Non-Repudiation and End-to-End Security for Electric-Vehicle Charging

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iCIS | Digital Security
Radboud University

European Union

OPoost
operationeel programma oost

European Regional Development Fund

Overview

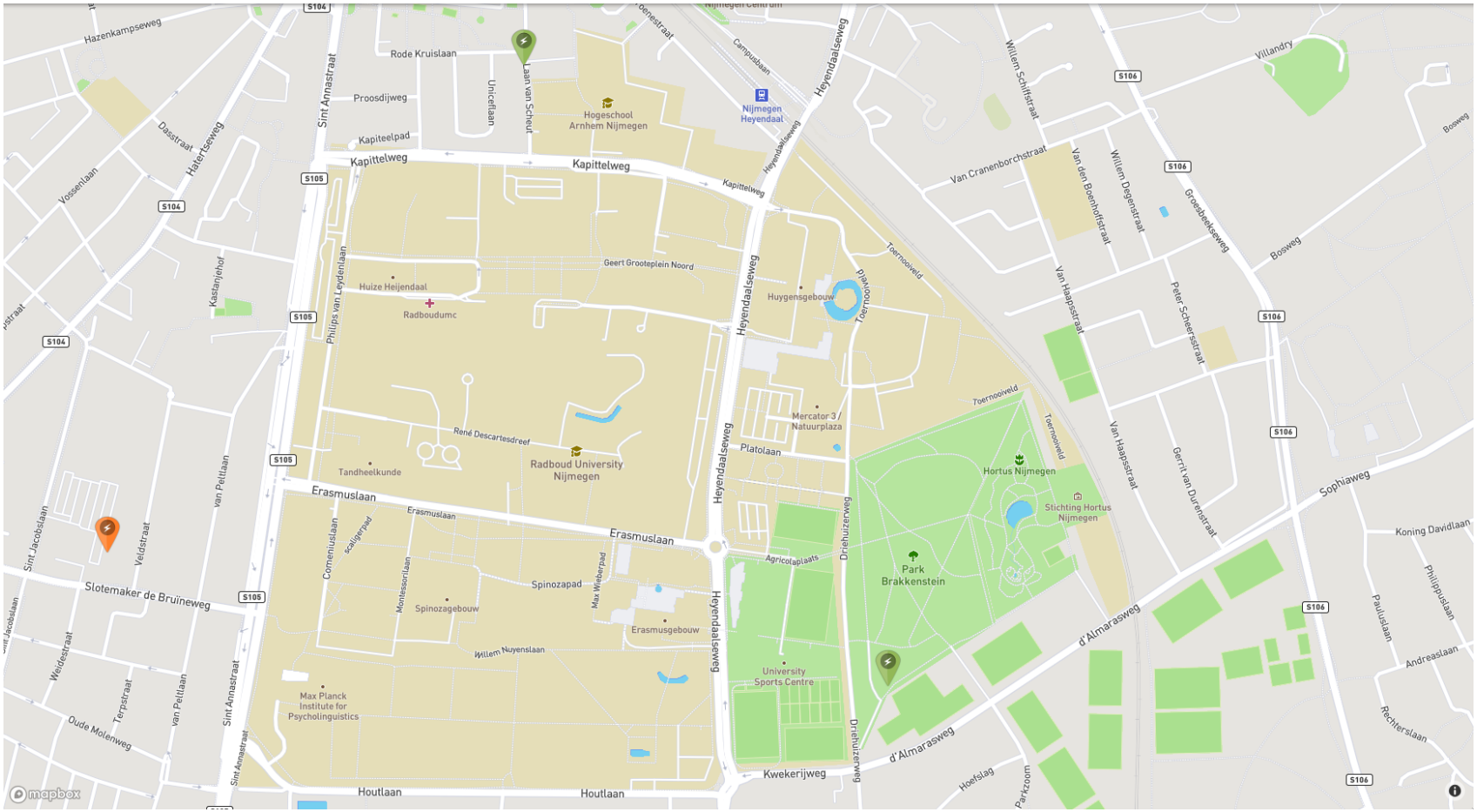
The EV-charging infrastructure

The need for security

End-to-end security

Conclusions

Where is the EV-charging infrastructure?



Source: openchargemap.io

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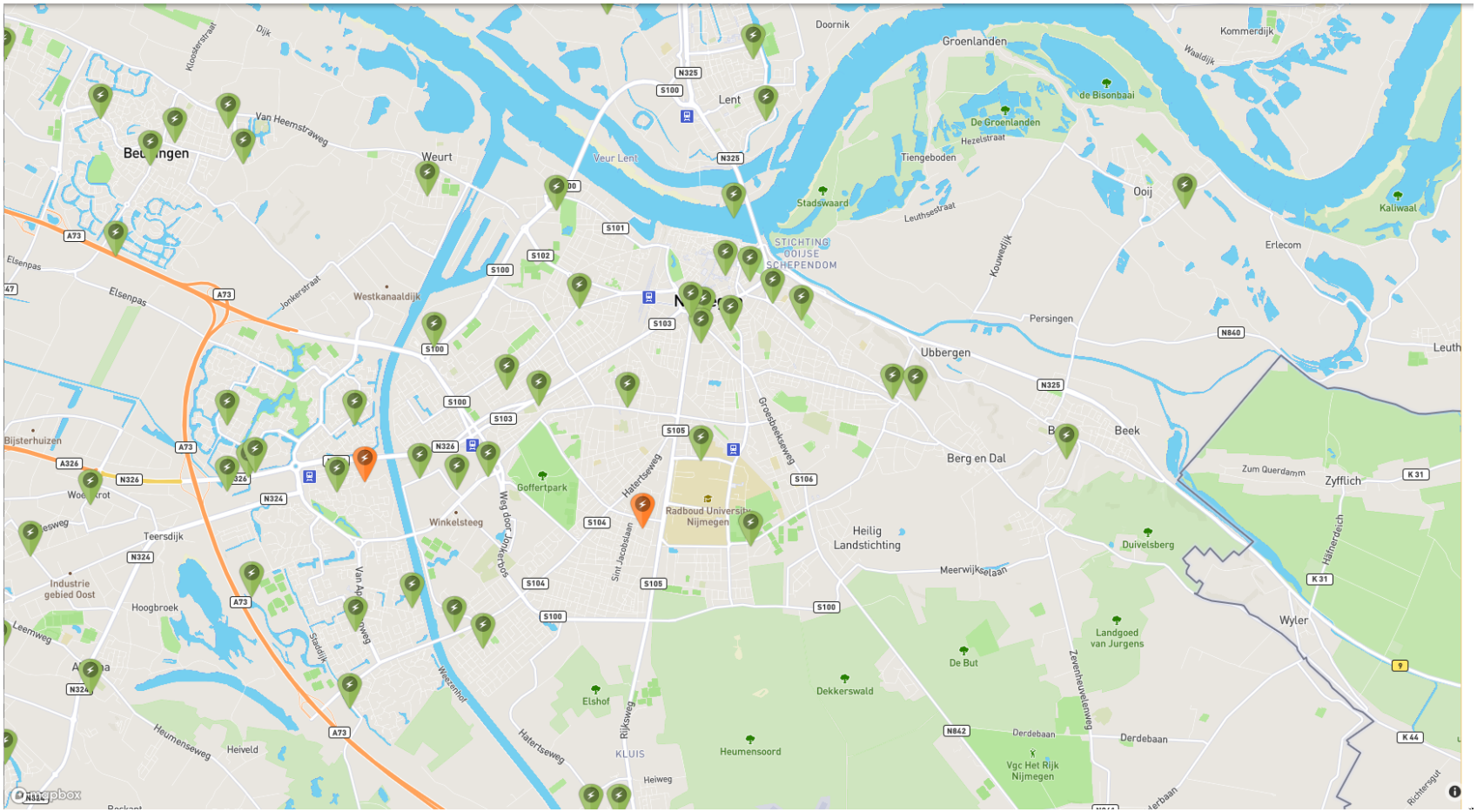

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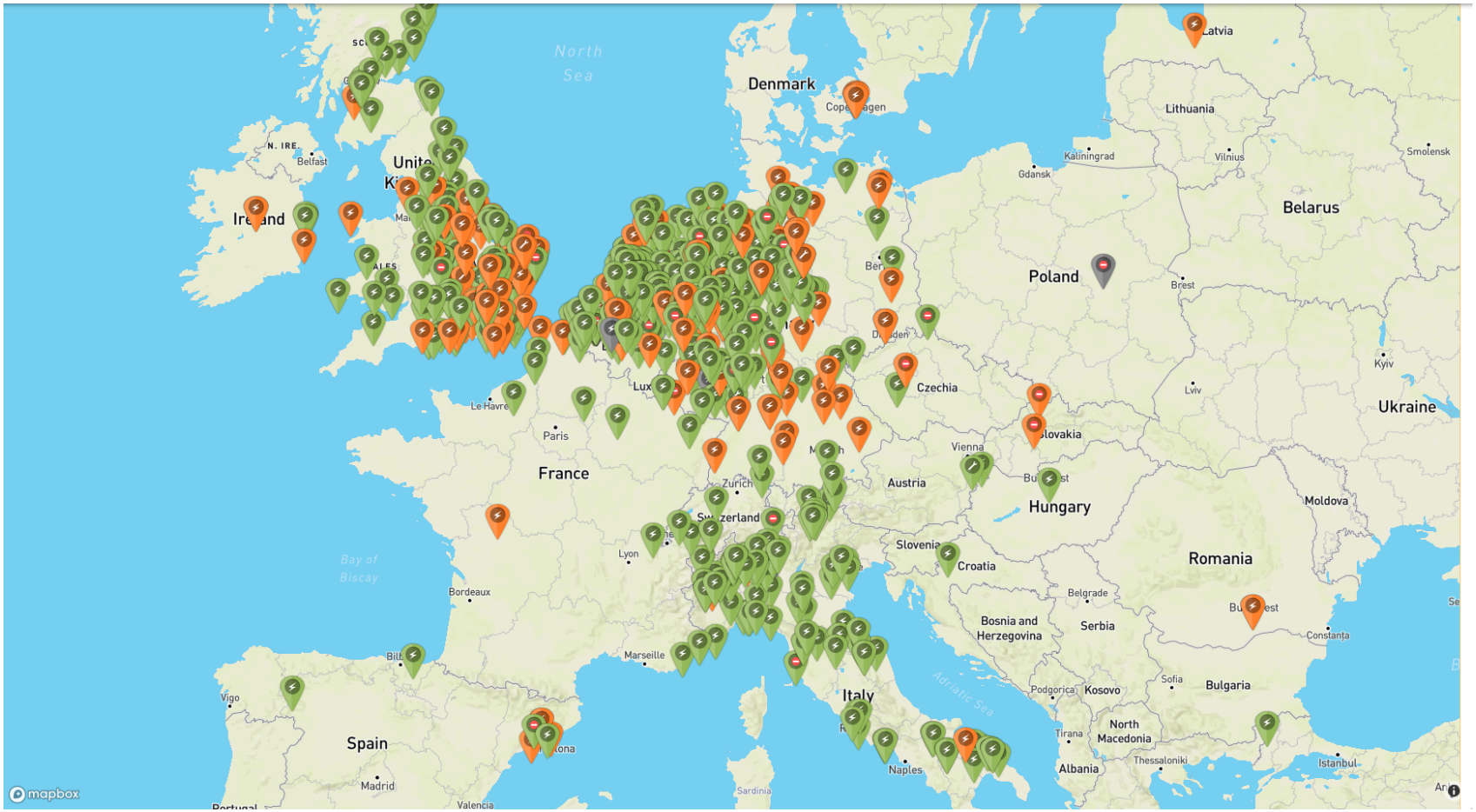

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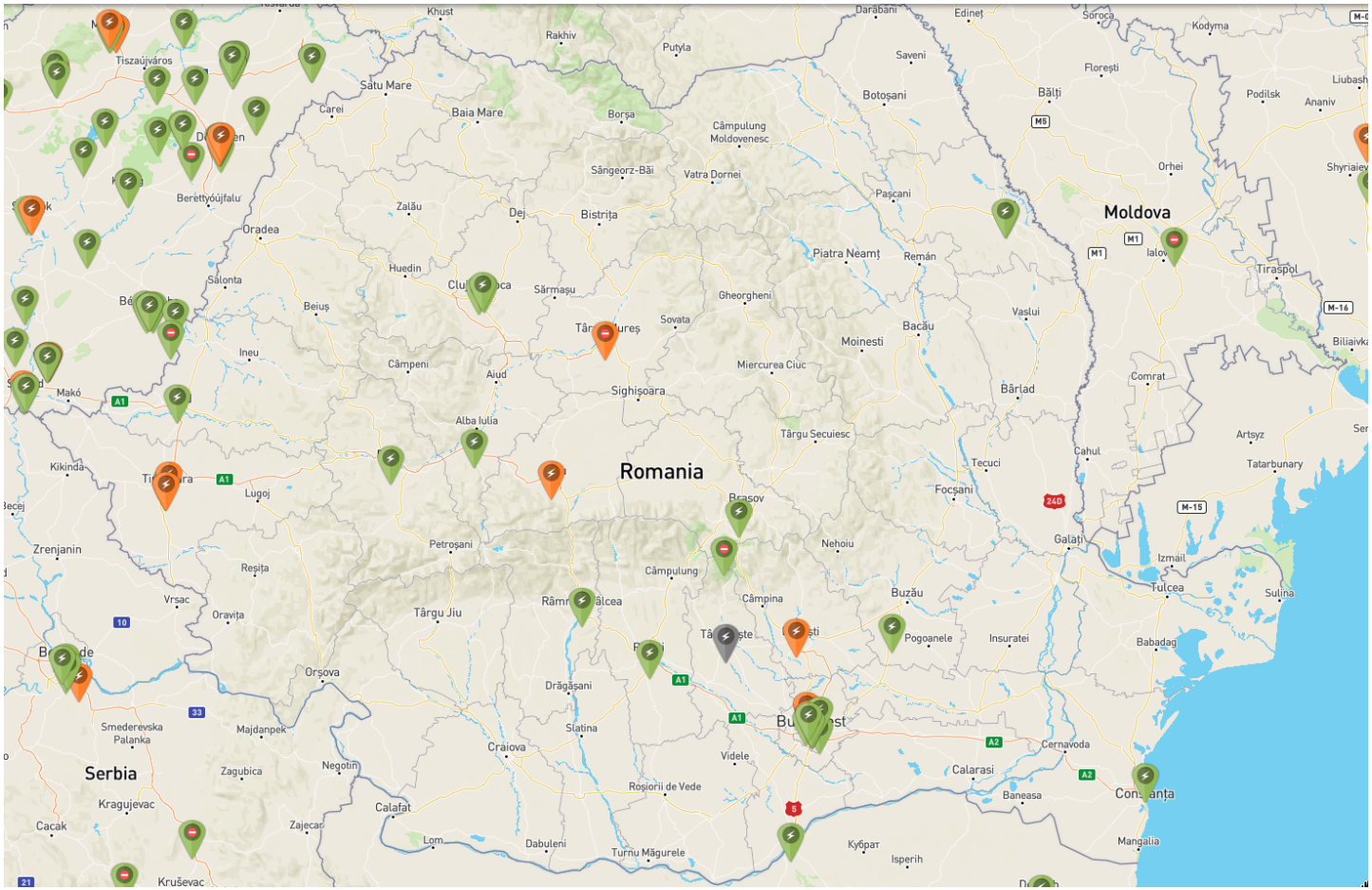

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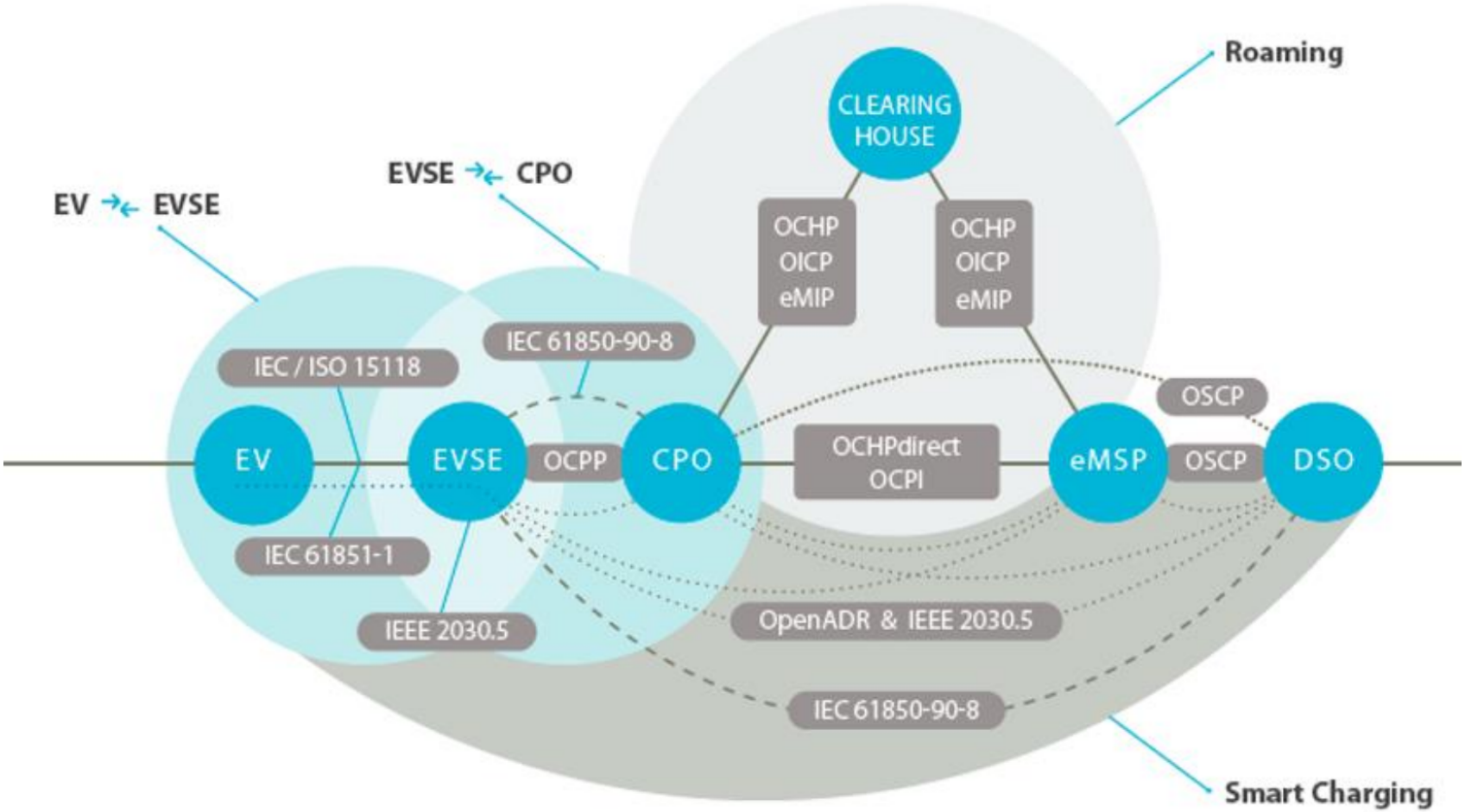

Source: EV Related Protocol Study – ElaadNL

Most important aspects

- Many roles, fulfilled by many different parties.

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- The only way for some of these to communicate is *via other parties*.

Overview

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- Fraud

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  - Customer location is sensitive information!
  - What other information should be secret?
  - GDPR compliance is not straightforward.

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- Authentication / authorization with RFID cards

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- Some TLS, lacking clear instructions

Envisioned state of security

- Strong authentication using challenge-response

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- Strong authentication using challenge-response
- TLS everywhere, standardized & specified well
- Better implementations and testing

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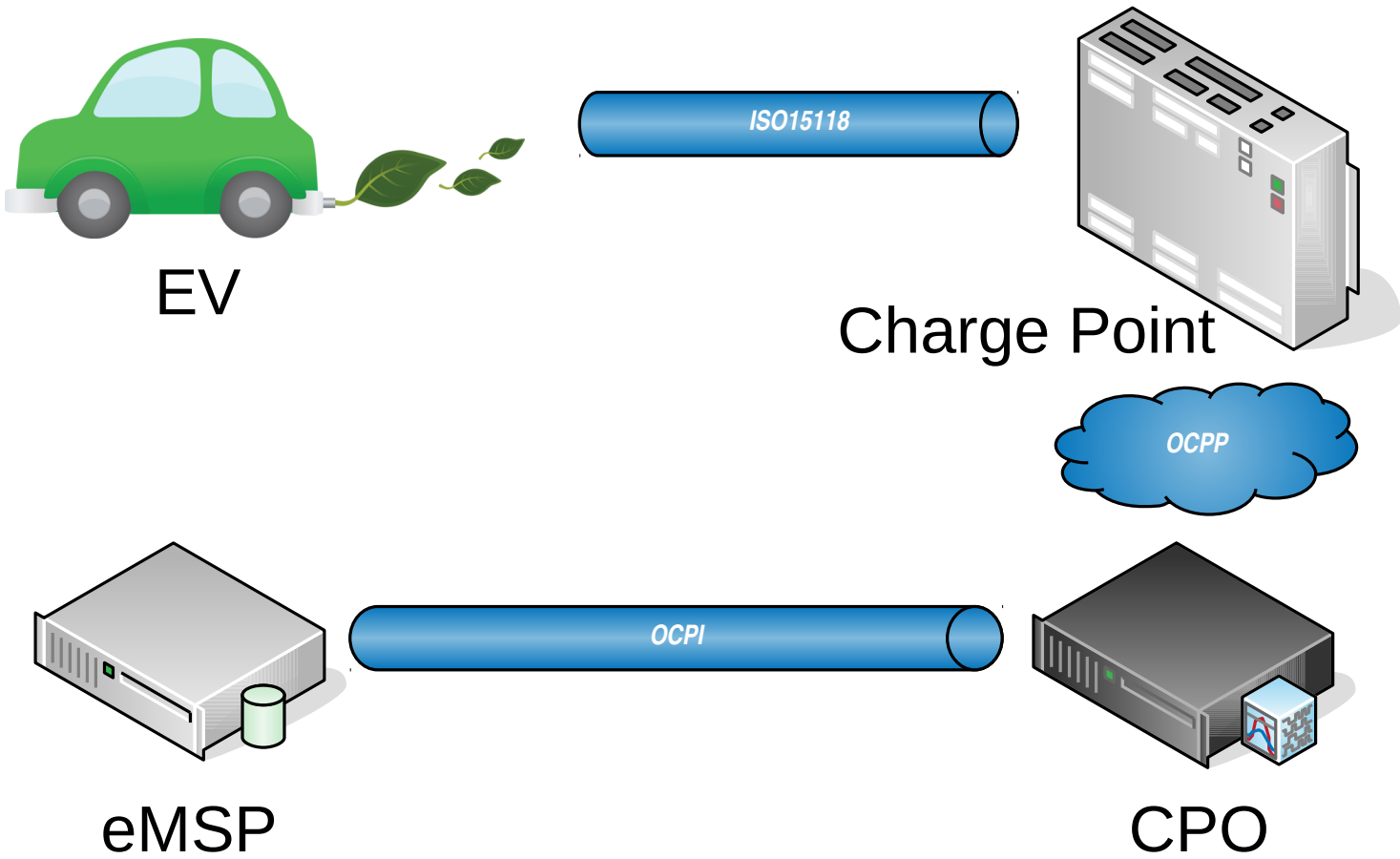

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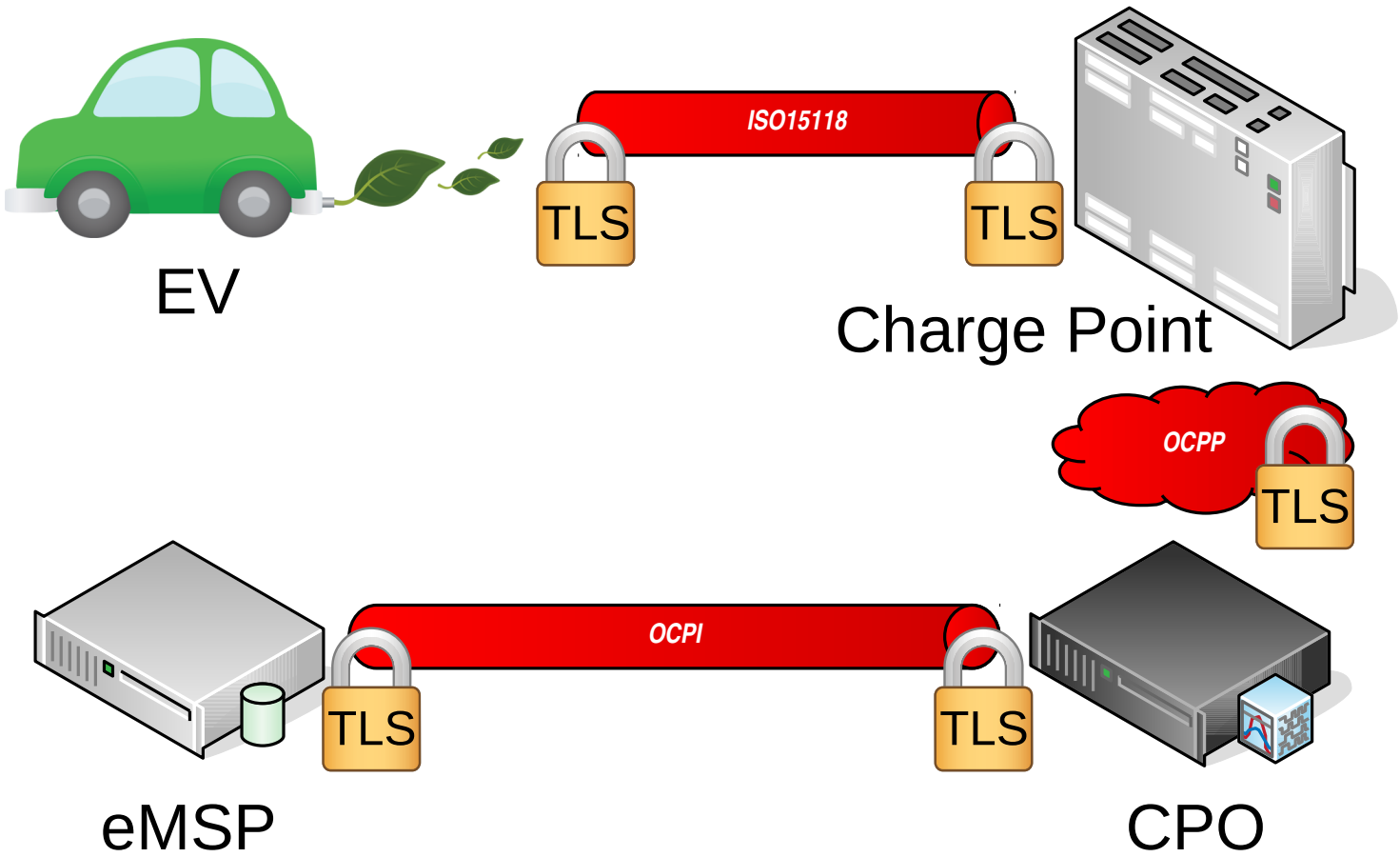

We're not done

- TLS protects the network traffic between individual parties.

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- Provides confidentiality and authenticity for the data *only while being communicated* between these parties.

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We have to trust that every party

- doesn't send what it shouldn't,

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for whatever reason.

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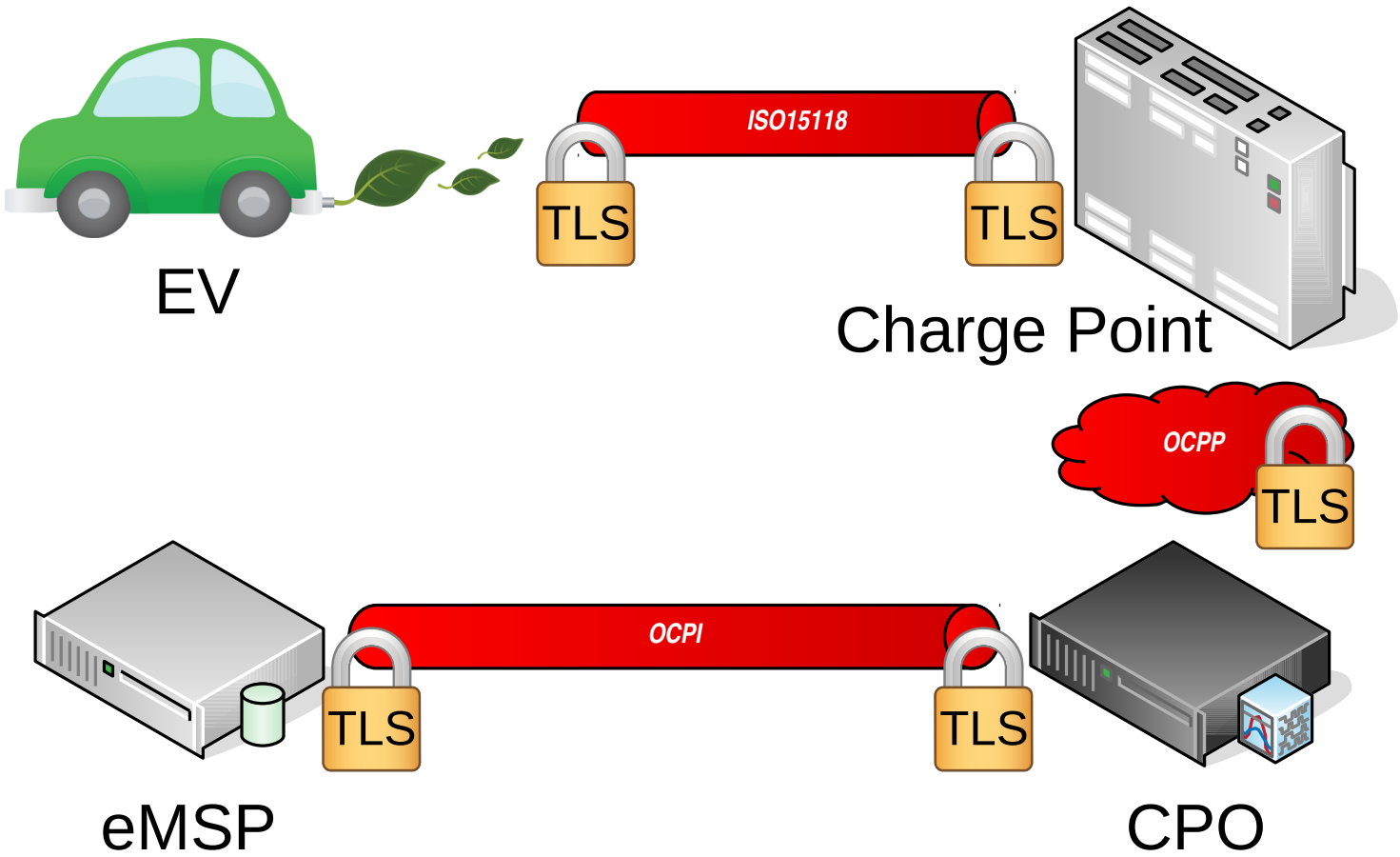
Main aspects:

- confidentiality.
- authenticity.
- non-repudiation.
- from end to end:
  - from the initial sending party on one side,
  - to the eventual receiving party on the other side,
  - regardless of how many parties are in between.

This is not end-to-end!



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  - (very useful in disputes!)

An example message

Charge Session Start sent from EV to CPO

EV ID	Time	CP Location	Contract ID	€/kWh
101	2019-09-30 14:50	51°49'30.6"N 5°52'06.5"E	12501932	0.21

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CP Location is dropped because the eMSP doesn't need it.

Adding authenticity & non-repudiation – naïvely

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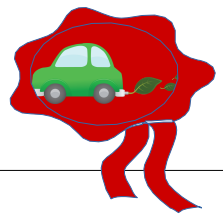

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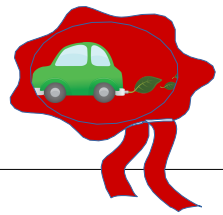

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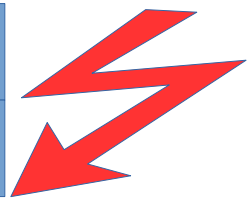

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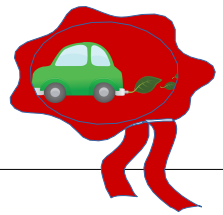

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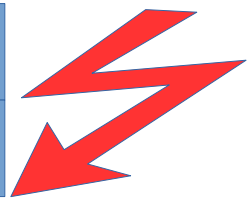

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CP Location cannot be dropped because that invalidates the signature!

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- Offline operation (some parties may be offline when a message is sent)

How do we solve this? Two signatures?

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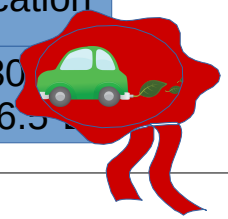

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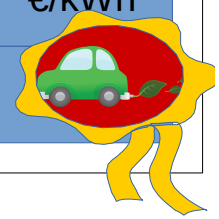

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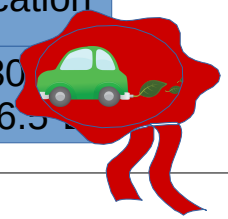

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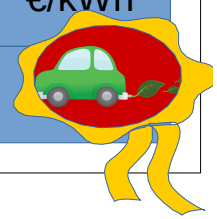

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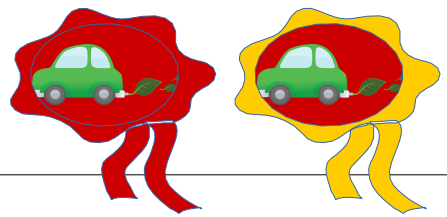

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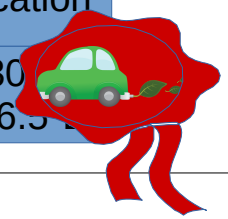

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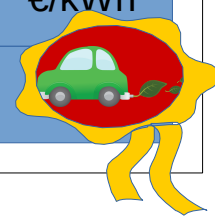

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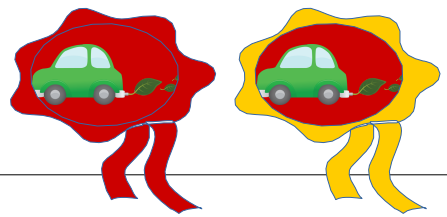

Charge Session Start sent from CPO to eMSP

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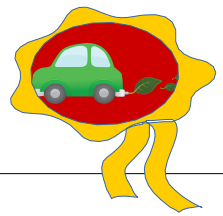

This works, but...

- That's still a lot of overhead

This works, but...

- That's still a lot of overhead
- Doesn't solve data minimization

One signature using a hash tree

Signed Charge Session Start

EV ID	Time	CP Location	Contract ID	€/kWh
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We take the hashes of individual data fields

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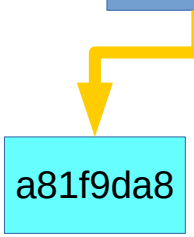

Build the collection of hashes...

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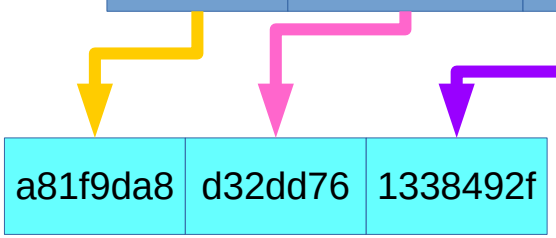

For each party that needs a signature

Signed Charge Session Start

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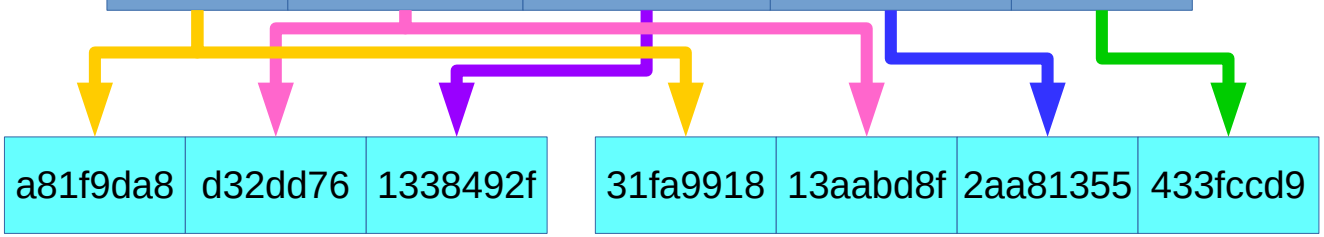
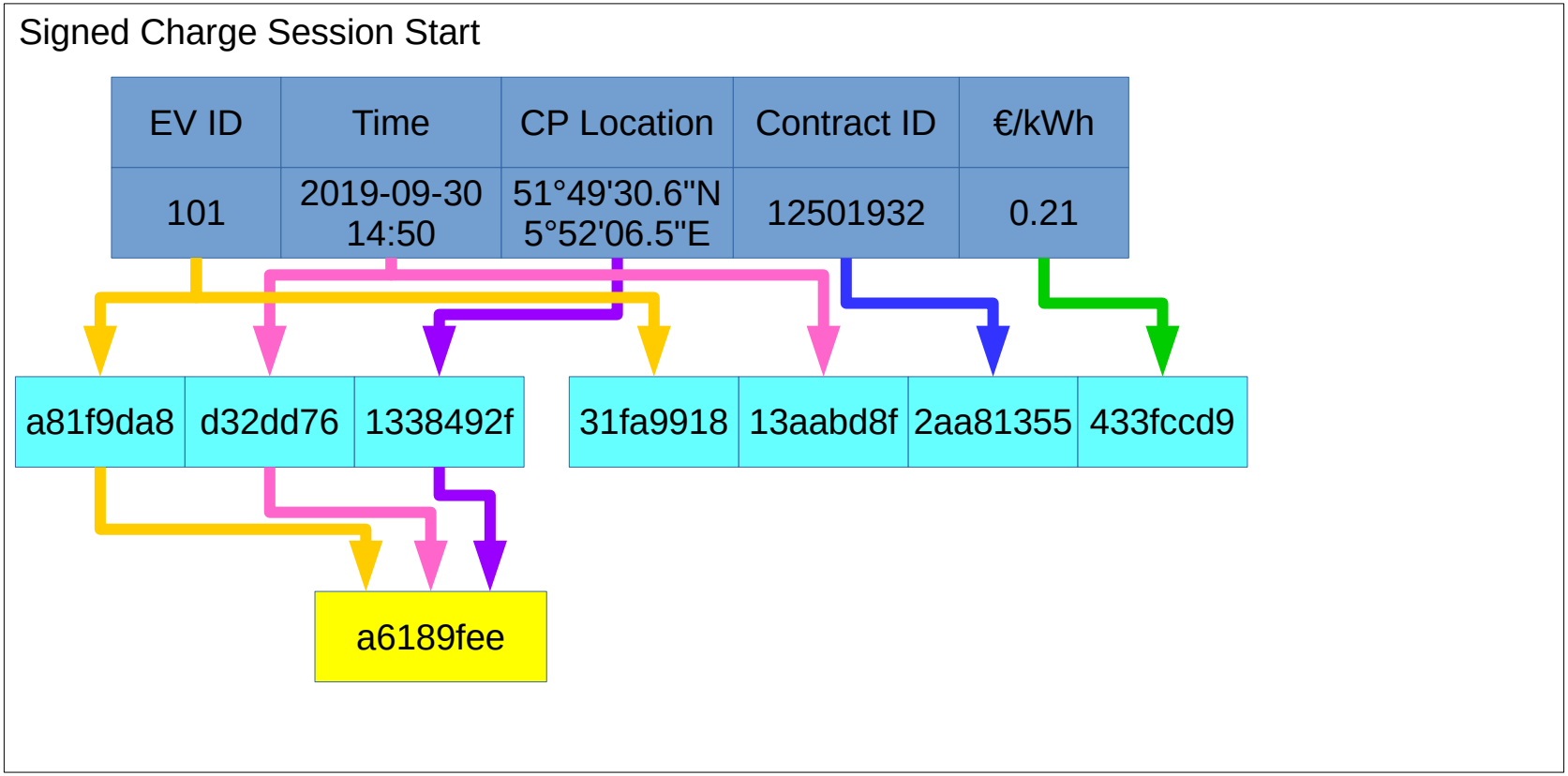
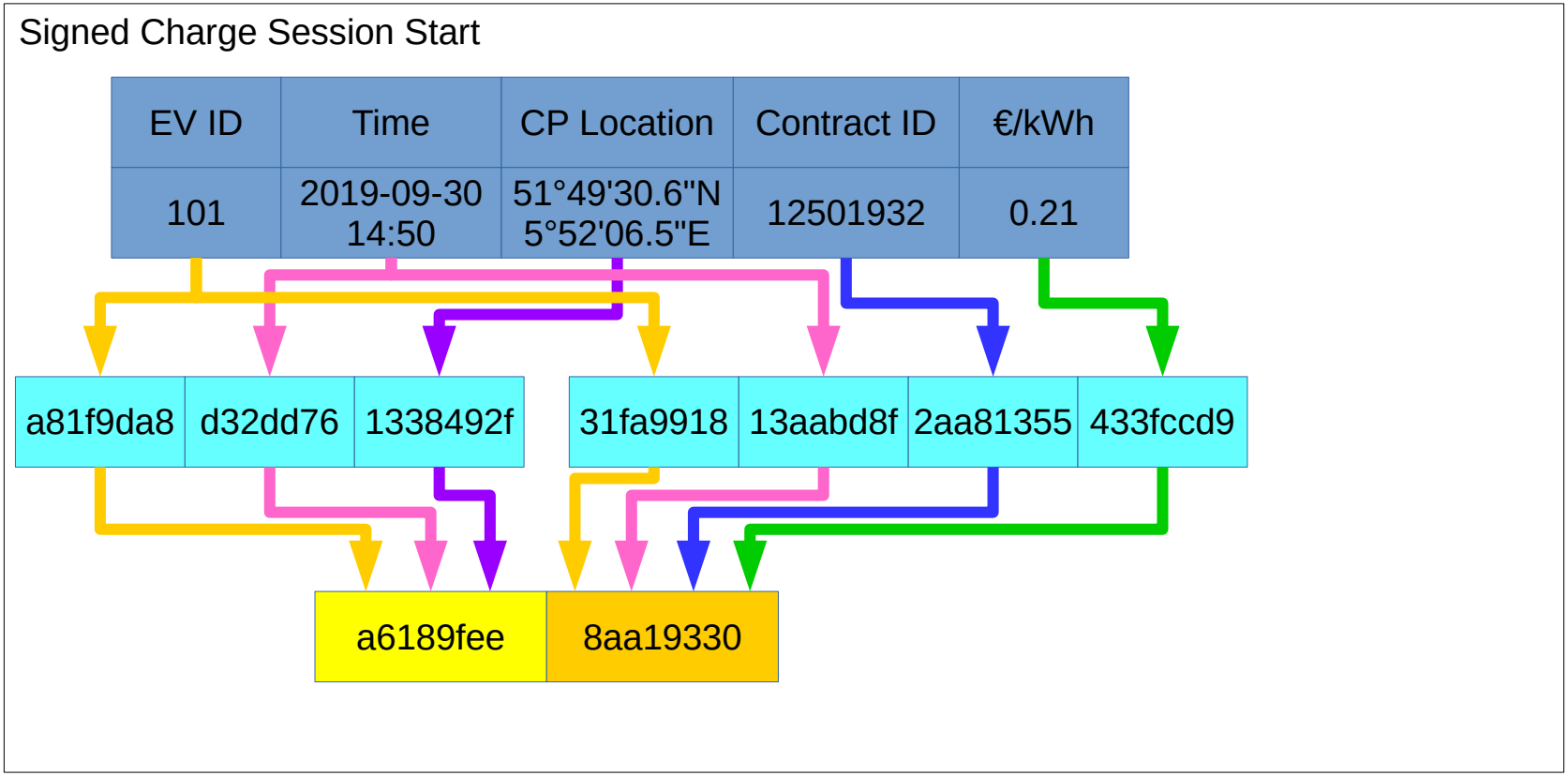


Then we hash those collections again...



Into a final couple of hashes



And sign those hashes

Signed Charge Session Start

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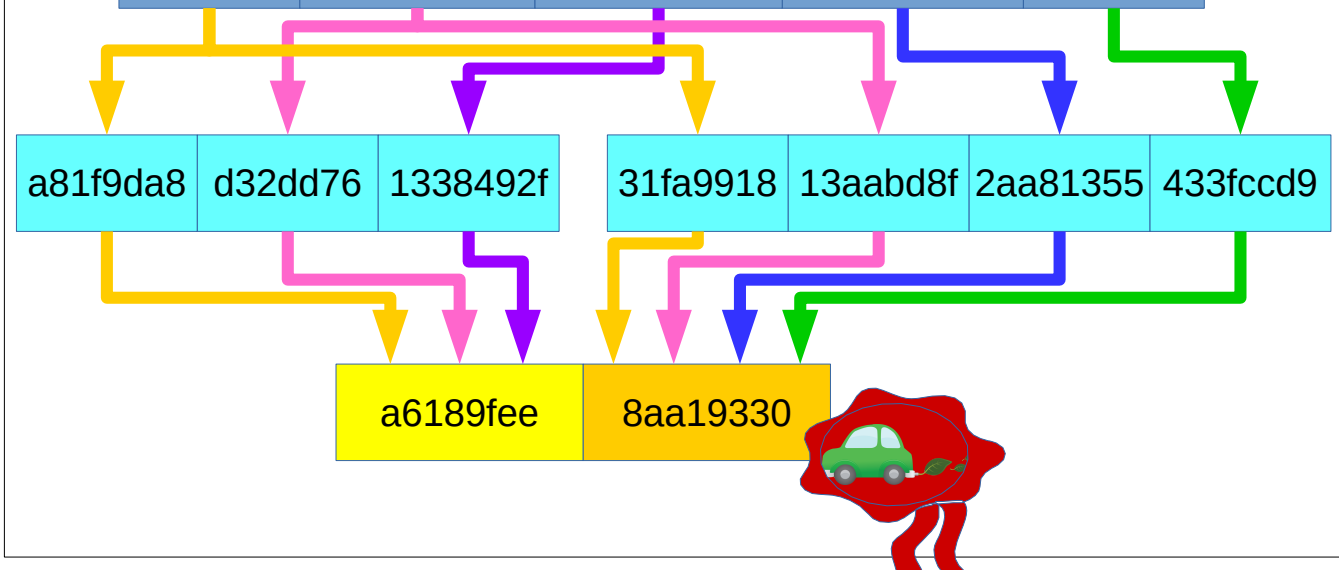
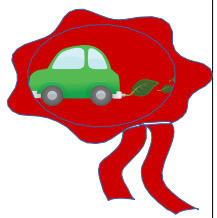


Overhead is minimized

Signed Charge Session Start sent by EV to CPO

EV ID	Time	CP Location	Contract ID	€/kWh	eMSP Hash
101	2019-09-30 14:50	51°49'30.6"N 5°52'06.5"E	Apf8da;w…	23ga…	8aa19330



CPO verification

Signed Charge Session Start verified by CPO

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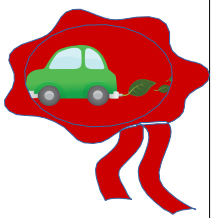

a81f9da8	d32dd76	1338492f

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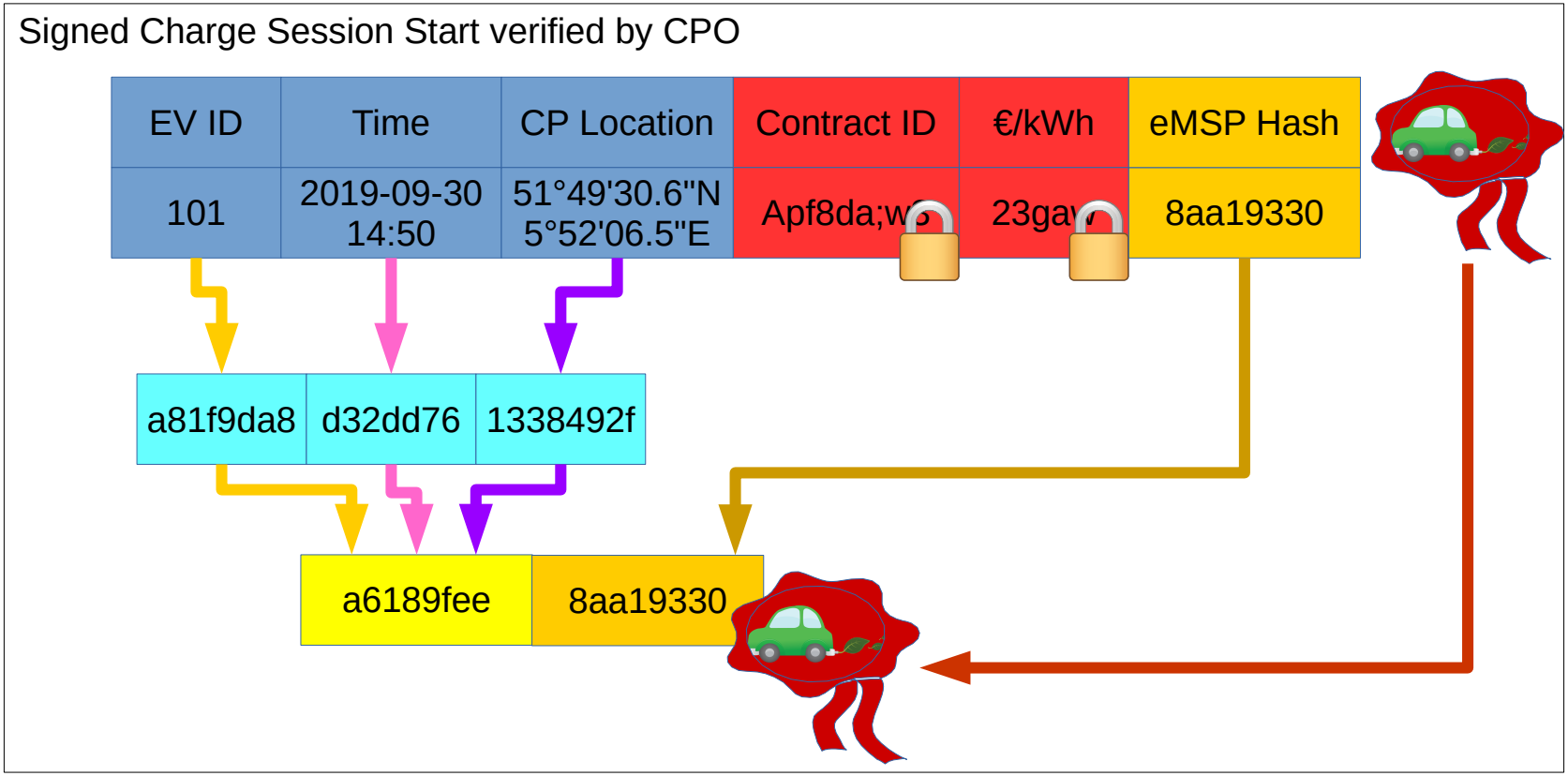

Dropping & encrypting data now works

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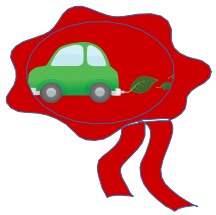
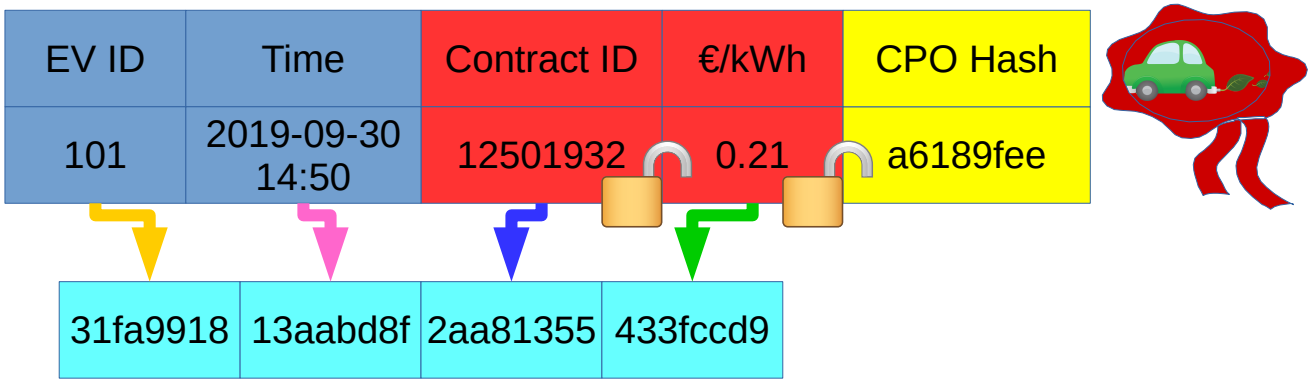
EV ID	Time	Contract ID	€/kWh	CPO Hash
101	2019-09-30 14:50	Apf8da;w	23gav	a6189fee



eMSP verification

Signed Charge Session Start verified by eMSP



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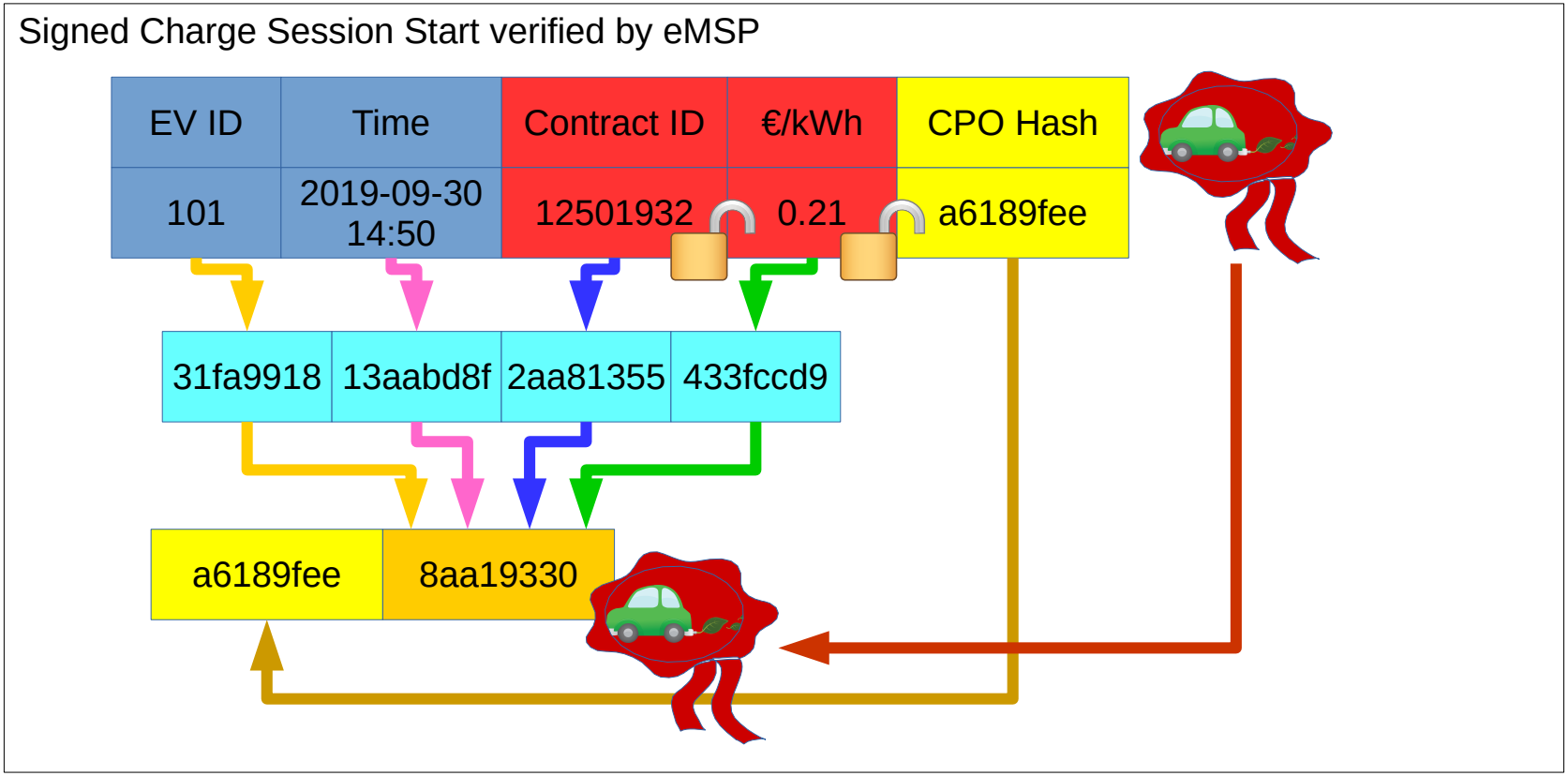

Cryptographic details

- We piggy-back on technologies that have to be present anyway:
  - Cryptographic algorithms from TLS
  - Public key infrastructure
  - JSON message formatting

Overview

The EV-charging infrastructure

The need for security

End-to-end security

Conclusions

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- This scheme works in other cases with similar requirements.

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