GRADUATE SCHOOL AND RESEARCH CENTER AT THE HEART OF THE DIGITAL SOCIETY

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VSSo: the Vehicle Signal and Attribute Ontology

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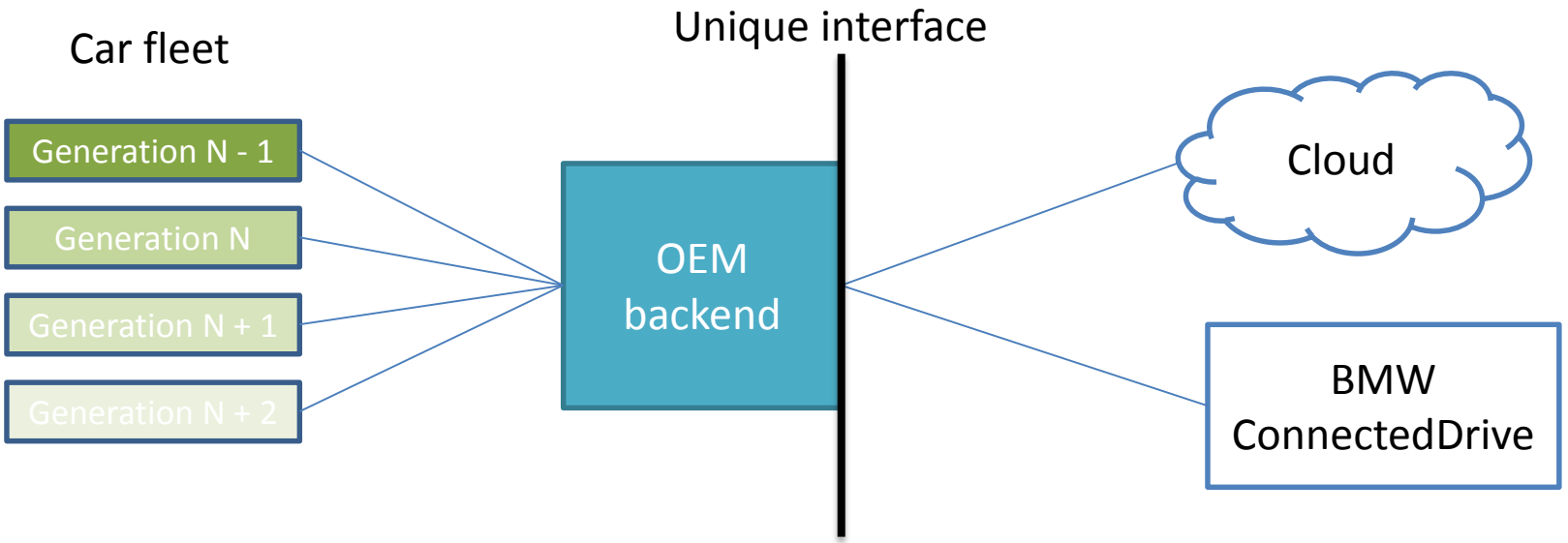
BMW GROUP THE NEXT 100 YEARS

Context

{"name":"accelerator_pedal_position","value":0,"timestamp":1361454211.483000}
{"name":"fuel_level","value":23.478279,"timestamp":1361454211.485000}
{"name":"torque_at_transmission","value":1,"timestamp":1361454211.488000}

- Adapt infotainment based on cloud usage, favorite playlists and volume
- Drive your car in front of the building you are leaving
- …

Traditional development approach



Requirements [1]

Get information about attributes and signals on connected vehicles:

Telematics/fleet management

What type of fuel does this car need?
What is the current gear?

E-commerce

What is the model of this car?
How old is this car?

Garage/diagnosis

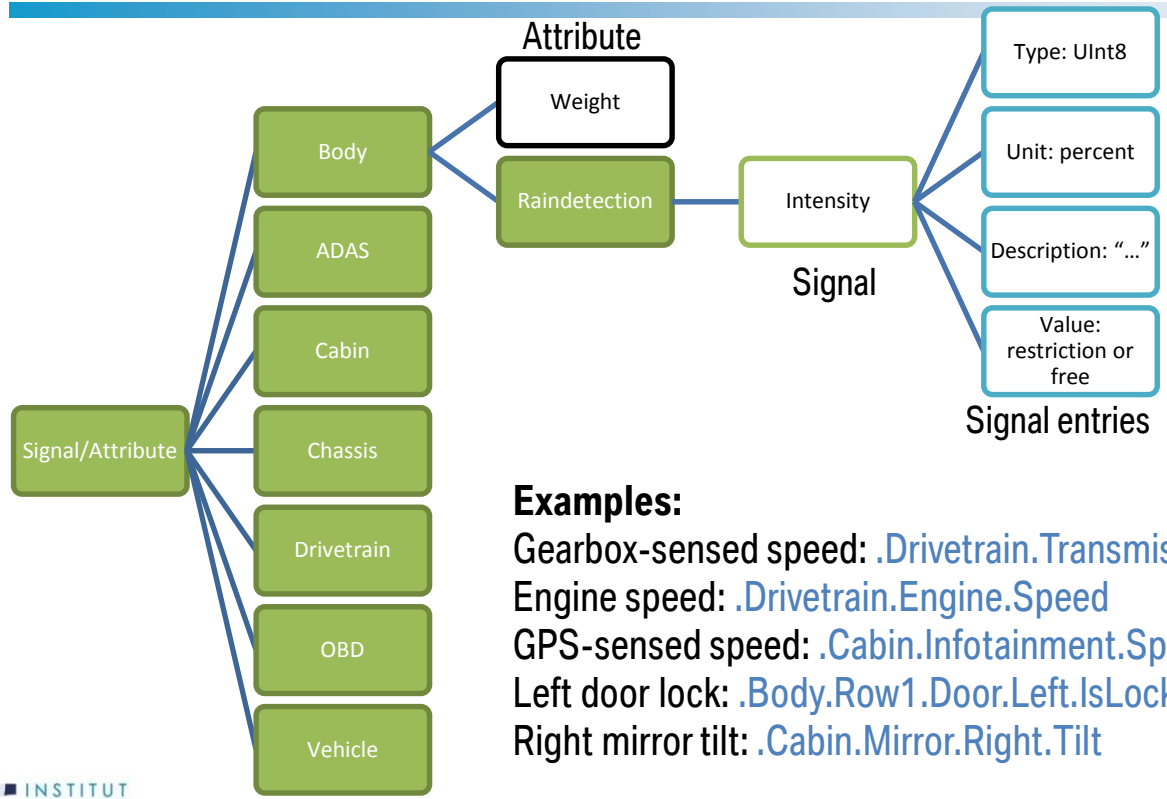
What type of transmission does this car have?
How many different speedometers does this car contain?

Seamless experience

What are the destination coordinates?
What is the local temperature on the driver side?

[1] Complete list: https://github.com/klotzbenjamin/vss-ontology

Vehicle signal specification (VSS) [2]



Figures (Apr 2018):

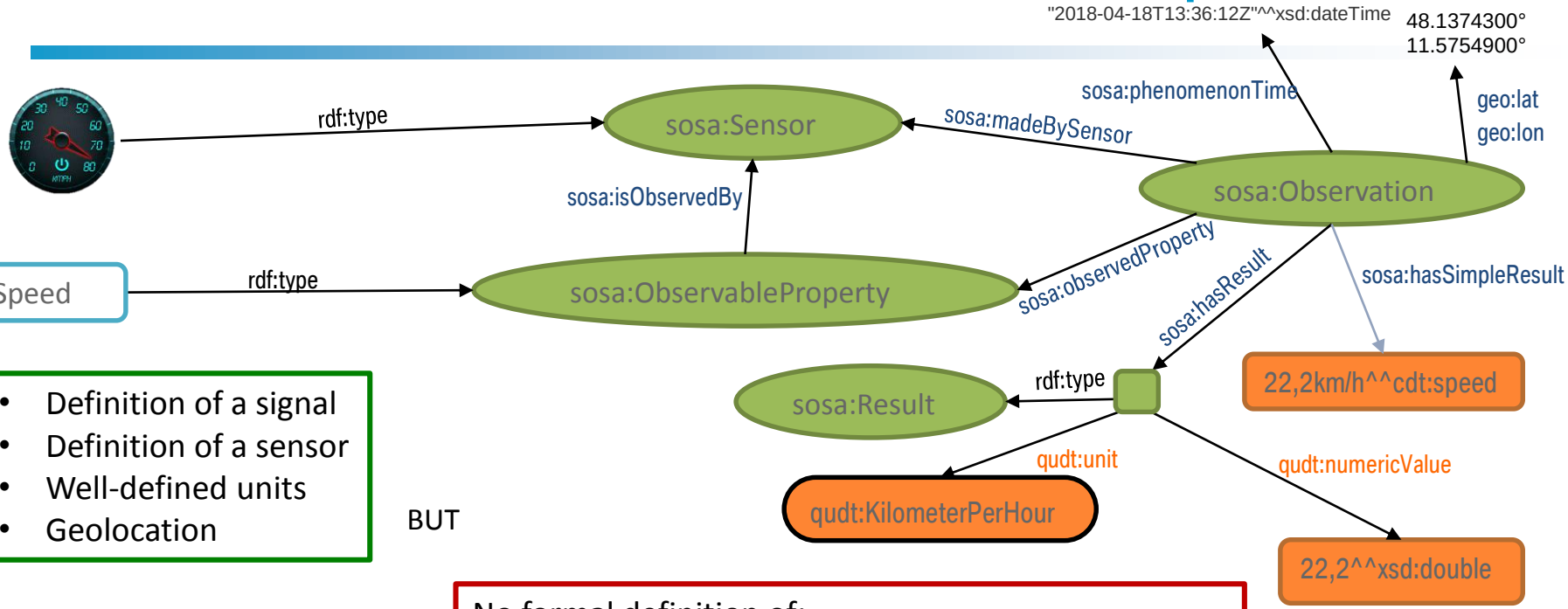
- 451 branches
- 1103 leaves:
  - 43 attributes
  - 1060 signals: including
    - (700 seat-related),
    - 268 with unit

Examples:

Gearbox-sensed speed: .Drivetrain.Transmission.Speed
Engine speed: .Drivetrain.Engine.Speed
GPS-sensed speed: .Cabin.Infotainment.Speed
Left door lock: .Body.Row1.Door.Left.IsLocked
Right mirror tilt: .Cabin.Mirror.Right.Tilt

[2] https://github.com/GENIVI/vehicle_signal_specification

SOSA/SSN observation & sensor pattern



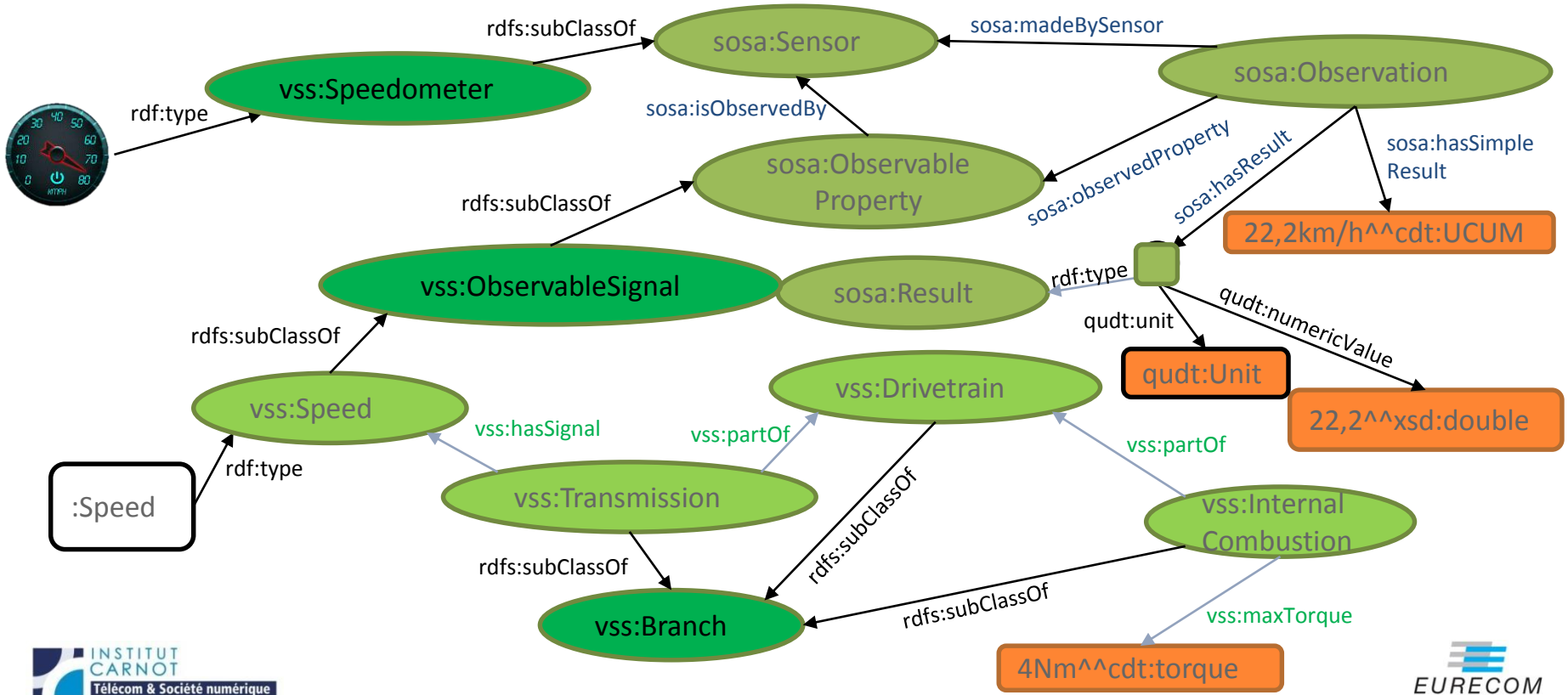
- Definition of a signal
- Definition of a sensor
- Well-defined units
- Geolocation

BUT

No formal definition of:

- “speed” or other observable properties
- “speedometer” or other car sensors/actuators
- “car” or vehicle parts

SSN/SOSA with a VSS ontology



VSSo: a Vehicle Signal Ontology

Map to existing Ontologies
- SSN/SOSA
- QUDT (unit)
- custom datatypes [4]

Generate definition of VSS concepts

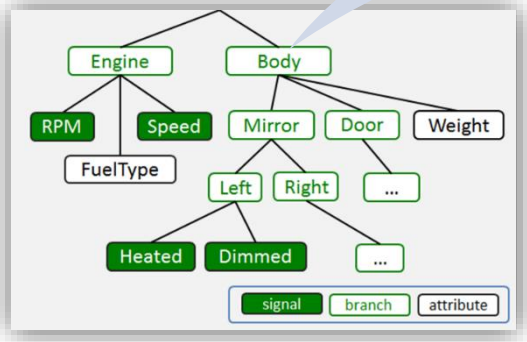
VSSontology [3]

Add sensors and actuators

Fixing problems

Manually validate and clean the generated ontology

VSS



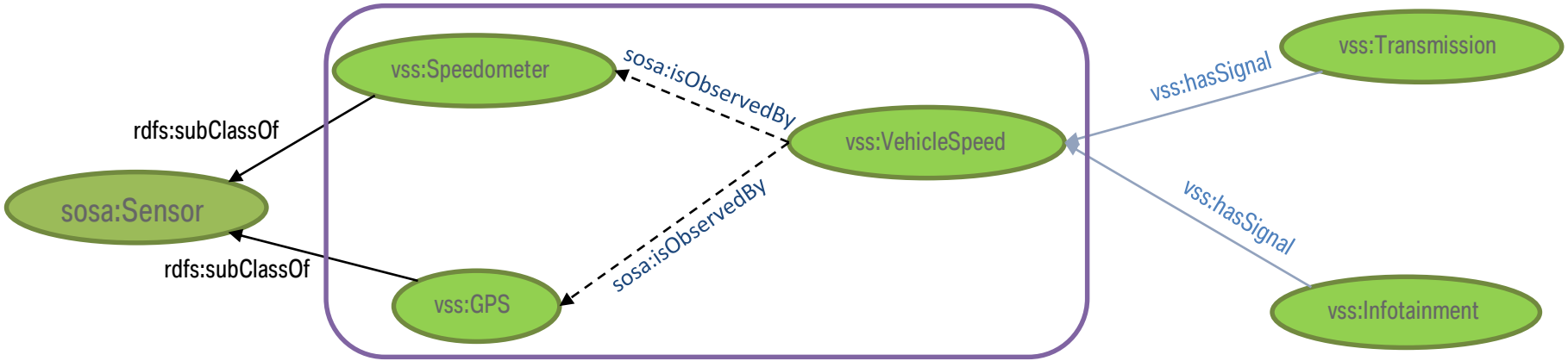
Modeling issues and resolutions

1. VSS concepts have NOW unique names
2. All signals are attached to (virtual) sensors or actuators
3. All branches are part of the top “vss:Vehicle” branch
4. All position-dependent branches have a property “position”

[3] http://automotive.eurecom.fr/vsso
[4] https://ci.mines-stetienne.fr/lindt/v1/custom_datatypes.html

#1: Uniqueness of names

- Some signals represent the same phenomenon, but sensed by different sensors
  - Ex: Drivetrain.Speed (sensed by the **gearbox**) and Infotainment.Speed (sensed by the **GPS**)



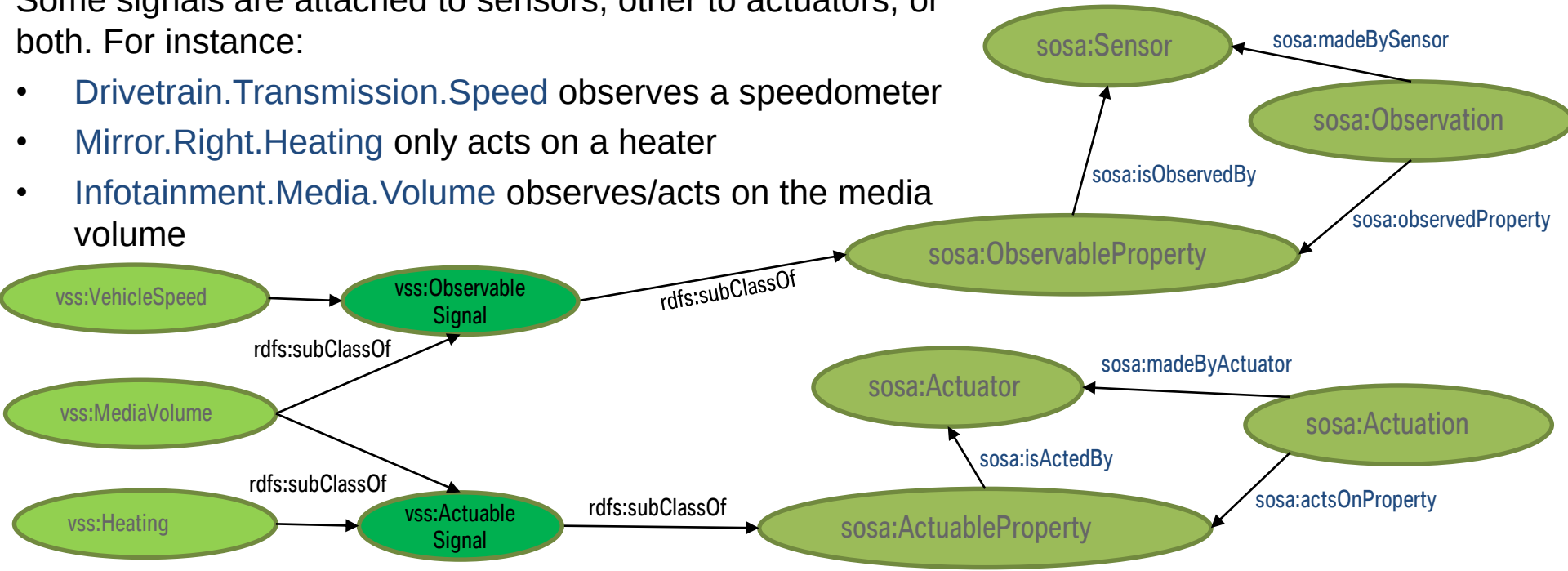
"vss:VehicleSpeed" is a unique phenomenon
↳ observed by different sensors
↳ Producing different signals

Names are clarified to avoid homonymy

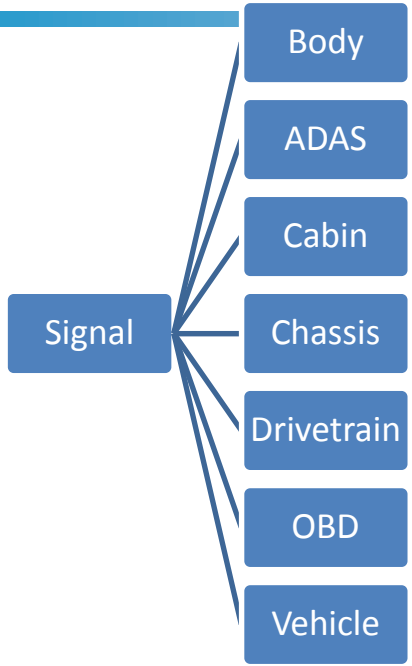
#2: Signals are attached to (virtual) sensors or actuators

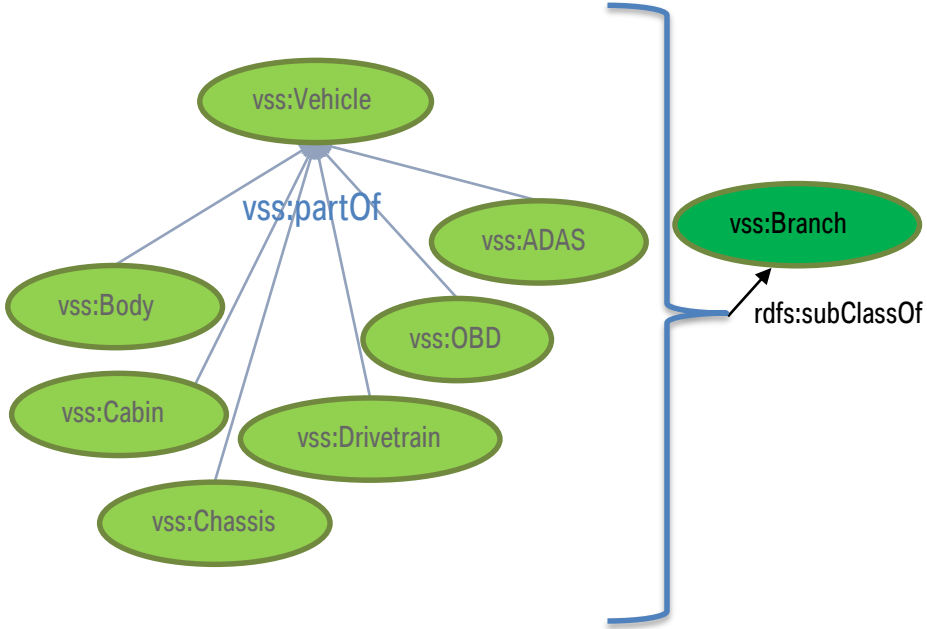
Some signals are attached to sensors, other to actuators, or both. For instance:

- Drivetrain.Transmission.Speed observes a speedometer
- Mirror.Right.Heating only acts on a heater
- Infotainment.Media.Volume observes/acts on the media volume



#3: Branches are vss:part of vss:Vehicle





Current VSS structure

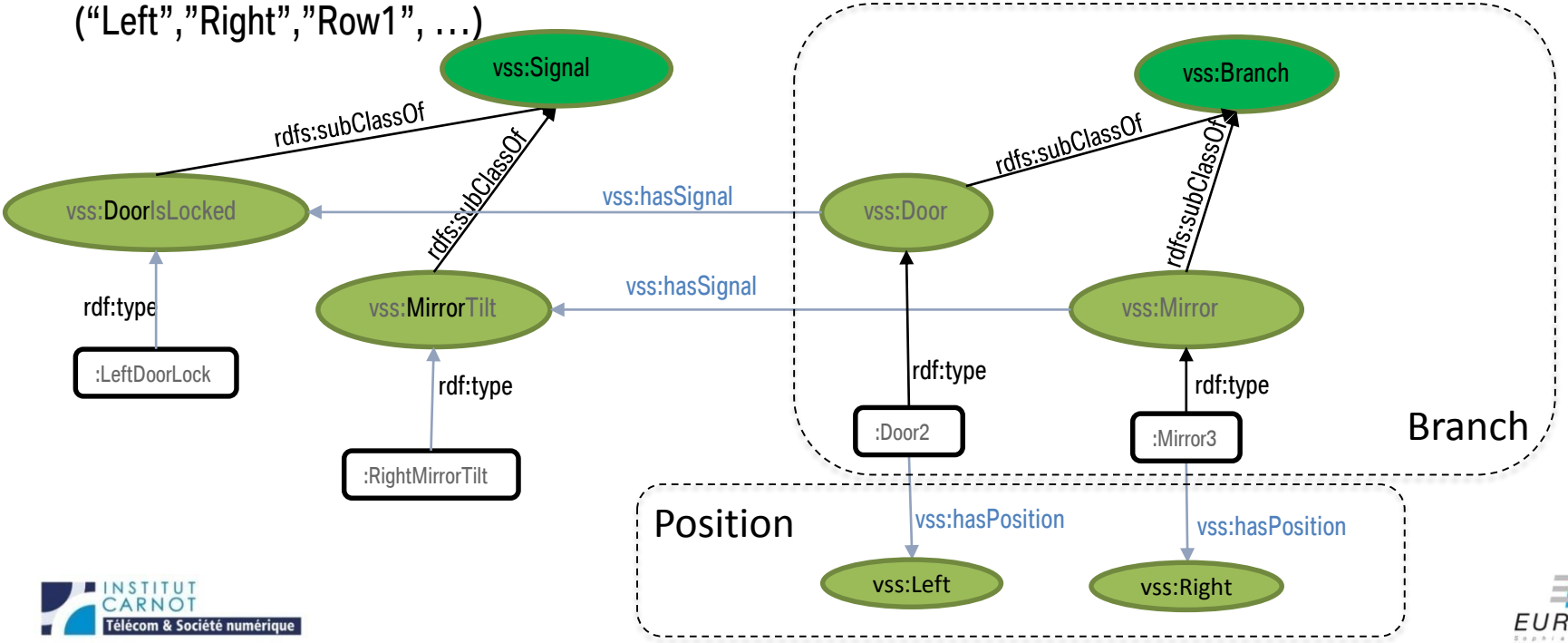
"Signal"/"Attribute" are the name of the top element

VSSo structure

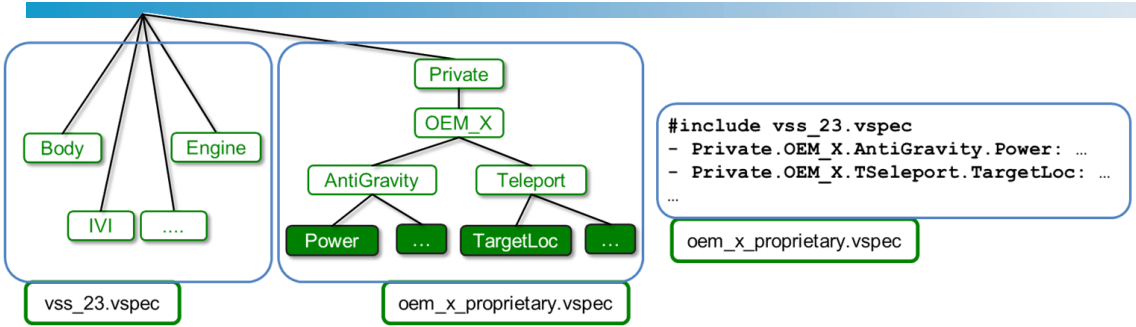
vss:Vehicle is the top element containing all branches

#4: position ≠ branch

- Ex: Door.Left.IsLocked, Mirror.Right.Tilt
- Branches vss:Door and vss:Mirror have **vss:hasPosition** property with limited potential values ("Left","Right","Row1", …)



VSS private branch



Private branch

- OEM-specific concepts
- Extension of VSS
- Merged into VSS when generating specifications

Private OEM-specific ontology cookbook:

1. Write VSS-compliant specification of private concepts (new signals, attributes and branches)
   - Follow the VSS policies just as when creating a private branch
2. Generate the ontology using the existing tool
3. Validate the ontology
   - Check the unicity of concepts and definitions (in the private branch and if possible with VSSo)
4. Define a private namespace for your ontology integrating VSSo

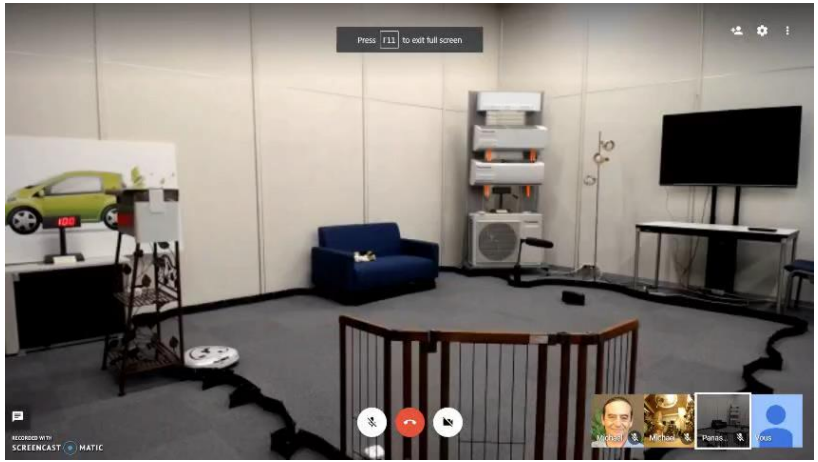
Evaluation

- VSSo expressivity: requirements can be fulfilled with SPARQL queries
  - What are the dimension of this car?
  - What is the current temperature on the driver side?

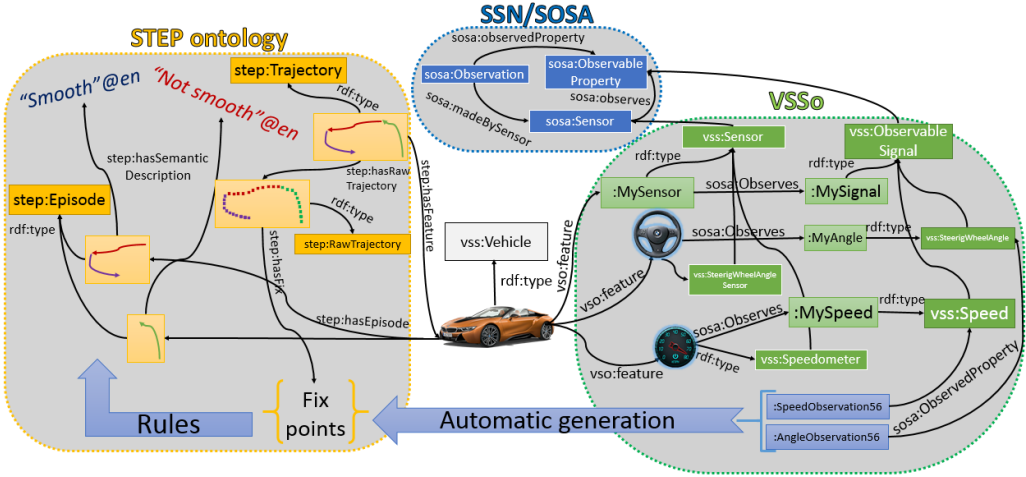
- VSSo extension mechanism is currently under test with real use cases at BMW
  - PoI definitions in the GPS and distance to the destination
  - New sensors for sign recognition (e.g. speed limit)

Applications [5,6]

Interact with a Smart Home



Generate semantic trajectories



http://automotive.eurecom.fr/trajectory

[5] B. Klotz, S. K. Datta, D. Wilms, R. Troncy, and C. Bonnet. A Car as a Semantic Web Thing: Motivation and Demonstration. In 2nd Global Internet of Things Summit (GIoTS), Bilbao, Spain, 2018.

[6] B. Klotz, R. Troncy, D. Wilms, and C. Bonnet. Generating Semantic Trajectories Using a Car Signal Ontology. In The Web Conference (WWW), Lyon, France, 2018.

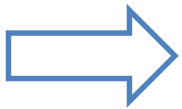
Conclusion

VSSo: a Vehicle Signal and Attribute ontology

- 483 classes (~300 signals); 63 properties (~50 attributes)
- Documentation: http://automotive.eurecom.fr/vsso (v1.1)
- Recommended prefix: vss
- Re-use SSN/SOSA modeling patterns
- Suitable for annotating things in the Web of Things as well as semantic trajectories

Future work

- Potential standard for the W3C automotive WG [7]
- Extensions need more documentation and concrete open examples
- Tools/converters to generate VSSo data from real car sensor data
- The SPARQL endpoint has proven to be inadequate for most cases (needless complexity).



Find what is more adapted for this domain and community

[7] https://www.w3.org/auto/wg/wiki/Main_Page

Thank you for your attention

Do you have questions ?

Contact:
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W3C Automotive Working Group [a]

- **Goal**: create specification protocols and APIs to expose vehicle data and information from an automotive network buses to a Web application.
- Candidate recommendation: Vehicle Information Server Specification (VISS)
  - Websocket (interest of HTTPS/REST)
  - Based on the Vehicle Signal Specification (VSS)
- **Neutral Vehicle** [b]: platform to provide an end-to-end framework for transferring rich vehicle data from the ground to the cloud and back.

[a] https://www.w3.org/auto/wg/
[b] https://neutralvehicle.com/

A description of a vss:Branch

```
vss:Branch a rdfs:Class, owl:Class;
  rdfs:label "Branch"@en;
  rdfs:comment "Branch of the vehicle. Either a component (Body, Chassis...) or the complete vehicle"@en.

vss:ObstacleDetection a rdfs:Class, owl:Class;
  rdfs:subClassOf vss:Branch;
  rdfs:label "ObstacleDetection"@en;
  rdfs:comment "Signal/Attribute.ADAS.ObstacleDetection: Signals form Obstacle Sensor System"@en;
  rdfs:subClassOf [
    a owl:Restriction;
    owl:onProperty vss:partOf;
    owl:allValuesFrom vss:ADAS
  ];
  rdfs:subClassOf [
    a owl:Restriction;
    owl:onProperty vss:hasSignal;
    owl:allValuesFrom [owl:unionOf vss:ObstacleDetectionIsActive, vss:ObstacleDetectionError]
  ].
```

A description of a vss:attribute

```
vss:attribute a owl:ObjectProperty;
  rdfs:label "Attribute"@en;
  rdfs:comment "Attribute signals that do not change during the power cycle of a vehicle."@en;
  rdfs:domain vss:Branch.

vss:driveType a owl:DatatypeProperty;
        rdfs:subPropertyOf vss:attribute;
        rdfs:label "DriveType"@en;
        rdfs:comment "Attribute.Drivetrain.Transmission.DriveType: Drive type."@en;
        rdfs:domain vss:Transmission;
        rdfs:range [
            owl:oneOf("unknown"@en "Front-wheel drive"@en "Rear-wheel drive"@en "All-wheel drive"@en)].
```

A description of a vss:Signal

```
vss:ObservableSignal a rdfs:Class, owl:Class;
  rdfs:subClassOf sosa:ObservableProperty;
  rdfs:label "Observable signal"@en;
  rdfs:comment "All observable signals that can dynamically be updated by the vehicle"@en.

vss:AmbientAirTemperature a rdfs:Class, owl:Class;
                    rdfs:subClassOf vss:ObservableSignal;
                    rdfs:label "AmbientAirTemperature"@en;
                    rdfs:comment "Signal.Vehicle.AmbientAirTemperature: Ambient air temperature"@en;
                    rdfs:subClassOf [
                                        a owl:Restriction;
                                        owl:onProperty sosa:isObservedBy;
                                        owl:allValuesFrom vss:Thermometer
                    ];
                    rdfs:subClassOf [
                                        a owl:Restriction;
                                        owl:onProperty qudt:unit;
                                        owl:allValuesFrom vocab:DegreeCelcius
                    ].
```