



# WoT Meetup



## WoT Digital Twin Ontology (WoTDT)

Ontology Engineering Group,  
Universidad Politécnica de Madrid

Salvador González-Gerpe, Andrea Cimmino,  
Raúl García-Castro



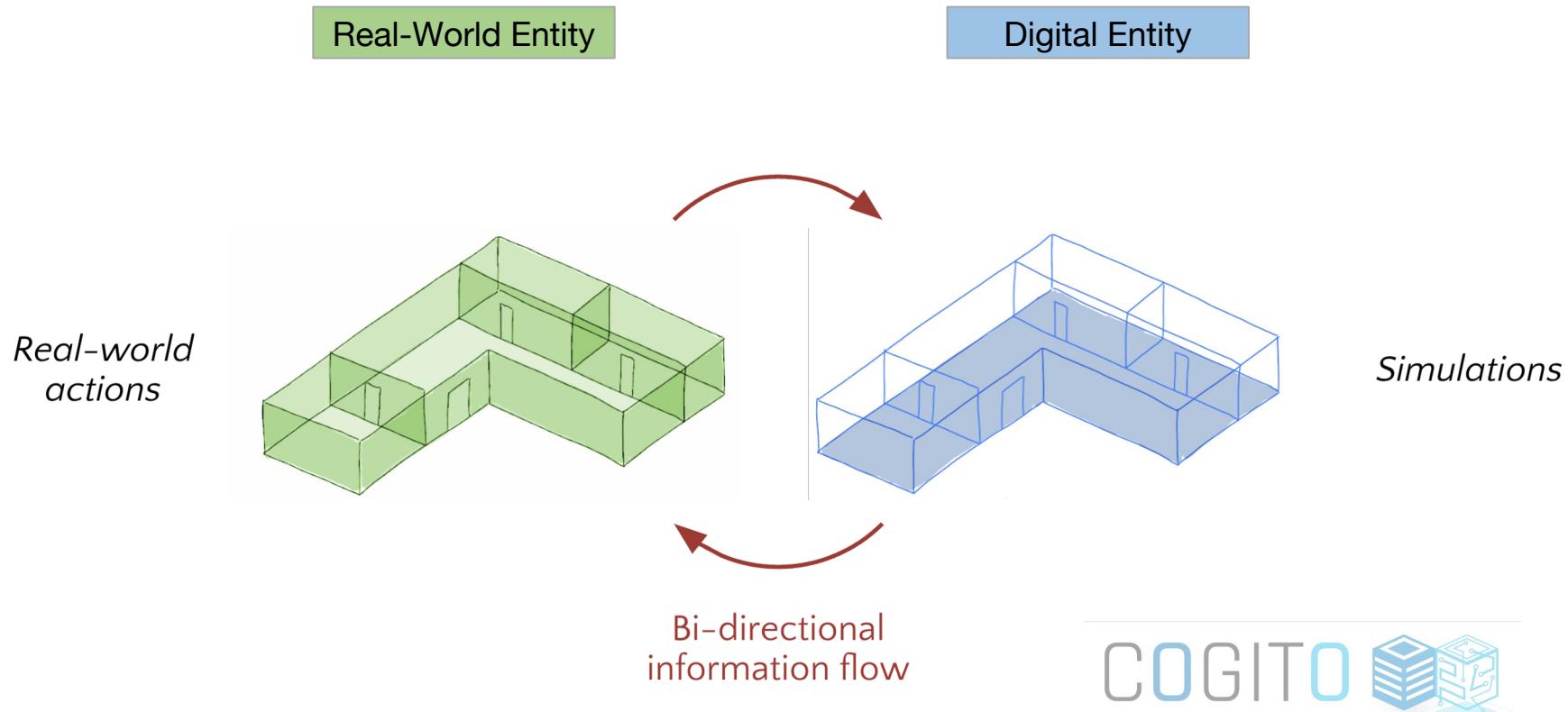
salvador.gonzalez.gerpe@upm.es



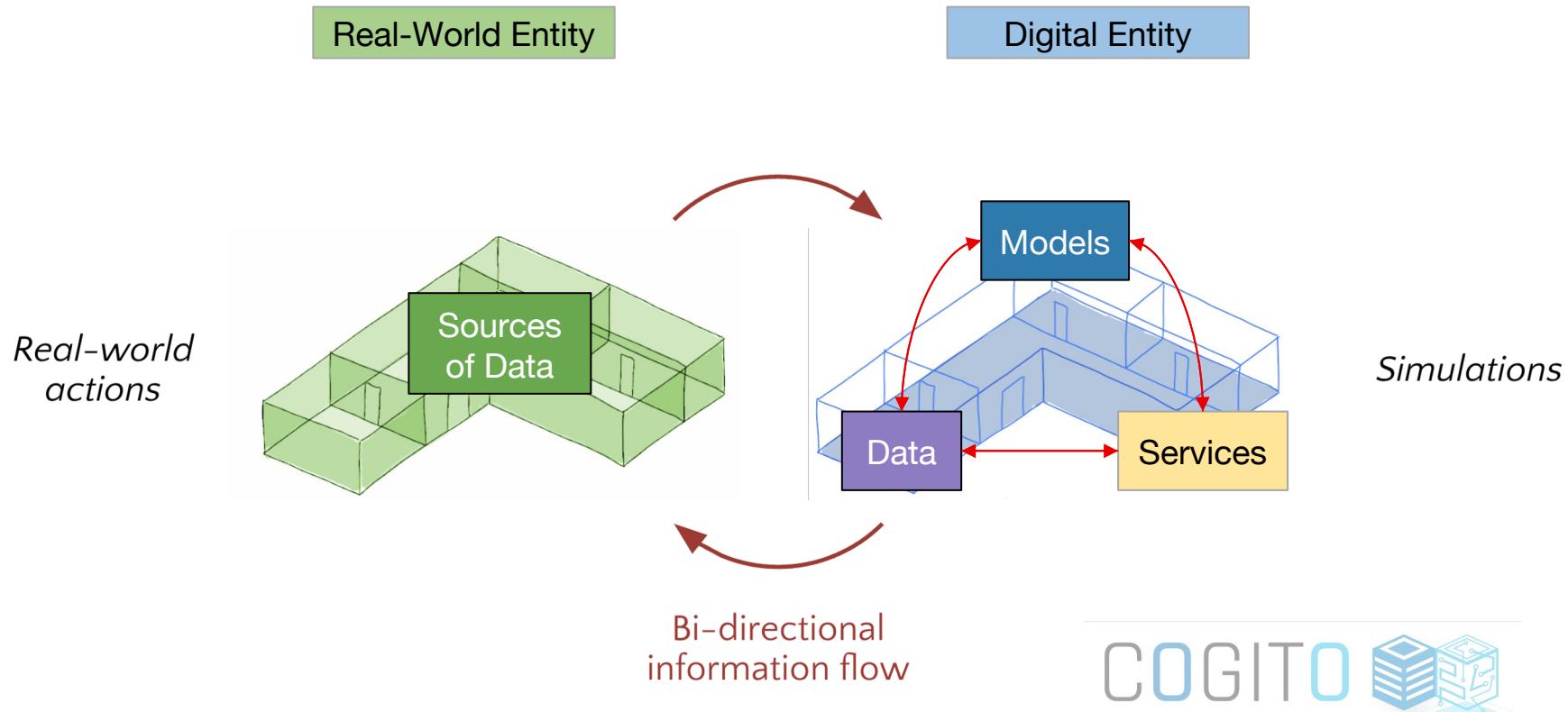
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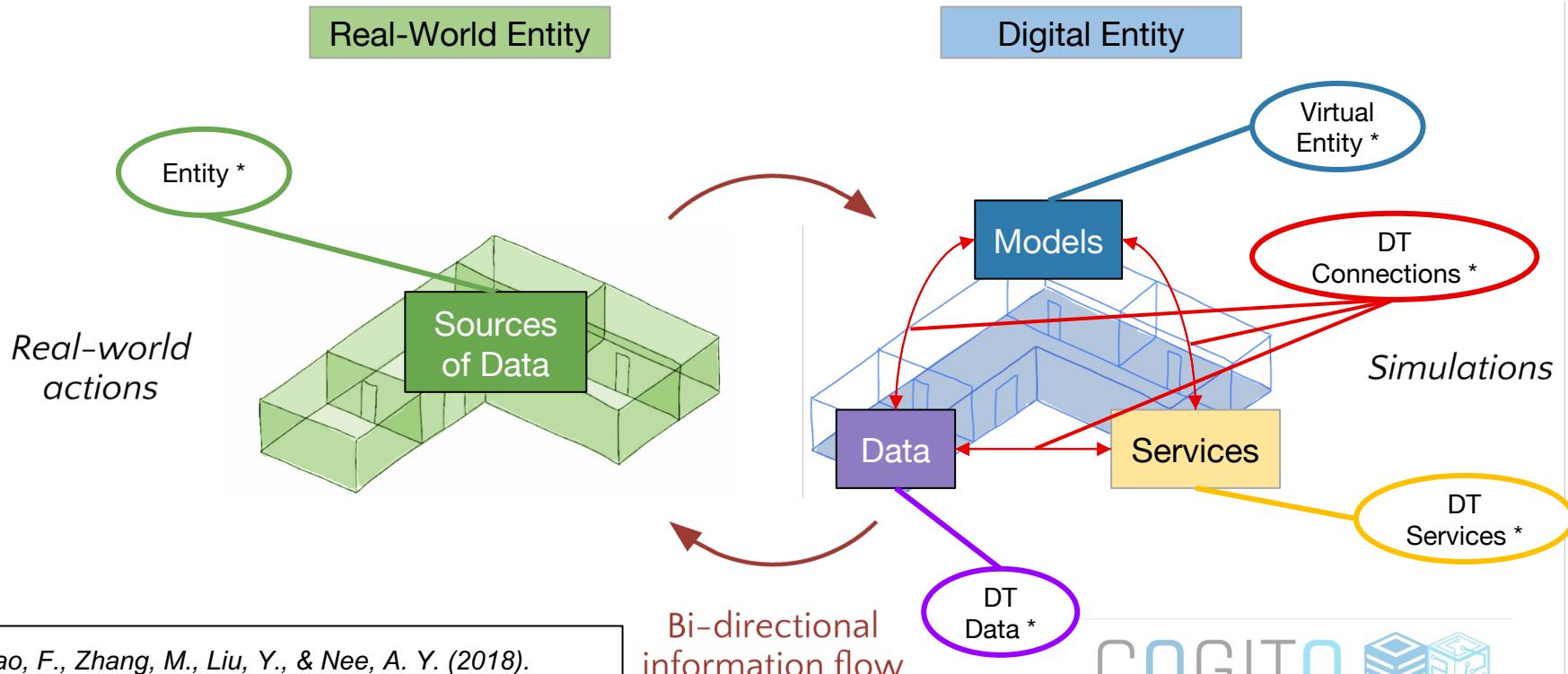
# What are Digital Twins?



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# Digital Twin five-dimensional architecture



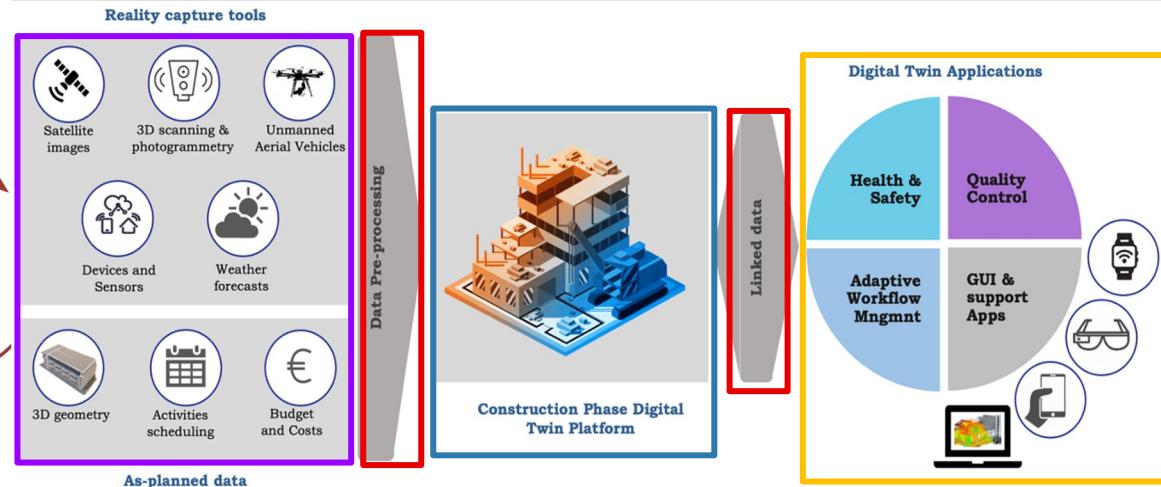
\* Tao, F., Zhang, M., Liu, Y., & Nee, A. Y. (2018).  
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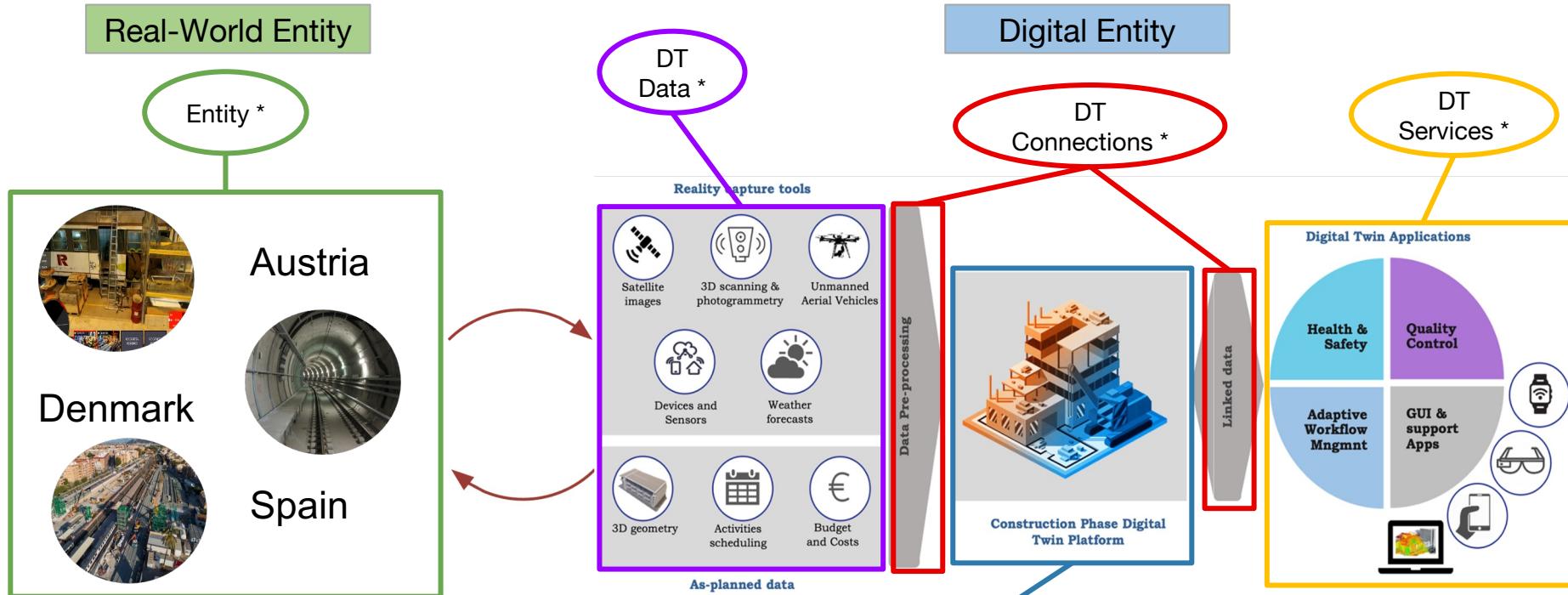


## Real-World Entity



## Digital Entity





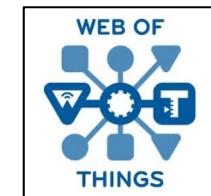
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**WoTDT ontology** has been developed in the COGITO project to **describe the 5 dimensions of a DTw** and its **features** extending **WoT**.

**WoTDT in DTws allows to:**

- **Conceptualise** the five-dimensional model architecture and its features
- **Describe** services of different dimensions
- **Discover** services across dimensions
- **Define** the **security** specification of each dimension
- Facilitates data **accessibility** of a specific dimension
- Promotes data **interoperability** in all dimensions
- Provide **direct access** to all DT functionalities

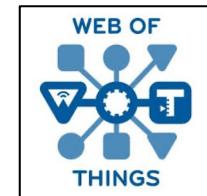


\* González-Gerpe, S., Cimmino, A., Bernardos, S., Poveda-Villalón, M., García-Castro, R. (2024). *WoTDT: an Extension of the WoT Thing Description Ontology for Digital Twins in the Construction Domain.* (publishing process)

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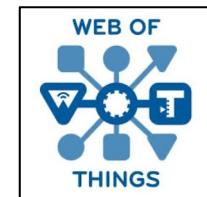
WoT TD

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WoT Discovery

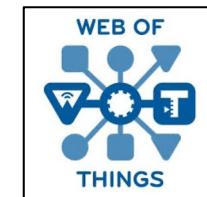
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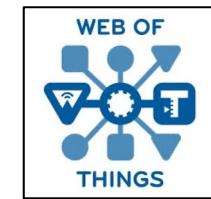
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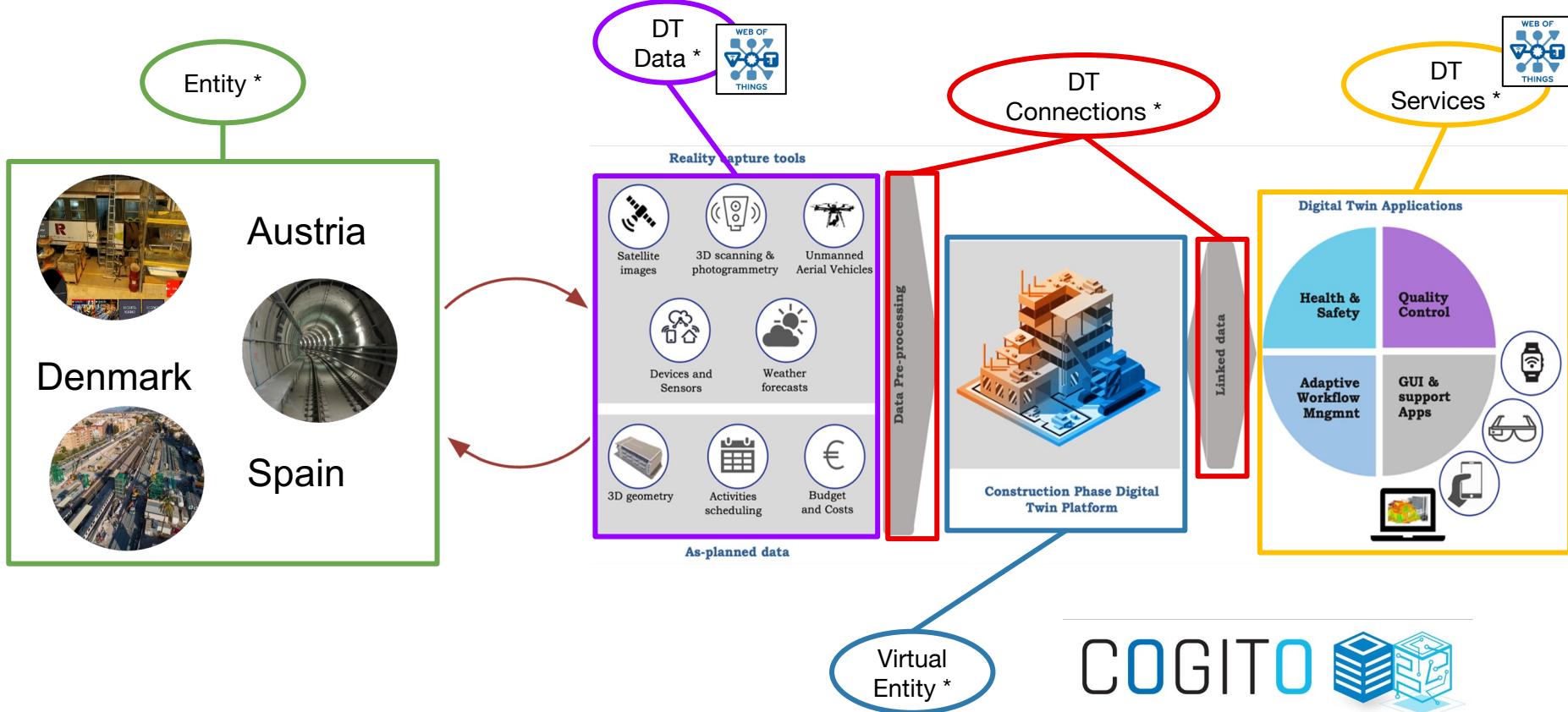


WoT Discovery

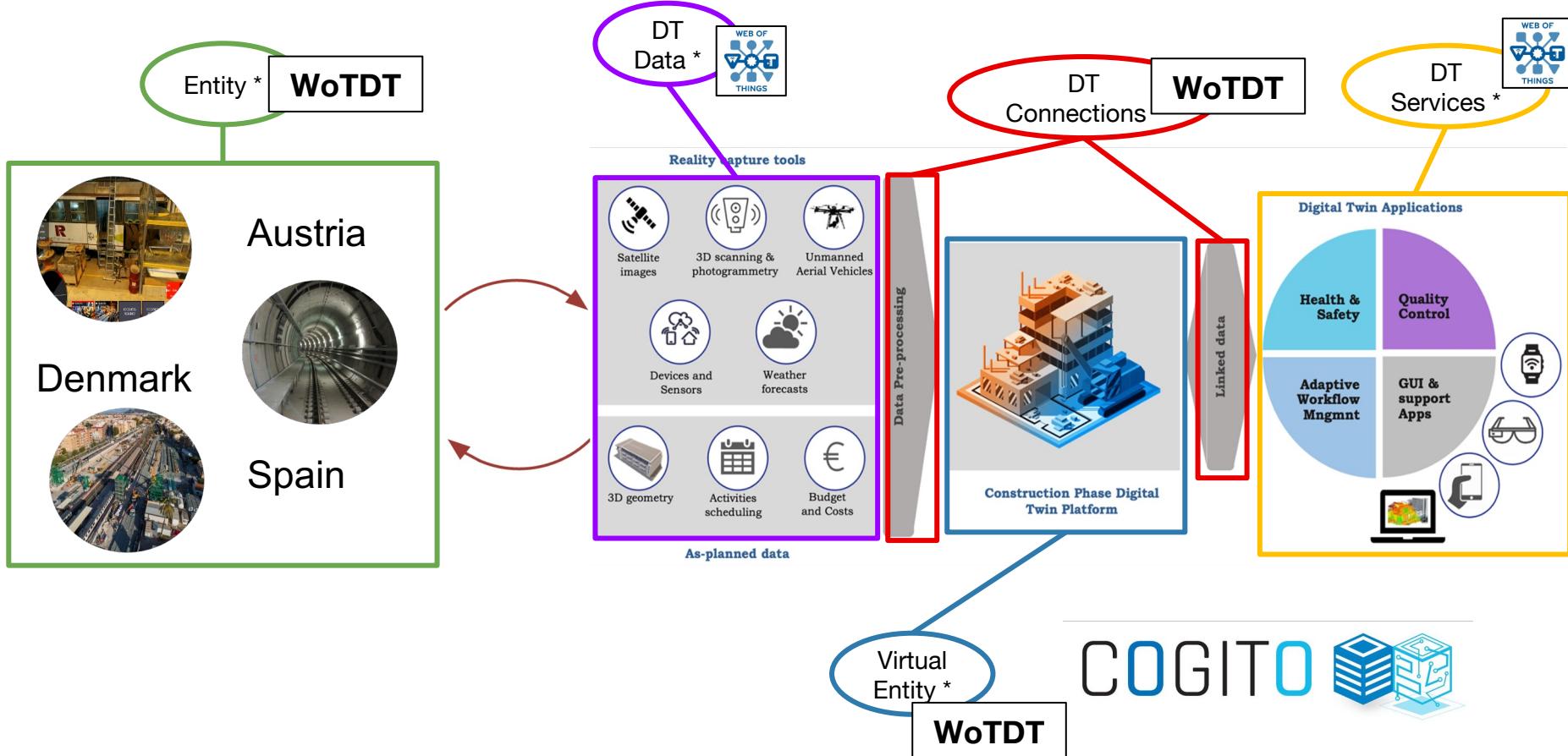
WoT TD

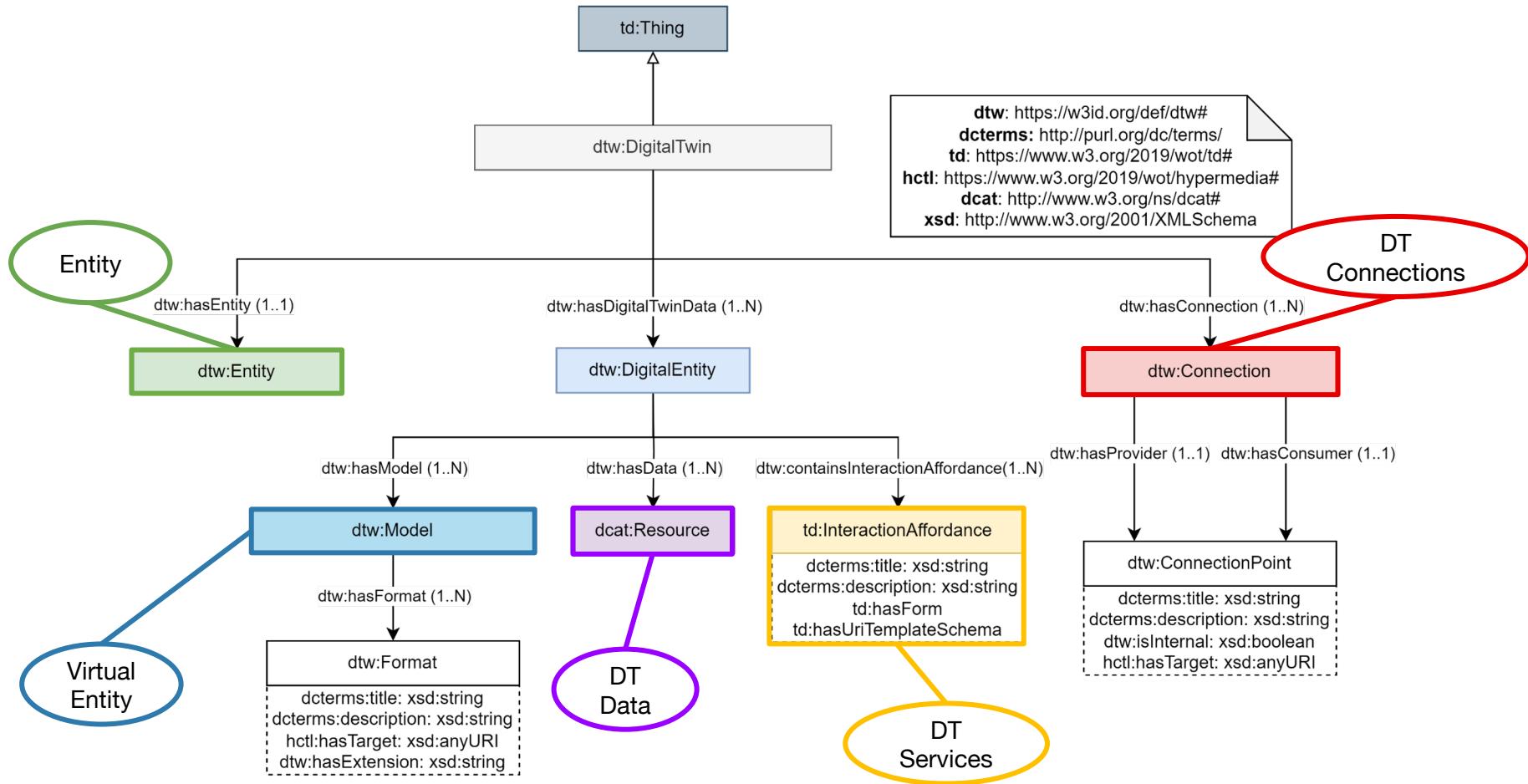
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# WoT Digital Twin Model

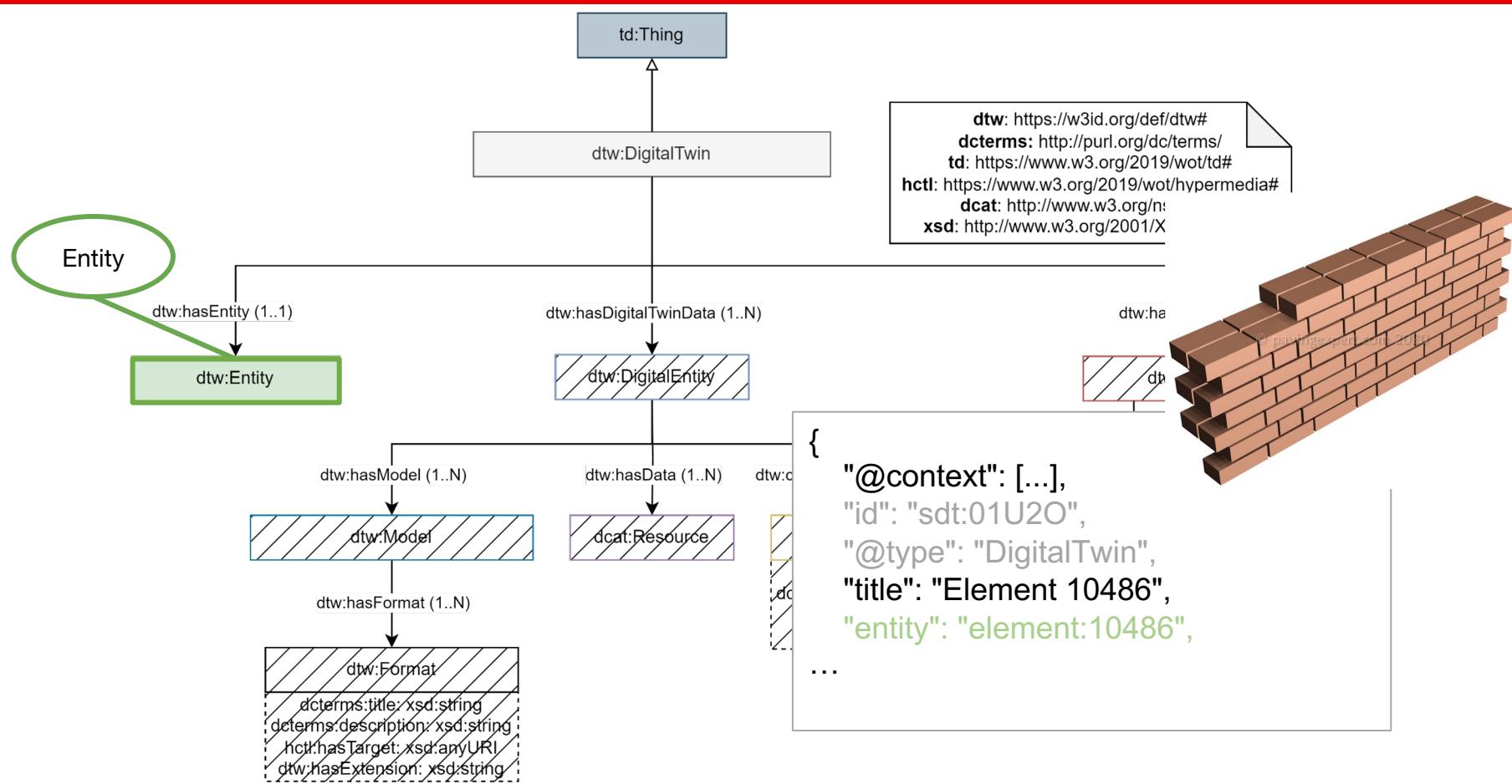


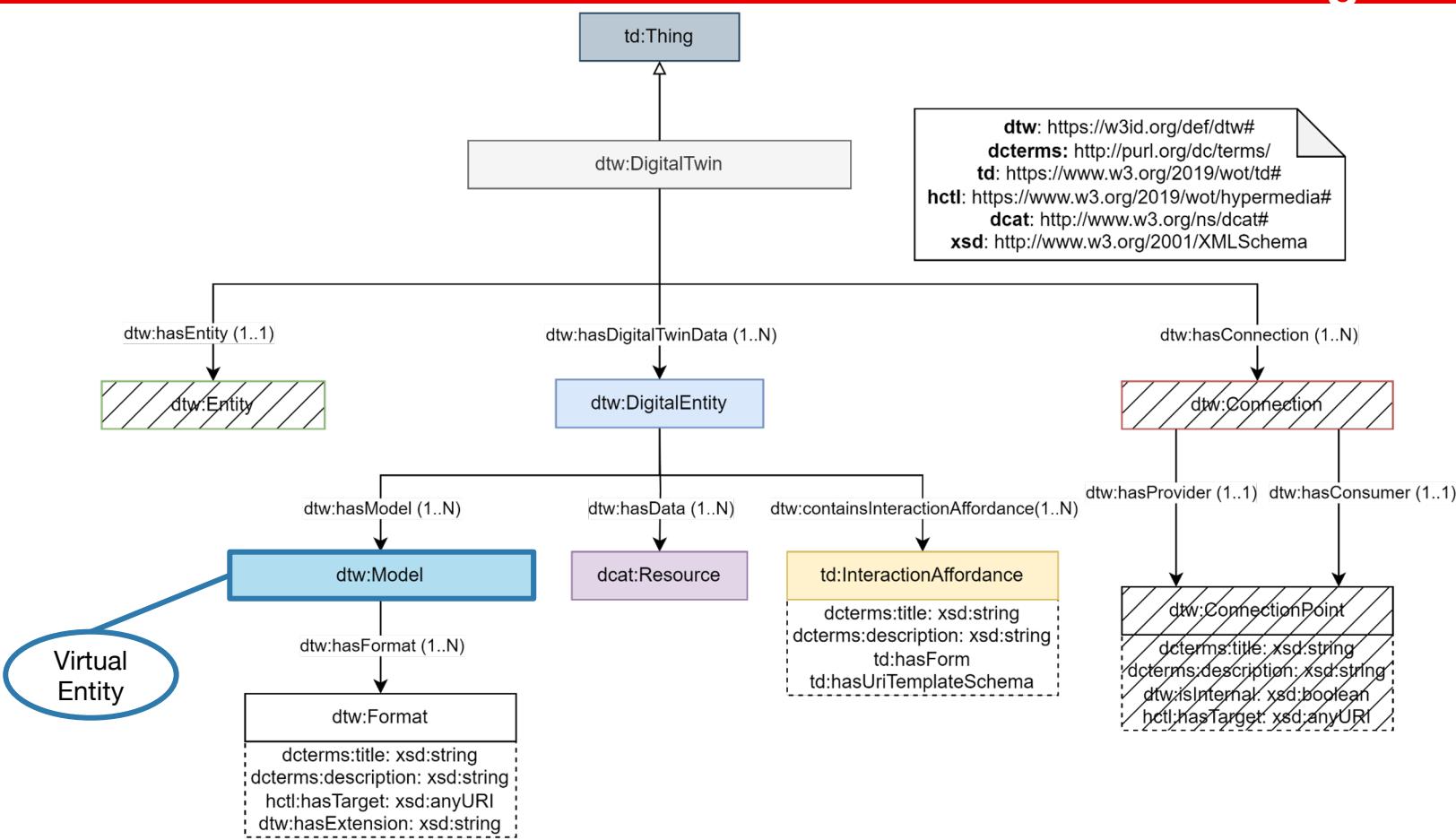
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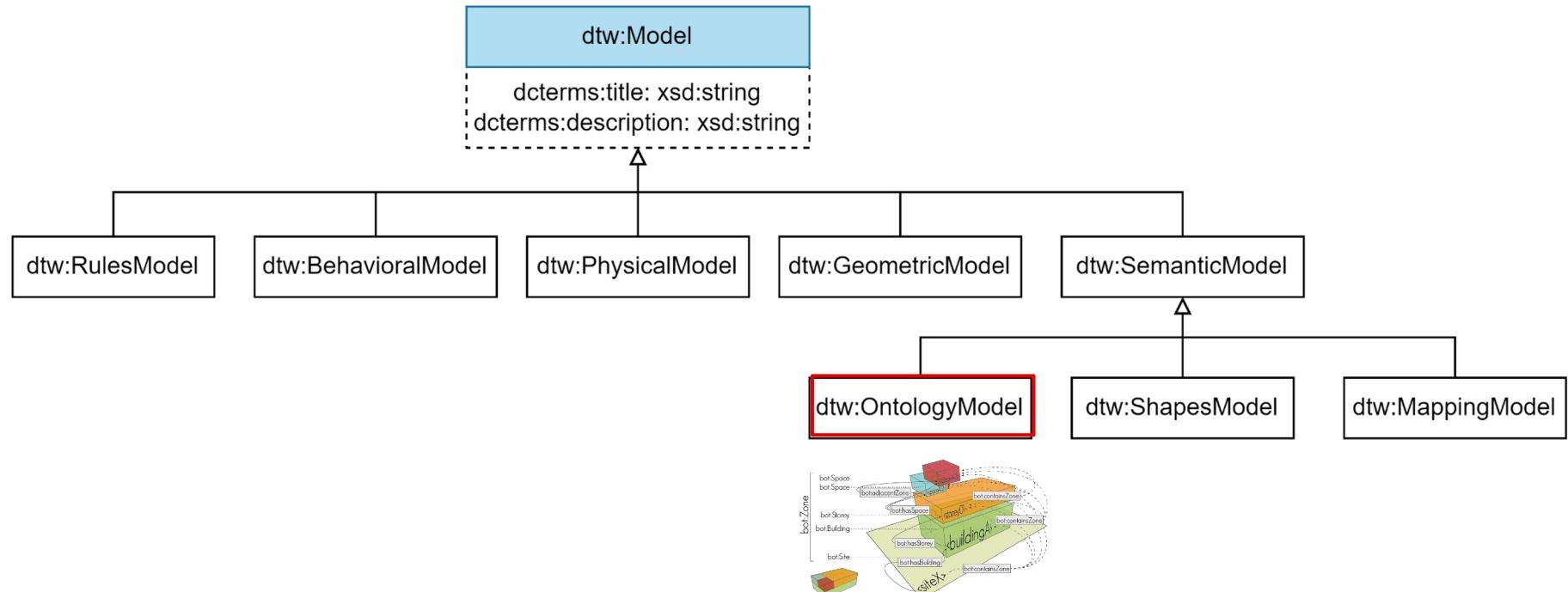




```
{  
  "@context": [  
    # Ontology URIs  
    "https://www.w3.org/2019/wot/td/v1",  
    "https://raw.githubusercontent.com/Salva5297/SemanticDT_TD/main/context/dt.td.context.jsonld",  
    "https://w3c.github.io/wot-discovery/context/discovery-core.jsonld",  
    # Namespaces for data  
    {  
      "element": "https://data.cogito.iot.linkeddata.es/resources/element/",  
      "sdt": "https://data.cogito.iot.linkeddata.es/resources/sdt/",  
      "dt_ve": "https://data.cogito.iot.linkeddata.es/resources/ve/",  
      "dt_dd": "https://data.cogito.iot.linkeddata.es/resources/dd/"  
    },  
  ],  
  ...  
}
```

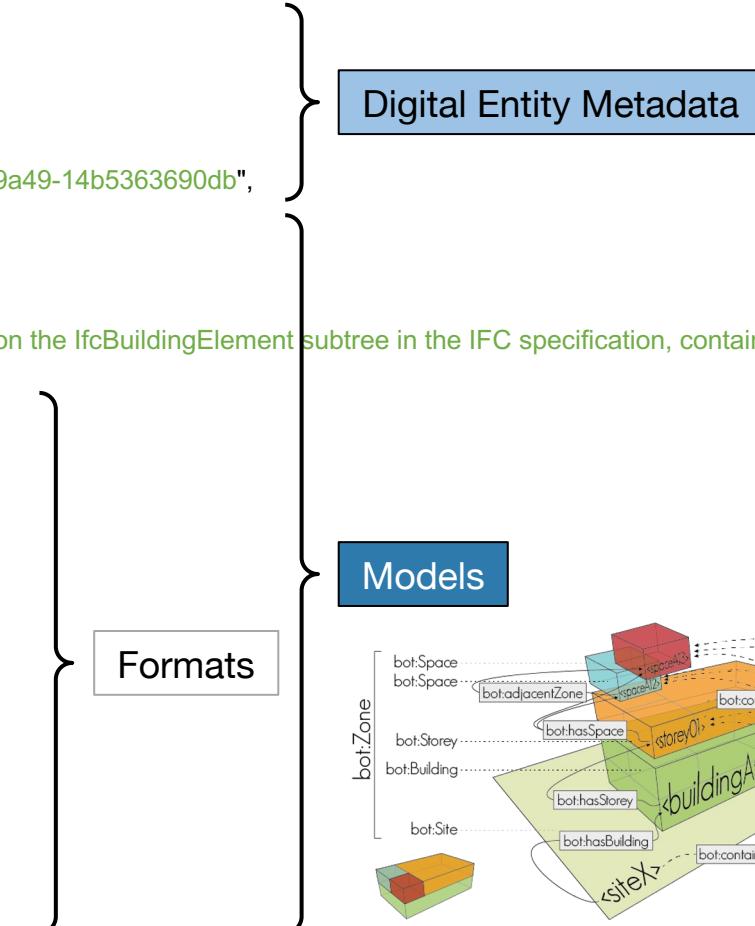


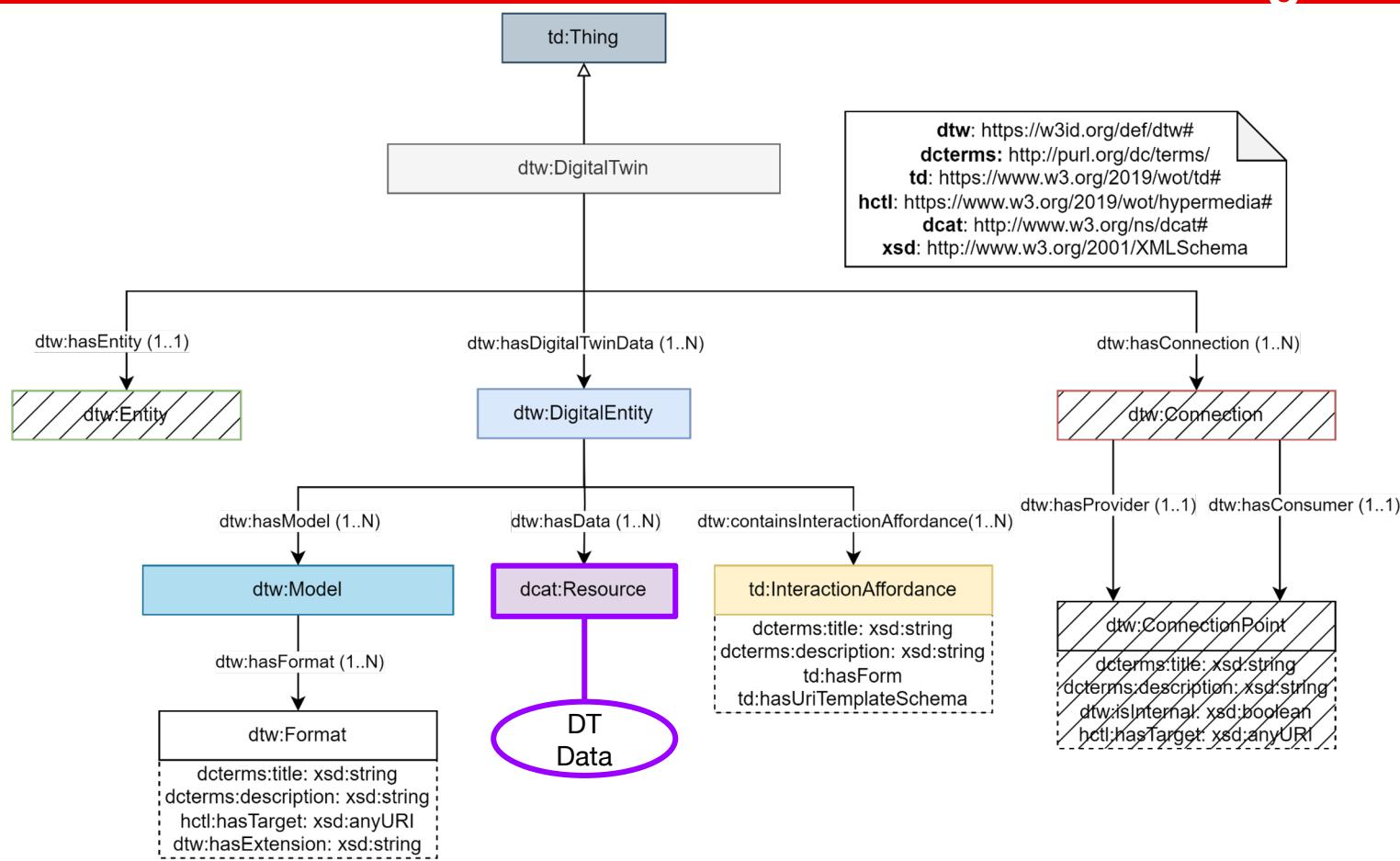




# DTw Thing Description Extension Digital Entity - Models

```
"digital_entity": [
  {
    "id": "dt_ve:7d6e5",
    "type": "Digital Entity",
    "title": "Digital Entity",
    "description": "Digital Entity of DTw 01U2O from project 308736f9-f533-4b4b-9a49-14b5363690db",
    "models": [
      {
        "type": "Ontology_Model",
        "title": "Building Element Ontology",
        "description": "The Building Element Ontology provides an ontology based on the IfcBuildingElement subtree in the IFC specification, containing a taxonomy of classes that allow to define common building elements.",
        "formats": [
          {
            "id": "format:fea24",
            "type": "Format",
            "title": "JSON-LD",
            "description": "JSON-LD format.",
            "href": "https://pi.pauwel.be/voc/buildingelement/ontology.json",
            "extension": "json"
          },
          {
            "id": "format:ca7ea",
            "type": "Format",
            "title": "RDF/XML",
            "description": "RDF/XML Format.",
            "href": "https://pi.pauwel.be/voc/buildingelement/ontology.xml",
            "extension": "xml"
          }
        ]
      }
    ]
  }
]
```





# DTw Thing Description Extension Digital Entity - Data

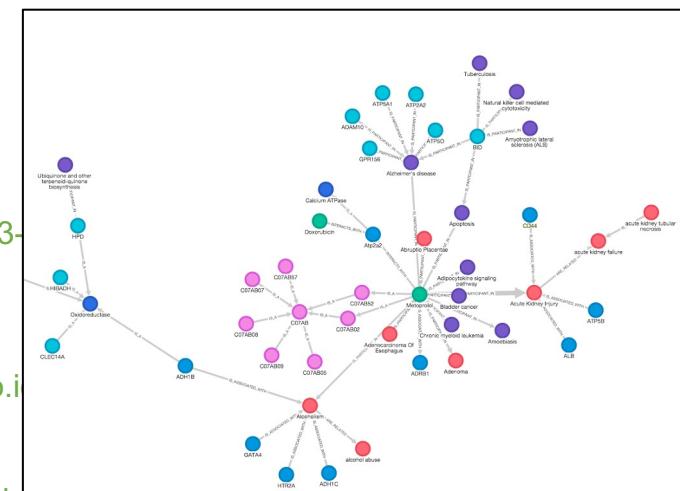
The figure displays a JSON-LD representation of a dataset and its corresponding knowledge graph visualization.

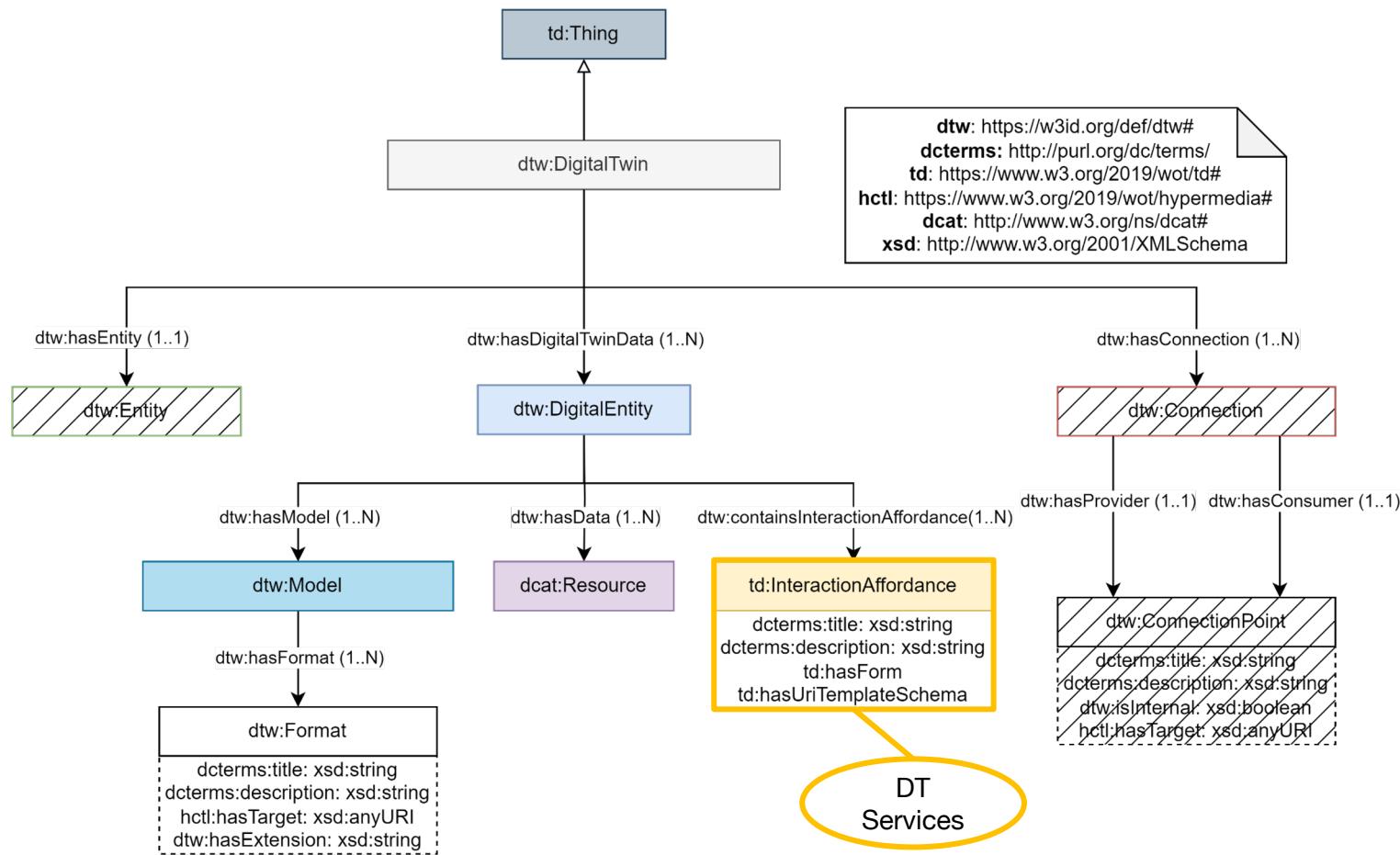
**JSON-LD Data:**

```
graph TD; data["data"] --> dcatResource["dcat:Resource"]; data["data"] --> distribution["distribution:abae0"]; distribution["distribution:abae0"] --> accessURL["dcat:accessURL"]; distribution["distribution:abae0"] --> mediaType["dcat:mediaType"]; distribution["distribution:abae0"] --> downloadURL["dcat:downloadURL"]; distribution["distribution:abae0"] --> dataService["data_service:f1526"]; dataService["data_service:f1526"] --> endpointURL["dcat:endpointURL"]; dataService["data_service:f1526"] --> endpointDescription["dcat:endpointDescription"];
```

**Knowledge Graph Visualization:**

The graph illustrates the interconnected nature of the dataset, showing how different diseases, genes, and other biological entities are related through various mechanisms.



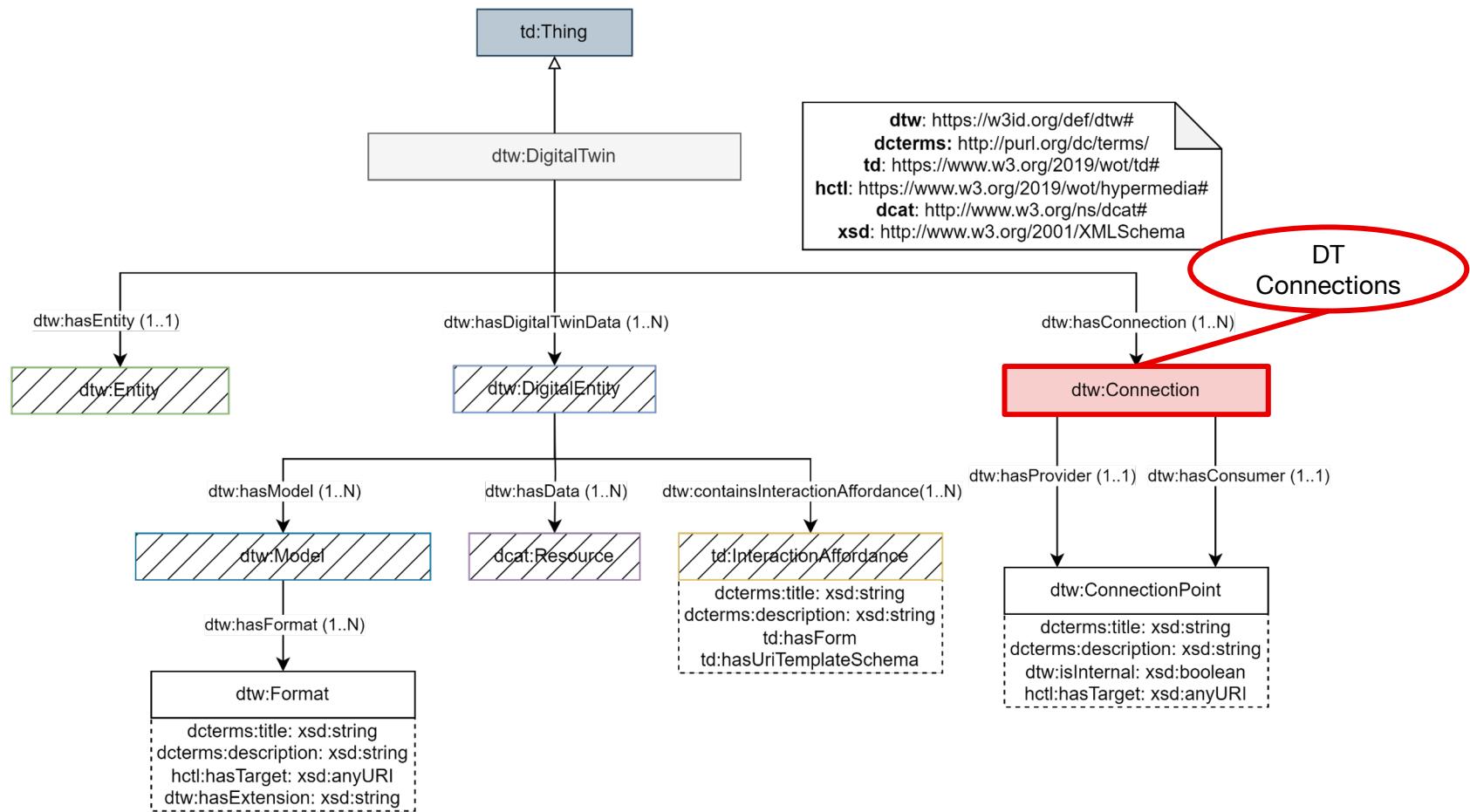




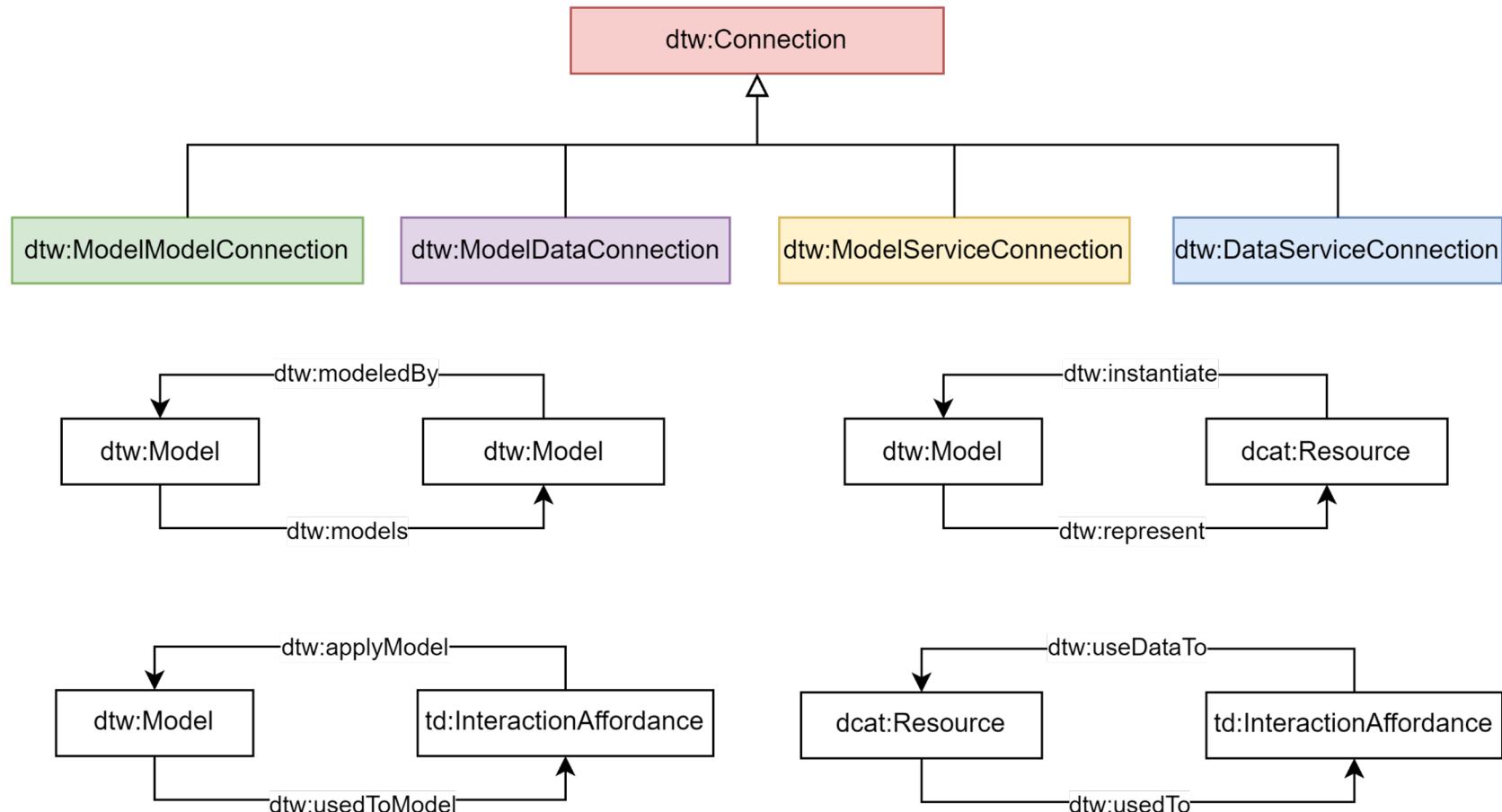
# DTw Thing Description Extension Digital Entity - Services

```
"services": [  
    "properties": { ← td:InteractionAffordance  
        "validate_rdf": {  
            "forms": [  
                {"href": "https://data.cogito.iot.linkeddata.es/validation/api/validate_rdf/data",  
                "type": "text/turtle"  
            ]  
        }  
    },  
    "actions": { ←  
        "register_shacl_model": {  
            "forms": [  
                {"href": "https://data.cogito.iot.linkeddata.es/validation/api/rdf_shacl/mapping",  
                "type": "application/octet-stream"  
            ]  
        }  
    },  
    "events": {} ←  
},  
...  
]
```

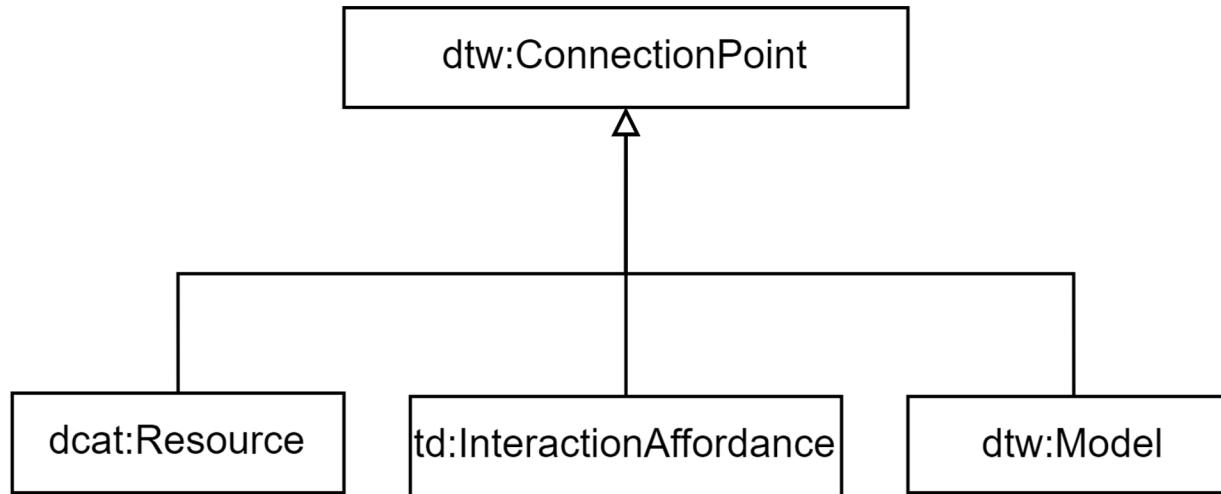




# Type of Connections



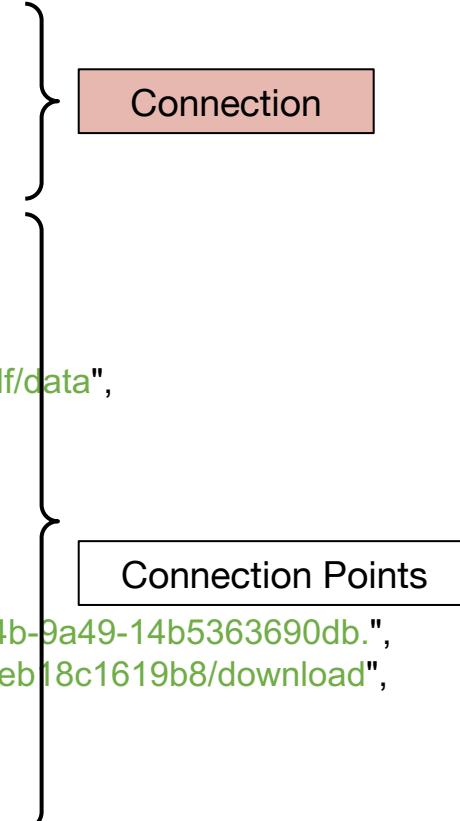
# Type of Connection Points





# DTw Thing Description Extension Connections

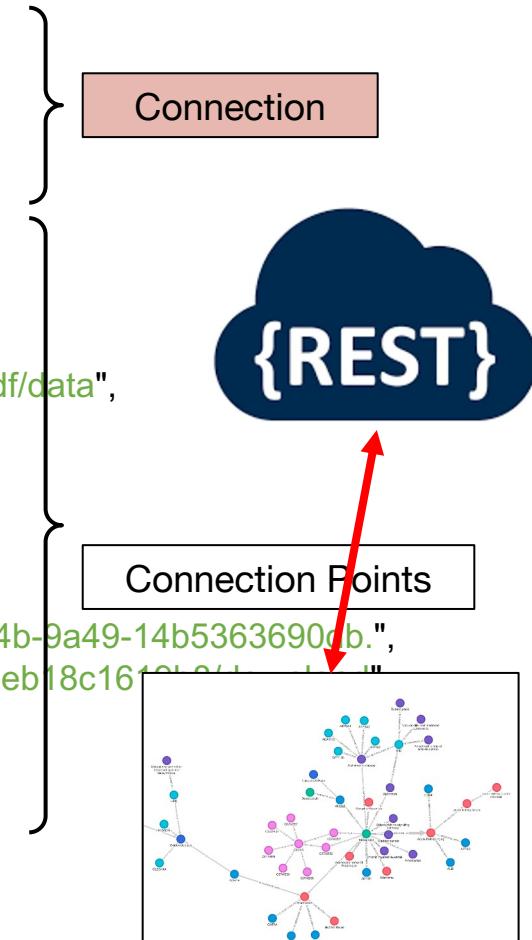
```
"connections": [  
    "dt_cn:190d0": {  
        "type": "Data_Service",  
        "title": "Materialization connection.",  
        "consumer": {  
            "type": "DTw_Service",  
            "title": "Helio",  
            "description": "Materialization service used to generate RDF data.",  
            "href": "https://data.cogito.iot.linkeddata.es/validation/api/project_to_rdf/data",  
            "internal": "true"  
        },  
        "provider": {  
            "type": "dcat:Dataset",  
            "title": "IFC File",  
            "description": "IFC File of SDT 01U2O from project 308736f9-f533-4b4b-9a49-14b5363690db.",  
            "href": "https://dtp.cogito-project.com/file/508bfae6-dada-46d1-8d40-beb18c1619b8/download",  
            "internal": "false"  
        }  
    },  
    ...  
],
```





# DTw Thing Description Extension Connections

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"connections": [  
    "dt_cn:190d0" : {  
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            "internal": "true"  
        },  
        "provider": {  
            "type": "dcat:Dataset",  
            "title": "IFC File",  
            "description": "IFC File of SDT 01U2O from project 308736f9-f533-4b4b-9a49-14b5363690cb.",  
            "href": "https://dtp.cogito-project.com/file/508bfae6-dada-46d1-8d40-beb18c161019/IFC%20File.dcat",  
            "internal": "false"  
        }  
    },  
    ...  
],  
...
```



The usage of WoT in COGITO has been a challenge due to:

- o The lack of conceptualization to represent DT dimensions.
- o The lack of conceptualization to represent some DT dimension features.
- o The lack of representation of the connections between DT dimensions and dimension features

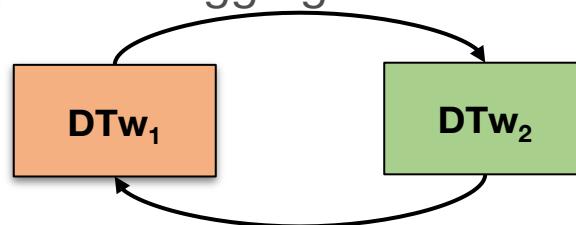
**WoTDT ontology** is developed as an **extension of TD ontology** to describe the **five-dimensional architecture** approach of **DTws**.

Thanks to **WoT**, this ontology enables a more **precise comprehension** of the DTws and provides **direct access** to all the **system functionalities**.

Despite being initially designed for the construction domain, the ontology is **flexible enough** to incorporate new classes and subclasses to the different dimensions, to **cover other domains**.

## Aggregation of DTws to create an ecosystem of DTws

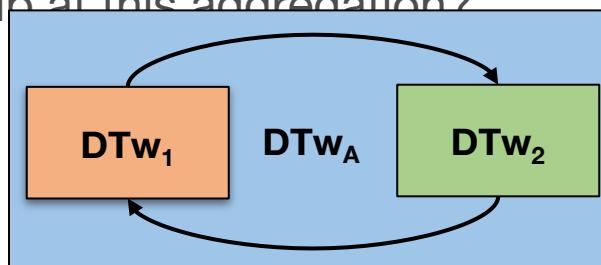
- o An **aggregation of DTws** consists on **combine two DTws** in order to **provide benefits** of one DTw to the other one linked.
- o An **ecosystem of DTws** can be created within the **combination of different DTws** in order to generate a **DTw composed of multiple DTws**.
- o How two **DTws** can be **combined**?
- o How WoT can help at this aggregation?



ANY IDEAS?

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# Many Thanks!

**Salvador González-Gerpe, Andrea Cimmino and Raúl García-Castro**

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