



# The Seventeenth International Conference on Internet and Web Applications and Services ICIW 2022

## Ontology for the Context of E-Mobility: Charging Station Recommendation based on the EV Trip



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# Who am I?

Bachelor in Computer Science

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December 2021, PhD at University of Tunis

And RESEARCH LABORATORY OF SMART GRIDS AND NANOTECHNOLOGY (LaRiNa) 

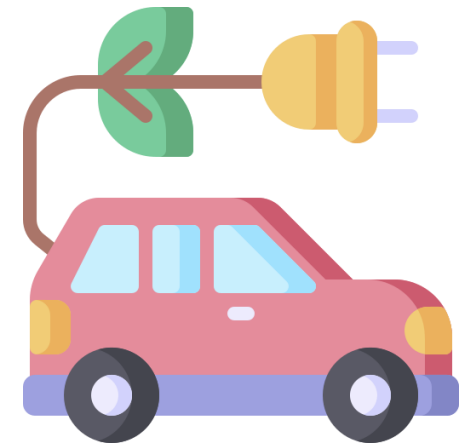
With Renewable Energies for E-MObility (REMO) project

Working on ML and Semantic Web



# Outline

1. Motivation
2. Approach
3. Evaluation and results
4. Conclusion and future directions

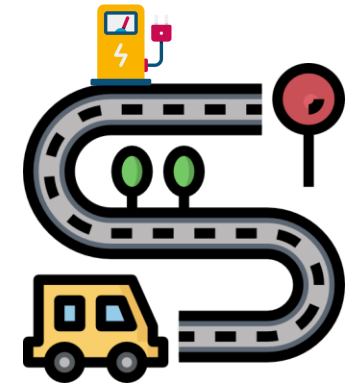


# Motivation: Key barriers



## Vehicle Users


- Is my State of Charge (SoC) enough to reach my destination? : **low driving ranges: range anxiety**
- Should I charge on the way?
- Is there a Charging Station (CS) on my way?
- Which CS to choose?
- How long will I wait to charge at the CS? : **long waiting/charging time**

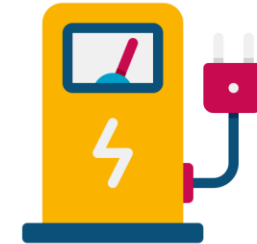


# Motivation: Goals



## Vehicle Users

- Reducing charging cost 
- EV charging experience more efficient and comfortable.
- user-oriented recommendation system (low prices, fastest route, etc..)

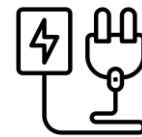


# Motivation: Goals



## Vehicle Users

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## Infrastructure Owners

- Generate new revenue streams



## Grid

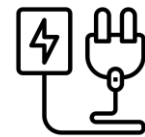
- Balance

# Motivation: Goals



## Vehicle Users

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## Grid

- Balance



## Interoperability

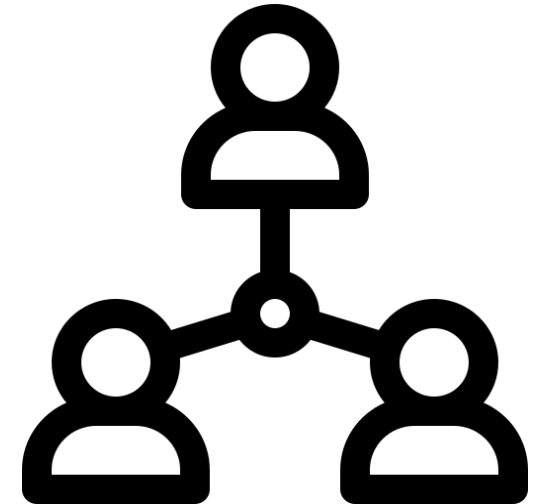
We need stakeholders to be **connected** and **share a common understanding** of the information structure



# E-Mobility: Trip planning application

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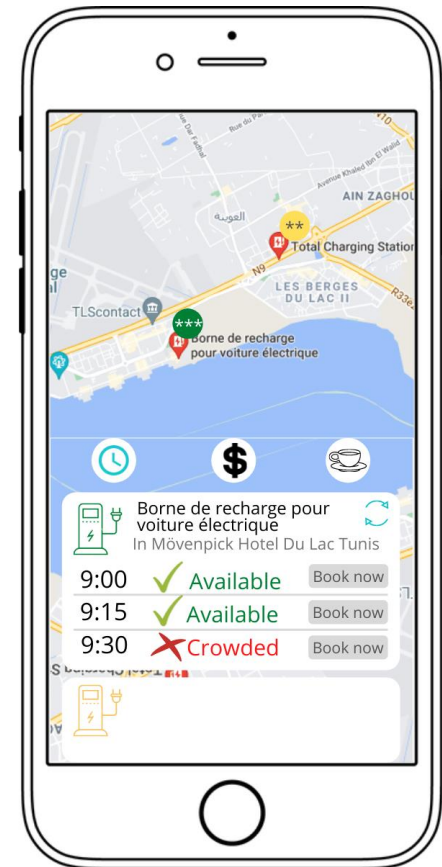
- Ensure the semantic interoperability between the different stakeholders.
- Ease their collaboration when sharing knowledge.





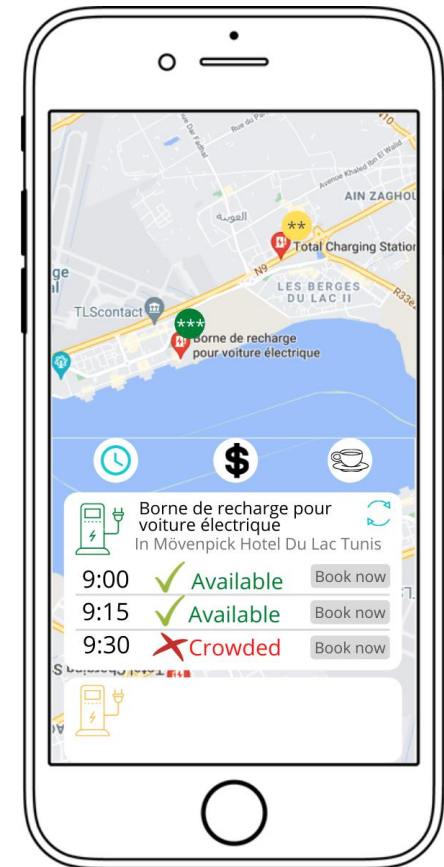
# E-Mobility: Trip planning application

- Ensure the semantic interoperability between the different stakeholders.
- Ease their collaboration when sharing knowledge.
- Validate through a [trip planning application](#) as a start.
- Helps the EV drivers:
  - plan their journeys and overcome the hurdle of range anxiety
  - offer the possibility to choose and book in advance [the most appropriate CS](#) to be used for recharging their EVs' batteries.



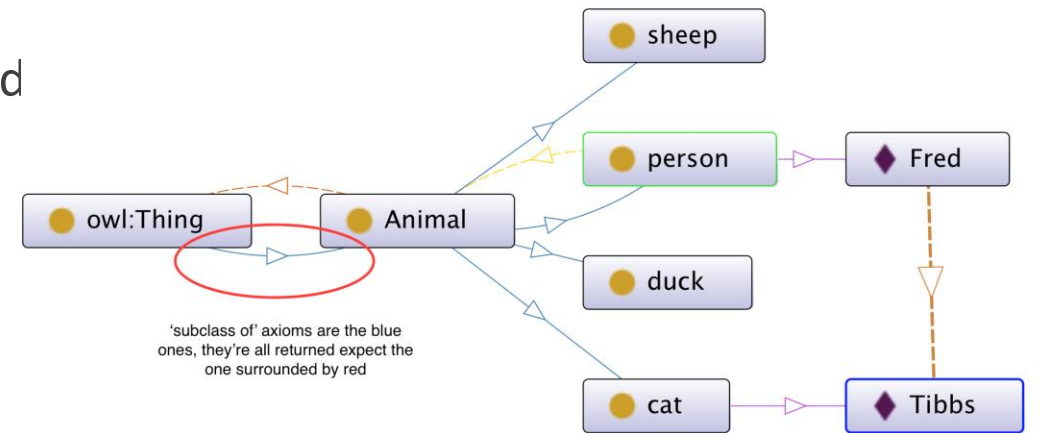
# E-Mobility: Trip planning application

- **Availability:** identify the CS that belongs to the geographical area matching the EV driver's path.
- **Compatibility:** Once the available CSs are identified, only those compatible with the EV are considered eligible (in terms of power, connector, etc.)
- **Charging Time:** the EV driver has access to the estimated charging time that would enable him/her to reach the targeted SoC.
- **Cost:** The EV driver can check the applied cost rates at a specific CS within a given time interval.
  - (Several pricing models can be implemented to avoid the grid overloading at peak time or to encourage EV drivers to take alternative paths, etc.)
- **Carbon Footprint:** how "green" is a given CS. Considered green if it is supplied by renewable energy sources (solar power, wind power, etc.).



# Ontology: graph database

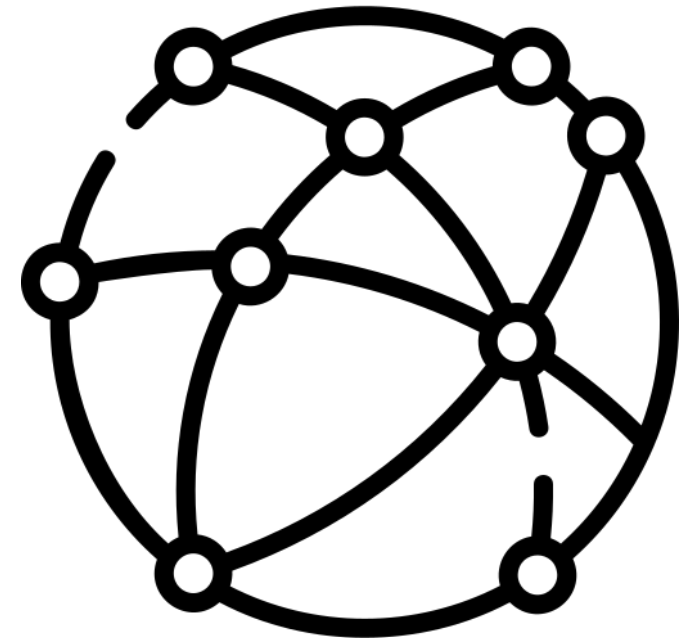
- o Encompasses a **representation**, formal naming, and definition of the categories, properties, and **relations between the concepts**, data, and entities.
- o Enable interoperability
- o Capture the main concepts of a domain knowledge and enable its reuse

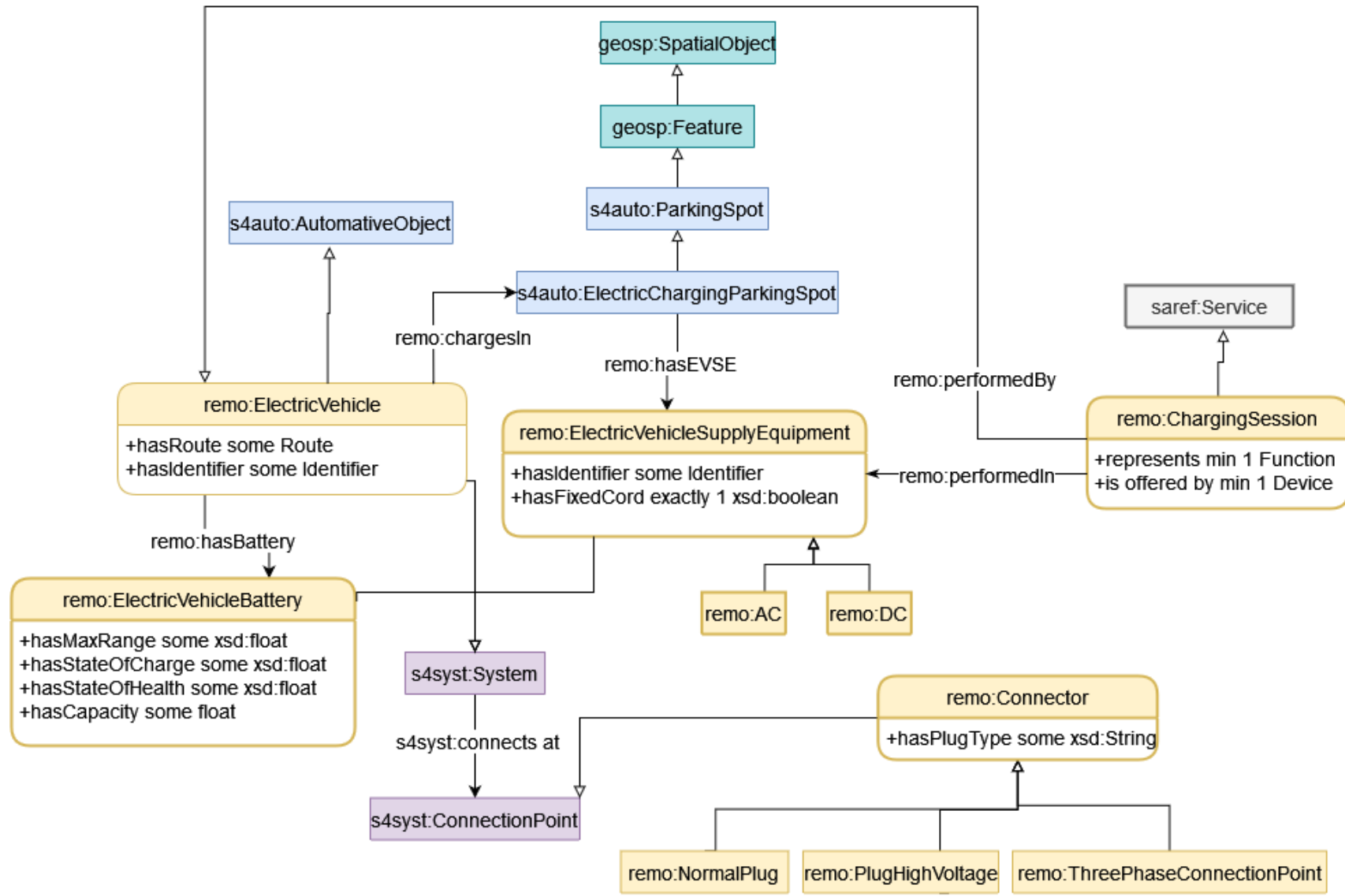


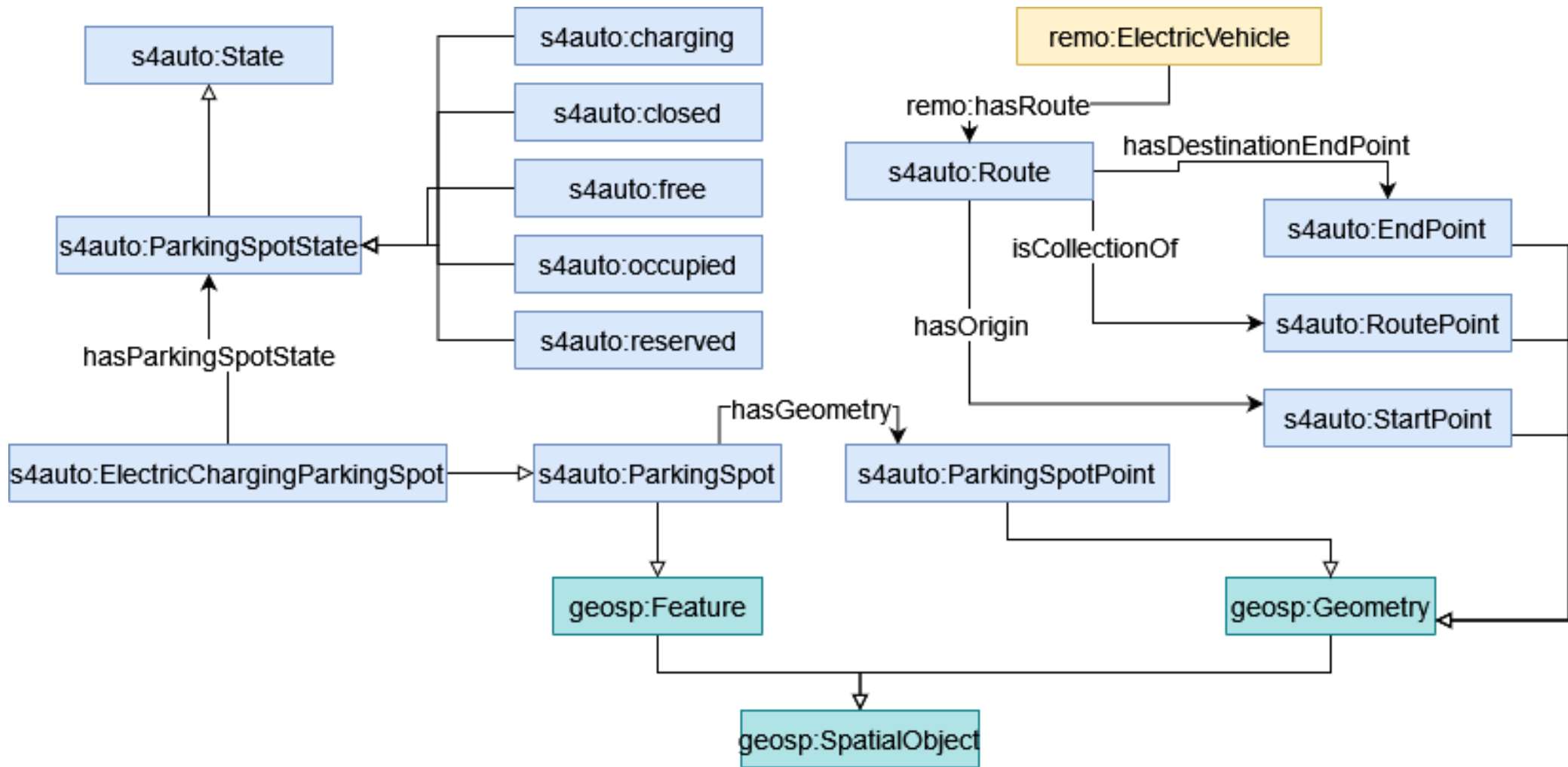
# Ontology: reuse

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- **The Smart Applications REFerence (SAREF) ontology**
  - **S4Syst**: extension for Systems, Connections, and Connection Points
  - **S4auto**: extension for the Automotive domain (*under development*)
- **Time ontology**
- **Geospatial ontology and Opengis geosparql**

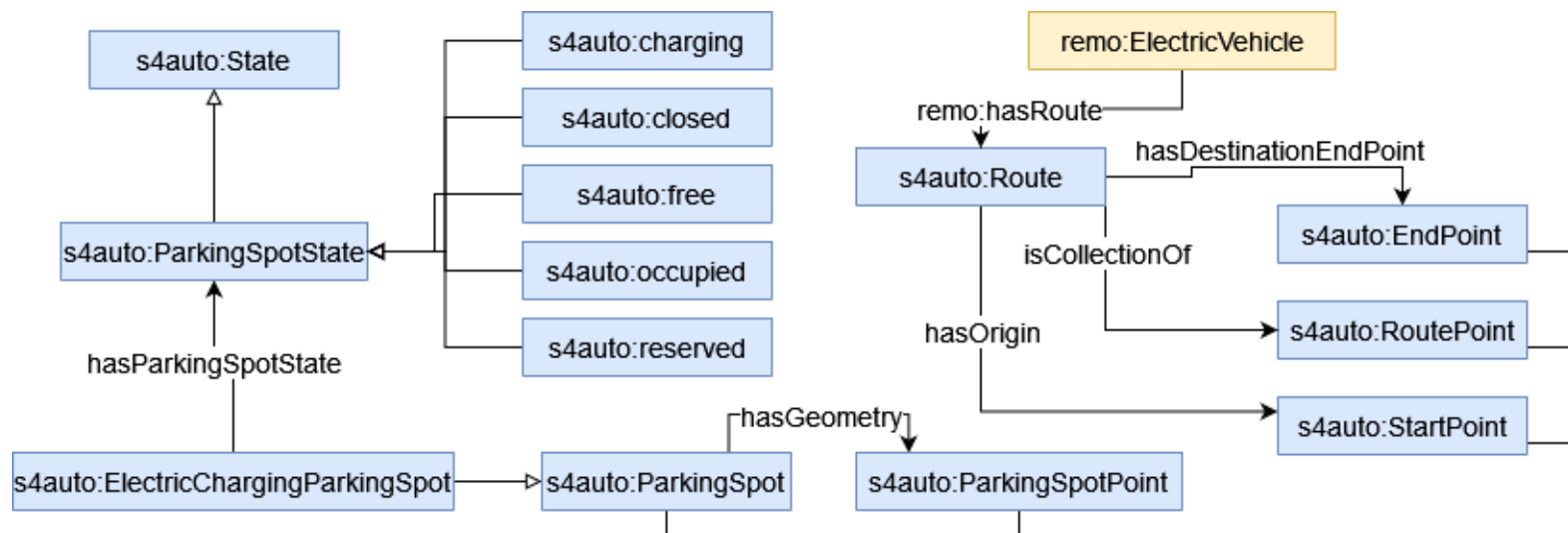
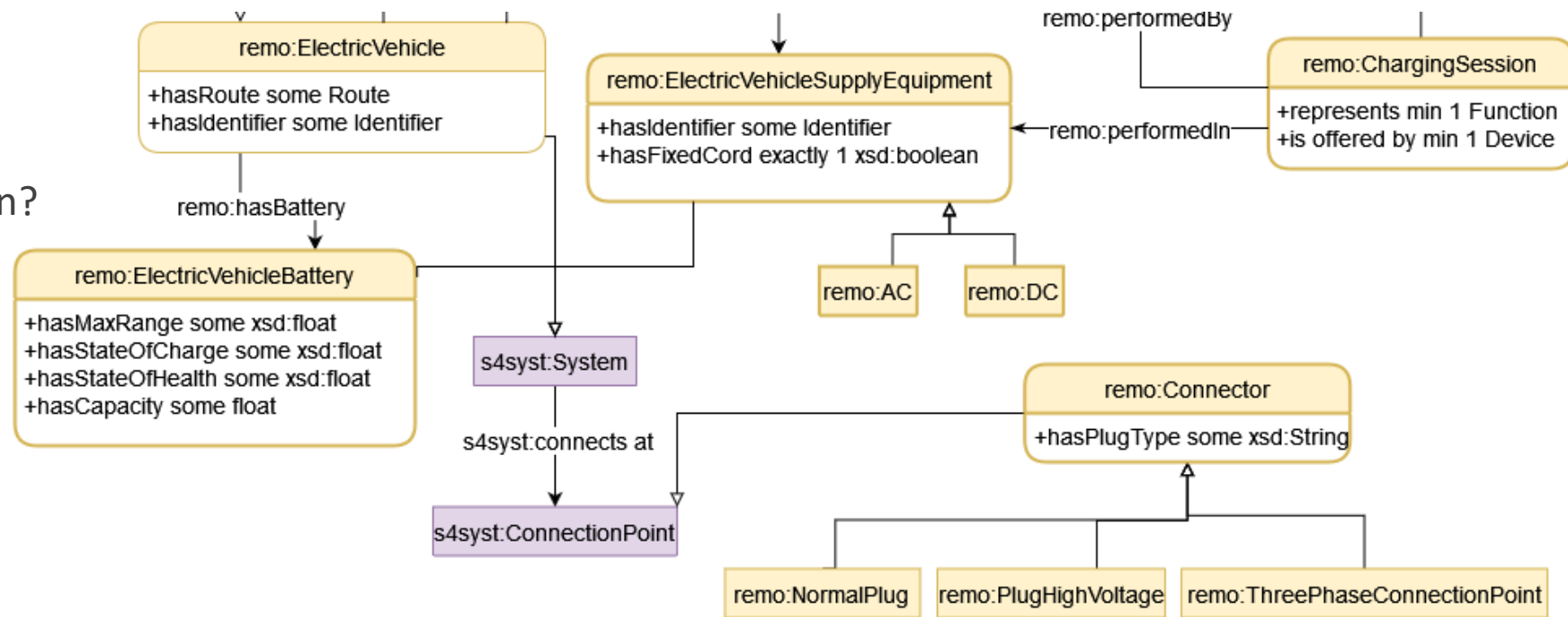






- Availability

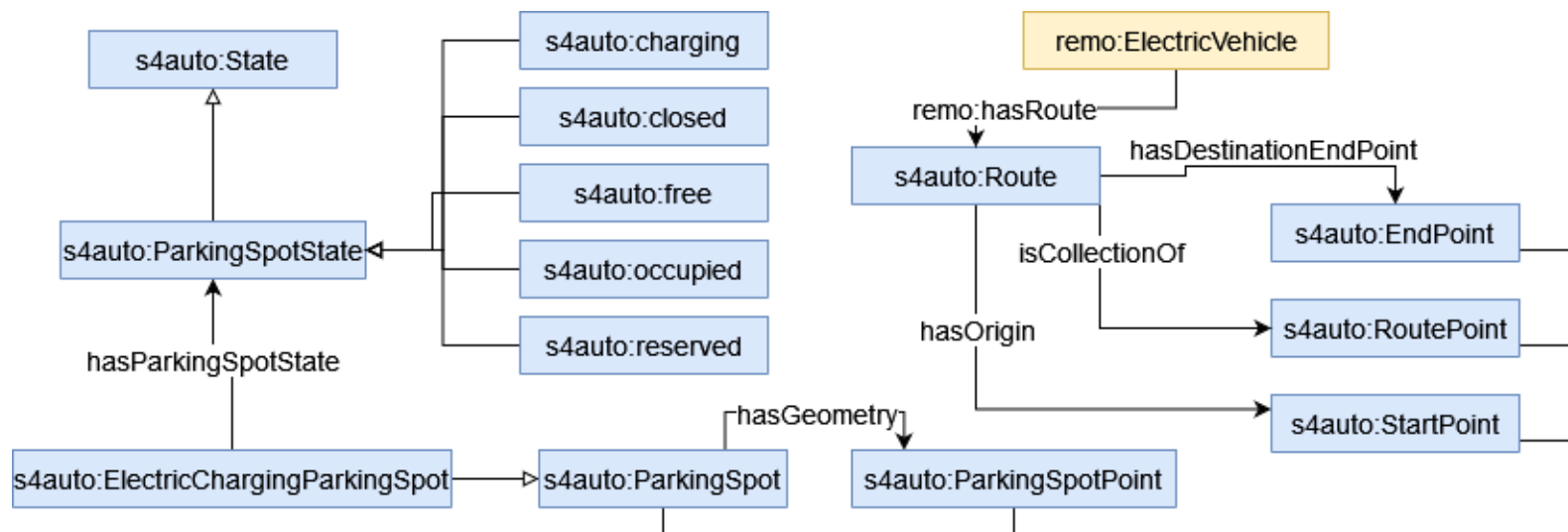
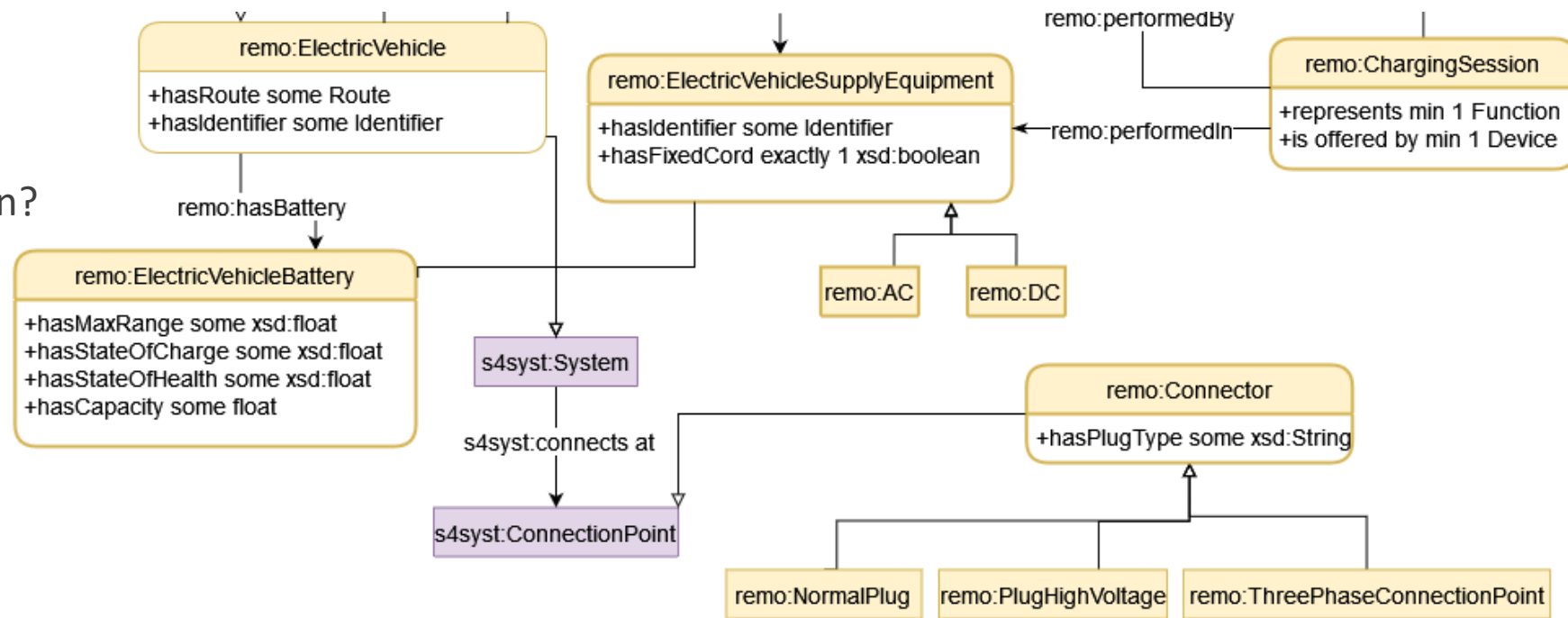
- Is there a CP at the EV destination?



## Availability

- Is there a CP at the EV destination?

```
SELECT ?ev ?cp ?endpoint ?parkingpt
WHERE {
  ?ev remo:hasRoute ?route.
  ?ev remo:hasIdentifier s4auto:id123 .
  ?route s4auto:hasDestinationEndPoint ?endpoint.
  ?endpoint owl:sameAs ?parkingpt.
  ?cp geosp:hasGeometry ?parkingpt.
}
```

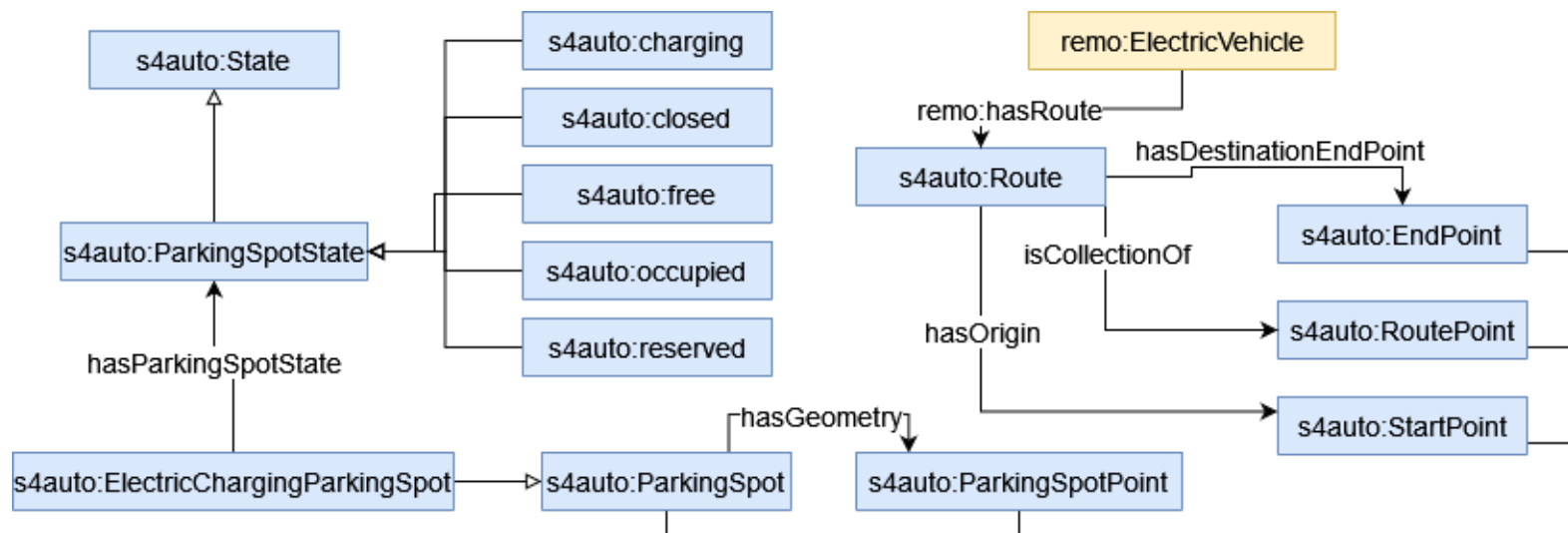
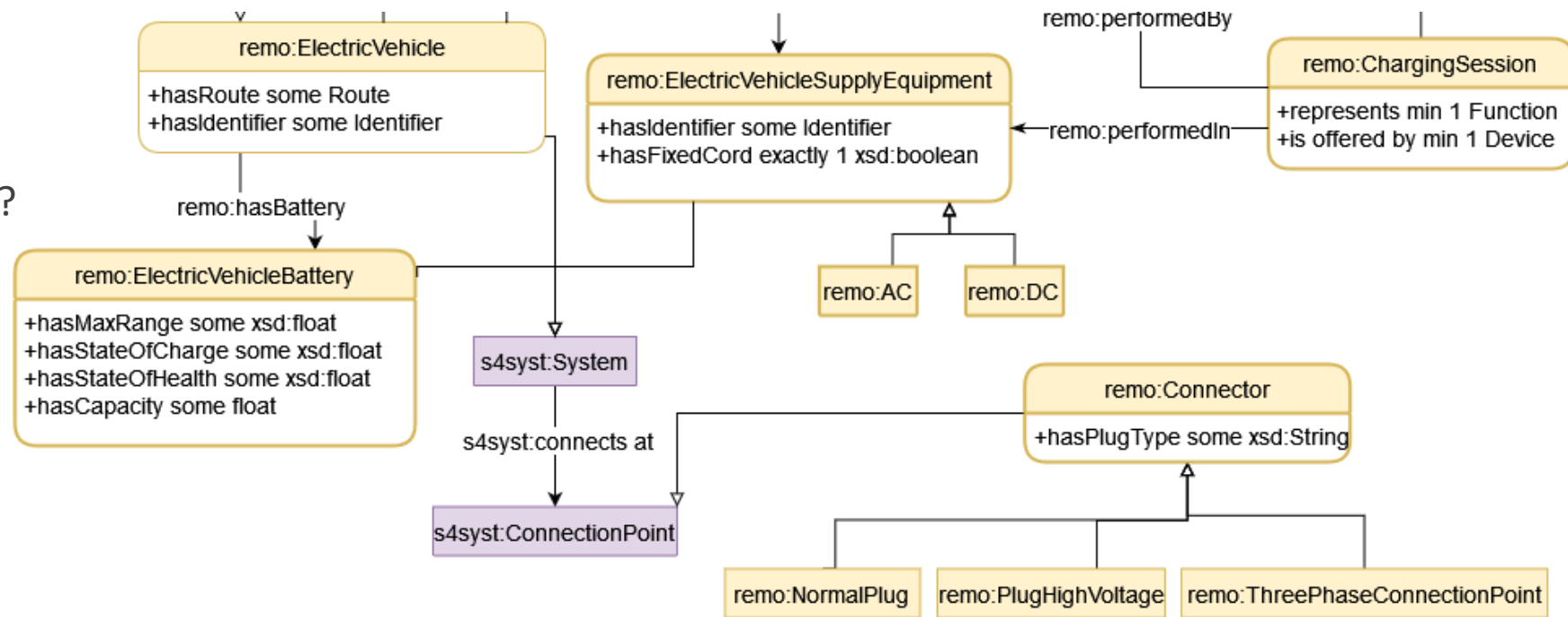




## Availability

- Are there any CS on the EV route?

```
SELECT ?ev ?cp
WHERE {
  ?ev remo:hasRoute ?route.
  ?ev remo:hasIdentifier s4auto:id123 .
  ?route s4auto:isCollectionOf ?routept.
  ?cp geosp:hasGeometry ?parkingpt.
  ?parkingpt owl:sameAs ?routept.
}
```



- o Availability

- o What are the CPs that can be reached from the EV start point within its maximum range?

```
SELECT ?cp ?range WHERE {  
  ?ev remo:hasMaxRange ?range.  
  ?ev remo:hasRoute ?route.  
  ?route s4auto:hasOrigin ?start.  
  ?start geosp:asWKT ?wkt1.  
  ?cp a s4auto:ElectricChargingParkingSpot.  
  ?cp geosp:hasGeometry ?pt.  
  ?pt geosp:asWKT ?wkt2.  
  FILTER (geof:distance(?wkt1, ?wkt2, uom:metre) < ?range).  
}
```



- o Availability

- o When is the CP available?

```
SELECT ?cp ?state ?time
WHERE {
    ?ev s4auto:hasRoute ?route.
    ?ev s4auto:hasIdentifier s4auto:id123 .
    ?route s4auto:isCollectionOf ?routept.
    ?cp geosp:hasGeometry ?parkingpt.
    ?parkingpt owl:sameAs ?routept.
    ?cp s4auto:hasParkingSpotState ?state.
    ?state a s4auto:Free.
    ?state saref:hasTimestamp ?time.
}
```



- o Compatibility

- o The EVSE of the CP must be compatible with EV connector

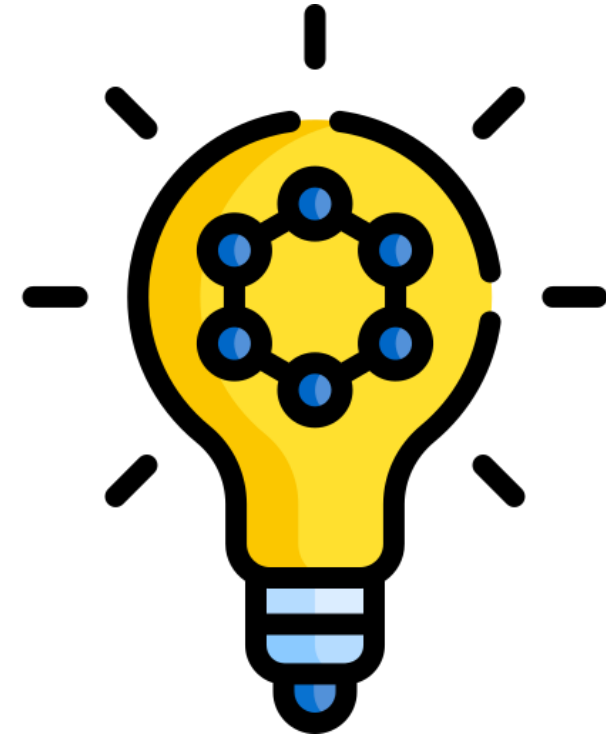
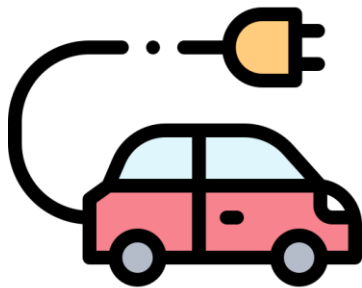
```
SELECT ?ev ?cp ?c WHERE {  
  ?ev s4syst:connectsAt ?c.  
  ?ev a remo:ElectricVehicle.  
  ?evse s4syst:connectsAt ?c.  
  ?cp remo:hasEVSE ?evse.  
}
```



# Future directions

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- Implement drivers' preferences
- Integrate features that would ease the monitoring of the grid resources and optimize their use.
- Integrate Reinforcement Learning technologies to optimize vehicles routing



Thank you!

# REMO Master Target group

- Mainly, ENSTAB Engineers in Advanced Technologies with options :
  - Energetic Systems and Clean Technologies **SETP**
  - Advanced Electronics and Nanotechnologies **EAN**
- Engineers or Equivalent Degree in : Electrical, Automotive, Energetic, ...
- Undergraduated (Bac +3) in : Electrical, Automotive, Energetic, ...