



Semantic DR interoperability through the H2020 DELTA Project

The OpenADR ontology and the DELTA CIM tool

DELTA

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DELTA Project Identity Card

*Future tamper-proof **D**emand **r**esponse framework through **s**elf-configured, self-optimized and **c**ollaborative virtual distributed energy nodes*

- H2020 Call: **H2020-LCE-2016-2017**,
 - Topic: **LCE-01-2016-2017**
- Funding Instrument: **RIA** (Research and Innovation Action)
- Duration: **36 Months** (Started on 1 May 2018)
- EU Contribution & Total Costs: **3.980.250,00 €**
- **10 Partners from 8 countries**



DELTA Vision & Concept

A new energy distribution structure

Today

- ▶ Demand Aggregators having DR contracts with large customers/businesses
- ▶ Inconvenient, semi-automated explicit DR
- ▶ Unreliable implicit DR
- ▶ Single-point, Centralized Management of Assets
- ▶ Fragmented standards/protocols for building monitoring & control systems



Tomorrow

- ▶ Exploit the untapped flexibility of small/medium prosumers, through a **novel, secure DR Management Platform**
- ▶ Ease Aggregator's computational effort through a **distributed intelligence** Architecture
- ▶ Engage prosumers in both explicit and implicit DR through a **social collaboration and incentivization platform** and personalized interfaces
- ▶ Achieve end-to-end interoperability through using/extending **open source protocols** (e.g. OpenADR)
- ▶ Propose new **business models** and **recommendations for policy makers** to accelerate market adoption



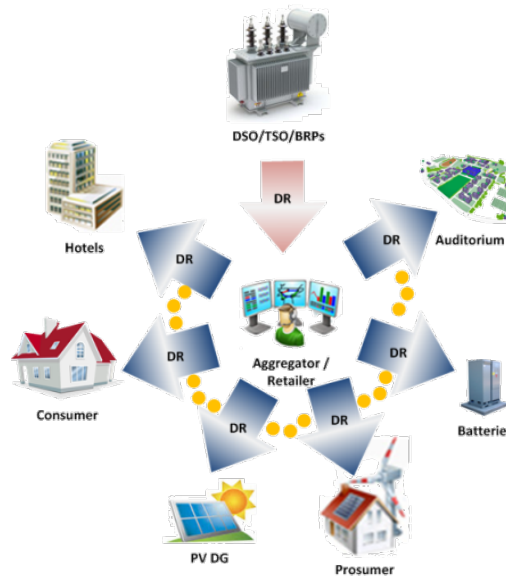
DELTA Vision & Concept

A new energy distribution structure (II)

Objectives

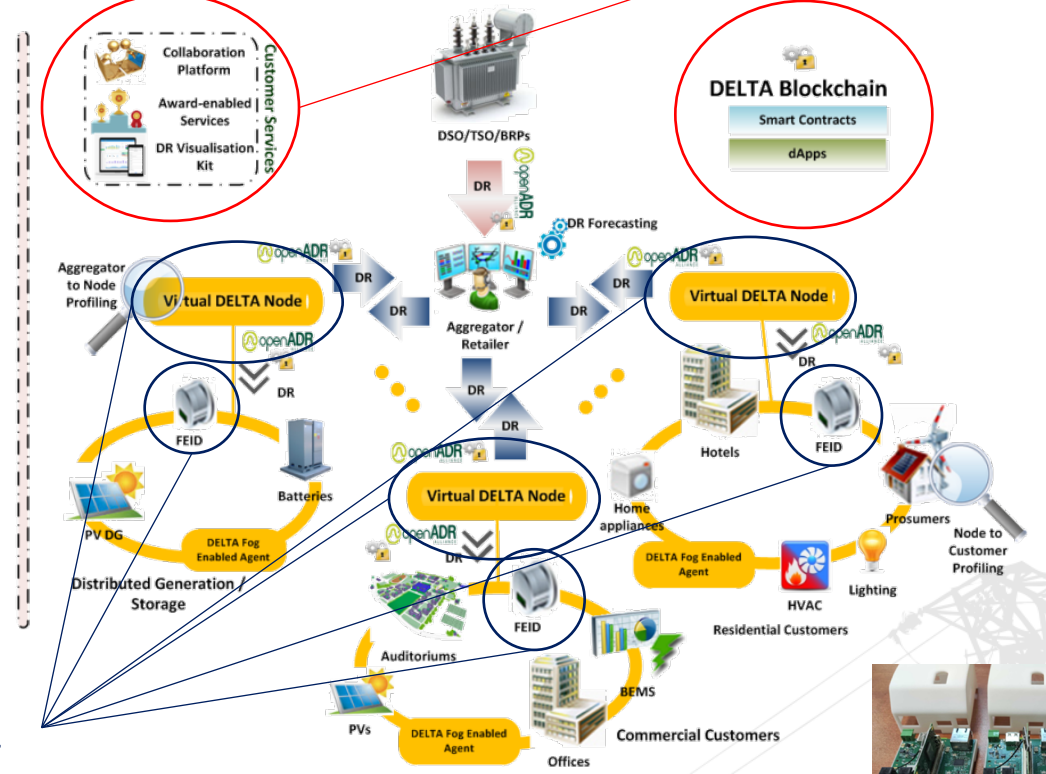
- Relieve Aggregators from resource-intensive tasks: **DELTA Virtual Node**
- Establish an automated, efficient DR management structure: **DELTA DR Management toolkit/ DELTA Fog-enabled Device**
- Simplify and fortify complex energy contractual agreements: **DELTA Blockchain**
- Enrich Aggregator's Portfolio by engaged Small/Medium prosumers: **DELTA Collaboration Platform and Award enabled services**

Current DR in the GRID



Key Innovations

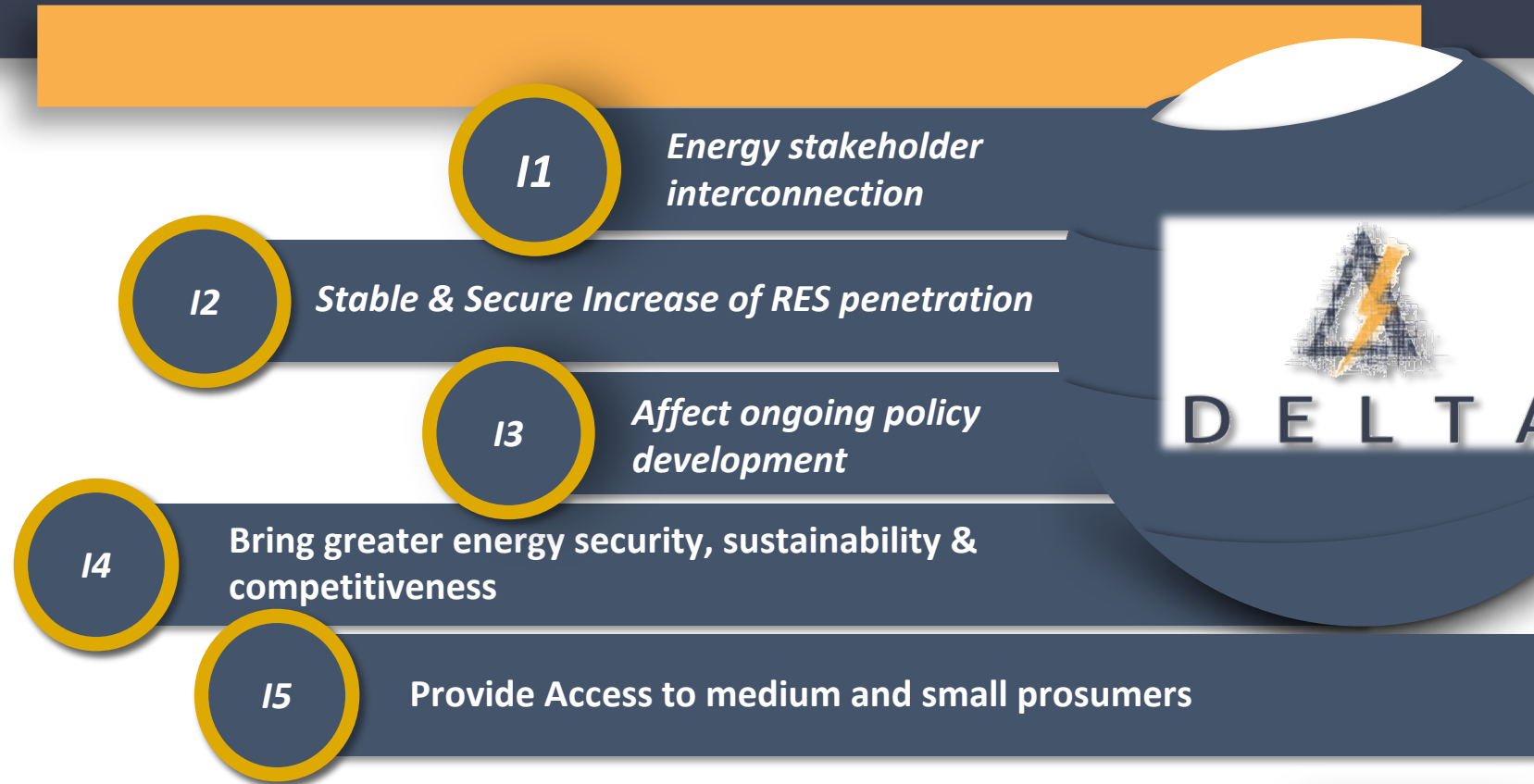
DELTA DR Framework



Key Enablers



DELTA Impact



Evaluation on 2 Major Pilot Sites & 1 Pre-Pilot Site

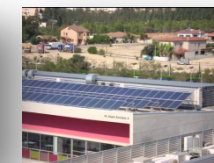


UK-P1



Greece PP

Cyprus-P2





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DELTA

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E.T.S. Ingenieros Informáticos, Universidad Politécnica de Madrid

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What is an ontology?

Definition

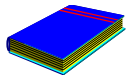
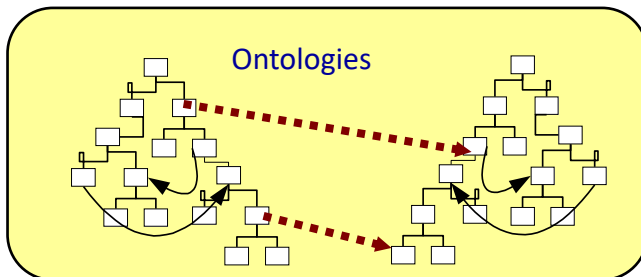
“An ontology is a formal, explicit specification of a shared conceptualization”

Machine-readable

**Concepts, properties
relations, functions,
constraints, axioms,
are explicitly defined**

**Consensual
Knowledge**

**Abstract model and
simplified view of some
phenomenon in the world
that we want to represent**



Studer, Benjamins, Fensel. Knowledge Engineering: Principles and Methods. *Data and Knowledge Engineering*. 25 (1998) 161-197

This slide has been taken from the “Introduction to ontologies” by Asunción Gómez-Perez



OpenADR ontology

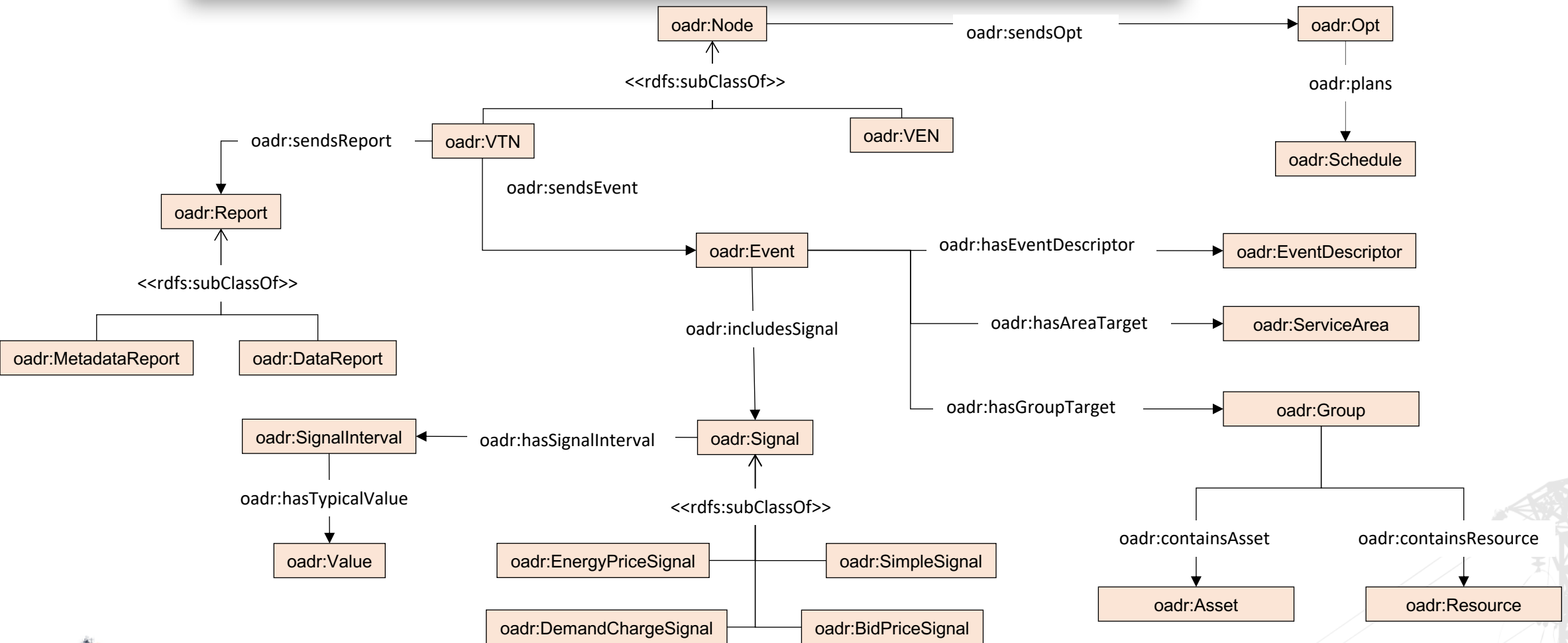
Goal in the H2020 DELTA project

- **To develop an ontology aligned with the OpenADR data model**
- Documentation:
 - OpenADR 2.0 Profile Specification B Profile
 - OpenADR 2.0 Demand Response Program Implementation Guide
- Analysed services:
 - EiEvent
 - EiOpt
 - EiReport
 - EiRegisterParty



OpenADR ontology

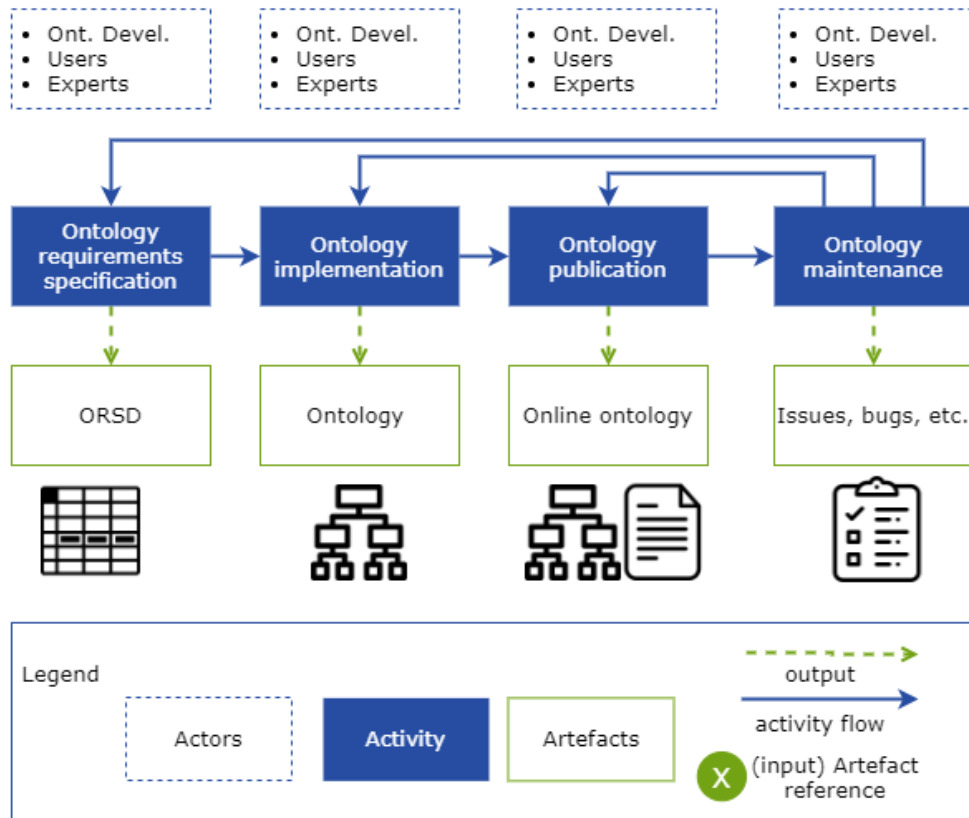
Overview



Ontology available in: <https://w3id.org/def/openadr>

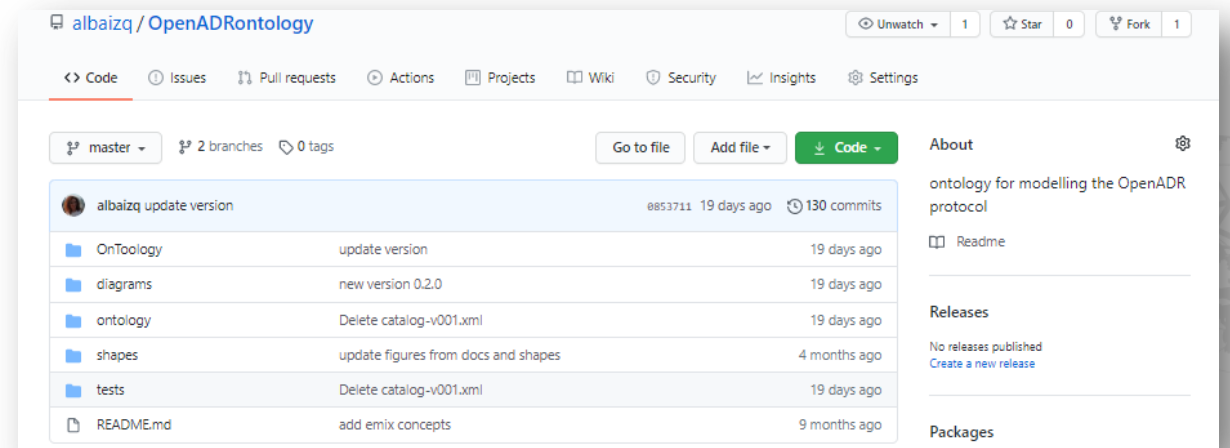
OpenADR ontology

Ontology development methodology



<http://lot.linkeddata.es/>

- The ontology is available in Github:
<https://github.com/albaizq/OpenADRontology>
- Anyone can contribute to the development of the ontology by adding issues:
<https://github.com/albaizq/OpenADRontology/issues>



OpenADR ontology benefits

Data validation

- Data validation with shapes

```
@prefix : <https://w3id.org/def/openadr#> .
@prefix sh: <http://www.w3.org/ns/shacl#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix owl: <http://www.w3.org/2002/07/owl#> .
@prefix xml: <http://www.w3.org/XML/1998/namespace> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .

<https://astrea.linkeddata.es/shapes#790eda9f1006c334de8cd96c41827613>
  a <http://www.w3.org/ns/shacl#NodeShape> ;
  rdfs:isDefinedBy "OpenADR 2.0 Demand Response Program Implementation Guide" ;
  rdfs:label "Virtual End Node (VEN)" ;
  sh:description "This is the OpenADR Virtual End Node that is used to interact with the VTN" ;
  sh:name "Virtual End Node (VEN)" ;
  sh:property [
    sh:path <https://w3id.org/def/openadr#receives> ;
    sh:minCount 1
  ] ;
  sh:targetClass <https://w3id.org/def/openadr#VEN> .
```

Shapes

:VEN1 a oadr:VEN .



:VEN a oadr:VEN
oadr:receives :Event;



Data



DELTA

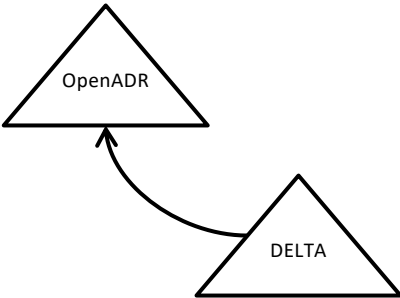
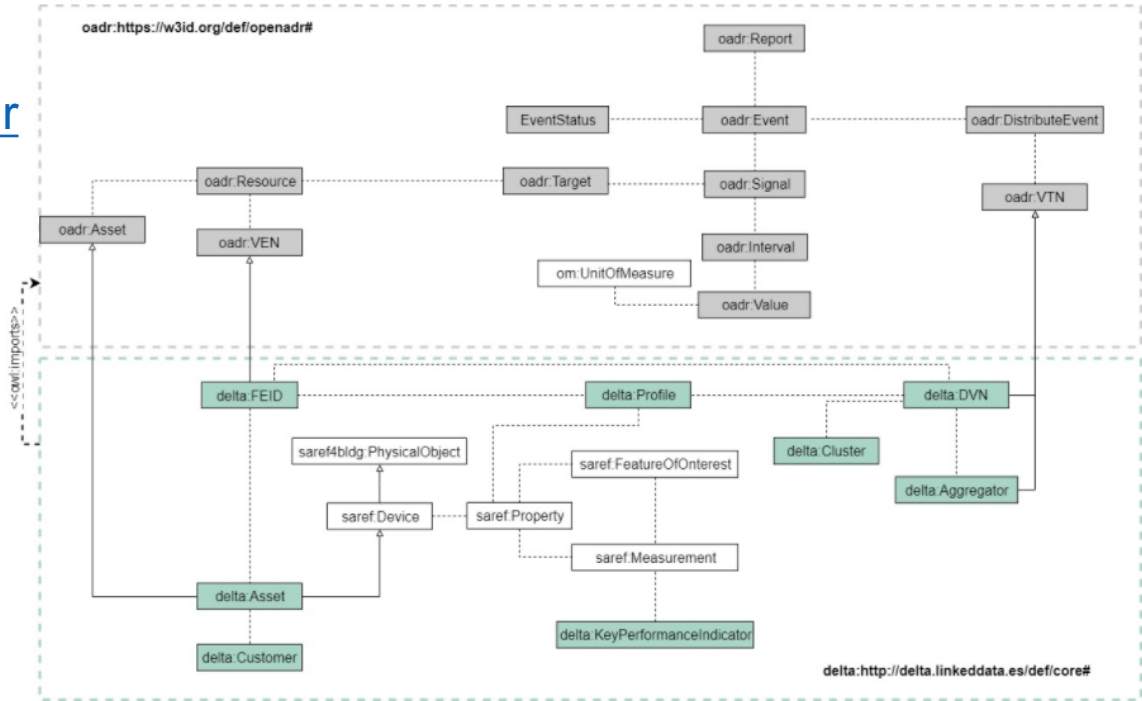
OpenADR SHACL shapes available in: <http://delta.iot.linkeddata.es/interfaces-oadr.html>

OpenADR ontology benefits

OpenADR ontology in the DELTA project

Ontology	Description	Repository	Issue tracker	Requirements	Releases	Payloads
DELTA ontology	This ontology aims to model the the architecture of the DELTA project	delta-ontology	ontology issues	ontology requirements	ontology releases	delta-payloads
OpenADR ontology	This ontology aims to model the OpenADR protocol	openadr-ontology	ontology issues	ontology requirements	ontology releases	openadr-payloads

<https://w3id.org/def/openadr>



<http://delta.iot.linkeddata.es/>

OpenADR ontology benefits

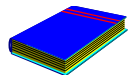
Semantic interoperability definition

“**Interoperability** is the ability of two or more systems or components to exchange information and to use the information that has been exchanged”

“**Semantic Interoperability** means that there is a common understanding between people of the meaning of the content (information) being exchanged”

Thanks to the CIM

Thanks to an ontology



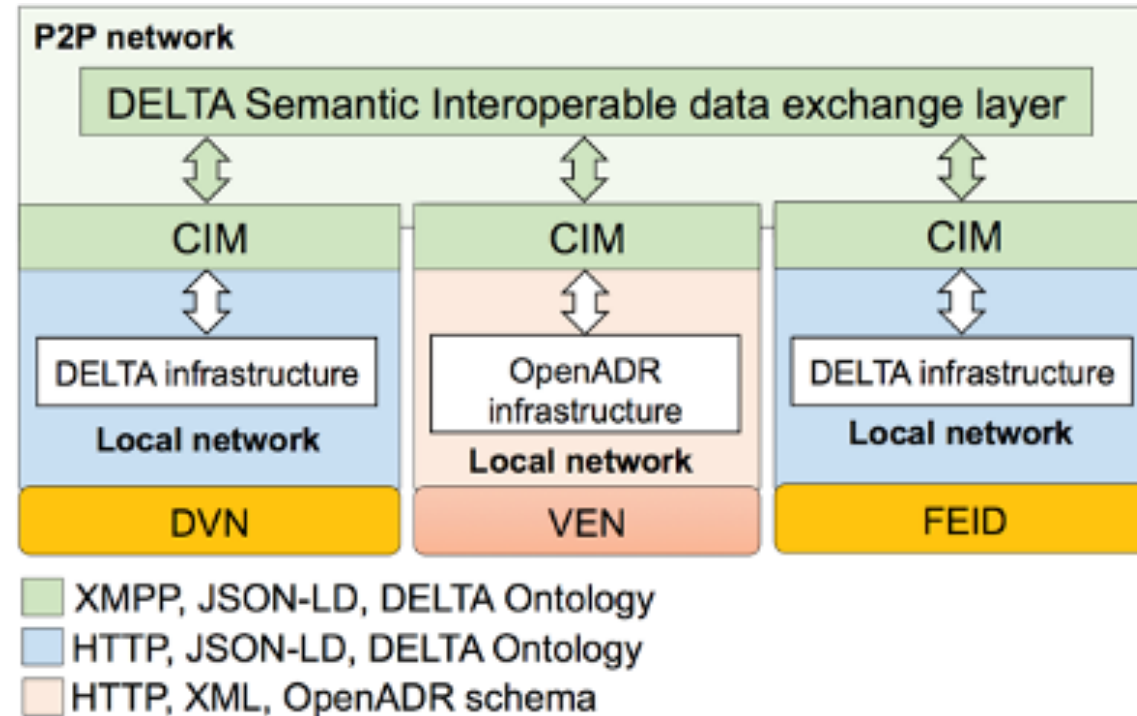
IEEE Standards Coordinating Committee.: IEEE standard glossary of software engineering terminology (IEEE Std 610.12–1990). Los Alamitos, CA: IEEE Computer Society, 169 (1990)

H. van der Veer, A. Wiles: Achieving Technical Interoperability - the ETSI Approach. 3rd Ed., (2008)

OpenADR ontology benefits

Semantic interoperability support

- Development of the DELTA Common Information Model (CIM)



DELTA CIM code available here: <https://github.com/oeg-upm/DeltaCimApp> under Apache 2.0 License



Semantic interoperability

DELTA CIM interoperability modules

DELTA CIM

XMPP Configuration

Bridging

Access List

Knowledge Graph

Cloud Access

Validation

Users

Logout

Dashboard / Bridging

Bridging Service

Xmpp route patterns:

Local service:

Xmpp URI pattern:

Method:

Append relative route:

Interoperability module:

Local endpoint

../delta/juan/Interface regex

GET

Yes

None

OpenADR-oadrUpdate.module

test-stars.module

+

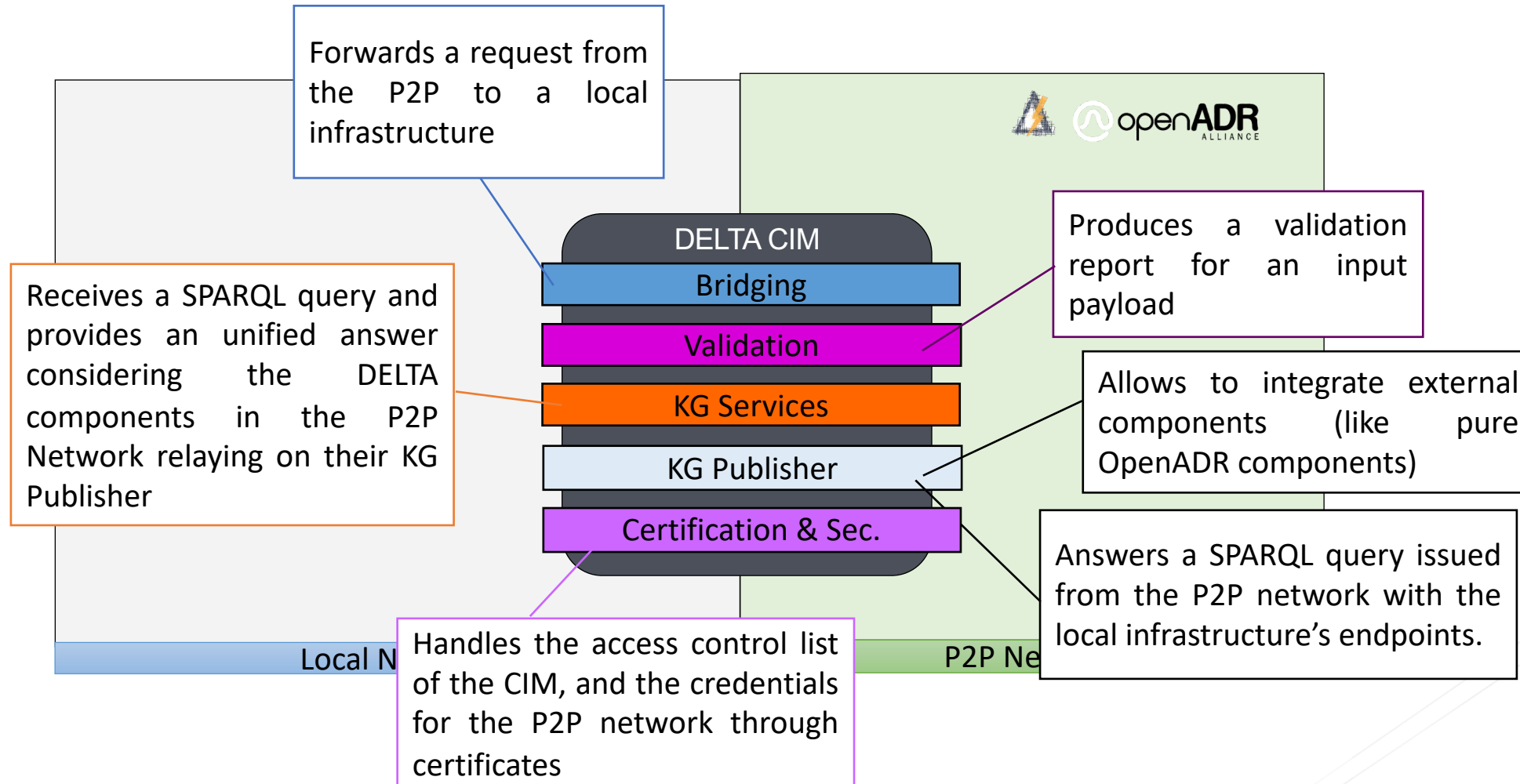
Local service	Xmpp URI pattern	Method	Append relative route	Interoperability module	
http://dbpedia.org/data/Madrid.jsonld	../delta/juan/madrid	GET	false		<div>Validate payload</div> <div></div>
http://localhost:7001	../delta/juan/test-post	POST	false		<div></div> <div></div>
http://localhost:7001	../delta/juan/test-put	PUT	false		<div></div> <div></div>
http://localhost:7001	../delta/juan/test-patch	PATCH	false		<div></div> <div></div>
http://localhost:7001	../delta/juan/test-delete	DELETE	false		<div></div> <div></div>
http://localhost:7001	../delta/juan/test-get	GET	false		<div>Validate payload</div> <div></div>

DELTA CIM code available: <https://github.com/oeg-upm/DeltaCimApp> under Apache 2.0 License



Semantic interoperability

DELTA CIM services



Results

Publications

- Fernández-Izquierdo, A., Cimmino, A., Patsonakis, C., Tsolakis, A. C., García-Castro, R., Ioannidis, D., & Tzovaras, D. (2020, September). **OpenADR Ontology: Semantic Enrichment of Demand Response Strategies in Smart Grids**. In *2020 International Conference on Smart Energy Systems and Technologies (SEST)* (pp. 1-6). IEEE.
- Cimmino, A., Andreadou, N., Fernández-Izquierdo, A., Patsonakis, C., Tsolakis, A. C., Lucas, A., ... & García-Castro, R. (2020, September). **Semantic Interoperability for DR Schemes Employing the SGAM Framework**. In *2020 International Conference on Smart Energy Systems and Technologies (SEST)* (pp. 1-6). IEEE.





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Thank you!

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