    - Connectors, Inlet, Plugs: IEC 62196, SAE J1772, GB/T 20234, CHAdeMO;
    - Onboard Charger, EVSE: IEC 61851, GB/T 18487, GB/T 27930;
    - Wireless Power Transfer (WPT) Systems: IEC 61980, SAE J2954;
    - Communication EV To EVSE: ISO 15118, DIN SPEC 70121, GB/T 27930, SAE J2847/2
- **Charging Combined System - CSS**
  - **Efforts towards a single unified system**
  - **Defines standards for communication, plugs, sockets and more**

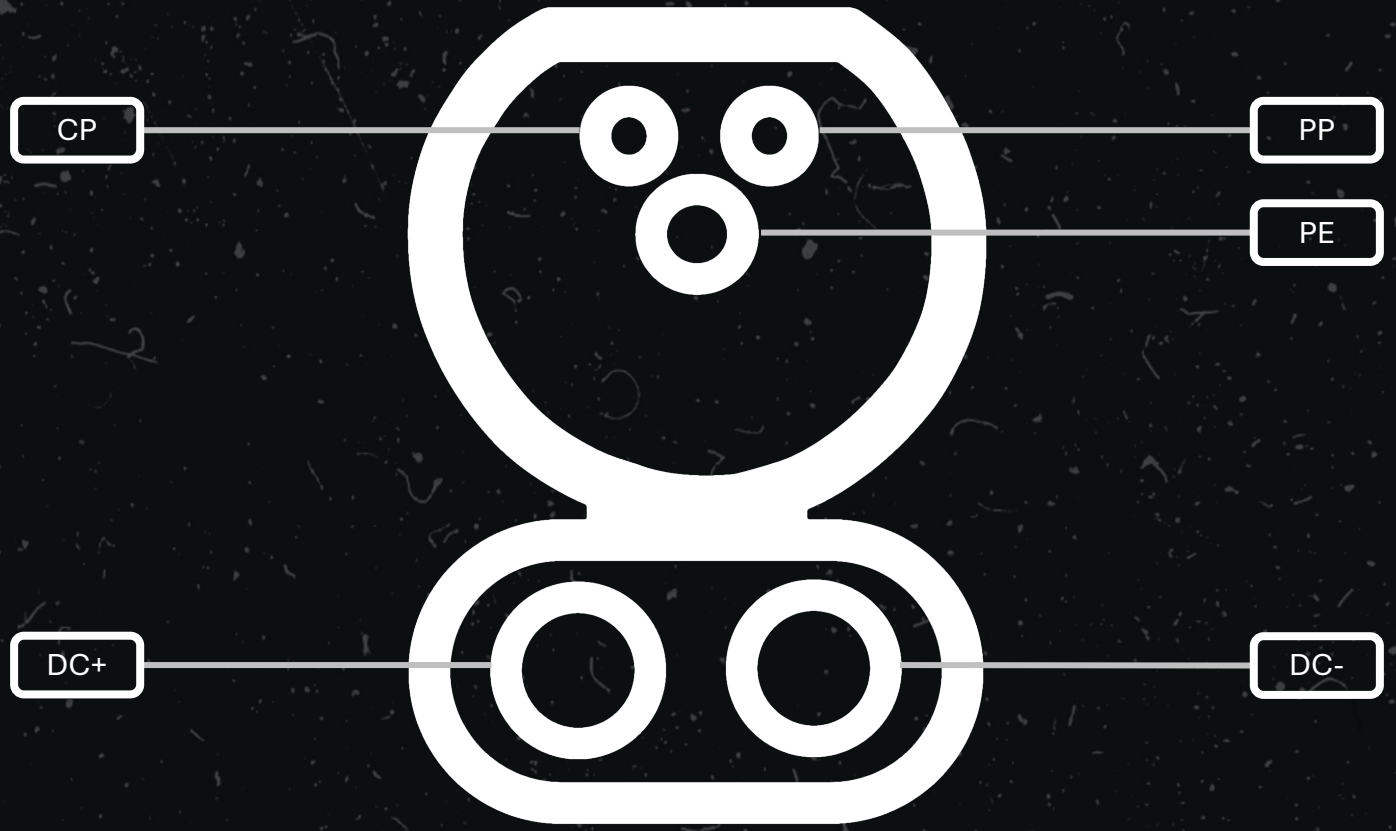
Charging Basics III

	N. America	Japan	EU *and the rest of markets*	China	All Markets *except EU*
AC	 **J1772** (Type 1)	 **J1772** (Type 1)	 **Mennekes** (Type 2)	 **GB/T**	 **Tesla**
DC	 **CCS1**	 **CHAdeMO**	 **CCS2**	 **GB/T**	

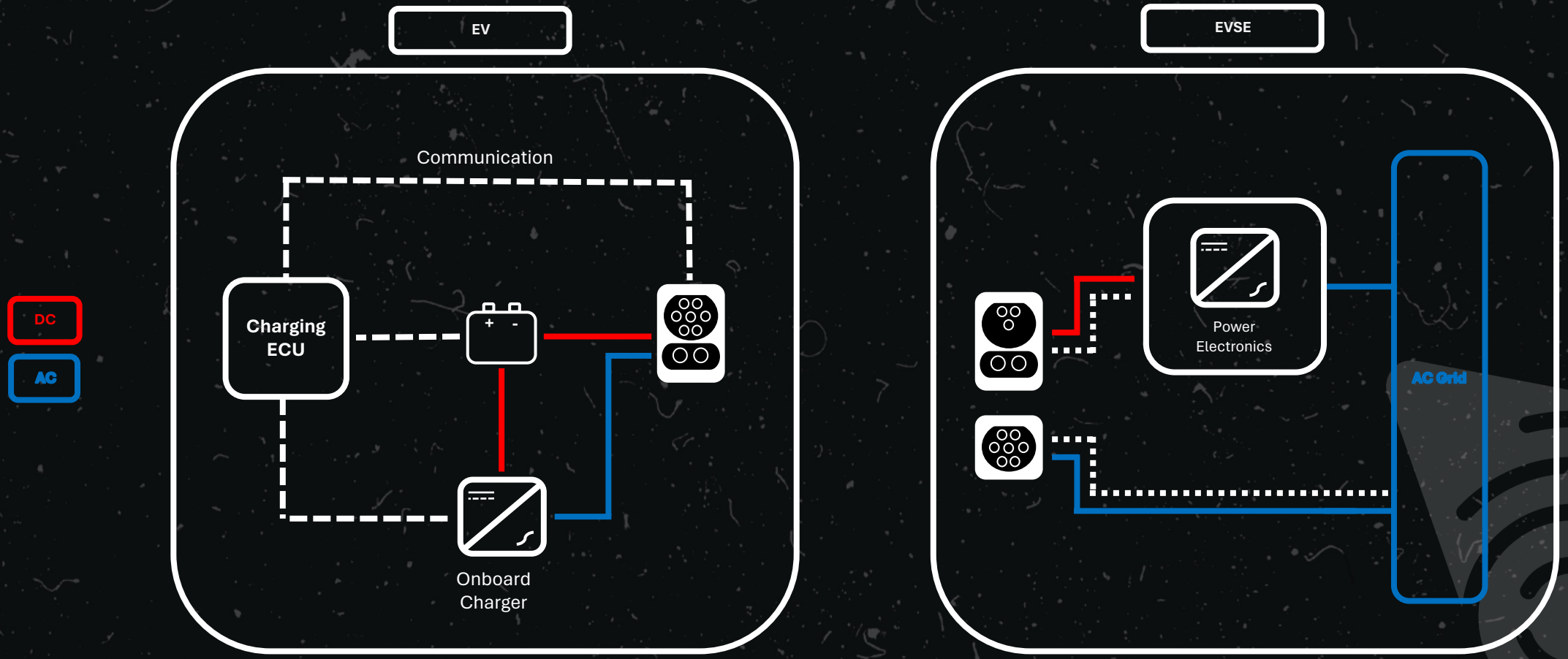
Charging Basics III - AC Type 2



Charging Basics III - CCS Type 2



Charging Basics IV



Charging communication I

- Charging is NOT only simple power transfer
- Digital data exchange
  - e.g. payment details, Required Voltage, Current, Time of charging
- Low level vs High level communication

CHARGING COMMUNICATION II

CHARGING COMMUNICATION III

KAPITOLA 3

LOW LEVEL COMMUNICATION

LOW LEVEL COMMUNICATION I

- Basic signaling
- Physical signaling – Pilot function
  - Control pilot circuit (CP and PE pins), PWM
- Voltage differentiate State of EV

Voltage	State	Description
+12V	State A	No coupler engagement, no EV is connected to EVSE
+9V (1kHz PWM)	State B	Coupler engagement detected (EV is connected to the EVSE), but EV not ready for charging. EVSE does not supply energy.
+6V (1kHz PWM)	State C	EV is connected and ready for charging. EVSE supplies energy.
+3V (1kHz PWM)	State D	EV is connected and ready for charging. EVSE supplies energy. Ventilation is required.
0V	State E	Short of CP to PE on the EVSE, no power supply.
-12V	State F	Charging station is not available.

LOW LEVEL COMMUNICATION II

- Based on duty cycle
  - Info about current
  - Force High level communication
- IEC 61851

Duty Cycle	Description
Duty cycle > 97%	Charging is not allowed.
96% < duty cycle 97%	Maximum current consumption for AC charging is 80 A.
85% < duty cycle 96%	Available current = (dutycycle - 64) * 2A.
10% duty cycle 85%	Available current = dutycycle * 0.6A.
8% duty cycle < 10%	Maximum current consumption for AC charging is 6 A.
7% < duty cycle < 8%	Charging is not allowed.
3% duty cycle 7%	Force use of high-level communication protocol (ISO 15118 or DIN 70121). If pilot function wire is used for digital communication, then the duty cycle 5 % shall be used.
Duty cycle < 3%	Charging is not allowed.

LOW LEVEL COMMUNICATION III

KAPITOLA 4

HIGH LEVEL COMMUNICATION

HIGH LEVEL COMMUNICATION I

- Why do we need that?
  - Optimized Charging
    - Thermal Management
    - Precise Communication for Optimal Charging
    - Fault Detection and Safety Mechanisms
  - Interoperability
  - Enhanced User Experience
  - Future-Proofing the EV Ecosystem

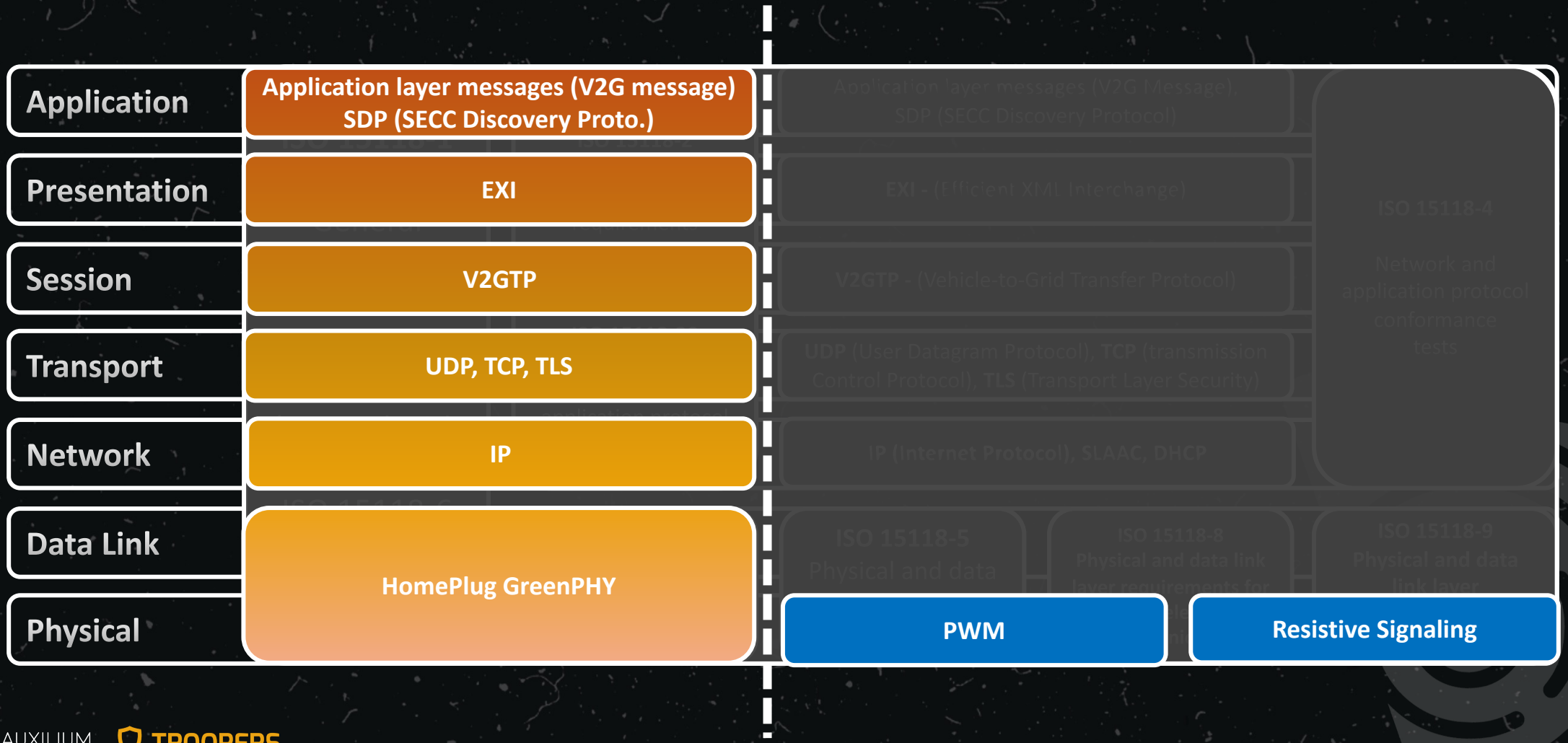
High Level Communication II

- Prerequisite: low-level comm. defined in IEC 61851
- Charging modes 3 and 4
- Communication between EVCC and SECC
- Protocols for high level communication are defined in ISO 15118

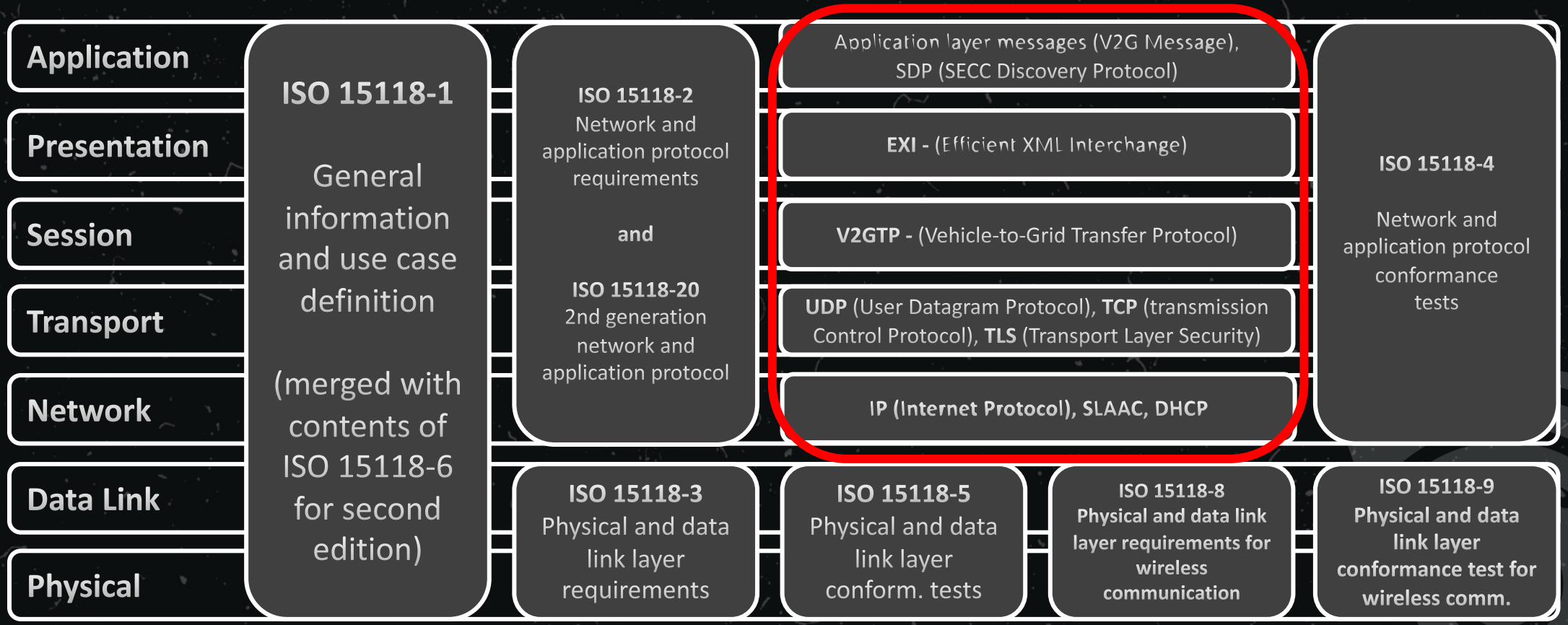
ISO 15118 I

- Vehicle-to-Grid Communication Interface = V2G
- PLC - Control Pilot circuit (CP and PE)
- Signal Level Attenuation Characterization (SLAC)
- Digital communication
  - Provides enhancements:
    - *Identification, payment, load levelling, energy transfer control, charging parameters*

ISO 15118 VS IEC 61851



ISO 15118 II

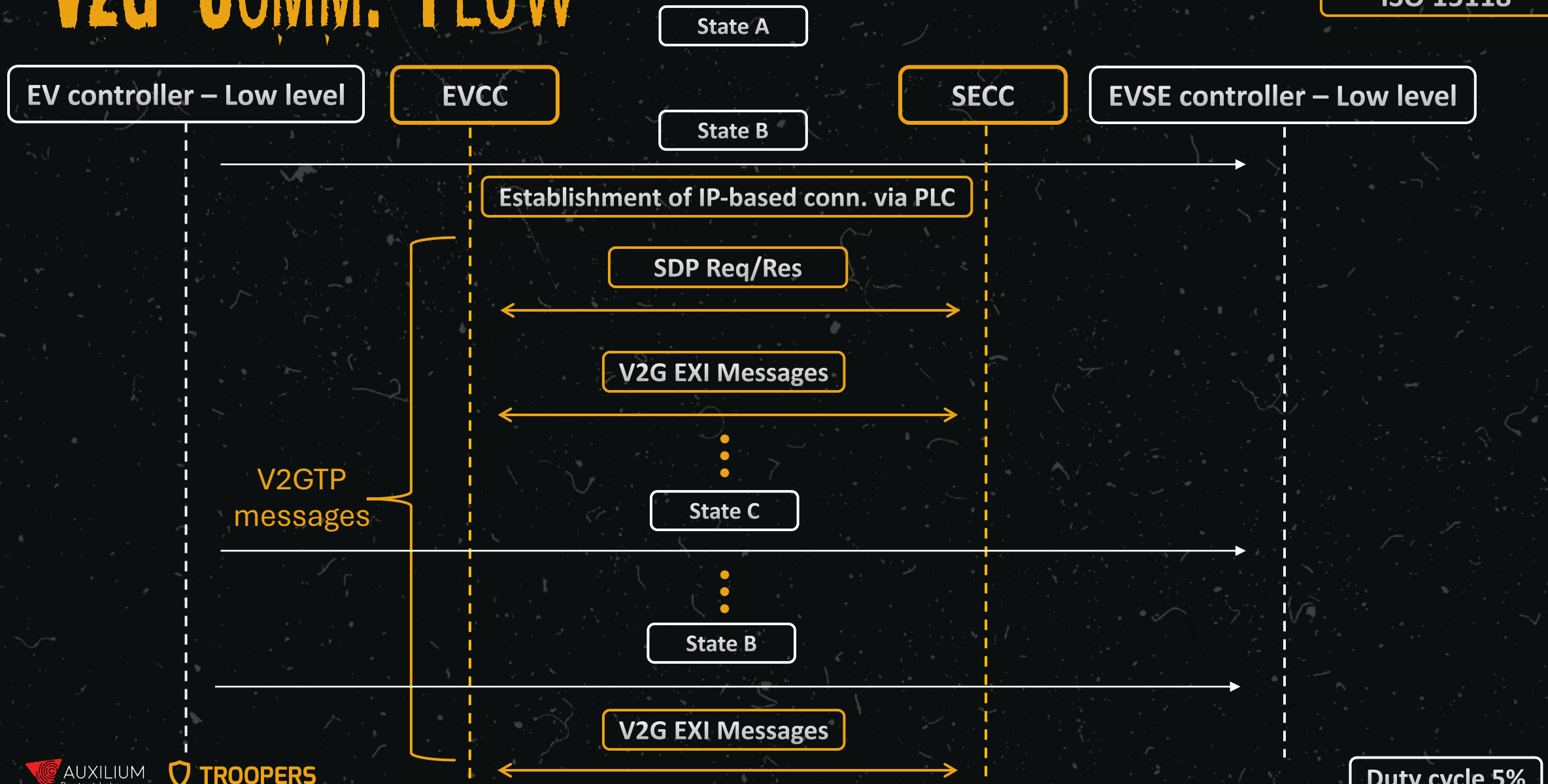

Application
Presentation
Session
Transport
Network
Data Link
Physical
ISO 15118-1
General information and use case definition
(merged with contents of ISO 15118-6 for second edition)
ISO 15118-2
Network and application protocol requirements
and
ISO 15118-20
2nd generation network and application protocol
Application layer messages (V2G Message), SDP (SECC Discovery Protocol)
EXI - (Efficient XML Interchange)
V2GTP - (Vehicle-to-Grid Transfer Protocol)
UDP (User Datagram Protocol), TCP (transmission Control Protocol), TLS (Transport Layer Security)
IP (Internet Protocol), SLAAC, DHCP
ISO 15118-4
Network and application protocol conformance tests
ISO 15118-3
Physical and data link layer requirements
ISO 15118-5
Physical and data link layer conform. tests
ISO 15118-8
Physical and data link layer requirements for wireless communication
ISO 15118-9
Physical and data link layer conformance test for wireless comm.

ISO 15118 III

V2G COMM. FLOW

IEC 61851

ISO 15118



Duty cycle 5%

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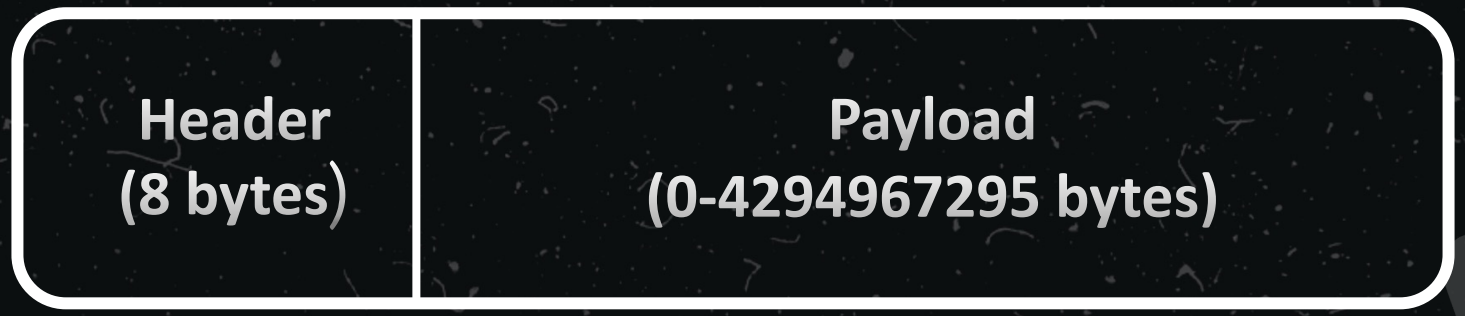
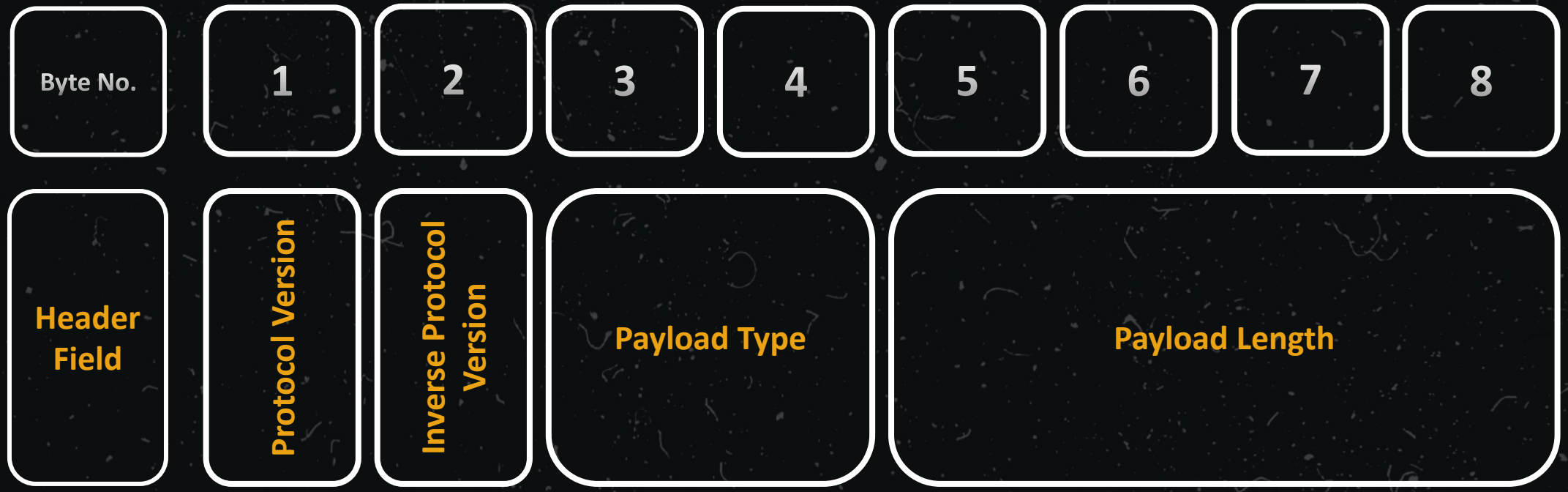
TROOPERS

V2GTP MESSAGE - PDU



V2GTP MESSAGE - HEADER



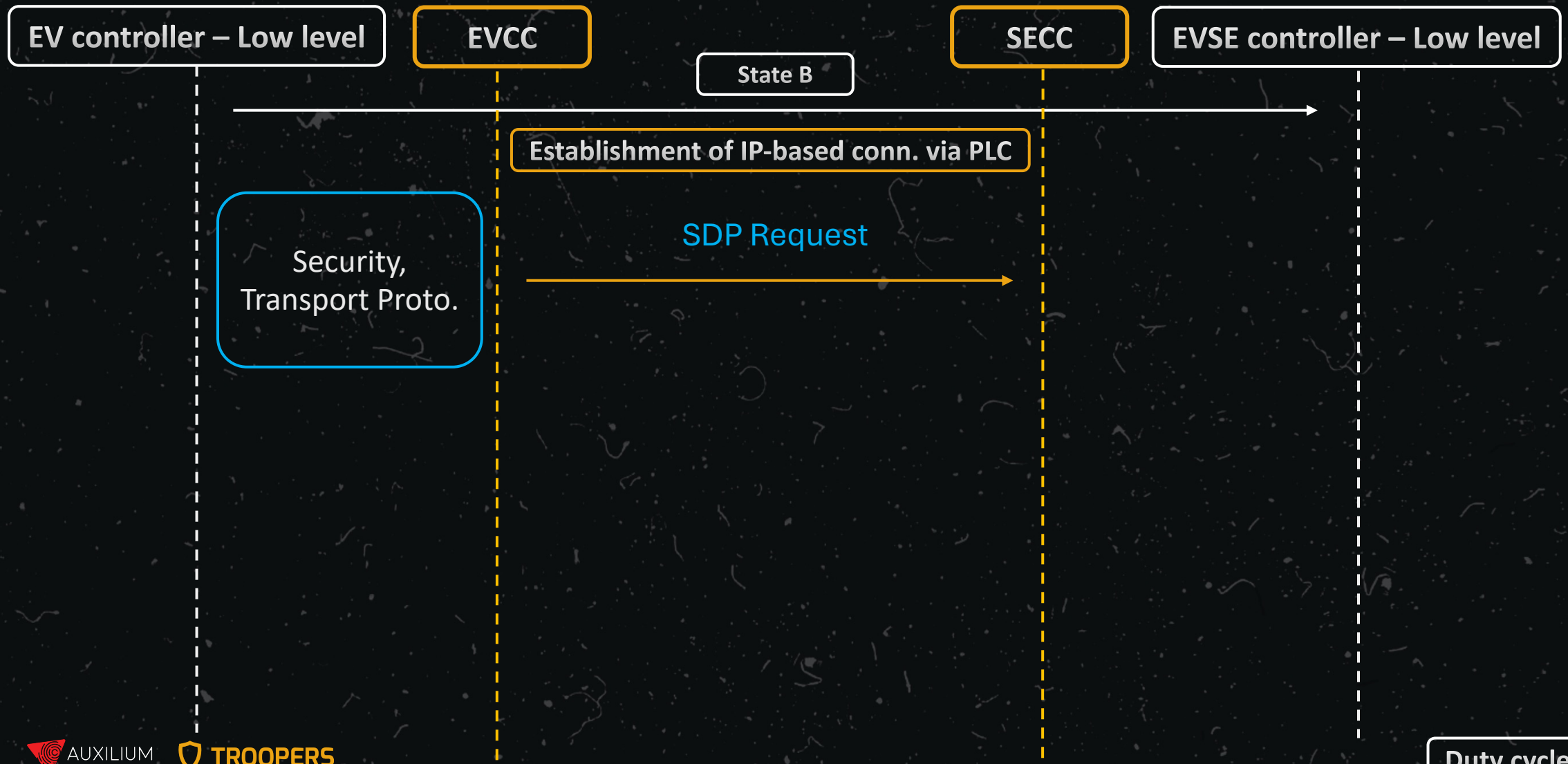
V2G PDU PAYLOAD TYPES

- SDP request message – 0x9000
- SDP response message – 0x9001
- EXI encoded V2G Message – 0x8001
- Manufacturer specific use – 0xA000 - 0xFFFF

V2G COMM. FLOW - SDP

IEC 61851

ISO 15118



Duty cycle 5%

SDP REQUEST

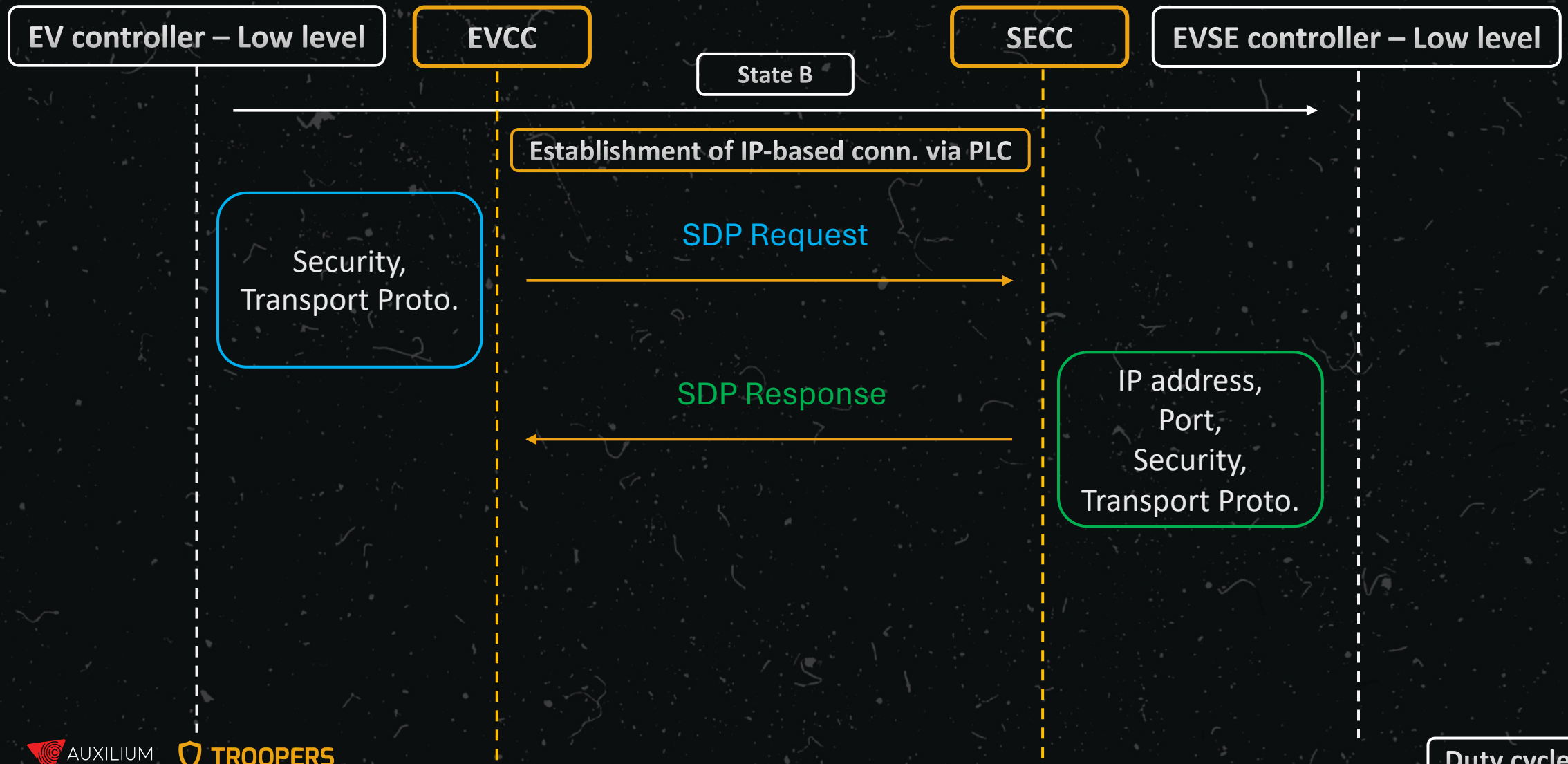
Security
- 0x00 == TLS
- 0x10 == No TSL
- Rest == Reserved

Transport Protocol
- 0x00 == TCP
- 0x10 == Reserved for UDP
- Rest == Reserved

V2G COMM. FLOW - SDP

IEC 61851

ISO 15118



Duty cycle 5%

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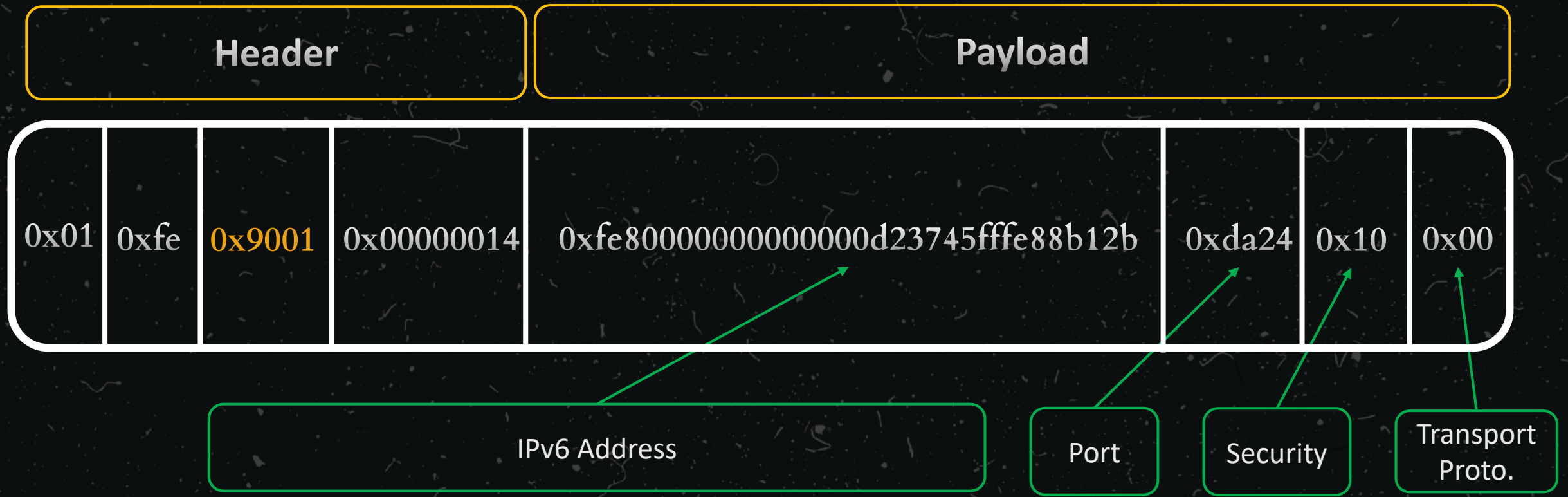
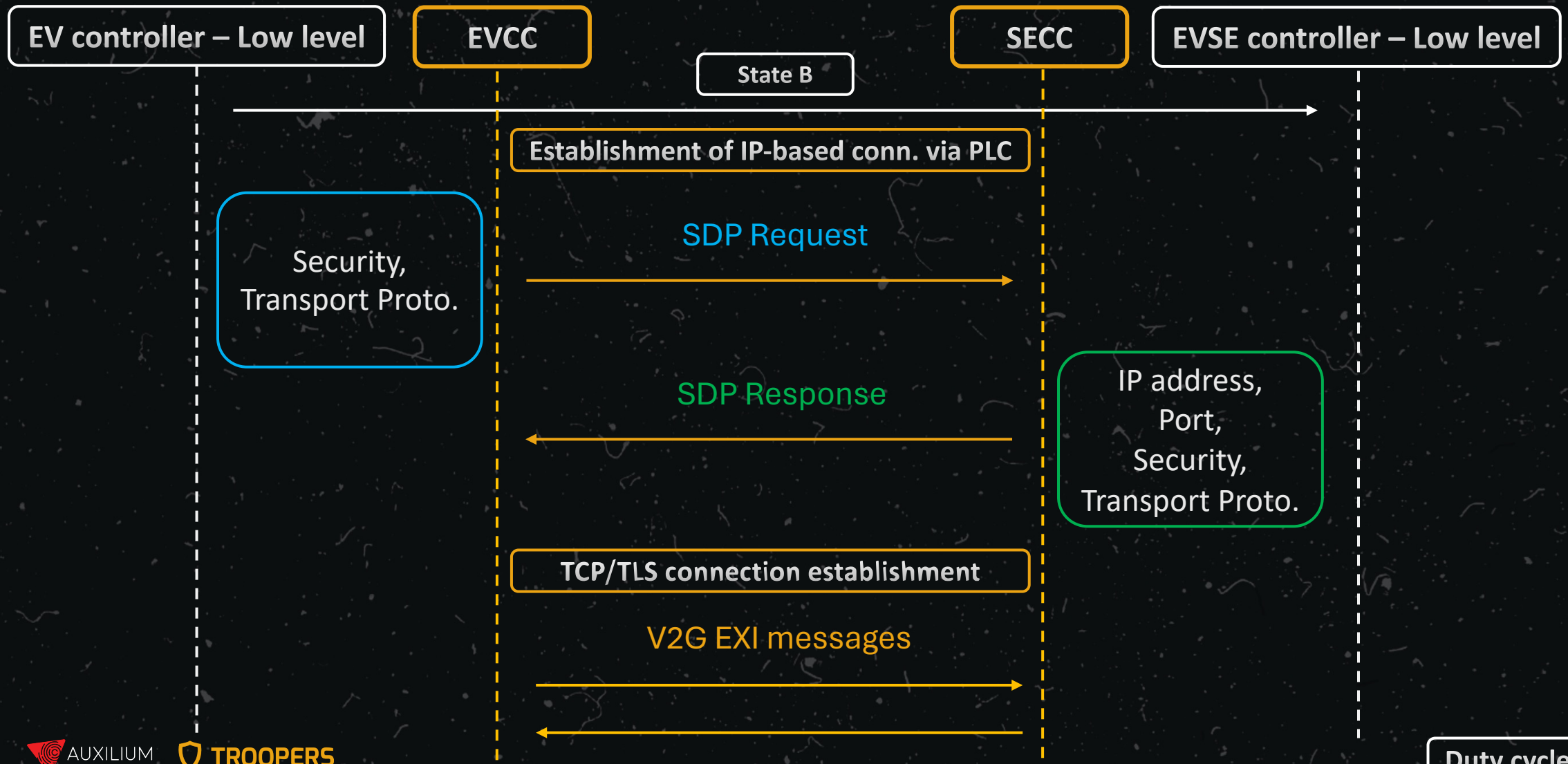
SDP RESPONSE



V2G COMM. FLOW - SDP

IEC 61851

ISO 15118



Duty cycle 5%

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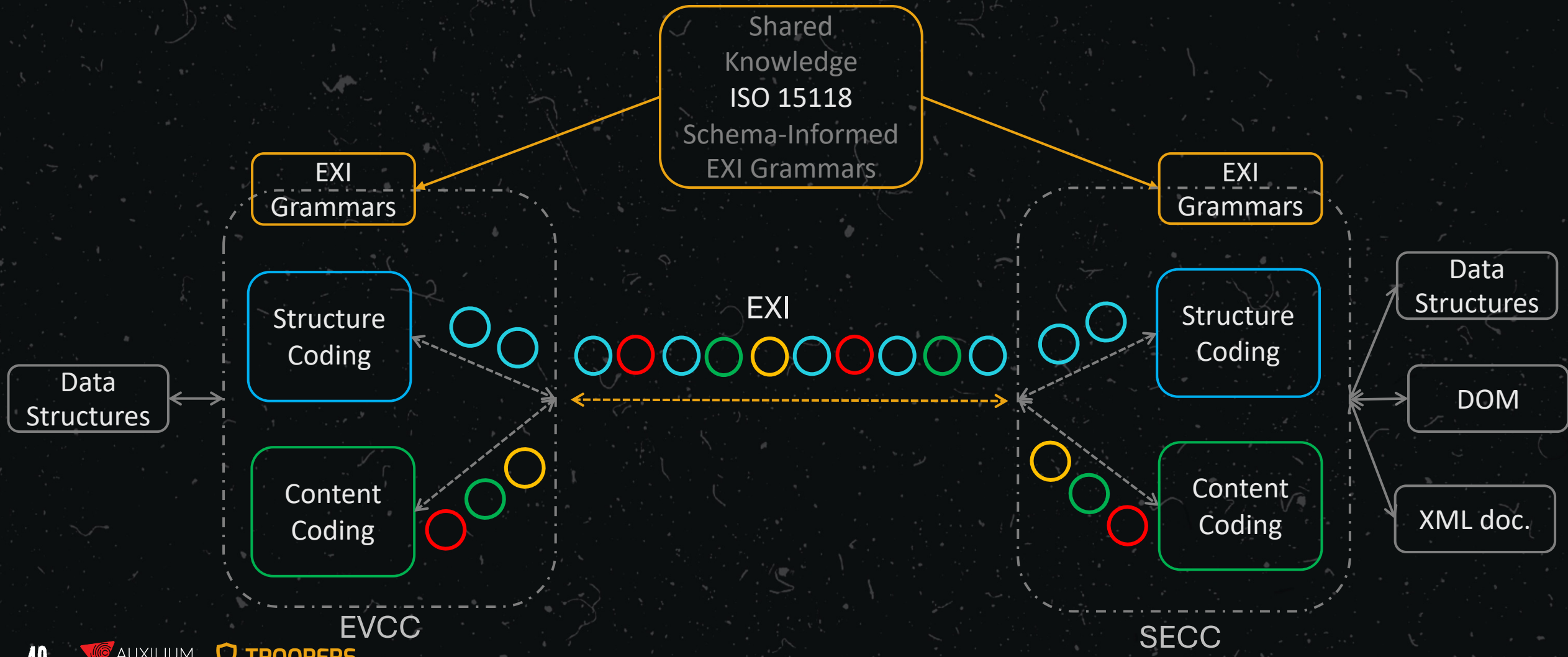
TROOPERS

EXI ENCODED V2G MESSAGE

- Payload Type: 0x8001
- V2G application layer protocol handshake messages
- V2G application layer messages

EXI ENCODED V2G MESSAGE CONCEPT



EXI ENCODED V2G MESSAGE EXAMPLE

Plain XML representation of a SessionSetupRes

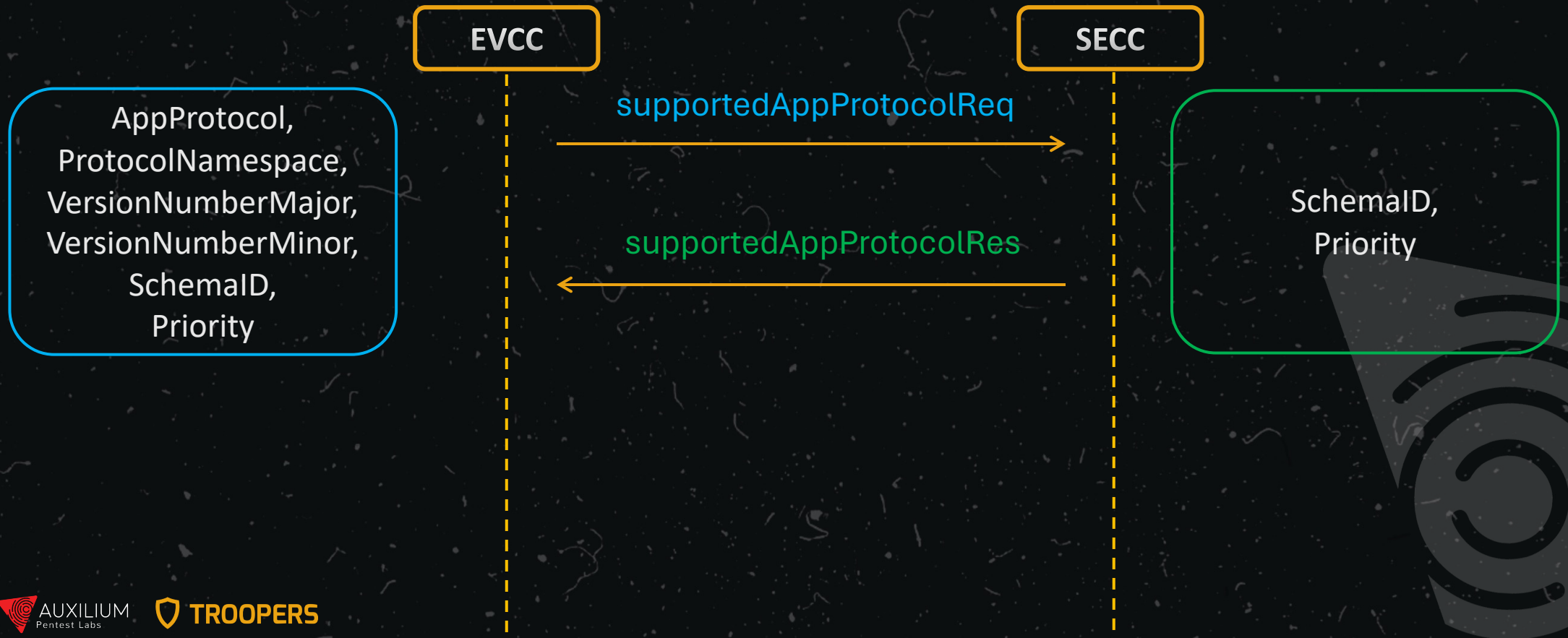
```xml
<?xml version="1.0" encoding="UTF-8"?>
<v2gci_d:V2G_Message xmlns:v2gci_h="urn:iso:15118:2:2013:MsgHeader"
    xmlns:v2gci_d="urn:iso:15118:2:2013:MsgDef"
    xmlns:v2gci_t="urn:iso:15118:2:2013:MsgDataTypes"
    xmlns:xmlsig="http://www.w3.org/2000/09/xmldsig#"
    xmlns:v2gci_b="urn:iso:15118:2:2013:MsgBody"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
    <v2gci_d:Header>
        <v2gci_h:SessionID>3031323334353637</v2gci_h:SessionID>
    </v2gci_d:Header>
    <v2gci_d:Body>
        <v2gci_b:SessionSetupRes>
            <v2gci_b:ResponseCode>OK</v2gci_b:ResponseCode>
            <v2gci_b:EVSEID>FRA23E45B78C</v2gci_b:EVSEID>
        </v2gci_b:SessionSetupRes>
    </v2gci_d:Body>
</v2gci_d:V2G_Message>
```

EXI data stream representation of the SessionSetupRes

```
80 98 02 0C 0C 4C 8C CD 0D 4D 8D D1 E0 00 39 19 49 04 C8 CD 14 D0 D5 08 DC E1 0C 80
```

V2G APPLICATION LAYER PROTOCOL HANDSHAKE

- Application layer protocol negotiation between EVCC and SECC



V2G APPLICATION LAYER PROTOCOL HANDSHAKE

```
<?xml version="1.0" encoding="UTF-8"?>
<n1:supportedAppProtocolReq
    xsi:schemaLocation="urn:iso:15118:2:2010:AppProtocol ../V2G_CI_AppProtocol.xsd"
    xmlns:n1="urn:iso:15118:2:2010:AppProtocol"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
<AppProtocol>
    <ProtocolNamespace>urn:iso:15118:2:2013:MsgDef</ProtocolNamespace>
```

```
<?xml version="1.0" encoding="UTF-8"?>
<n1:supportedAppProtocolRes
    xsi:schemaLocation="urn:iso:15118:2:2010:AppProtocol ../V2G_CI_AppProtocol.xsd"
    xmlns:n1="urn:iso:15118:2:2010:AppProtocol"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
    <ResponseCode>OK_SuccessfulNegotiation</ResponseCode>
    <SchemaID>10</SchemaID>
</n1:supportedAppProtocolRes>
```

```
    <Priority>2</Priority>
</AppProtocol>
</n1:supportedAppProtocolReq>
```

V2G APPLICATION LAYER MESSAGES

- Messages for exchanging info during charging session

- V2G Message
  - Header
  - Body

V2G APPLICATION LAYER MESSAGES

- Example message

```
<?xml version="1.0" encoding="UTF-8"?>
<v2gci_d:V2G_Message xmlns:v2gci_h="urn:iso:15118:2:2013:MsgHeader"
    xmlns:ds="http://www.w3.org/2000/09/xmldsig#"
    xmlns:v2gci_b="urn:iso:15118:2:2013:MsgBody"
    xmlns:v2gci_d="urn:iso:15118:2:2013:MsgDef"
    xmlns:v2gci_t="urn:iso:15118:2:2013:MsgDataTypes"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
    <v2gci_d:Header>
        <v2gci_h:SessionID>3031323334353637</v2gci_h:SessionID>
    </v2gci_d:Header>
    <v2gci_d:Body>
        <v2gci_b:PaymentServiceSelectionReq>
            <v2gci_b:SelectedPaymentOption>Contract</v2gci_b:SelectedPaymentOption>
            <v2gci_b:SelectedServiceList>
                <v2gci_t:SelectedService>
                    <v2gci_t:ServiceID>1</v2gci_t:ServiceID>
                    <!-- charge service -->
                </v2gci_t:SelectedService>
                <v2gci_t:SelectedService>
                    <v2gci_t:ServiceID>3</v2gci_t:ServiceID>
                    <!-- internet service -->
                    <v2gci_t:ParameterSetID>3</v2gci_t:ParameterSetID>
                </v2gci_t:SelectedService>
            </v2gci_b:SelectedServiceList>
        </v2gci_b:PaymentServiceSelectionReq>
    </v2gci_d:Body>
</v2gci_d:V2G_Message>
```

KAPITOLA 5

TESTING ENVIRONMENT

V2G Board Setup I

- dLAN® Green PHY eval board with dLAN® Green PHY Module
- PLC support, PLC-to-Ethernet bridging support, support of HPGP, local connection to PC via RJ45

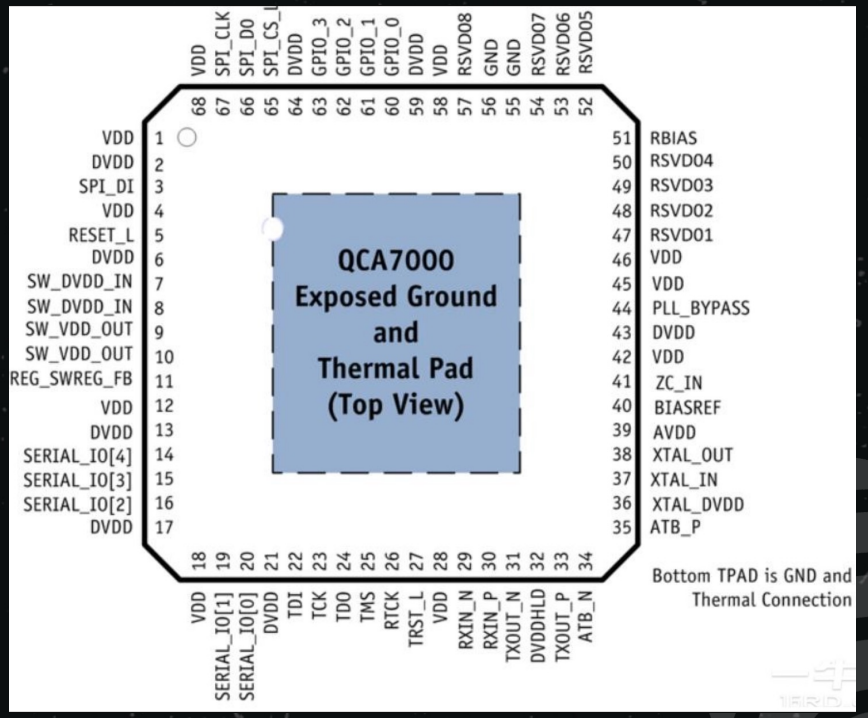
V2G Board Setup II

- QCA7000_GreenPHY_Firmware
  - Allow to configure module as an emob-charger or emob-vehicle
  - Implicit support of the SLAC – EVCC and SECC side

```
PS D:\FIT_CVUT\Ing\NI-DIP\Master's_Thesis\Devolo_Boards\dlan-greenphy-sdk-master\QCA7000_GreenPHY_Firmware\qca7000_1-2-4
-00-1_kit_2022-03-11_windows\qca7000_1-2-4-00-1_kit\windows> .\qca7000-update.cmd
Usage:
qca7000-update <config-profile> [mac-address]

 config-profile must be one of:

  iot-generic    IoT generic, optimized for performance: 50561 off (SLAC off)
  iot-conform    IoT over mains, optimized for conformity: 50561 on (SLAC off)
  emob-charger   e-mobility use as charging station: SLAC in EVSE mode (50561 off)
  emob-vehicle   e-mobility use as vehicle: SLAC in PEV mode (50561 off)

 mac-address is optional, if omitted, the first
 localy attached adapter will be programmed
```

V2G Board Setup III

V2G Board Setup III



V2G Testing Environment

- SLAC implementation is provided by FW
  - emob-charger or emob-vehicle

- Josev – Joint Operating System for EV chargers
  - Repository called iso15118
    - EVCC part to simulate the EV controller
    - SECC part to simulate the EVSE controller

KAPITOLA 6

V2GEVIL INTRO

V2GEVIL - ARCHITECTURE

- Tool is modular
  - cli
  - v2gtp
  - sniffer
  - messages
  - station
  - enumerator
  - fuzzer

```
└─$ v2gevil --help

Usage: v2gevil [OPTIONS] COMMAND [ARGS]...

Main entry point for the CLI

 Options
 --version                 Show the version and exit.
 --debug/--no-debug        Enable/Disable debug mode, default: Disabled
 --help                    Show this message and exit.

 Commands
 car-tools                 Car tool related commands
 message-tools             Message tool related commands
 modules-tools             Modules tool related commands
 sender-tools              Sender tool related commands
 sniffer-tools             Sniffer tool related commands
 station-tools             Station tool related commands
 v2gtp-tools               V2GTP tool related commands
```

V2GEVIL - FUNCTIONALITY I

- V2GTP Module:
  - Packet parsing - IPv6, UDP/TCP, V2GTP PDUs
  - V2GTP packet - SDP response/request, V2G EXI message
  - Decoding V2G EXI message - using V2Gdecoder
  - Creating V2GTP responses
- Sniffer Module:
  - Live and static sniffing of V2G communication
  - Inspect specific packet from pcap file
  - Decoding and filtering capabilities

V2GEVIL - FUNCTIONALITY II

- Messages Module
  - V2G EXI messages - XML schema
  - Conversion between formats (XML, JSON, EXI)
  - Default dictionaries for AC/DC charging modes
  - Message dictionary generator
- Station Module
  - Based on the V2GTP and Messages modules
  - Implementation of SECC
    - SDP (UDP) and TCP/TLS servers
  - Core for security modules

V2GEVIL - FUNCTIONALITY III

- Enumerator Module
  - TLS required or not
  - TLS version
  - TLS supported cipher suites
  - Application protocols
  - Any type of V2G EXI request can be added for enumeration

V2GEVIL - FUNCTIONALITY IV

- Fuzzer Module
  - Testing resilience of EVCC implementation
  - Invalid values for parameters in V2G response message
  - Modes: all, custom, config, message
  - Can cause message processing failures
  - Focus on EXI/XML parsing issues

KAPITOLA 6

DEMO TIME

V2GEVIL SNIFFER

```
(v2g㉿v2g-virtual-machine)-[~/V2G/repos/V2GEvil]
$
```

```
}}}}
INFO    2023-08-11 12:26:38,585 - iso15118.shared.comm_session (235): PowerDeliveryRes received
INFO    2023-08-11 12:26:38,587 - iso15118.shared.exi_codec (245): Message to encode (ns=urn:iso:1511
8:2:2013:MsgDef): {"V2G_Message": {"Header": {"SessionID": "D1255DC60E8D278A"}, "Body": {"SessionStop
Req": {"ChargingSession": "Terminate"}}}}
INFO    2023-08-11 12:26:38,653 - iso15118.shared.comm_session (428): Sent SessionStopReq
INFO    2023-08-11 12:26:38,653 - iso15118.shared.states (139): Entered state SessionStop
DEBUG    2023-08-11 12:26:38,653 - iso15118.shared.states (143): Waiting for up to 2.0 s
INFO    2023-08-11 12:26:38,959 - iso15118.shared.exi_codec (299): Decoded message (ns=urn:iso:15118:
2:2013:MsgDef): {"V2G_Message":{"Header":{"SessionID":"D1255DC60E8D278A"},"Body":{"SessionStopRes":{"
ResponseCode":"OK"}}}}
INFO    2023-08-11 12:26:38,961 - iso15118.shared.comm_session (235): SessionStopRes received
INFO    2023-08-11 12:26:38,961 - iso15118.shared.comm_session (396): The data link will terminate in
 2 seconds and the TCP connection will close in 5 seconds.
INFO    2023-08-11 12:26:38,961 - iso15118.shared.comm_session (400): Reason: Communication session t
erminated
INFO    2023-08-11 12:26:40,964 - iso15118.shared.comm_session (407): terminated the data link
INFO    2023-08-11 12:26:43,968 - iso15118.shared.comm_session (414): TCP connection closed to peer w
ith address ('fe80::d237:45ff:fe88:b12b', 52342, 0, 8)
^CDEBUG    2023-08-11 12:26:58,148 - __main__ (37): EVCC program terminated manually


(v2g㉿v2g-virtual-machine)-[~/V2G/repos/iso15118]
$ ./scripts/start_evcc.sh                                                    130 ×
```

```
(v2g㉿v2g-virtual-machine)-[~/V2G/repos/V2Gdecoder]
$                                                                            130 ×
```

```
INFO    2023-08-11 12:26:38,782 - iso15118.shared.comm_session (235): SessionStopReq received
INFO    2023-08-11 12:26:38,787 - iso15118.shared.exi_codec (245): Message to encode (ns=urn:iso:1511
8:2:2013:MsgDef): {"V2G_Message": {"Header": {"SessionID": "D1255DC60E8D278A"}, "Body": {"SessionStop
Res": {"ResponseCode": "OK"}}}}
INFO    2023-08-11 12:26:38,890 - iso15118.shared.comm_session (428): Sent SessionStopRes
INFO    2023-08-11 12:26:38,891 - iso15118.secc.controller.simulator (634): iso15118 state: SessionSt
op
INFO    2023-08-11 12:26:38,897 - iso15118.shared.comm_session (396): The data link will terminate in
 2 seconds and the TCP connection will close in 5 seconds.
INFO    2023-08-11 12:26:38,899 - iso15118.shared.comm_session (400): Reason: EV requested to termina
te the communication session
INFO    2023-08-11 12:26:40,904 - iso15118.shared.comm_session (407): terminated the data link
INFO    2023-08-11 12:26:43,909 - iso15118.shared.comm_session (414): TCP connection closed to peer w
ith address ('fe80::d237:45ff:fe88:b12a', 34132, 0, 7)
WARNING    2023-08-11 12:26:43,909 - iso15118.secc.transport.tcp_server (151): Closing TCP server
WARNING    2023-08-11 12:26:43,910 - iso15118.secc.comm_session_handler (319): Unexpected error endin
g current session: ('fe80::d237:45ff:fe88:b12a', 34132, 0, 7)
INFO    2023-08-11 12:26:43,910 - iso15118.secc.transport.udp_server (206): UDP server has been resum
ed.
^CDEBUG    2023-08-11 12:27:10,702 - __main__ (35): SECC program terminated manually


(v2g㉿v2g-virtual-machine)-[~/V2G/repos/iso15118]
$                                                                            130 ×
```

SNIFFER MODULE I

```
└─$ sudo v2gevil sniffer-tools sniff --live --ipv6 --decode
Sniffing packets...
Sniffing packets live on interface %s eth_car
Packet from: fe80::d237:45ff:fe88:b12a to ff02::1.
        V2GTP header: 01fe900000000002
        V2GTP payload: 1000
        Decoded V2GTP packet:
        SDP request:
        Security: 0x10 => No transport layer security
        Transport layer: 0x00 => TCP

Packet from: fe80::d237:45ff:fe88:b12b to fe80::d237:45ff:fe88:b12a.
        V2GTP header: 01fe900100000014
        V2GTP payload: fe80000000000000d23745fffe88b12bcdd21000
        Decoded V2GTP packet:
        SDP response:
        IP address: fe80000000000000d23745fffe88b12b
        Port: 52690
        Security: 0x10 => No transport layer security
        Transport layer: 0x00 => TCP

No VTGTP layer for this packet:
        Ether / IPv6 / TCP fe80::d237:45ff:fe88:b12a:56122 > fe80::d237:45ff:fe88:b12b:52690 S
```

SNIFFER MODULE II

```
No VTGTP layer for this packet:
        Ether / IPv6 / TCP fe80::d237:45ff:fe88:b12b:52690 > fe80::d237:45ff:fe88:b12a:56122 SA

No VTGTP layer for this packet:
        Ether / IPv6 / TCP fe80::d237:45ff:fe88:b12a:56122 > fe80::d237:45ff:fe88:b12b:52690 A

Packet from: fe80::d237:45ff:fe88:b12a to fe80::d237:45ff:fe88:b12b.
        V2GTP header: 01fe800100000024
        V2GTP payload: 8000ebab9371d34b9b79d189a98989c1d191d191818999d26b9b3a232b30020000040040
        Decoded V2GTP packet:
        <?xml version="1.0" encoding="UTF-8"?><ns4:supportedAppProtocolReq xmlns:ns4="urn:iso:15
118:2:2010:AppProtocol" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:ns3="http://
www.w3.org/2001/XMLSchema"><AppProtocol><ProtocolNamespace>urn:iso:15118:2:2013:MsgDef</Protocol
Namespace><VersionNumberMajor>2</VersionNumberMajor><VersionNumberMinor>0</VersionNumberMinor><S
chemaID>1</SchemaID><Priority>1</Priority></AppProtocol></ns4:supportedAppProtocolReq>
```

V2GEVIL ENUMERATOR

```
XML
{Format=EXI, Accept=*/*, User-Agent=python-requests/2.31.0, Connection=keep-alive, Host=localhost:9000, Accept-Encoding=gzip, deflate, Content-Length=28}
EXI
{Format=XML, Accept=*/*, User-Agent=python-requests/2.31.0, Connection=keep-alive, Host=localhost:9000, Accept-Encoding=gzip, deflate, Content-Length=674}
XML
{Format=EXI, Accept=*/*, User-Agent=python-requests/2.31.0, Connection=keep-alive, Host=localhost:9000, Accept-Encoding=gzip, deflate, Content-Length=12}
EXI
{Format=XML, Accept=*/*, User-Agent=python-requests/2.31.0, Connection=keep-alive, Host=localhost:9000, Accept-Encoding=gzip, deflate, Content-Length=1749}
XML
{Format=EXI, Accept=*/*, User-Agent=python-requests/2.31.0, Connection=keep-alive, Host=localhost:9000, Accept-Encoding=gzip, deflate, Content-Length=18}
EXI
{Format=XML, Accept=*/*, User-Agent=python-requests/2.31.0, Connection=keep-alive, Host=localhost:9000, Accept-Encoding=gzip, deflate, Content-Length=594}
XML
{Format=EXI, Accept=*/*, User-Agent=python-requests/2.31.0, Connection=keep-alive, Host=localhost:9000, Accept-Encoding=gzip, deflate, Content-Length=72}
EXI
```

```
(v2gevil-zORstogo-py3.10)-(v2g㉿v2g-virtual-machine)-[~/V2G/repos/V2GEvil]
$ v2gevil modules-tools enumerate-EV --mode all
```

```
onnection
INFO    2024-01-09 17:00:27,458 - iso15118.shared.comm_session (407): terminated the data link
INFO    2024-01-09 17:00:30,461 - iso15118.shared.comm_session (414): TCP connection closed to peer with address ('fe80::d237:45ff:fe88:b12b', 53313, 0, 9)
ERROR    2024-01-09 17:00:30,461 - iso15118.evcc.comm_session_handler (557): EVCC tried to initiate a V2GCommunicationSession, but maximum number of SDP retry cycles (1) is now reached. Shutting down high-level communication. Unplug and plug in the cable again if you want to start anew.
Traceback (most recent call last):
  File "/home/v2g/V2G/repos/iso15118/iso15118/evcc/comm_session_handler.py", line 555, in get_from_rcv_queue
    await self.restart_sdp(True)
  File "/home/v2g/V2G/repos/iso15118/iso15118/evcc/comm_session_handler.py", line 378, in restart_sdp
    raise SDPFailedError(
iso15118.shared.exceptions.SDPFailedError: EVCC tried to initiate a V2GCommunicationSession, but maximum number of SDP retry cycles (1) is now reached. Shutting down high-level communication. Unplug and plug in the cable again if you want to start anew.
^CDEBUG    2024-01-09 17:00:32,640 - __main__ (37): EVCC program terminated manually

(iso15118-gAdVIpLN-py3.10)-(v2g㉿v2g-virtual-machine)-[~/V2G/repos/iso15118]
$ ./scripts/start_evcc.sh                                                    130 ×
```

```
o:15118:2:2013:MsgDef): {"V2G_Message": {"Header": {"SessionID": "29782C50551B53DA"}, "Body": {"SessionStopRes": {"ResponseCode": "OK"}}}}
INFO    2024-01-09 14:13:27,646 - iso15118.shared.comm_session (428): Sent SessionStopRes
INFO    2024-01-09 14:13:27,646 - iso15118.secc.controller.simulator (634): iso15118 state: SessionStop
INFO    2024-01-09 14:13:27,646 - iso15118.shared.comm_session (396): The data link will terminate in 2 seconds and the TCP connection will close in 5 seconds.
INFO    2024-01-09 14:13:27,646 - iso15118.shared.comm_session (400): Reason: EV requested to terminate the communication session
INFO    2024-01-09 14:13:29,649 - iso15118.shared.comm_session (407): terminated the data link
INFO    2024-01-09 14:13:32,657 - iso15118.shared.comm_session (414): TCP connection closed to peer with address ('fe80::d237:45ff:fe88:b12a', 38542, 0, 10)
WARNING    2024-01-09 14:13:32,658 - iso15118.secc.transport.tcp_server (151): Closing TCP server
WARNING    2024-01-09 14:13:32,658 - iso15118.secc.comm_session_handler (319): Unexpected error ending current session: ('fe80::d237:45ff:fe88:b12a', 38542, 0, 10)
INFO    2024-01-09 14:13:32,658 - iso15118.secc.transport.udp_server (206): UDP server has been resumed.
^CDEBUG    2024-01-09 14:15:16,499 - __main__ (35): SECC program terminated manually

(v2g㉿v2g-virtual-machine)-[~/V2G/repos/iso15118]
$                                                                            130 ×
```

ENUMERATOR MODULE

```
--------------------------------------------------------------------------------
EV enumeration results:
--------------------------------------------------------------------------------
Supported App protocols result:
{'AppProtocol': [{'ProtocolNamespace': 'urn:iso:15118:2:2013:MsgDef', 'VersionNumberMajor': 2,
'VersionNumberMinor': 0, 'SchemaID': '1', 'Priority': 1}]}

Supported protocols by EV:
Number of supported protocols: 1
ProtocolNamespace: urn:iso:15118:2:2013:MsgDef, VersionMajor: 2, VersionMinor: 0, SchemaID: 1,
Priority: 1
--------------------------------------------------------------------------------
TLS check result:
EV requested security: TLS and as a transport protocol: TCP for communication
--------------------------------------------------------------------------------
TLS enumeration result:
TLS negotiated version: TLSv1.2
TLS negotiated cipher suite: ('ECDHE-ECDSA-AES128-SHA256', 'TLSv1.2', 128)
TLS shared ciphers: [('ECDHE-ECDSA-AES128-SHA256', 'TLSv1.2', 128)].
Shared ciphers are ciphers available in both the EV and the EVSE.
```

V2GEVIL FUZZER

```
EXI
{Format=XML, Accept=*/*, User-Agent=python-requests/2.31.0, Connection=keep-alive, Host=localh
ost:9000, Accept-Encoding=gzip, deflate, Content-Length=1640}
XML
{Format=EXI, Accept=*/*, User-Agent=python-requests/2.31.0, Connection=keep-alive, Host=localh
ost:9000, Accept-Encoding=gzip, deflate, Content-Length=72}
EXI
{Format=XML, Accept=*/*, User-Agent=python-requests/2.31.0, Connection=keep-alive, Host=localh
ost:9000, Accept-Encoding=gzip, deflate, Content-Length=322}
XML
{Format=EXI, Accept=*/*, User-Agent=python-requests/2.31.0, Connection=keep-alive, Host=localh
ost:9000, Accept-Encoding=gzip, deflate, Content-Length=28}
EXI
{Format=XML, Accept=*/*, User-Agent=python-requests/2.31.0, Connection=keep-alive, Host=localh
ost:9000, Accept-Encoding=gzip, deflate, Content-Length=674}
XML
{Format=EXI, Accept=*/*, User-Agent=python-requests/2.31.0, Connection=keep-alive, Host=localh
ost:9000, Accept-Encoding=gzip, deflate, Content-Length=12}
EXI
{Format=XML, Accept=*/*, User-Agent=python-requests/2.31.0, Connection=keep-alive, Host=localh
ost:9000, Accept-Encoding=gzip, deflate, Content-Length=1677}
XML
```

```
(iso15118-gAdVIpLN-py3.10)-(v2g㉿v2g-virtual-machine)-[~/V2G/repos/iso15118]
$                                                                          130 ×
```

```
(v2gevil-zORstogo-py3.10)-(v2g㉿v2g-virtual-machine)-[~/V2G/repos/V2GEvil]
$ v2gevil modules-tools fuzz-EV --mode config --config-filename ev_fuzzer_example_3.toml
```

```
(v2g㉿v2g-virtual-machine)-[~/V2G/repos/iso15118]
$
```

FUZZER MODULE

```
Created response object:
{'ResponseCode': 'OK_SuccessfulNegotiation', 'SchemaID': '1'}
--------------------------------------------------------------------------------
Received from client: 01fe80010000000e8098004011d01b40dd1622c4ac00
{'Header': {'SessionID': '00'}, 'Body': {'SessionSetupReq': {'EVCCID': 'D0374588B12B'}}}
Created response object:
{'Header': {'SessionID': '00'}, 'Body': {'SessionSetupRes': {'ResponseCode': 'OK', 'EVSEID': '
FRA23E45B78C', 'EVSETimeStamp': 1700593914}}}
--------------------------------------------------------------------------------
Received from client: 01fe800100000068098004011b8
{'Header': {'SessionID': '00'}, 'Body': {'ServiceDiscoveryReq': {}}}
Created response object:
{'Header': {'SessionID': '00'}, 'Body': {'ServiceDiscoveryRes': {'ResponseCode': -914000732215
5668586, 'PaymentOptionList': {'PaymentOption': ['dyMubdnlHoshpVttmAWLkqOTOXKvXLmNwAdUIsqsjBrp
vdsGTvQfcfCALOLxWSSBuVhRGGV']}, 'ChargeService': {'SupportedEnergyTransferMode': {'EnergyTrans
ferMode': ['yUdzaDMRZUmjwqzAYuHqpgyeEhgiLxUsmXHmkftxhpWPGlEWGWeVLMqkKoFojXGWhtgVqxowieOSYrMWc'
]}, 'ServiceID': 9152111138964487569, 'ServiceName': -244716853120383435}, 'ServiceList': {'Se
rvice': [{'ServiceID': 3, 'ServiceName': 'Fast Internet', 'ServiceCategory': 'Internet', 'Free
Service': True}, {'ServiceID': 2, 'ServiceName': 'Certificate', 'ServiceCategory': 'ContractCe
rtificate', 'FreeService': True}]}}}}
TCP connection closed
SDP server is running in while loop
```

FUZZER MODULE

```
Created response object:                                                    [0/1939]
{'ResponseCode': 'OK_SuccessfulNegotiation', 'SchemaID': '1'}
--------------------------------------------------------------------------------
Received from client: 01fe80010000000e8098004011d01b40dd1622c4ac00
{'Header': {'SessionID': '00'}, 'Body': {'SessionSetupReq': {'EVCCID': 'D0374588B12B'}}}
Created response object:
{'Header': {'SessionID': '00'}, 'Body': {'SessionSetupRes': {'ResponseCode': 'OK', 'EVSEID': '
FRA23E45B78C', 'EVSETimeStamp': 1700593914}}}
--------------------------------------------------------------------------------
Received from client: 01fe800100000068098004011b8
{'Header': {'SessionID': '00'}, 'Body': {'ServiceDiscoveryReq': {}}}
Created response object:
{'Header': {'SessionID': '00'}, 'Body': {'ServiceDiscoveryRes': {'ResponseCode': -914000732215
5668586, 'PaymentOptionList': {'PaymentOption': ['dyMubdnlHoshpVttmAWLkqOTOXKvXLmNwAdUIsqsjBrp
vdsGTvQfcfCALOLxWSSBuVhRGGV']}, 'ChargeService': {'SupportedEnergyTransferMode': {'EnergyTrans
ferMode': ['yUdzaDMRZUmjwqzAYuHqpgyeEhgiLxUsmXHmkftxhpWPGlEWGWeVLMqkKoFojXGWhtgVqxowieOSYrMWc'
]}, 'ServiceID': 9152111138964487569, 'ServiceName': -244716853120383435}, 'ServiceList': {'Se
rvice': [{'ServiceID': 3, 'ServiceName': 'Fast Internet', 'ServiceCategory': 'Internet', 'Free
Service': True}, {'ServiceID': 2, 'ServiceName': 'Certificate', 'ServiceCategory': 'ContractCe
rtificate', 'FreeService': True}]}}}}
TCP connection closed
SDP server is running in while loop
```

FUZZER MODULE

```
DEBUG    2024-01-10 14:54:17,490 - iso15118.shared.states (143): Waiting for up to 20.[35/1909]
INFO    2024-01-10 14:54:17,682 - iso15118.shared.exi_codec (299): Decoded message (ns=urn:iso:
15118:2:2013:MsgDef): {"V2G_Message":{"Header":{"SessionID":"00"},"Body":{"SessionSetupRes":{"R
esponseCode":"OK","EVSEID":"FRA23E45B78C","EVSETimeStamp":1700593914}}}}
INFO    2024-01-10 14:54:17,682 - iso15118.shared.comm_session (235): SessionSetupRes received
INFO    2024-01-10 14:54:17,683 - iso15118.shared.exi_codec (245): Message to encode (ns=urn:is
o:15118:2:2013:MsgDef): {"V2G_Message": {"Header": {"SessionID": "00"}, "Body": {"ServiceDiscov
eryReq": {}}}}
INFO    2024-01-10 14:54:18,569 - iso15118.shared.comm_session (428): Sent ServiceDiscoveryReq
INFO    2024-01-10 14:54:18,569 - iso15118.shared.states (139): Entered state ServiceDiscovery
DEBUG    2024-01-10 14:54:18,569 - iso15118.shared.states (143): Waiting for up to 2.0 s
ERROR    2024-01-10 14:54:19,727 - iso15118.shared.comm_session (222): EXIDecodingError (Except
ion): Transformer Exception: java.lang.RuntimeException: EXI profile stream does not respect pa
rameter maxBuiltInElementGrammars. Expected 0 but was 2
Traceback (most recent call last):
  File "/home/v2g/V2G/repos/iso15118/iso15118/shared/exi_codec.py", line 285, in from_exi
    exi_decoded = self.exi_codec.decode(exi_message, namespace)
  File "/home/v2g/V2G/repos/iso15118/iso15118/shared/exificient_exi_codec.py", line 50, in deco
de
    raise Exception(self.exi_codec.get_last_decoding_error())
Exception: Transformer Exception: java.lang.RuntimeException: EXI profile stream does not respe
ct parameter maxBuiltInElementGrammars. Expected 0 but was 2
```

FUZZER MODULE

```
└─$ v2gevil modules-tools fuzz-EV --mode message --message-name ServiceDiscoveryRes
WARNING  2024-01-10 09:43:29,842 src.v2gevil.fuzzer.fuzz_datatypes: Not  fuzz_datatypes.py:159
         all required parameters are specified for fuzz in method .
WARNING  2024-01-10 09:43:29,846 src.v2gevil.fuzzer.fuzz_datatypes: Not  fuzz_datatypes.py:159
         all required parameters are specified for fuzz in method .
WARNING  2024-01-10 09:43:29,848 src.v2gevil.fuzzer.fuzz_datatypes: Not  fuzz_datatypes.py:159
         all required parameters are specified for fuzz in method .
WARNING  2024-01-10 09:43:29,849 src.v2gevil.fuzzer.fuzz_datatypes: Not  fuzz_datatypes.py:159
         all required parameters are specified for fuzz in method .
Station configuration:
Interface: eth_station
IPv6 address: fe80::d237:45ff:fe88:b12b
Protocol: b'\x00'
SDP port: 15118
TCP port: 54497
TLS flag: False
Accept security: True
Charging mode: AC
Validate flag for model_dump/construct: False
Cert PATH: /home/v2g/V2G/repos/V2GEvil/src/v2gevil/station/certs/cpoCertChain.pem
Keyfile PATH: /home/v2g/V2G/repos/V2GEvil/src/v2gevil/station/certs/seccLeaf.key
SDP server started
```

FUZZER MODULE

```
SDP server started
SDP server is running in while loop
Plain TCP, Connected by:  ('fe80::d237:45ff:fe88:b12a', 38792, 0, 12)
TCP server loop ended after connection established
TCP server connection established
------------------------------------------------------------------------
Received from client: 01fe80010000000248000ebab9371d34b9b79d189a98989c1d191d191818999d26b9b3a23
2b30020000040040
{'AppProtocol': [{'ProtocolNamespace': 'urn:iso:15118:2:2013:MsgDef', 'VersionNumberMajor': 2,
 'VersionNumberMinor': 0, 'SchemaID': '1', 'Priority': 1}]}

Created response object:
{'ResponseCode': 'OK_SuccessfulNegotiation', 'SchemaID': '1'}
------------------------------------------------------------------------
Received from client: 01fe80010000000e8098004011d01b40dd1622c4ac00
{'Header': {'SessionID': '00'}, 'Body': {'SessionSetupReq': {'EVCCID': 'D0374588B12B'}}}
Created response object:
{'Header': {'SessionID': '00'}, 'Body': {'SessionSetupRes': {'ResponseCode': 'OK', 'EVSEID': '
FRA23E45B78C', 'EVSETimeStamp': 1700593914}}}
```

FUZZER MODULE

```
------------------------------------------------------------------------
Received from client: 01fe8001000000068098004011b8
{'Header': {'SessionID': '00'}, 'Body': {'ServiceDiscoveryReq': {}}}
Created response object:
{'Header': {'SessionID': '00'}, 'Body': {'ServiceDiscoveryRes': {'ResponseCode': -474379419508
8843863, 'PaymentOptionList': {'PaymentOption': [25570115874304181811}, 'ChargeService': {'Ser
viceID': 12613137940555096731, 'ServiceName': -6319726005006735731, 'ServiceCategory': 'YYhpZimb
bvQAkakMIhaavNkAJVpAAQWbAzjBjuWNEXbPGOgpdMRCaODNIWeSEWETxoLUsltmbzAfXgGvSTxPsKuCyKbwgvJZi', 'F
reeService': 'wcjuqlnQxnXkFHbedUfjSkPUnhhGc', 'SupportedEnergyTransferMode': {'EnergyTransferM
ode': ['CYZQyPpaMfUyUzIhgGzxmPAnGNmCjkkfIaPmHKqhuhXoCskkDmesCNNqmPfSUSuvDEvhtRGdD']}}, 'Servic
eList': {'Service': [{'ServiceID': 6.078804982723869e+18, 'ServiceName': 'FvVKbfXbJXSrdiTXQKPE
CeIAMHXXGSlZyMpqCTXsTYyodoReAhbfb', 'ServiceCategory': 503402615467551945, 'FreeService': -588
9312028921686995}]}}}}
TCP connection closed
SDP server is running in while loop
```

FUZZER MODULE

```
INFO    2024-01-10 09:47:25,683 - iso15118.shared.exi_codec (245): Message to encode (ns=urn:is
o:15118:2:2013:MsgDef): {"V2G_Message": {"Header": {"SessionID": "00"}, "Body": {"SessionSetupR
eq": {"EVCCID": "D0374588B12B"}}}}
INFO    2024-01-10 09:47:25,791 - iso15118.shared.comm_session (428): Sent SessionSetupReq
INFO    2024-01-10 09:47:25,791 - iso15118.shared.states (139): Entered state SessionSetup
DEBUG    2024-01-10 09:47:25,791 - iso15118.shared.states (143): Waiting for up to 20.0 s
INFO    2024-01-10 09:47:25,941 - iso15118.shared.exi_codec (299): Decoded message (ns=urn:iso:
15118:2:2013:MsgDef): {"V2G_Message":{"Header":{"SessionID":"00"},"Body":{"SessionSetupRes":{"R
esponseCode":"OK","EVSEID":"FRA23E45B78C","EVSETimeStamp":1700593914}}}}
INFO    2024-01-10 09:47:25,941 - iso15118.shared.comm_session (235): SessionSetupRes received
INFO    2024-01-10 09:47:25,942 - iso15118.shared.exi_codec (245): Message to encode (ns=urn:is
o:15118:2:2013:MsgDef): {"V2G_Message": {"Header": {"SessionID": "00"}, "Body": {"ServiceDiscov
eryReq": {}}}}
INFO    2024-01-10 09:47:26,036 - iso15118.shared.comm_session (428): Sent ServiceDiscoveryReq
INFO    2024-01-10 09:47:26,036 - iso15118.shared.states (139): Entered state ServiceDiscovery
DEBUG    2024-01-10 09:47:26,036 - iso15118.shared.states (143): Waiting for up to 2.0 s
ERROR    2024-01-10 09:47:26,194 - iso15118.shared.comm_session (222): EXIDecodingError (Except
ion): Exception: javax.xml.bind.UnmarshalException
Traceback (most recent call last):
  File "/home/v2g/V2G/repos/iso15118/iso15118/shared/exi_codec.py", line 285, in from_exi
    exi_decoded = self.exi_codec.decode(exi_message, namespace)
```

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THE END

FURTHER ENHANCEMENTS

- Basic signaling and implementation of SLAC
- Modules for bidirectional testing (both to and from EV)
- Modules for testing the bidirectional power transfer
  - e.g. charging of other vehicles, vehicle as powersource, etc.
- Fuzzing of PDU structure
- And more…
  - (Exhaustive list of enhancements will be included in our repository)

CONCLUSION

- Communication in Electric Vehicles hasn’t reached its assumed potential
- With bigger needs in the future, more sensitive data will start to flow and subsequently parsed by EVs and EVSEs
- No opensource tools are available to cover this emerging attack surface
- We want our tool to act as an easy way for people to get introduced and start researching both EVs and chargers in an efficient and modular way

TO BE RELEASED AFTER **DEFCON32**

THANK YOU FOR YOUR ATTENTION

TROOPERS

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