This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 101016854.

AURORAL

ENABLING DISTRIBUTED SEMANTIC INTEROPERABILITY, PRIVACY, AND DISCOVERY FOR SMART COMMUNITIES BASED ON STANDARDS

Andrea Cimmino

Juan Cano-Benito, Ahlem Rhayem, María Poveda Villalón, Raúl García-Castro

POLITÉCNICA | UNIVERSIDAD POLITÉCNICA DE MADRID

SUSTAINABLE PLACES 2023

Ontology Engineering Group

SMART COMMUNITIES: A MULTI-DOMAIN DATA ENVIRONMENT

Data domain:

- Government
- Energy Efficiency
- Transport
- Industry
- Food and Agriculture
- Air quality
- Finance
- Research
- Libraries
- …

Data producers/consumers:

- Entities
- People
- Sensors
- Smart objects
- …

Any where
Any one
Any time
Any technology
Any language

SMART COMMUNITIES: A MULTI-DOMAIN DATA ENVIRONMENT

Multiple data producers & consumers

Multiple data-domains

IEEE Standard Computer Dictionary
Interoperability: The ability of two or more systems or components to exchange information and to use the information that has been exchanged.

- Distributed set of data ecosystem
  - Developed with heterogeneous solutions
- Heterogeneity in protocols, data syntax, and data models
- Different understanding of data and procedures

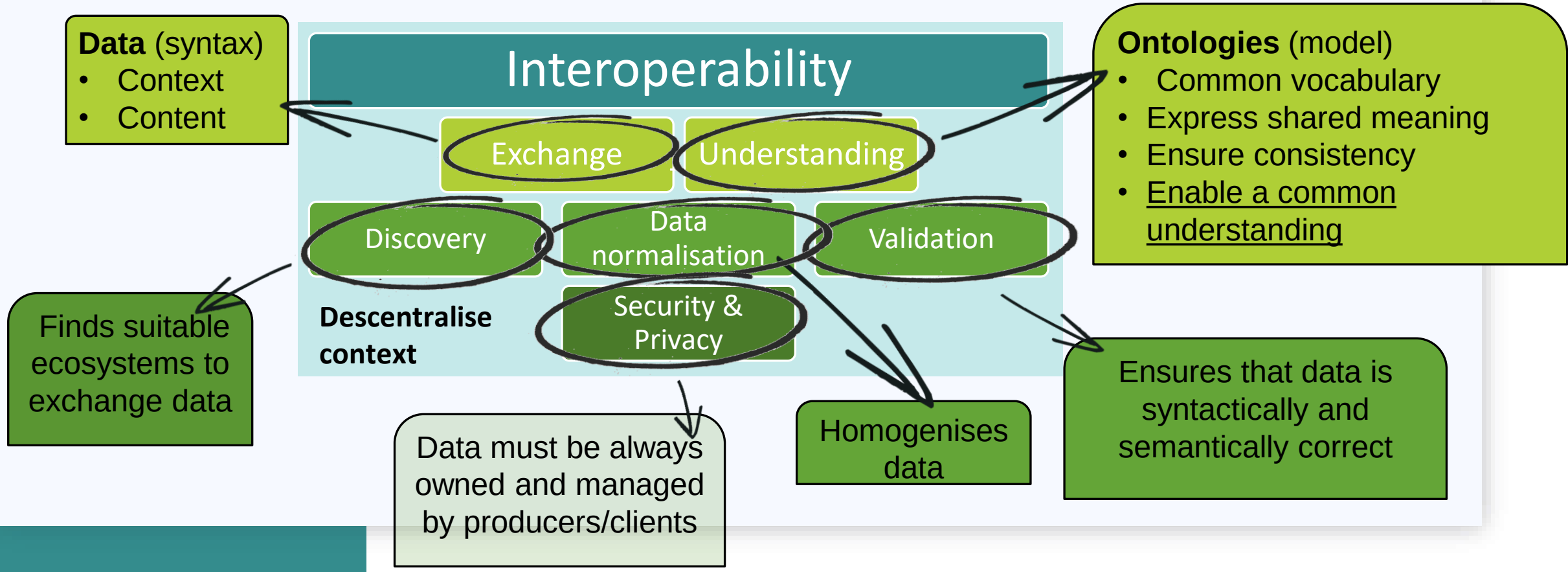
HOW TO TACKLE THESE CHALLENGES

The key factor is standardization and consensus

Consensus on using common protocols, discovery methods, privacy and security policies, data formats and ontologies that are (open) standards

THE BOTTOM LINE PROBLEM: INTEROPERABILITY OF PRODUCERS/CONSUMERS

Interoperability enables the **collaboration**
between networks of **cross-domain** devices and services



THE AURORAL H2020 SOLUTION

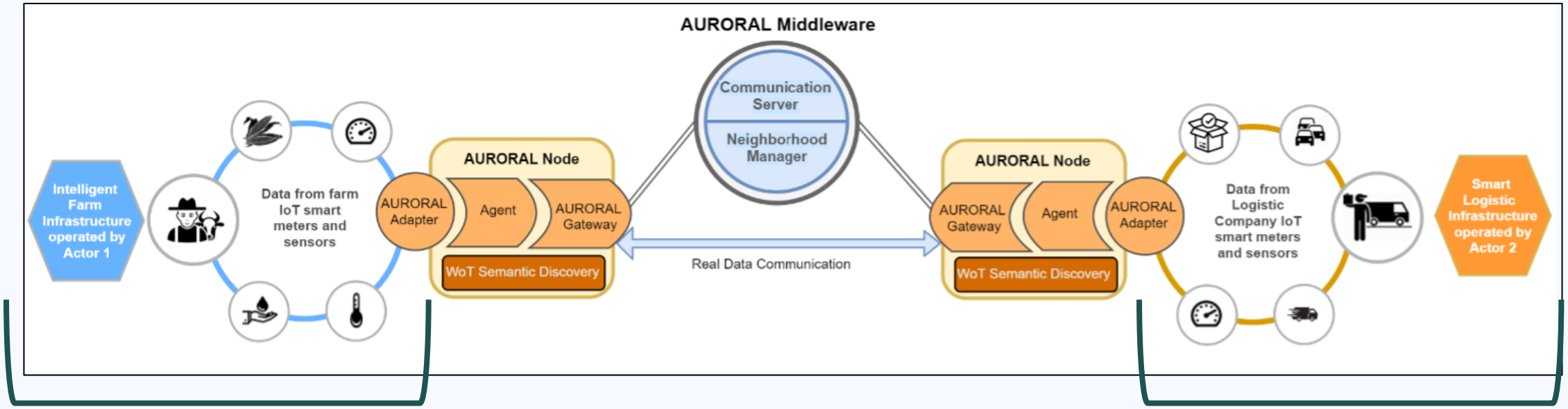
https://www.auroral.eu/

AURORAL focuses on **increasing connectivity and delivering a digital environment of smart objects interoperable services platforms able to trigger dynamic rural ecosystems of innovation chains, applications and services.**

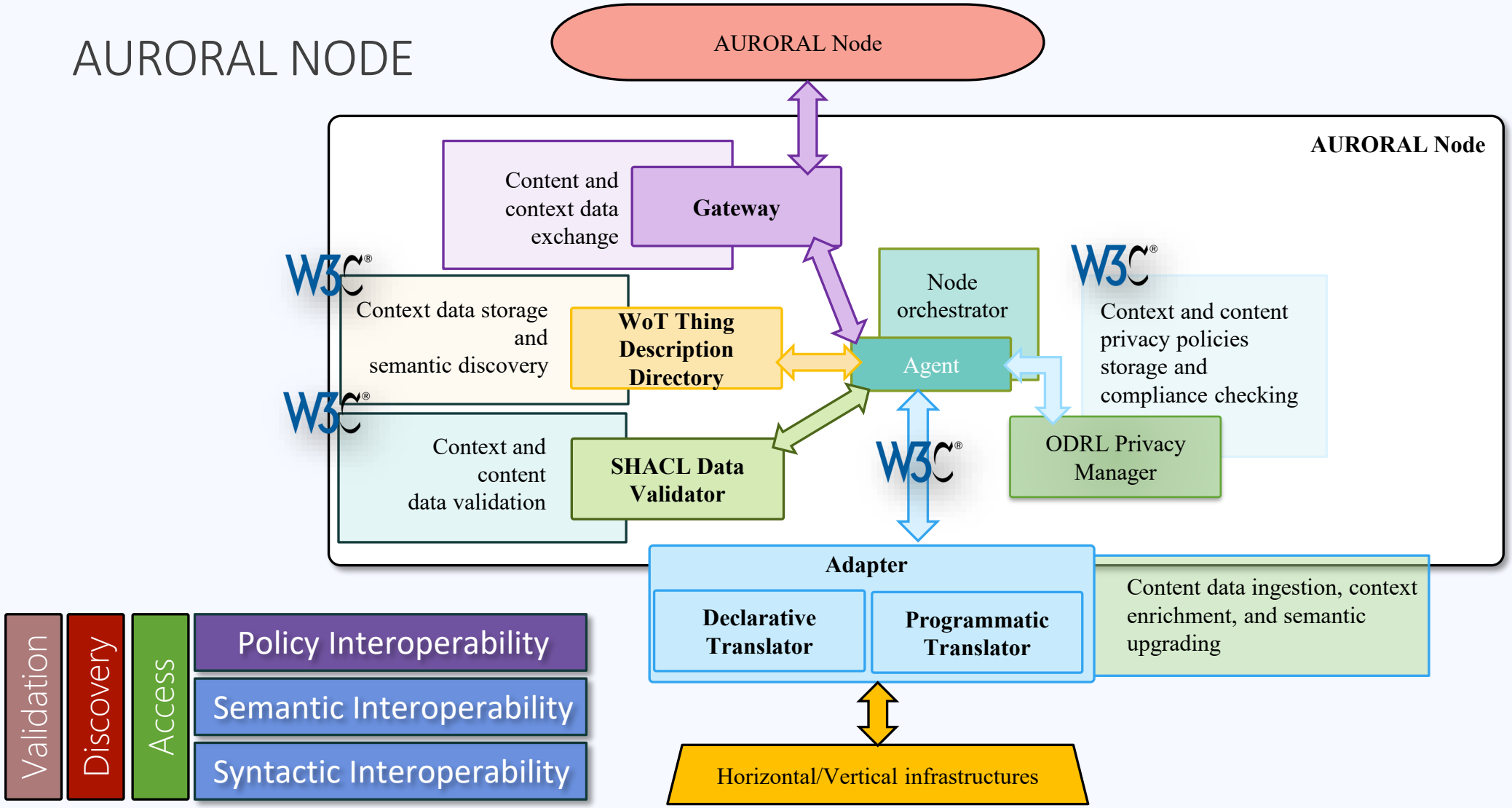
Thus, AURORAL contributes to increase economic growth and create jobs in rural areas and to tackle significant societal challenges, contributes to overcoming digital divide between rural and urban areas and to develop the potential offered by increased connectivity and digitisation of rural areas. AURORAL digital environment is demonstrated by cost-efficient and flexible cross-domain applications through large-scale pilots in seven European regions. It builds on an open, API-based, interoperable and federated Internet of Things (IoT) architecture and includes a reference implementation supporting flexible integration of heterogeneous services, bridging the interoperability gap of the smart object platforms and creating markets for services in rural areas.

Architecture for **U**nified **R**egional and **O**pen digital ecosystems for Smart Communities and **R**ural **A**reas **L**arge scale application (**AURORAL**)

AURORAL ARCHITECTURE



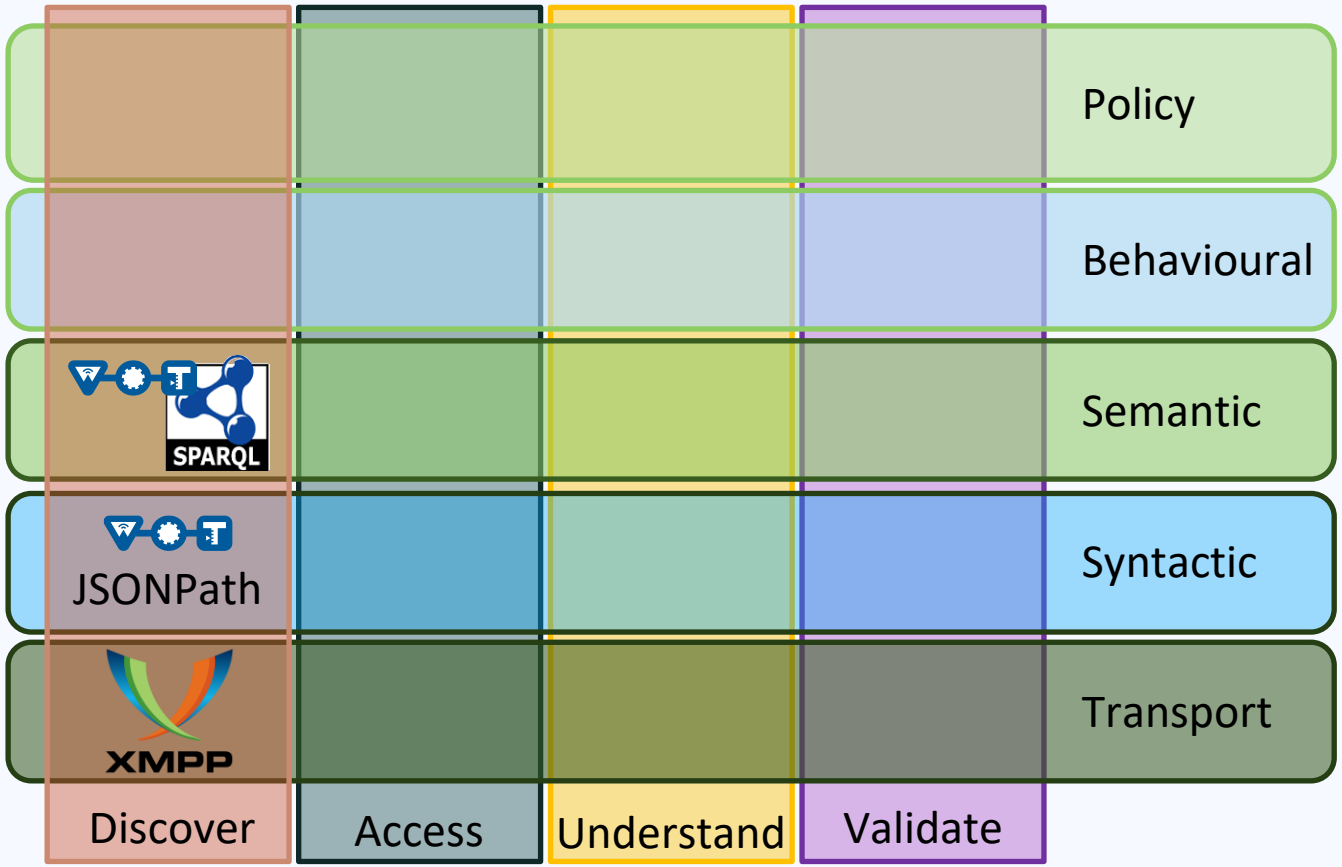
AURORAL NODE



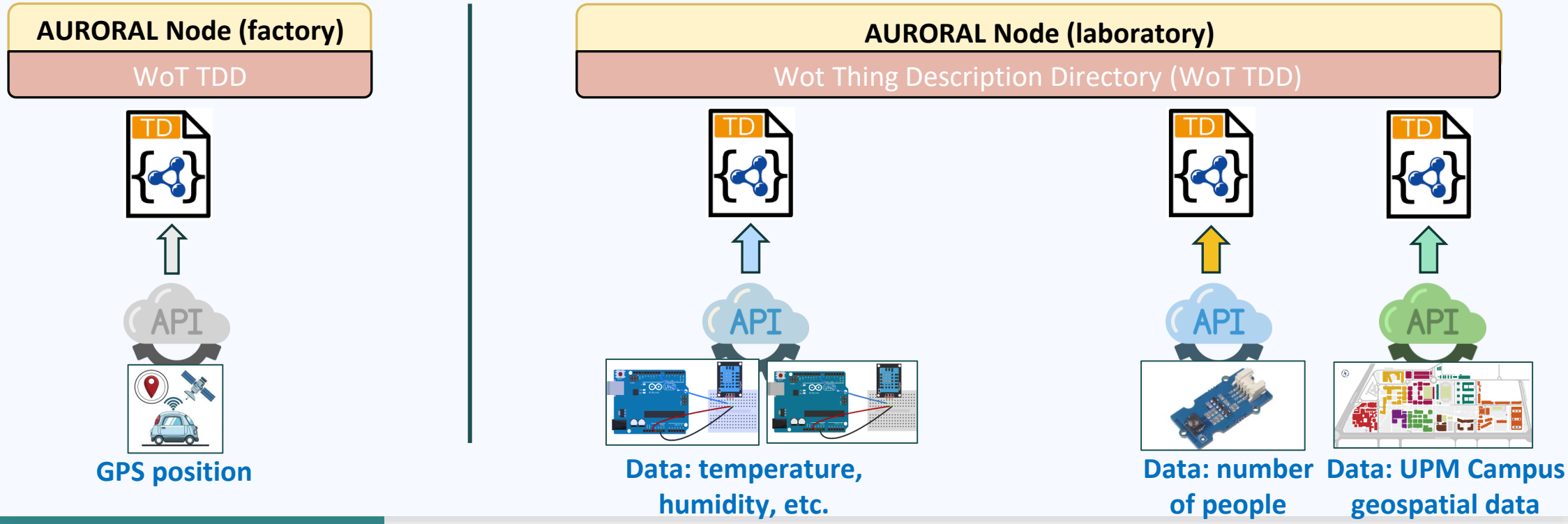
DISCOVERY

DISCOVERY IN AURORAL: STANDARDS

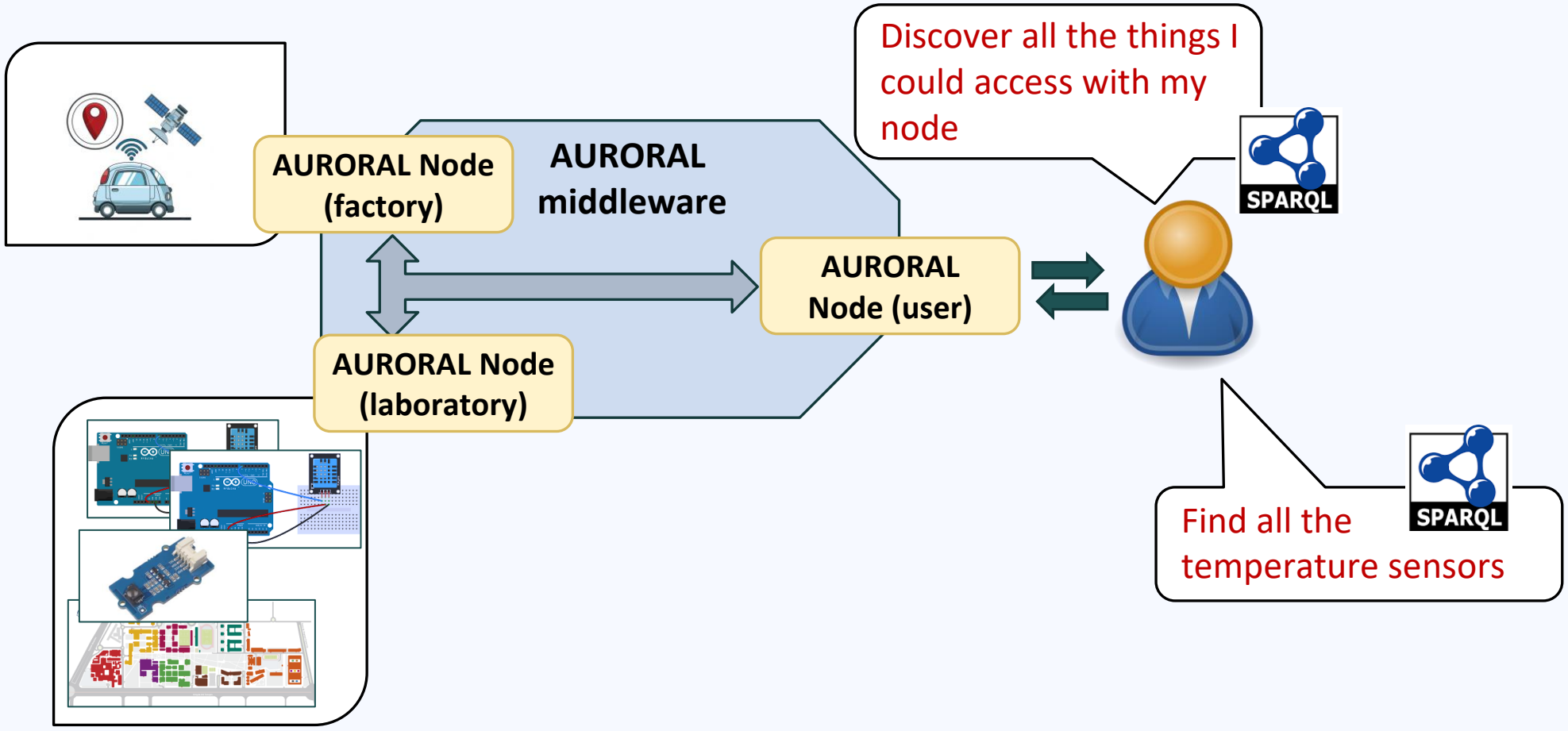
- **CHALLENGE**: Find nodes to exchange data with, which have suitable data for the exchange
- **PROBLEM**: Data exchange only happens if the remote node and the underlying data are known beforehand by means of external mechanisms
- **SOLUTION**: Adopt a discovery procedure for making nodes and their underlying data discoverable



DISCOVERY: AURORAL APPROACH



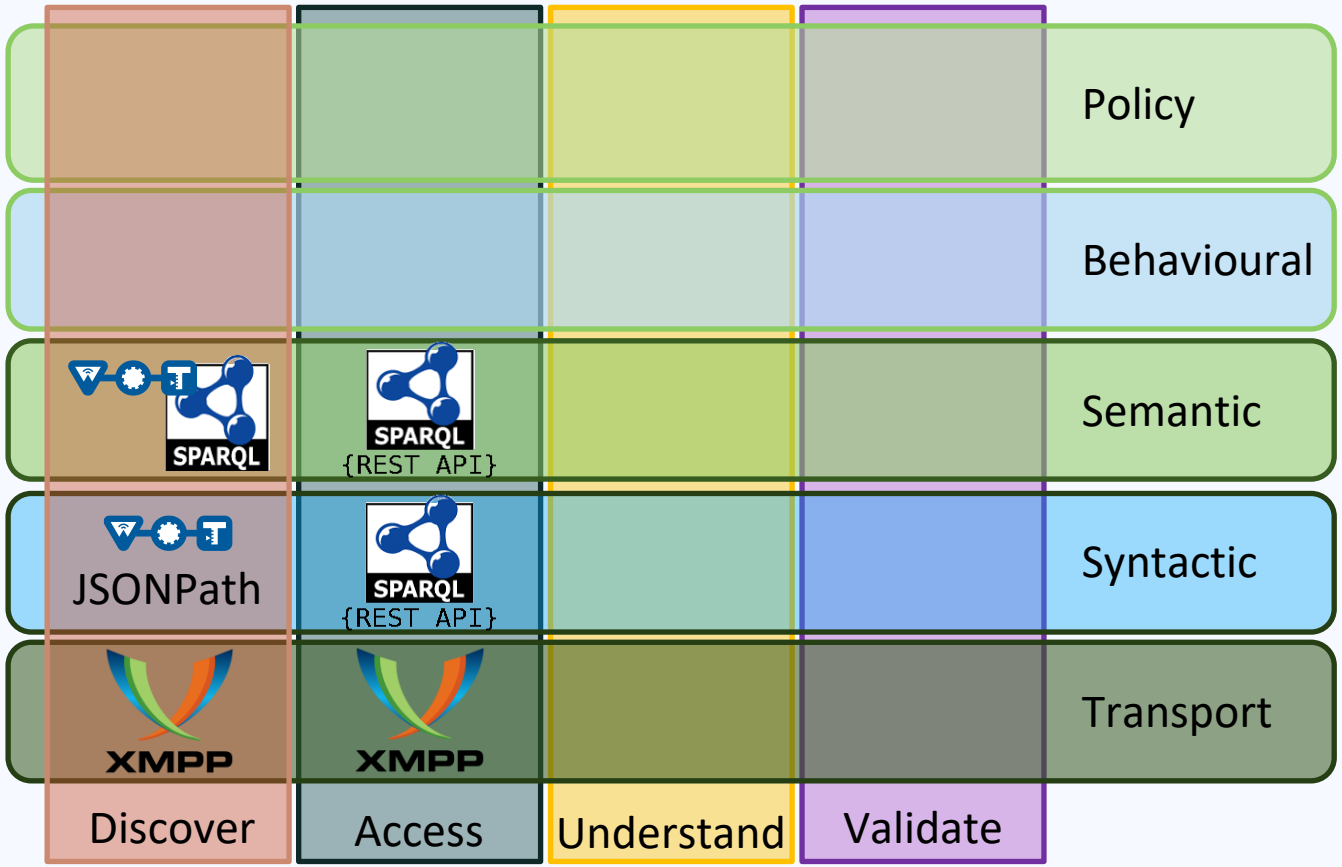
DISCOVERY: AURORAL APPROACH



ACCESS & UNDERSTANDING

ACCESS IN AURORAL

- **CHALLENGE**: Establish by consensus one or more protocols to exchange data
- **PROBLEM**: Nodes do not know how to exchange data
- **SOLUTION**: Adopt a standard access protocol, preferably point-to-point and distributed

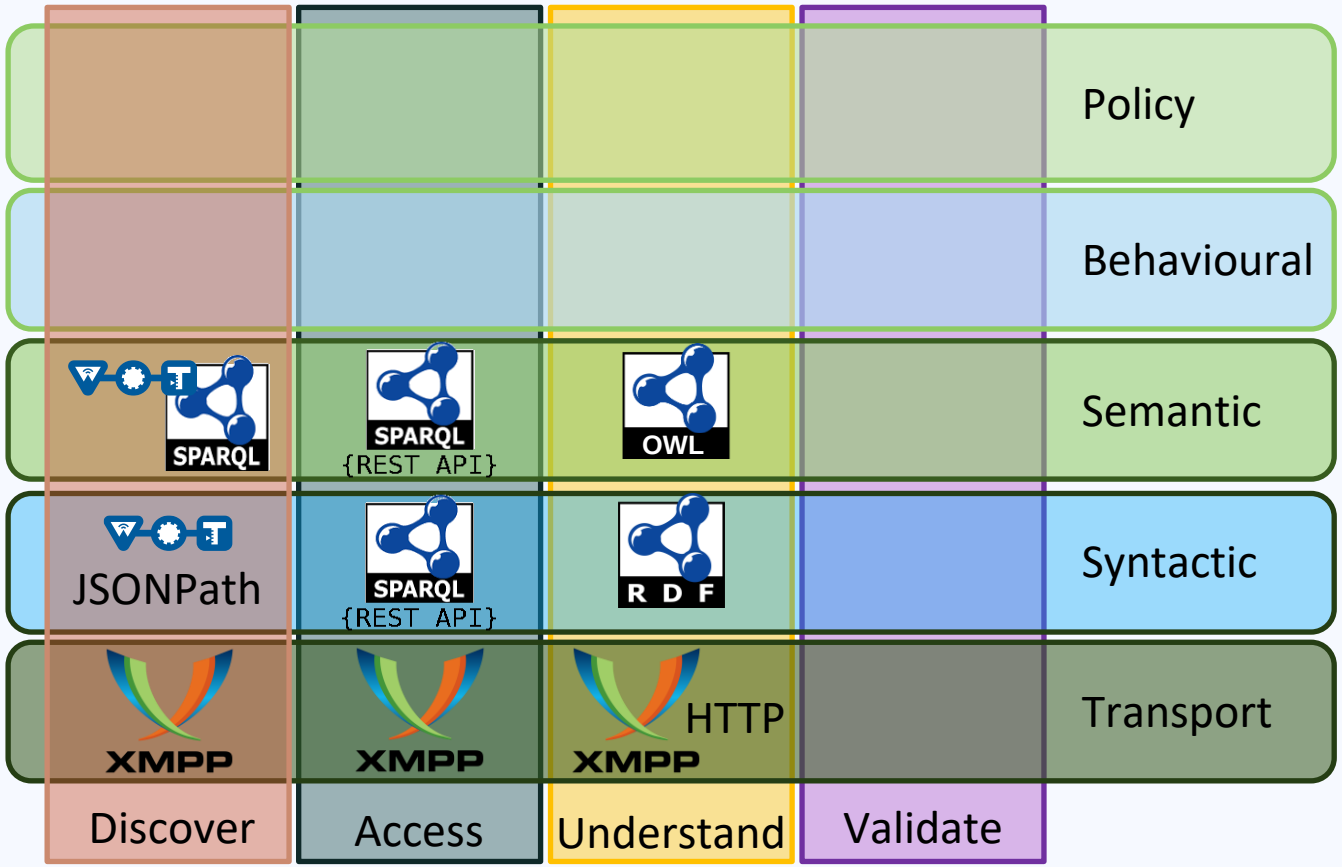


UNDERSTAND IN AURORAL

- **CHALLENGE**: Transparently understand and integrate different sources of heterogeneous data
- **PROBLEM**: Nodes do not know how to interpret data and may derive wrong conclusions
- **SOLUTION**: Establish a shared ontology model, based on existing standards, to support data understanding and integration

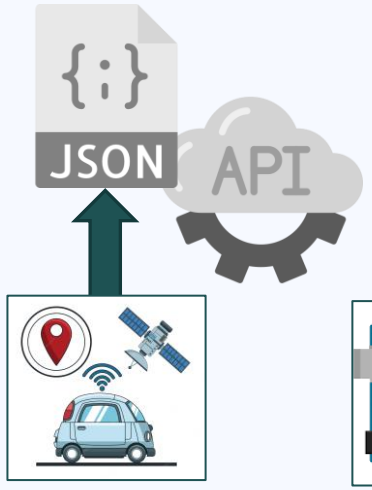
W3C ODRL

ETSI SAREF



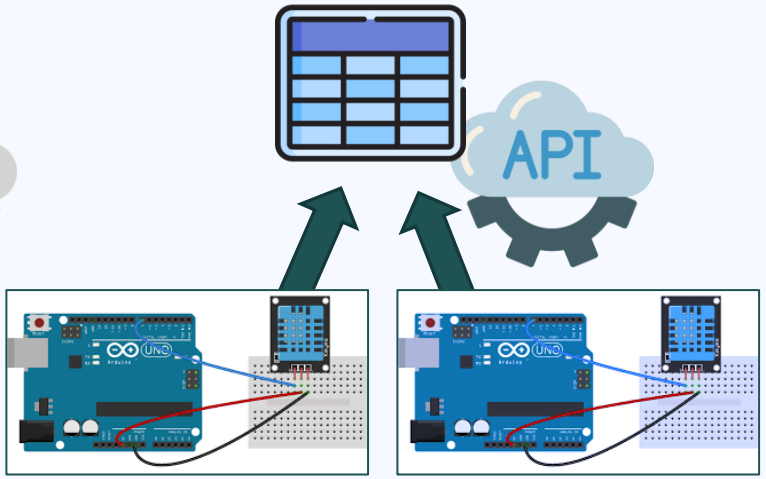
ACCESS & UNDERSTAND: AURORAL SEMANTIC INTEROPERABILITY

JSON data



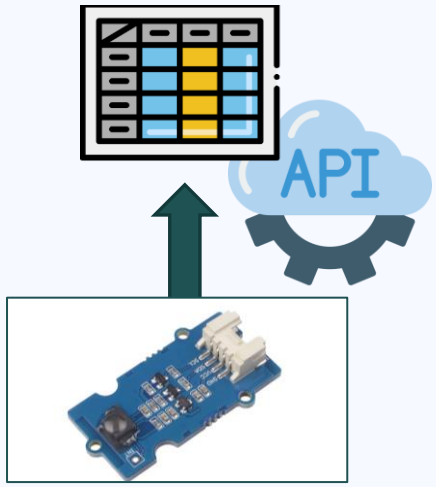
GPS position

Tabular data



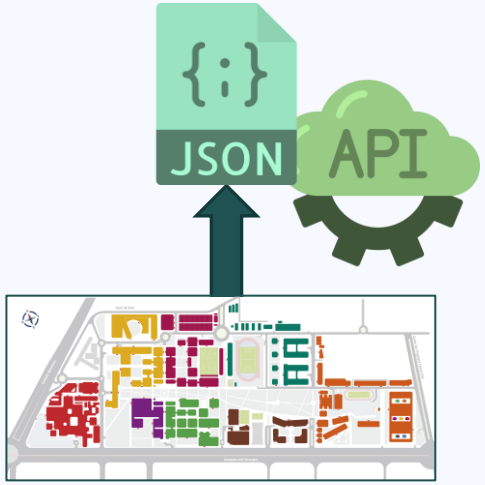
Data: temperature, humidity, etc.

Tabular data



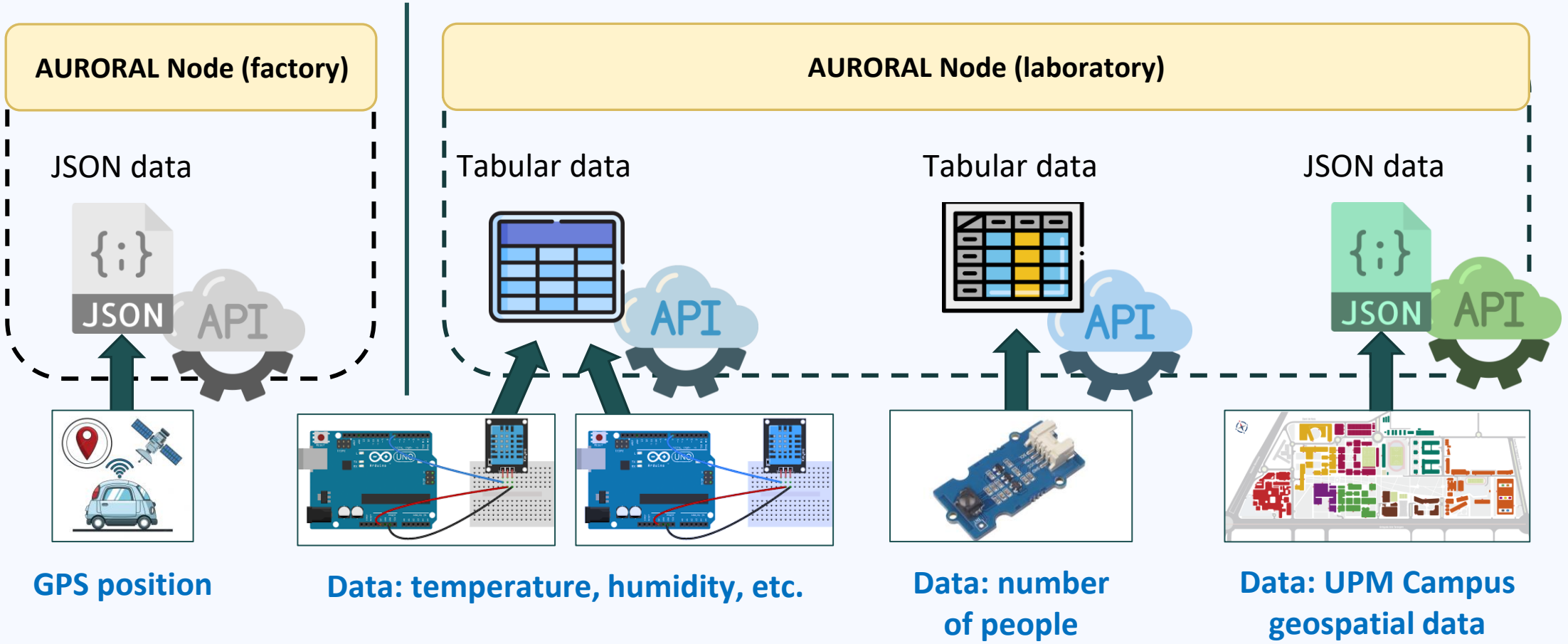
Data: number of people

JSON data

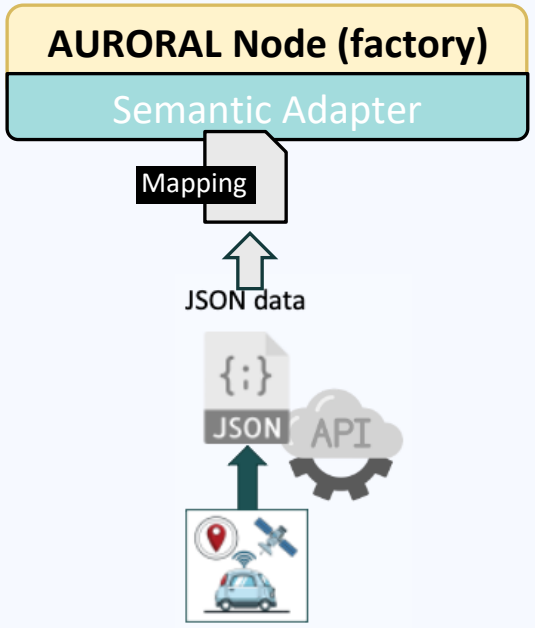


Data: UPM Campus geospatial data

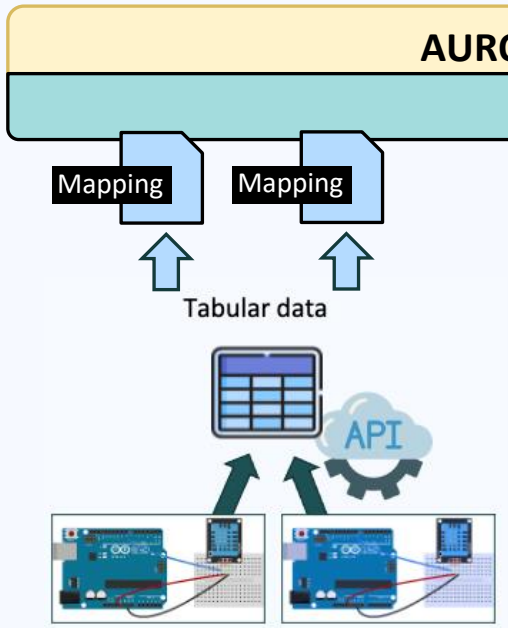
ACCESS & UNDERSTAND: AURORAL SEMANTIC INTEROPERABILITY



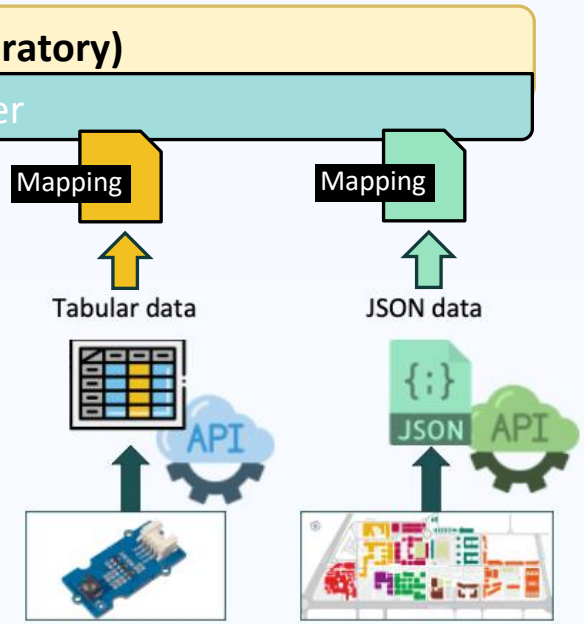
ACCESS & UNDERSTAND: AURORAL SEMANTIC INTEROPERABILITY



GPS position



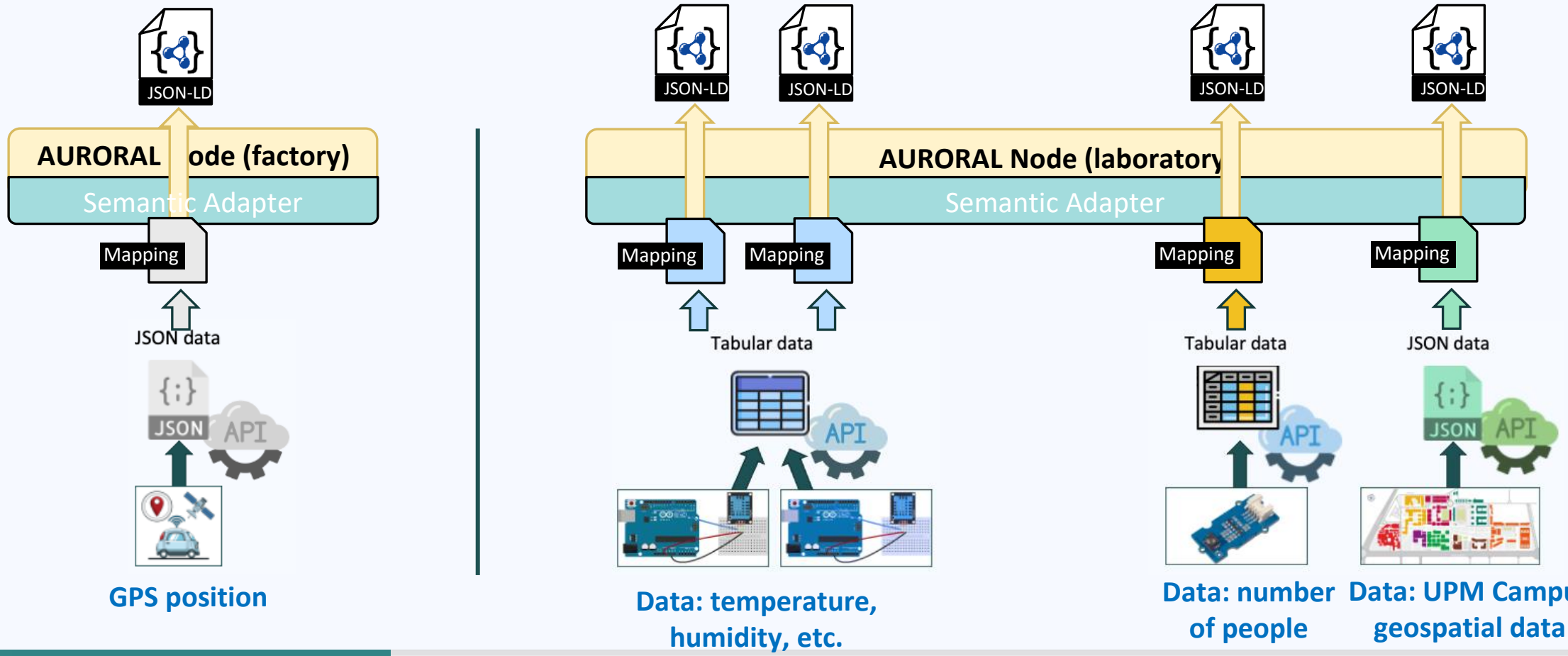
Data: temperature, humidity, etc.



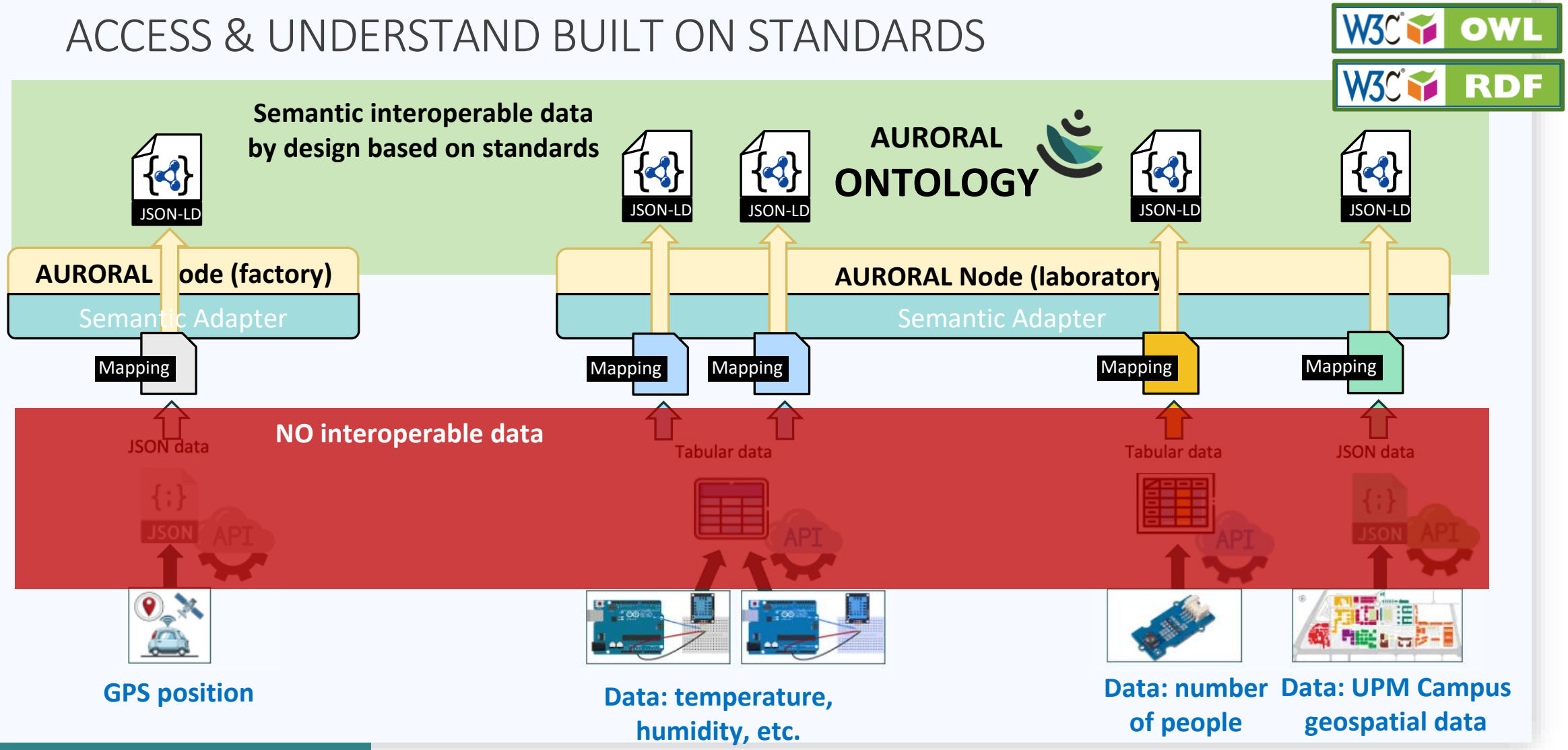
Data: number of people

Data: UPM Campus geospatial data

ACCESS & UNDERSTAND: SEMANTIC INTEROPERABILITY

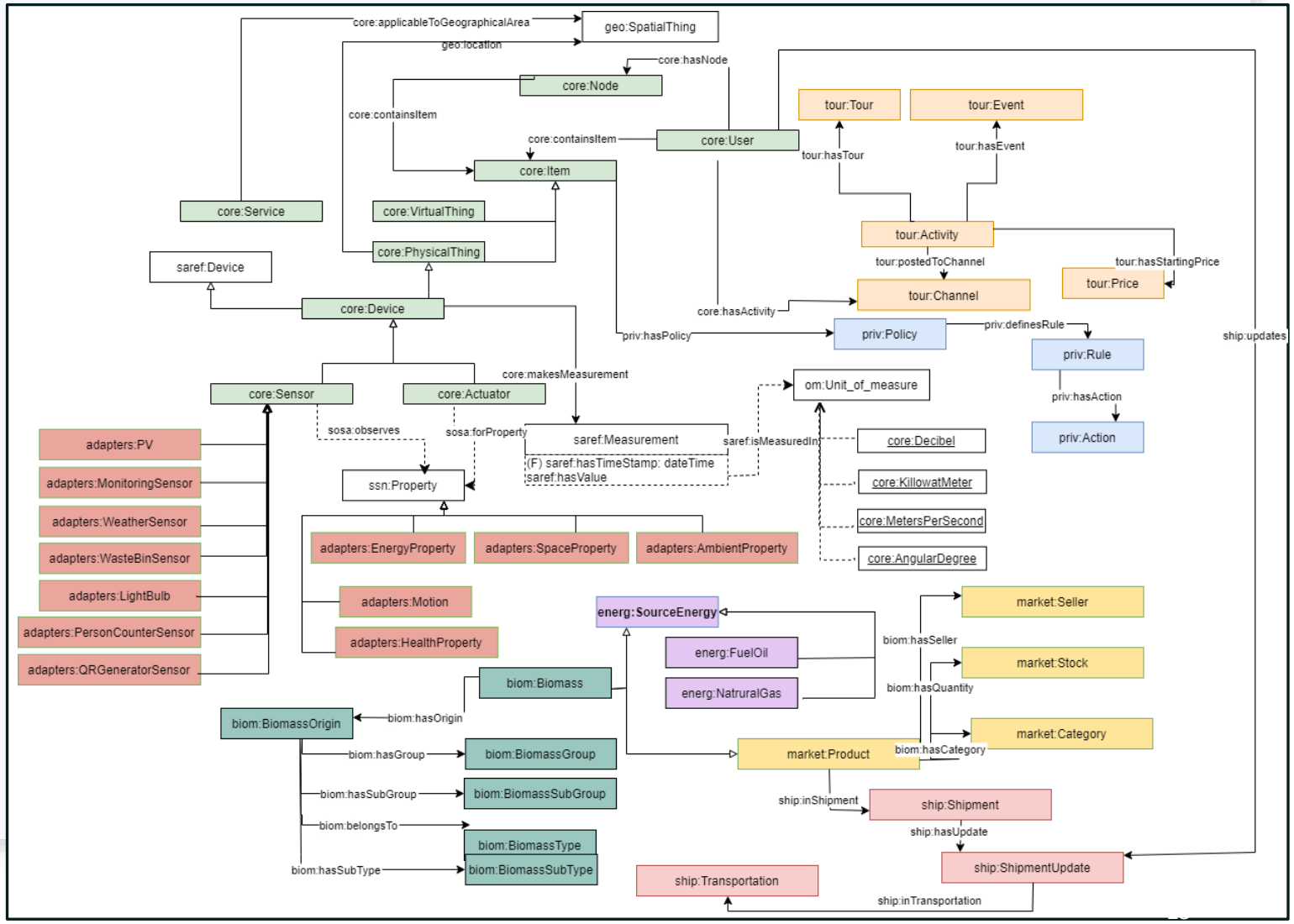


ACCESS & UNDERSTAND BUILT ON STANDARDS



ACCESS & UNDERSTAND: AURORAL ONTOLOGY

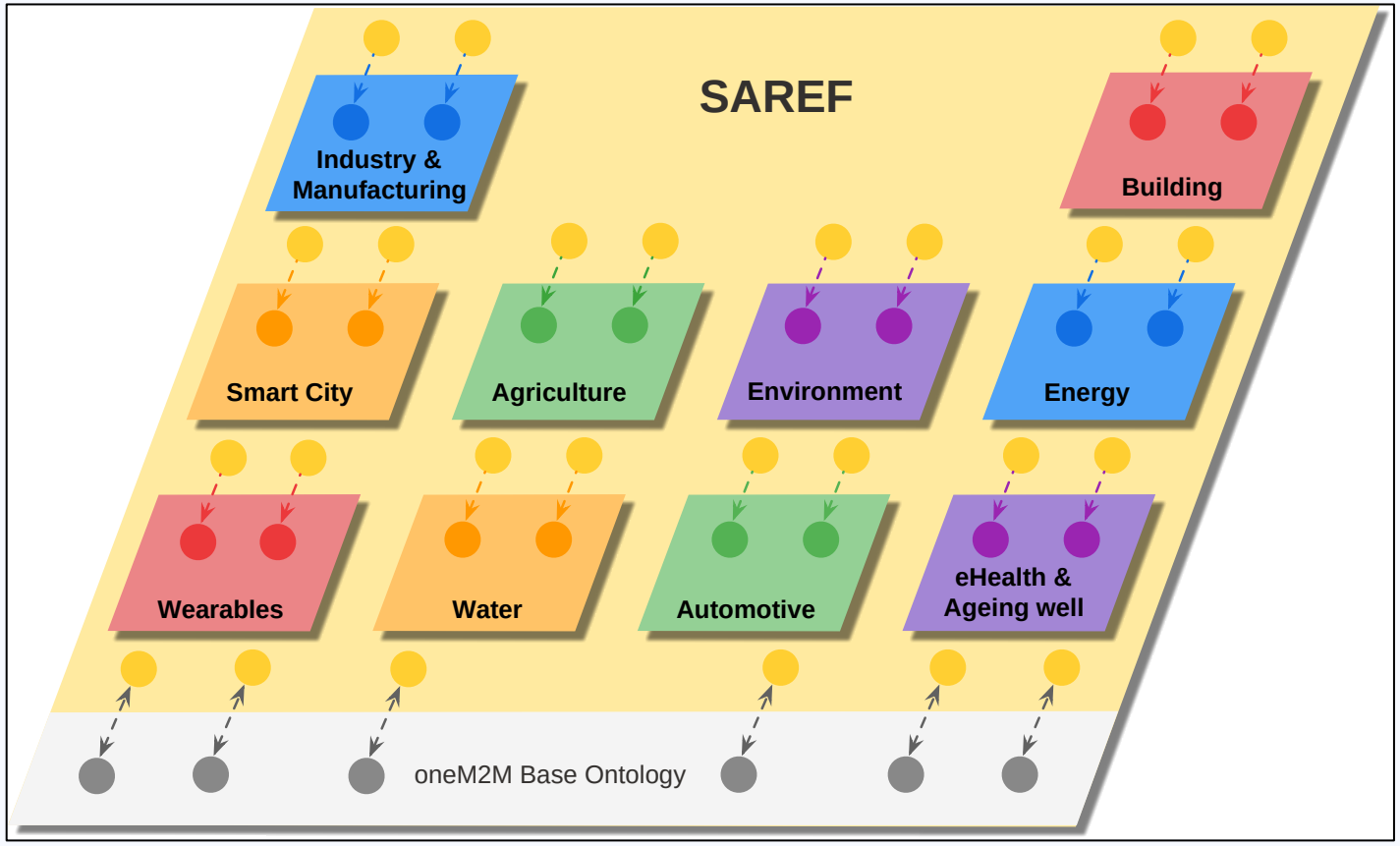
- **Based on standards**
- Follows LOT methodlogy
- 12 specific modules



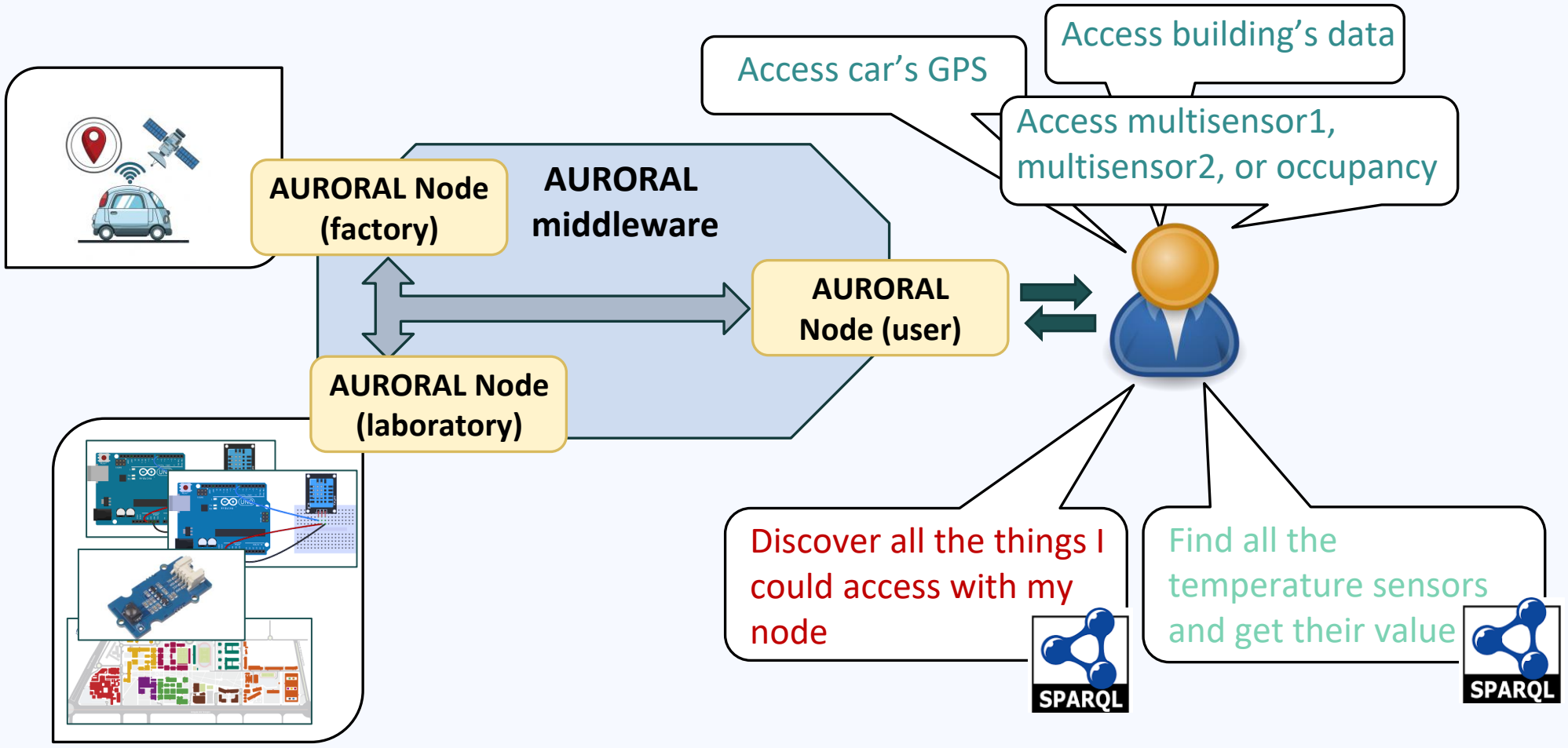
ACCESS & UNDERSTAND: AURORAL ONTOLOGY BACKBONE

The SAREF initiative

- Started in 2013
- Promoted by the EC and ETSI (TC SmartM2M)
- Development of the SAREF ontology and its extensions
- Publication as ETSI standards
- https://saref.etsi.org/



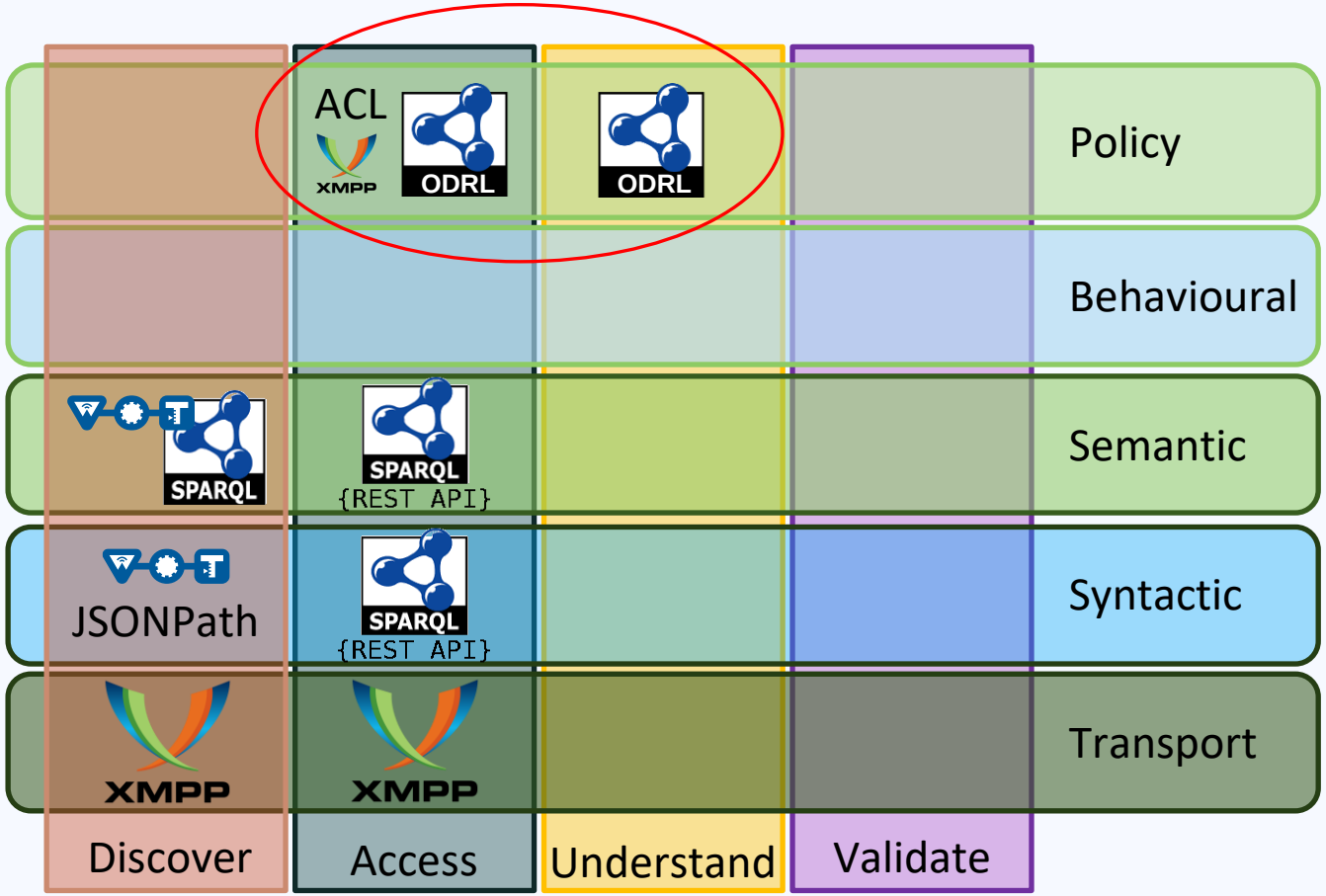
DISTRIBUTED DISCOVERY, ACCESS, UNDERSTAND



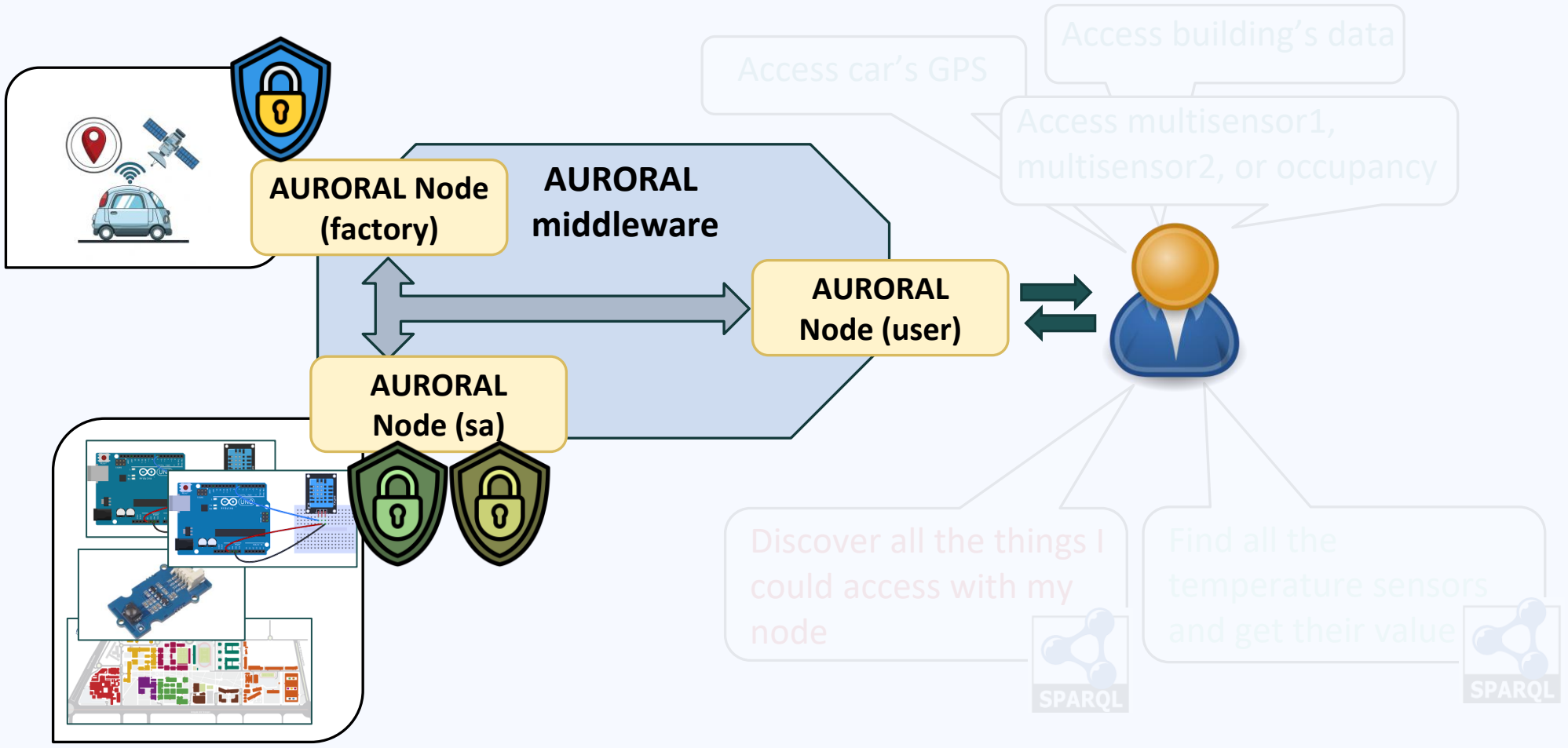
PRIVACY

ACCESS IN AURORAL

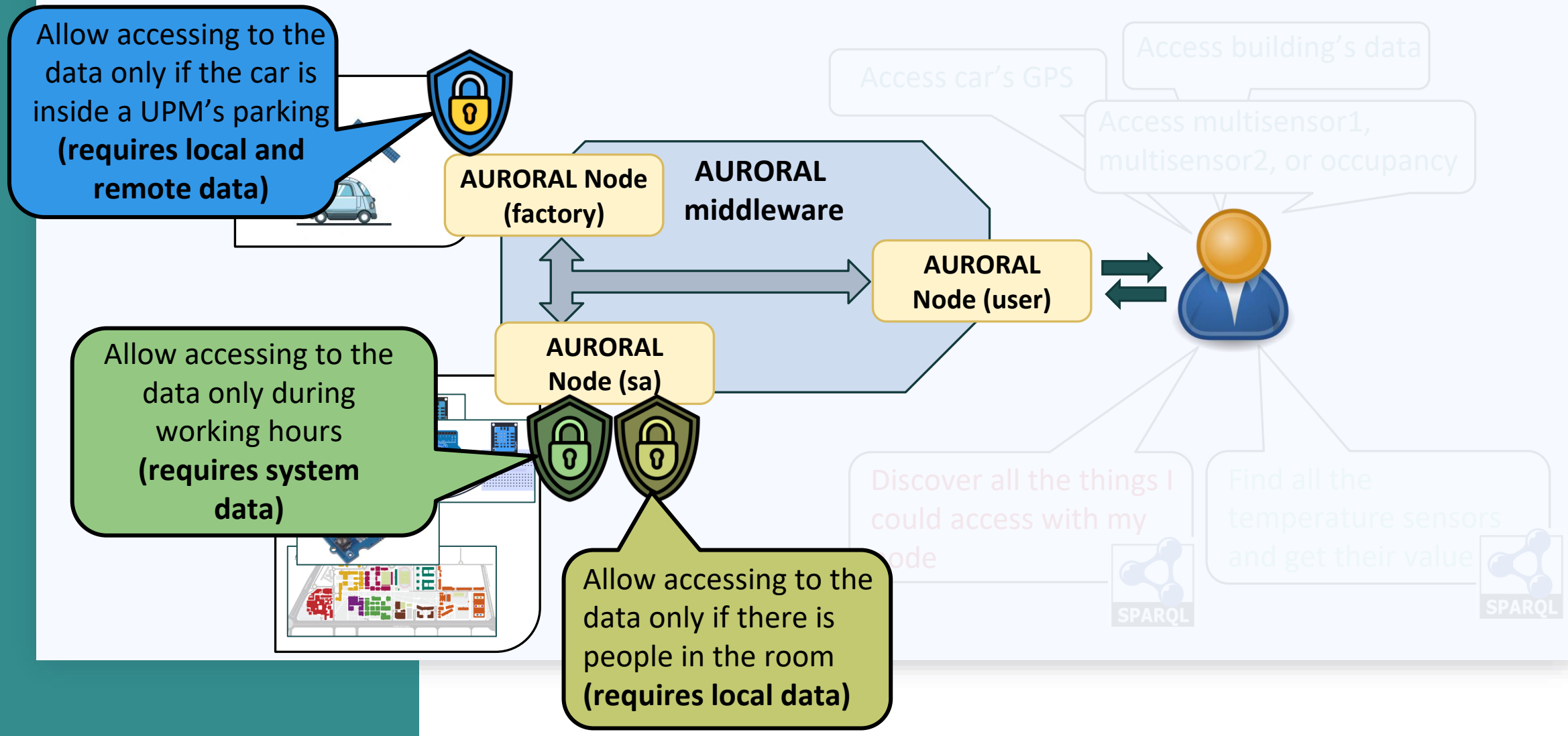
- **CHALLENGE**: Establish by consensus one or more protocols to exchange data
- **PROBLEM**: Nodes do not know how to exchange data
- **SOLUTION**: Adopt a standard access protocol, preferably point-to-point and distributed



DISTRIBUTED PRIVACY



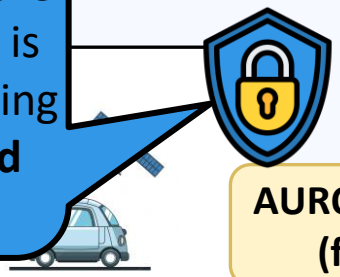
DISTRIBUTED PRIVACY: REQUIREMENTS



DISTRIBUTED PRIVACY BUILT ON STANDARDS

DESCENTRALISED PRIVACY POLICY EVALUATION

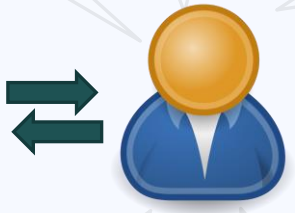
Allow accessing to the data only if the car is inside a UPM's parking **(requires local and remote data)**



AURORAL Node (factory)

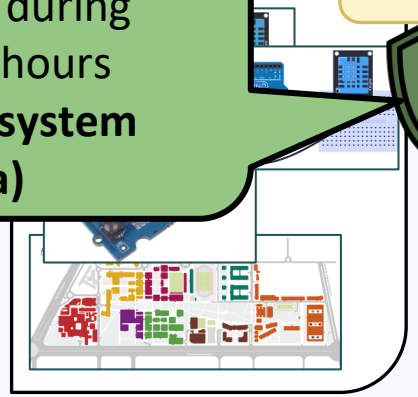
AURORAL middleware

AURORAL Node (user)



AURORAL Node (sa)

Allow accessing to the data only during working hours **(requires system data)**



Allow accessing to the data only if there is people in the room **(requires local data)**

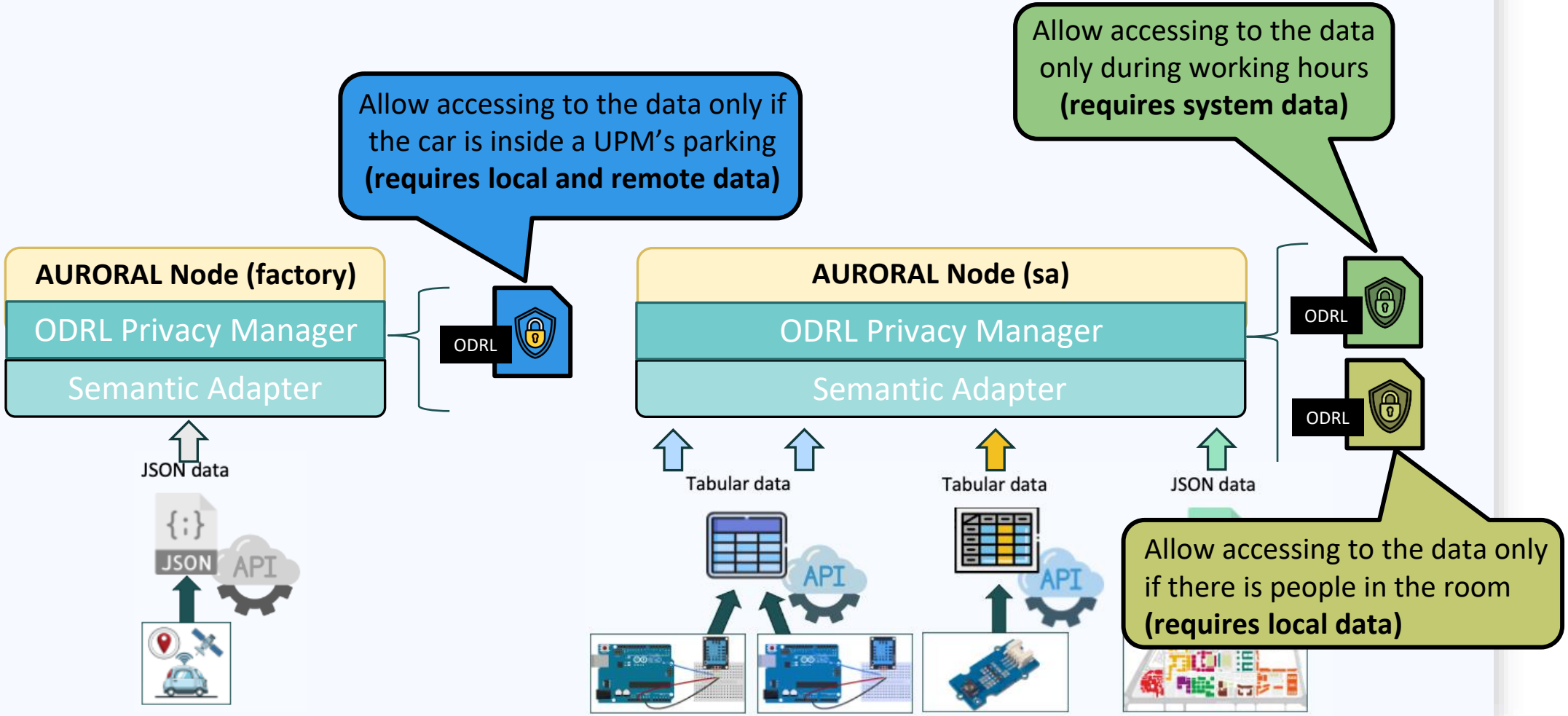
Access multisensor1, multisensor2, or occupancy

Discover all the things I could access with my

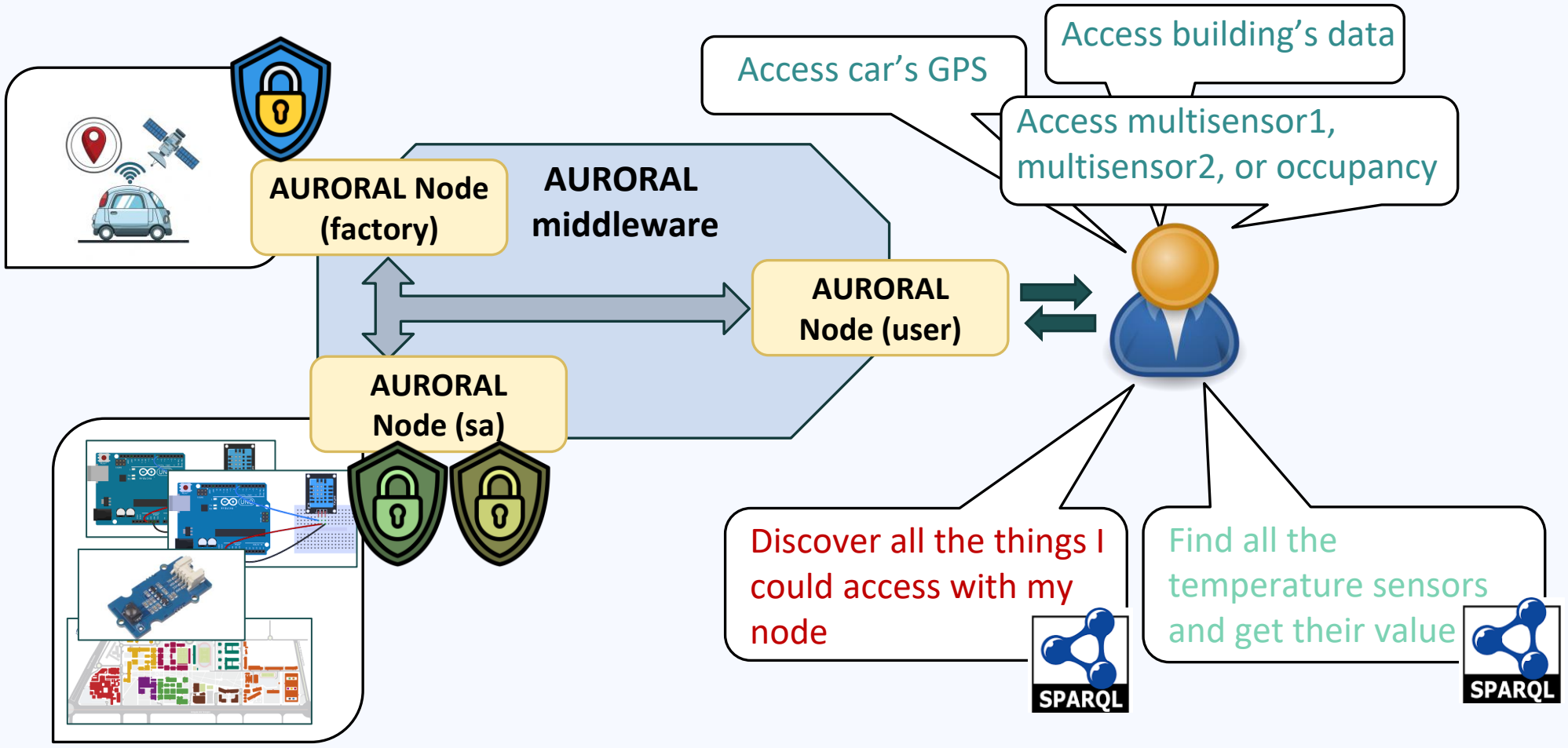
Find all the temperature sensors and get their value

ODRL Information Model 2.2
W3C Recommendation 15 February 2018

ODRL PRIVACY POLICIES

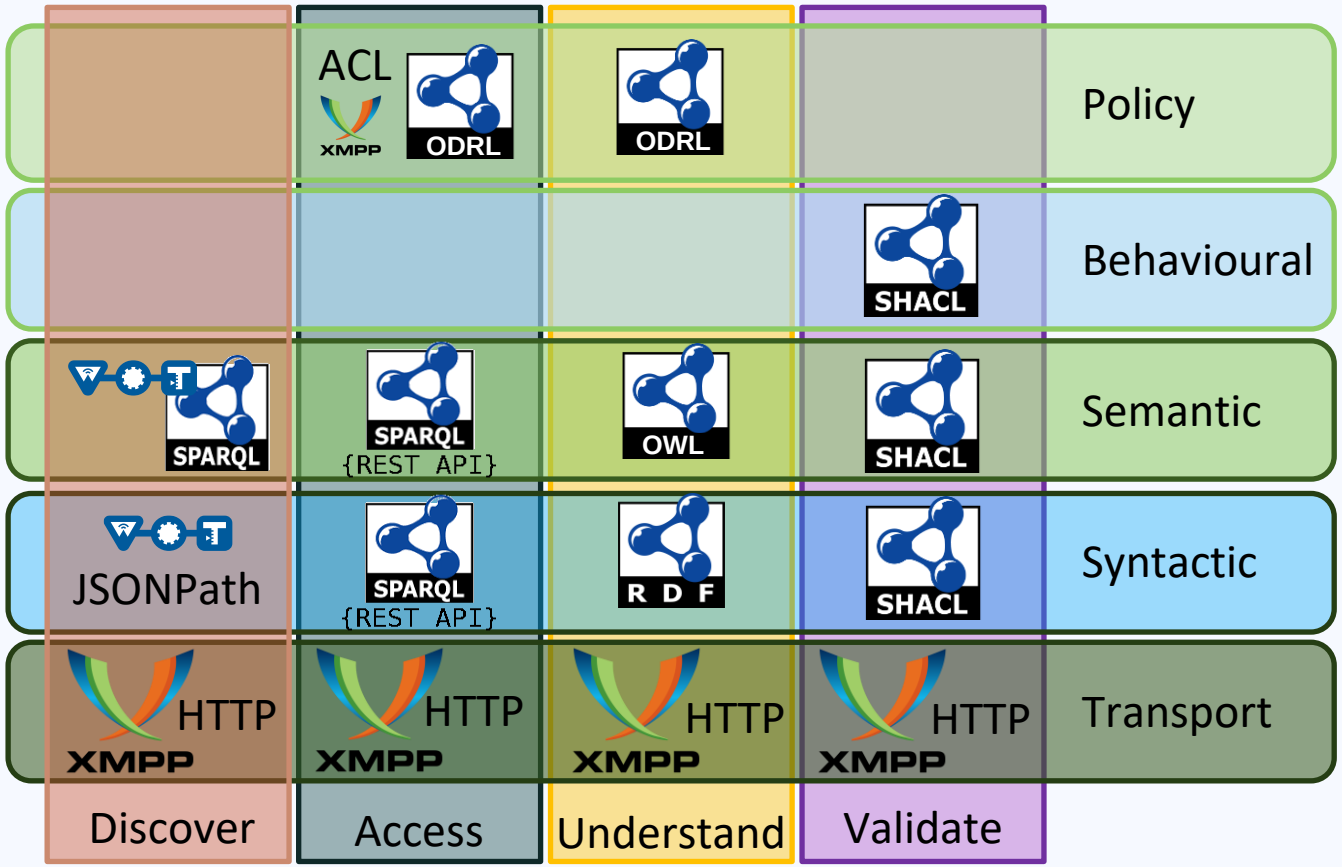


PRIVACY BY DESIGN



VALIDATE IN AURORAL

- **PROBLEM**: Data exchanged needs to satisfy certain business constraints
- **CONSECUENCES**: Data that is not valid cannot be automatically consumed
- **SOLUTION**: Validate data at different levels: syntax, semantics, behaviour



CONLUSIONS

CONCLUSIONS

- Smart communities require interoperability to exploit their maximum value

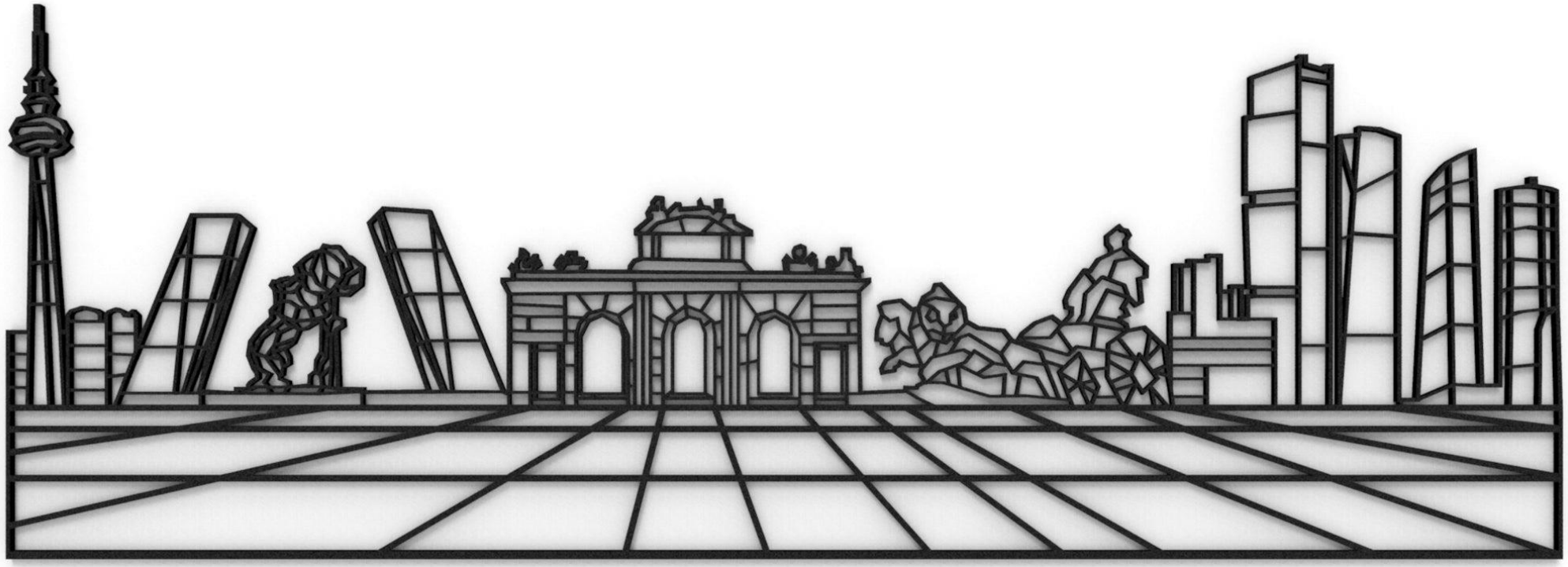
- Standards and consensus are the pillar for achieving interoperability
  - Using open standards
  - Taking into account legacy systems

- AURORAL brings a novel solution that relies on W3C standards for achieving interoperability
  - Provides features to integrate other systems thanks to its flexible architecture
  - Is not only built on top of the standards but has been actively collaborating with them

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 101016854.

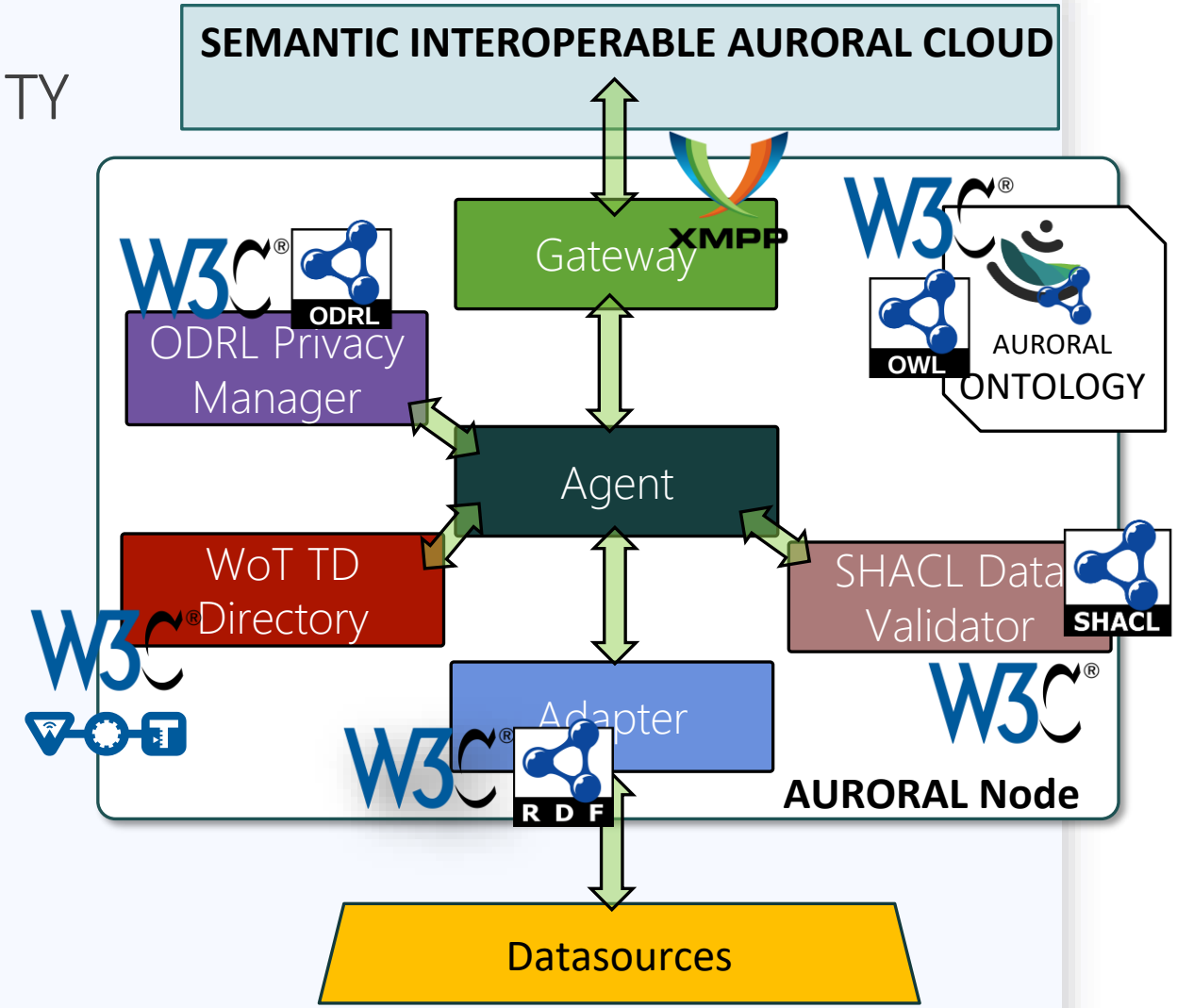
AURORAL

THANK YOU!



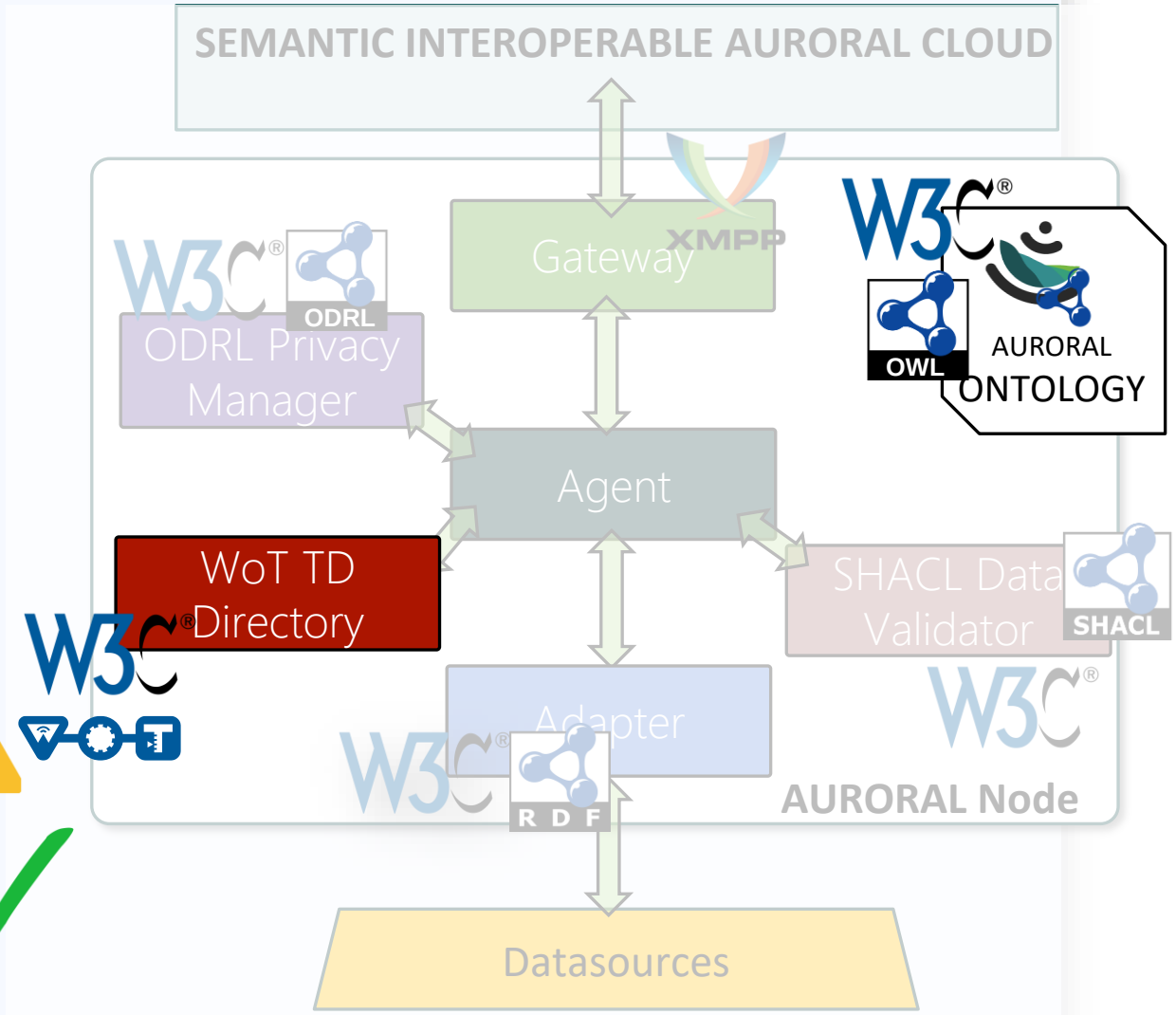
MIMS BACKUP

BEYOND SEMANTIC INTEROPERABILITY



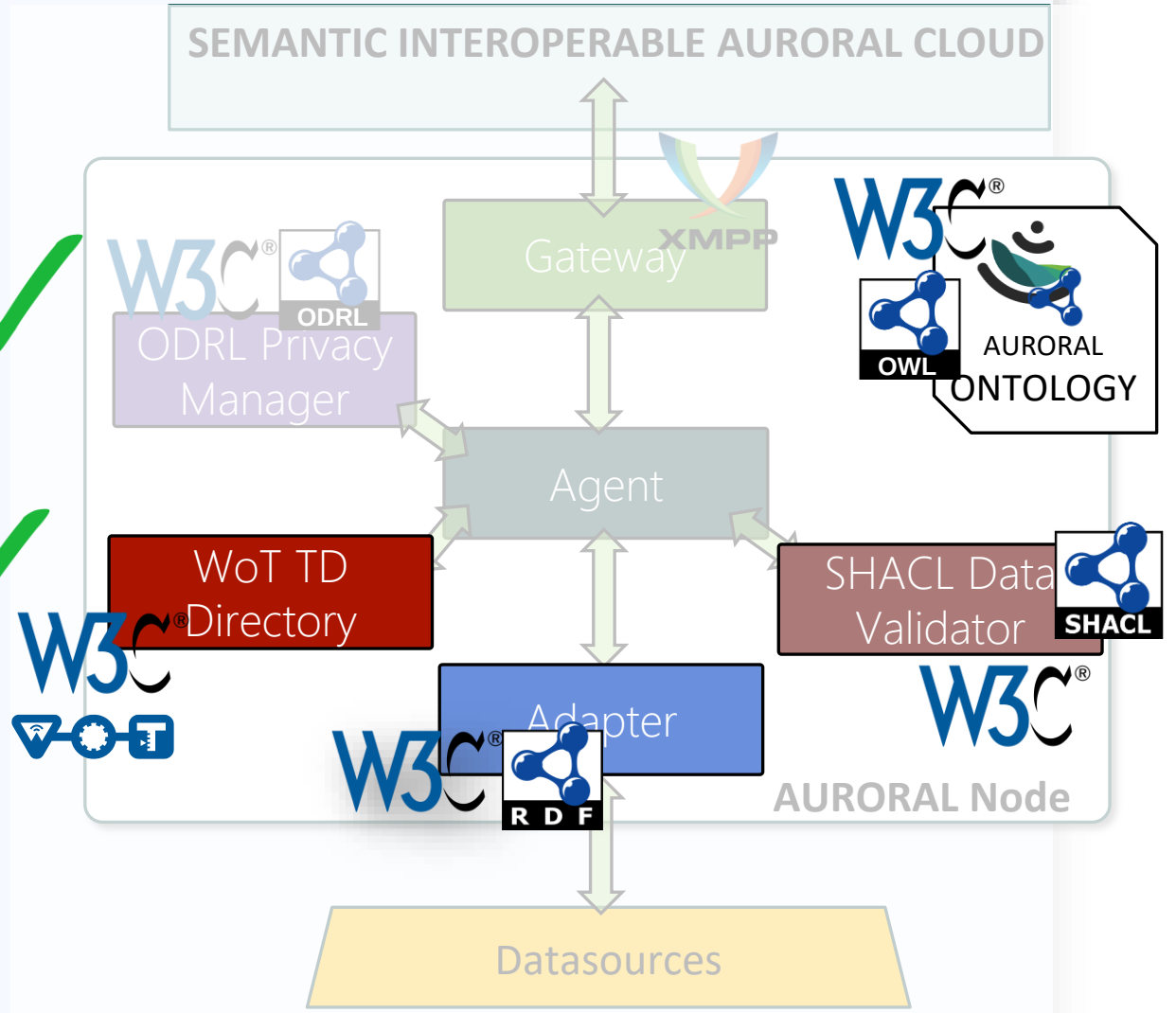
OASC MIM1: CONTEXT

- Discover resources using contextual information ✓
- Define contextual information using concepts provided by data models ✓
- Querying information ✓
  - Value
  - Historical ⚠
  - Geospatial way ✓
- Applications can subscribe to changes of information ⚠
- Common model for describing how to interact with discovered resources ✓



OASC MIM2: DATA MODELS

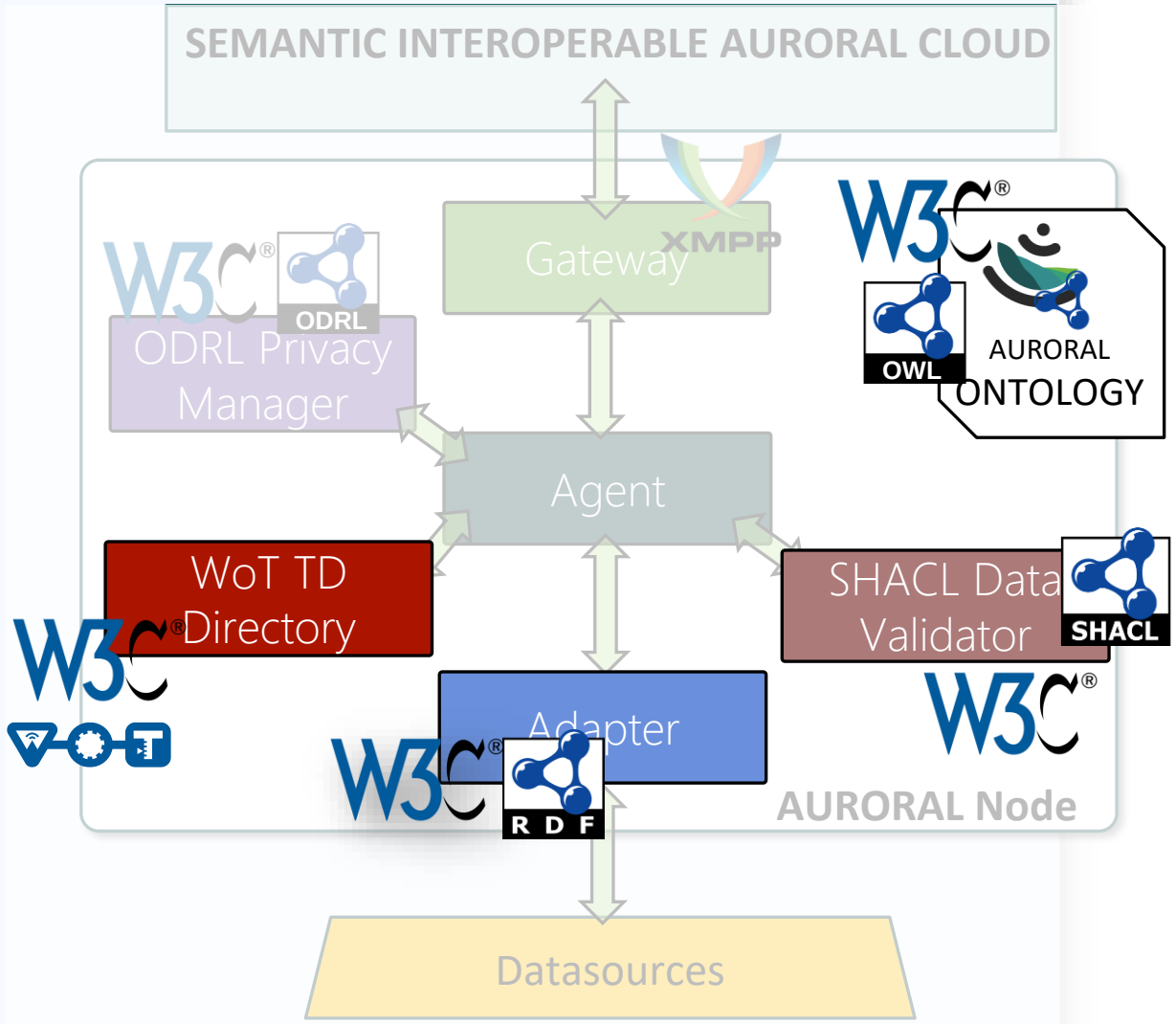
- Data models are clearly defined ✓
- Data models capture the complete context they need to represent ✓
- Harmonization across data models ✓
- Transforming data between the different standards ✓



OASC MIM7: PLACES

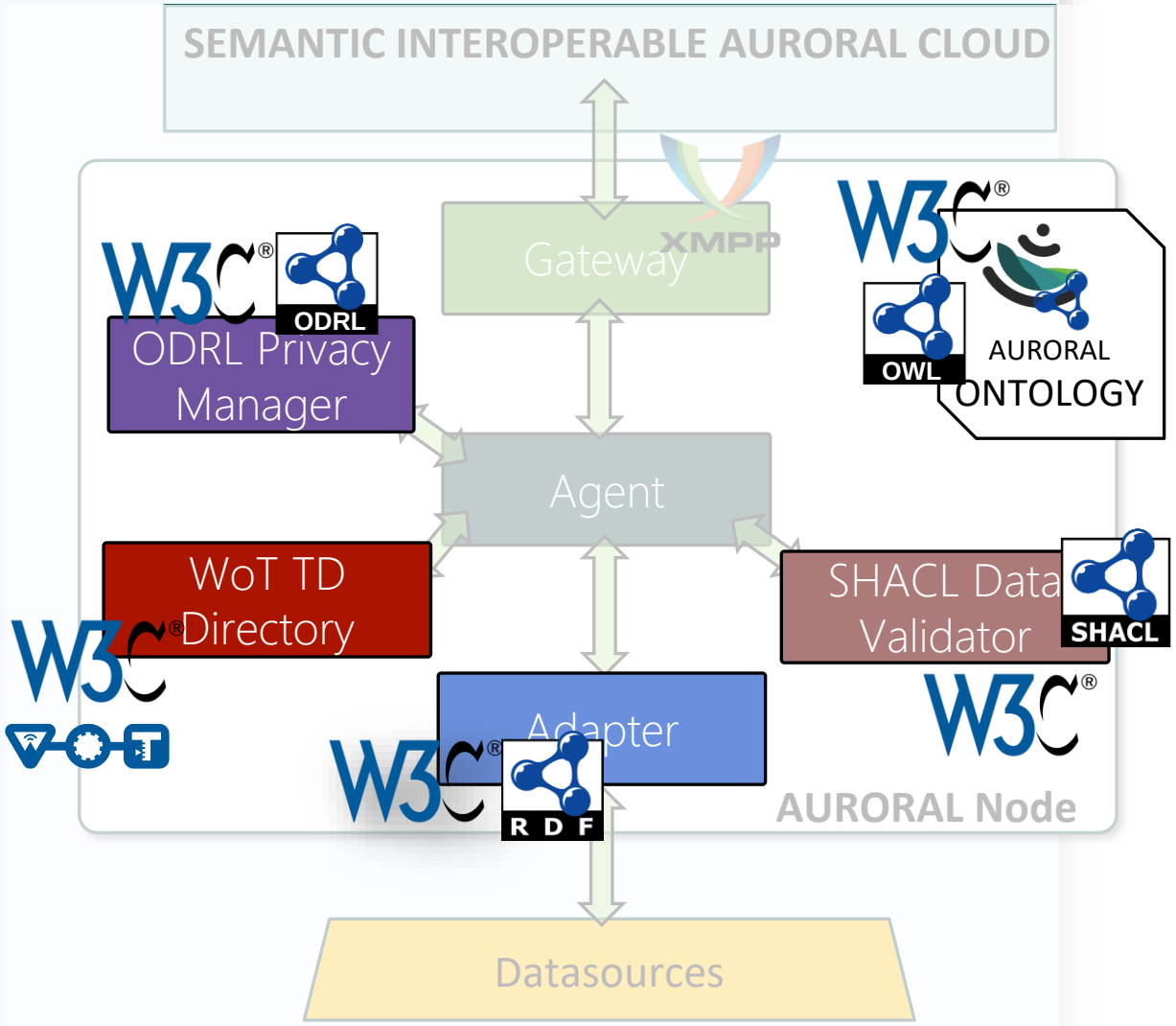
- Mechanisms related to geo-temporal data ✓

Open Geospatial Consortium



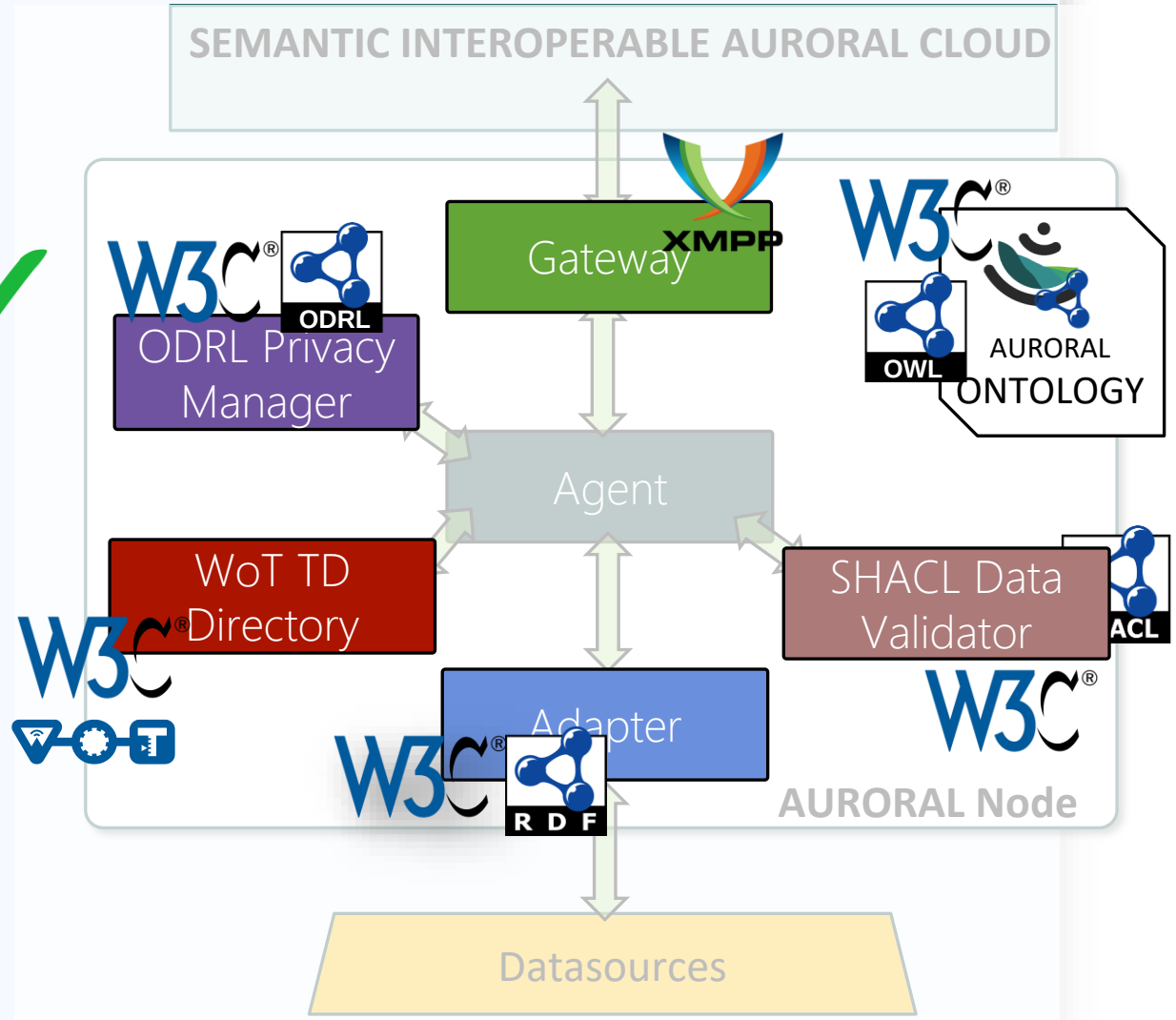
OASC MIM4 : TRUST

- Methods to control which personal data can be accessed ✓
- Define clear circumstances under which data can accessed ✓
- Interoperability between the different solutions ⚠



OASC MIM6 : SECURITY

- Identify security-related risks ✓
- Provide right measures to protect systems and data ✓
- Provide a framework for governance ⚠



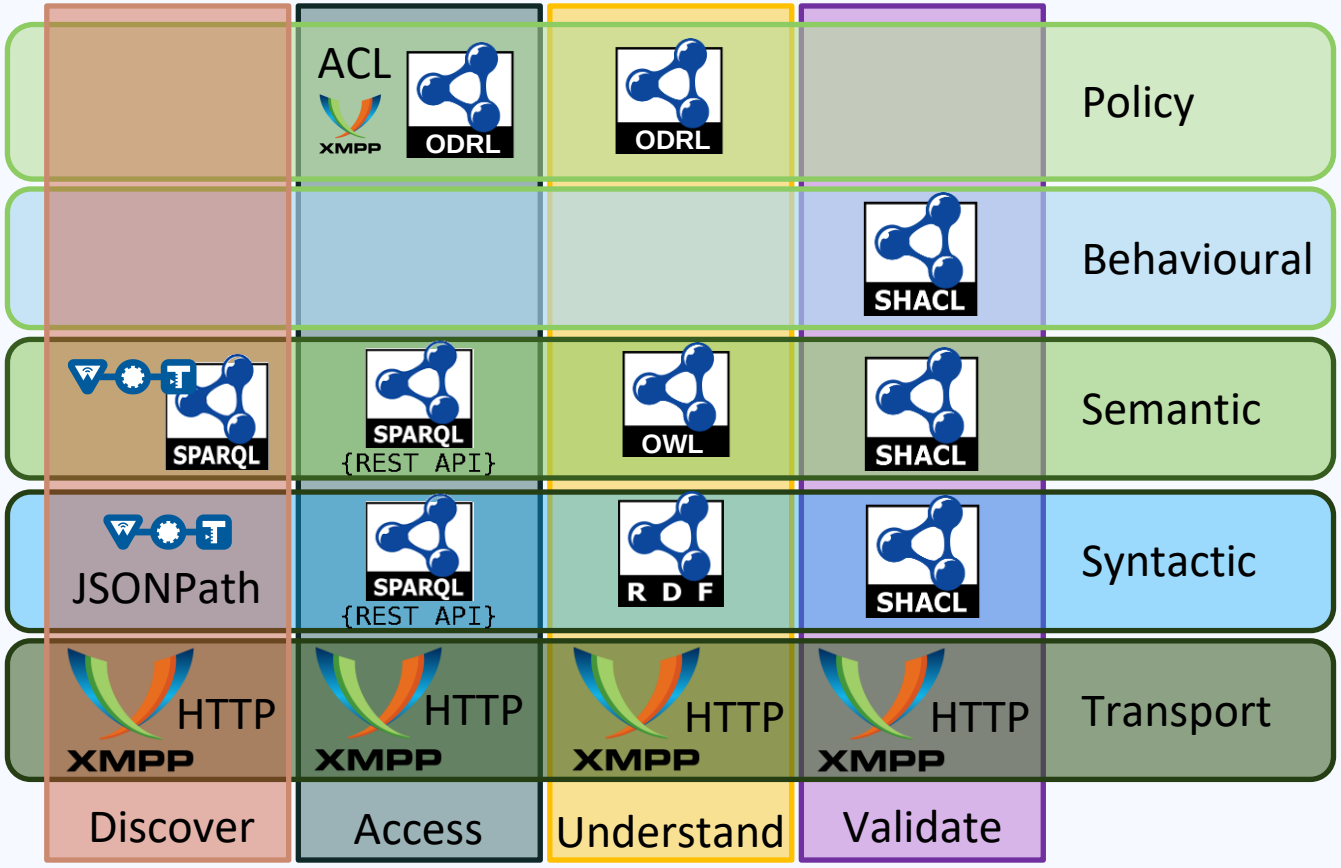
OASC MIM3: CONTRACTS

- Have a catalogue of suitable local data sources ⚠️
- Have a marketplace ⚠️

OASC MIM9: ANALYTICS

- Make complex data models interoperable ✓
- Allowing efficient analytics ⚠️

AURORAL INTEROPERABILITY CASE



ISO/IEC 21823-1:2019 Internet of things (IoT) — Interoperability for IoT systems — Part 1: Framework

PWI JTC1-SC41-8 Internet of Things (IoT) - Behavioral and policy interoperability (under development)