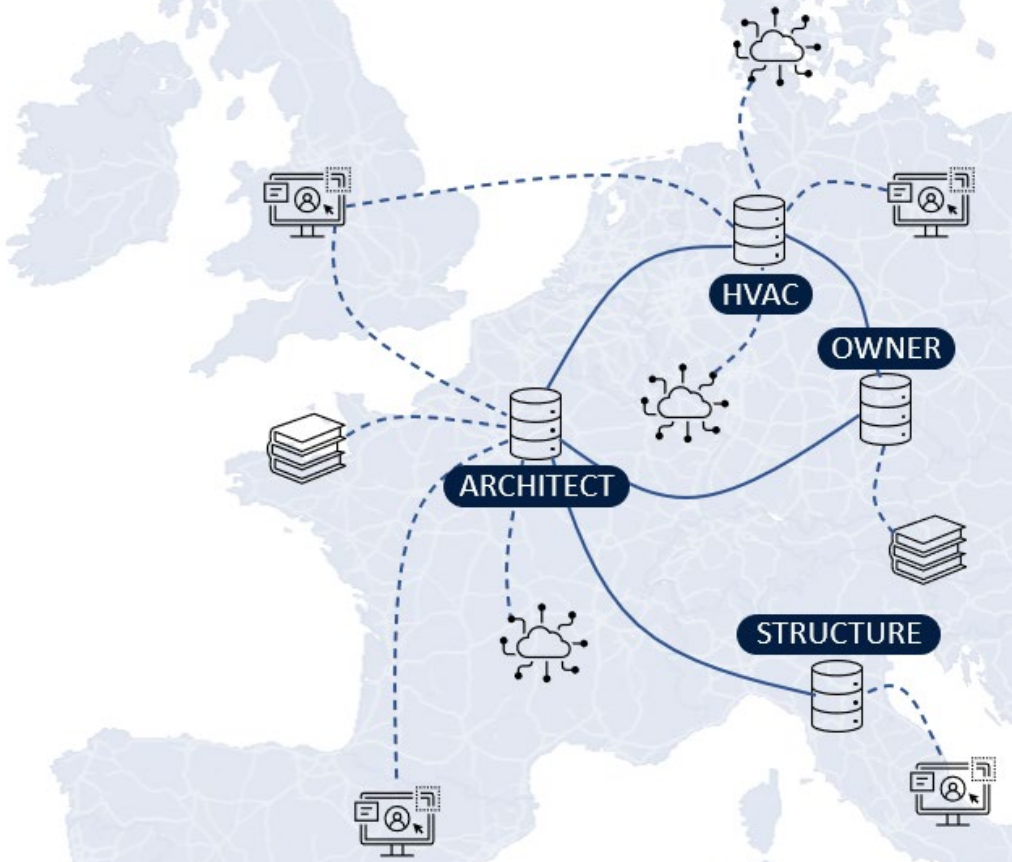
Mapping Federated AEC Projects to Industry Standards using Virtual Views



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INTRODUCTION

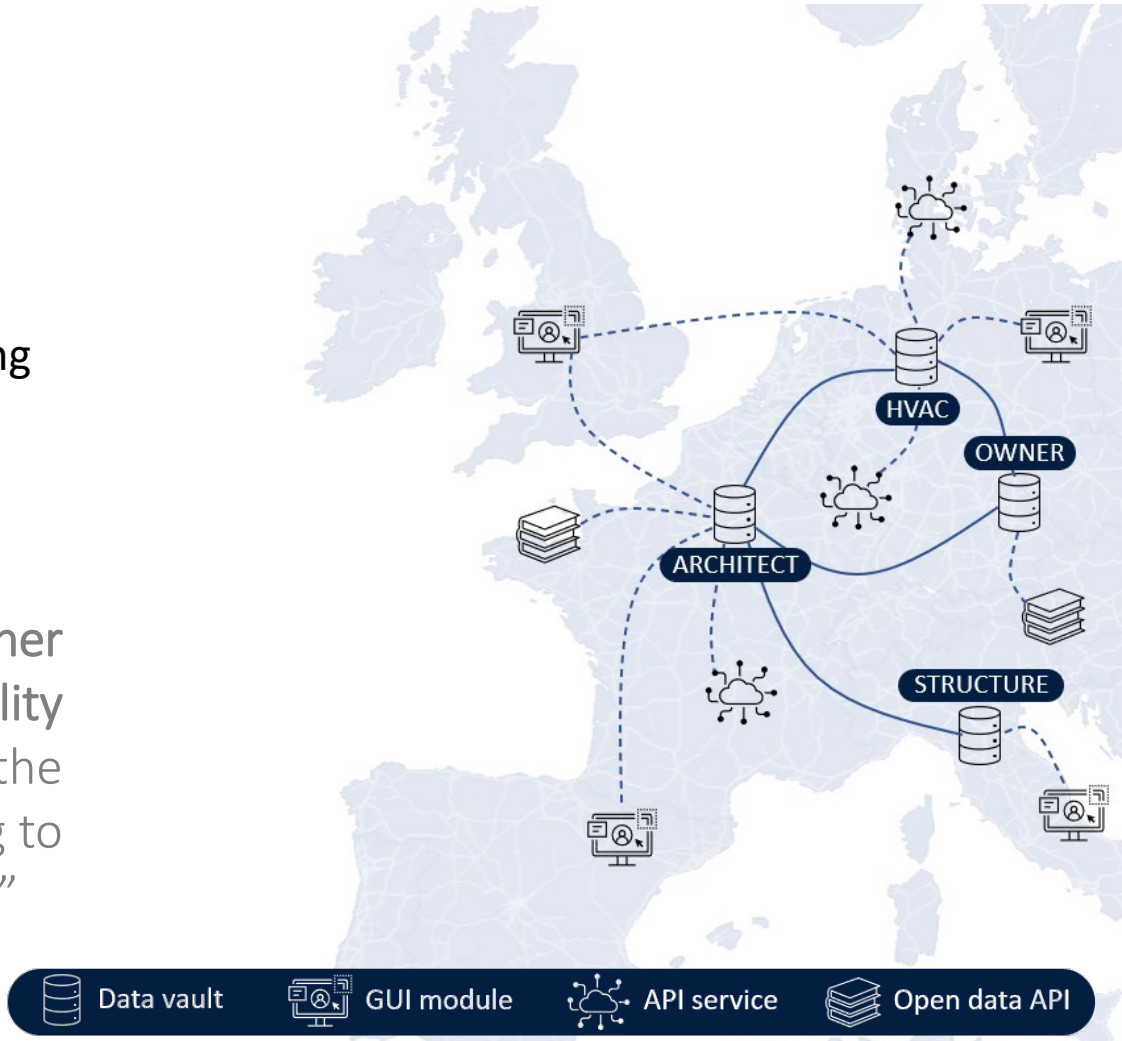
CONTEXT: DATA FEDERATION IN AEC

- Project-specific data
- Contextual data
- Data heterogeneity
- BLC-services

Decentralised project catalogs

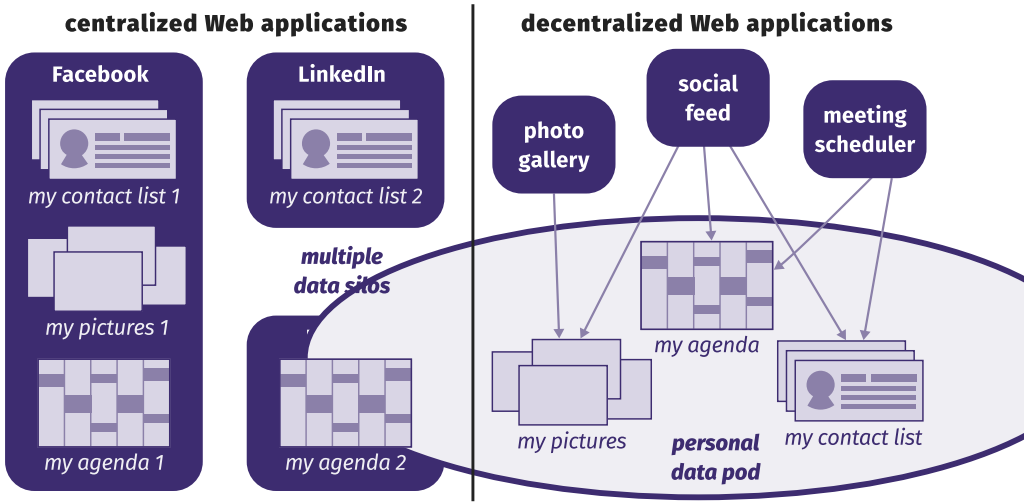
Sub-document information linking

"Using a 3rd party Web BIM service, the **Asset Owner** localises a damage pattern on a picture of the **Facility Manager**, linking it to an existing building element via the as-built 3D model provided by the **Architect**, and referring to external regulation datasets provided by the **government**."



CONTEXT: SOLID

- Web ID: A URL that represents an actor on the Web ➡ "Web username"
- Data Pod: Personal data storage linked to a Web ID ➡ Linked Data Platform (LDP) + AUTH
- Identity Provider: Instance hosting your WebID (and Pod) ➡ Can be self-hosted



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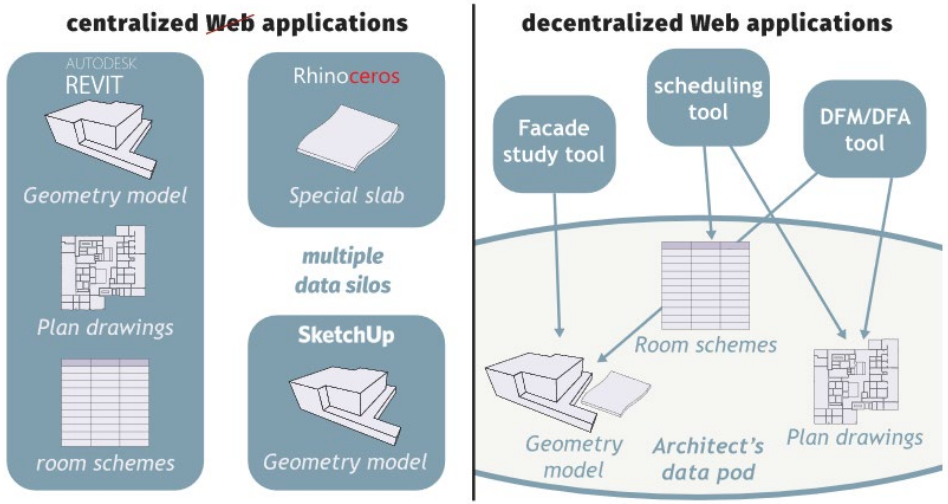

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RESEARCH BASELINE

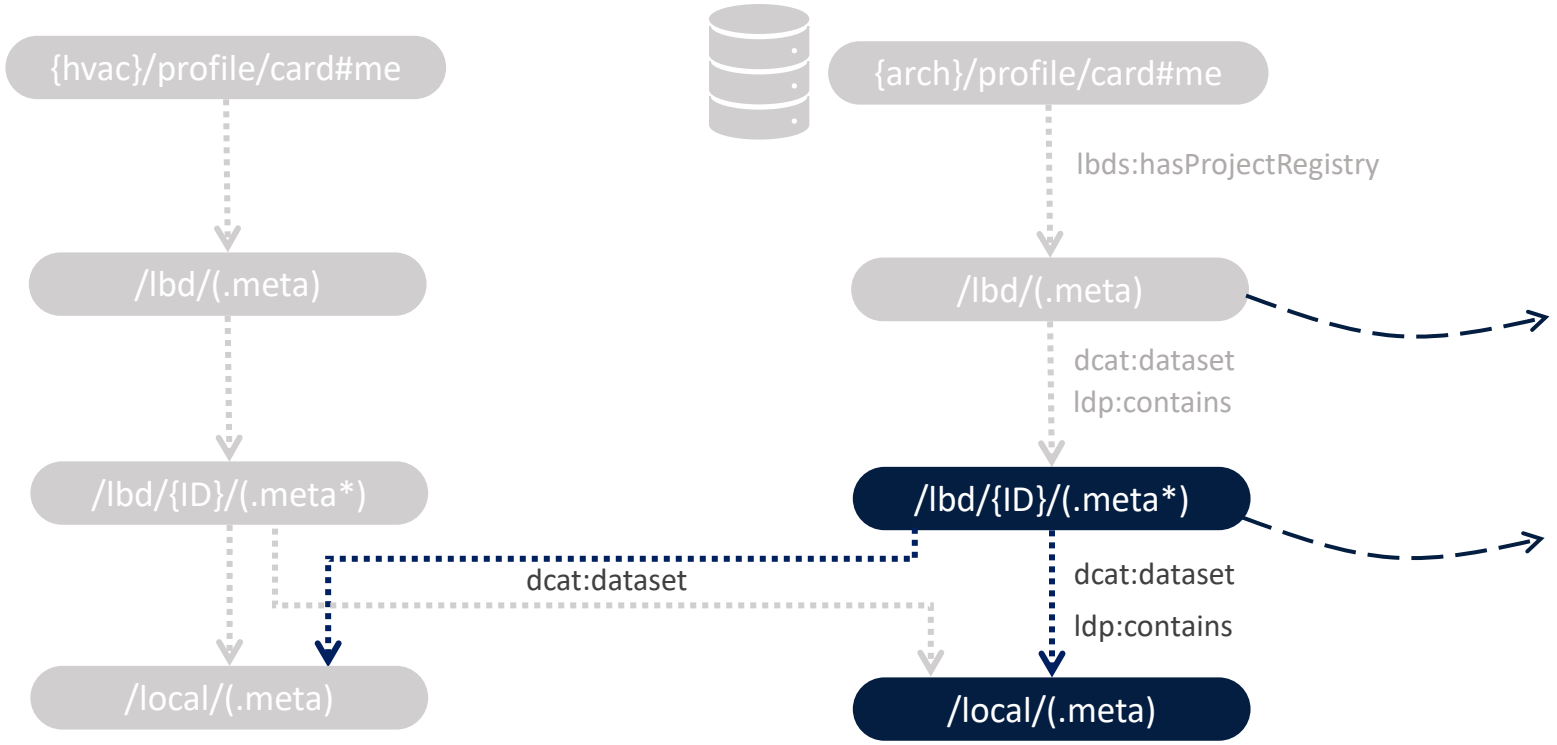
- **“Semantics” should be managed in metadata resources rather than in URLs/containment triples**
- **Metadata can be used to containerise resources according to certain parameters**
- **A resource being contained in a Solid POD/LDP container does not mean it cannot be contained *virtually* elsewhere**
- **Separate “Storage” from “Discovery”**

“Virtual views” generate particular views on federated data catalogs, based on metadata queries

⇒ URLs should not contain “meaning”, in order to keep them stable

⇒ Compliance with standard-imposed data structures can happen at presentation level (middleware)

FEDERATED PROJECT DISCOVERY

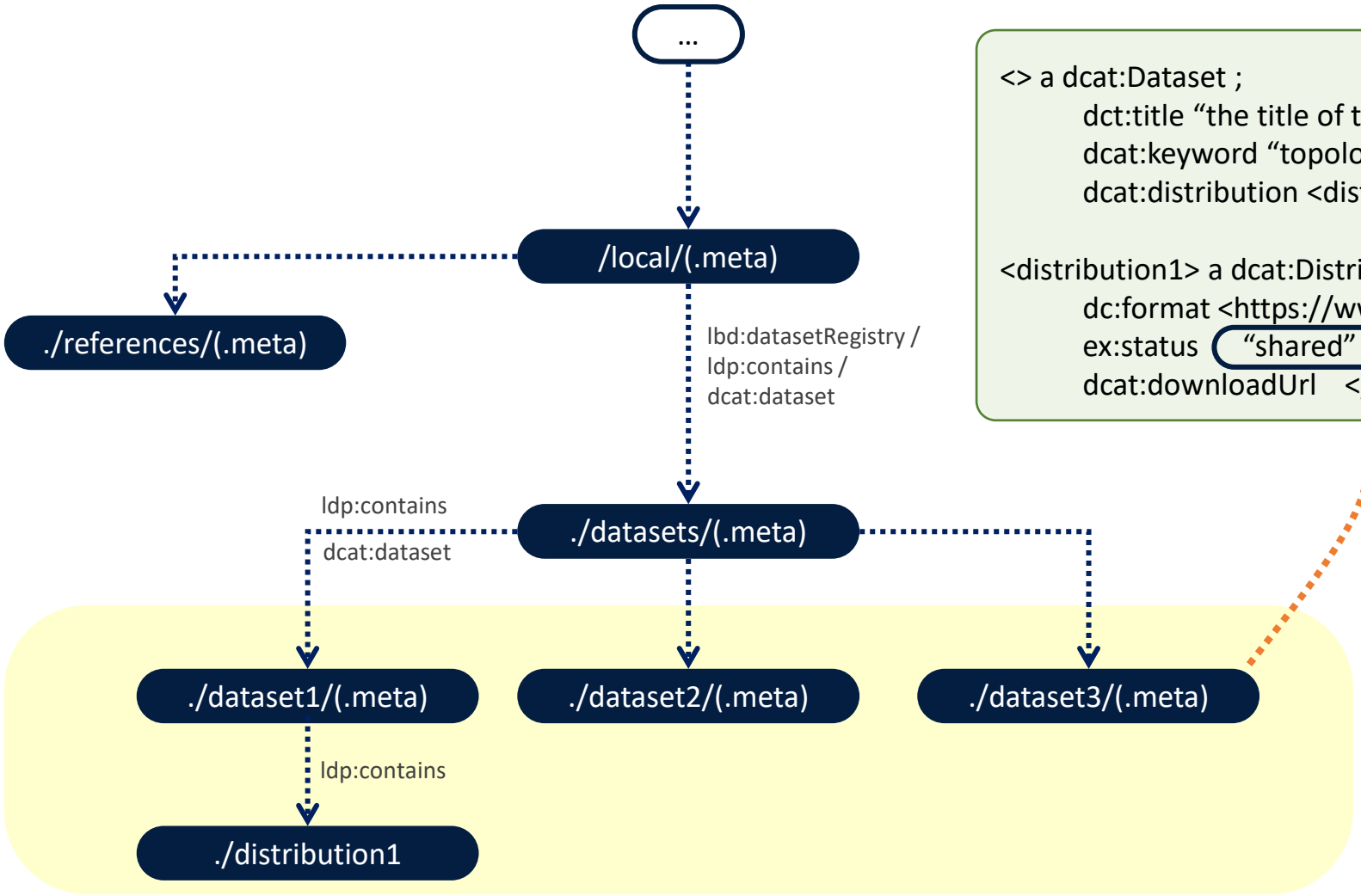


The project registry of a stakeholder is no more than a specific "**aggregator**". It is modelled as a DCAT Catalog, in this case one that groups projects this stakeholder participates in.

The "**project access point**" is an LDP container which aggregates relevant project data. It *effectively* contains (ldp:contains) the contributions of the stakeholder (/local/), and *virtually* contains relevant contributions of other stakeholders in the project.

* In Solid, ".meta" files are mapped to specific LDP containers. Dereferencing the container yields the .meta resource.
** By default, ".meta" files in Solid cannot be edited directly. In this case, this restriction was overruled in favor of project organisation

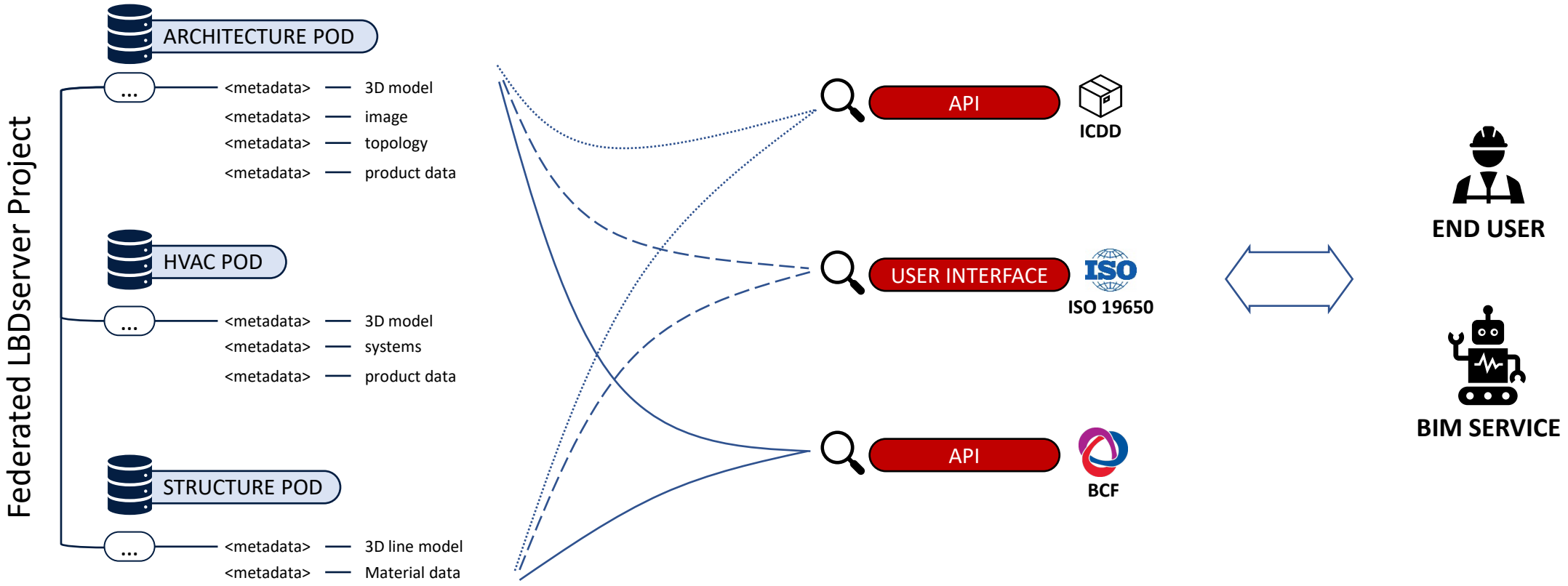
DATASET STORAGE




```
<> a dcat:Dataset ;
        dct:title “the title of the dataset”;
        dcat:keyword “topology” ;
        dcat:distribution <distribution1> , <distribution2> .

<distribution1> a dcat:Distribution ;
        dc:format <https://www.iana.org/assignments/media-types/text/turtle>;
        ex:status  “shared”
        dcat:downloadUrl    </distribution1>      .
```

Query **UNION** to generate virtual views

VIRTUAL VIEWS



VIRTUAL CONTAINERS

- Solid Pods use LDP (Linked Data Platform) to organise resources in a hierarchic, **tree-based** container structure
- Virtual view structured as an LDP Container

“REAL” container on Solid Pod

```
<>      ldp:contains    <subfolder1/> ,
                        <subfolder2/> ,
                        <file1.ttl> ,
                        <file2.jpg> .
```

“VIRTUAL” container at API

```
<https://my-api.org?project=7712c210&?mediaType=image/jpeg>
        ldp:contains    <https://pod.architects.com/lbd/7712c210/local/datasets/a4828ea6/a66f3253> ,
                        <https://pod.architects.com/lbd/7712c210/local/datasets/ 4e577874/58bfd7eb> ,
                        <https://pod.hvac.org/lbd/7712c210/local/datasets/74021f62/18b65cbc> ,
                        <https://pod.structural.com/lbd/7712c210/local/datasets/ea774a29/bb0e8c3c> .
```

- Virtual containers can organise resources in a **graph-based** “container” structure
  - Solid compatibility: use LDP containment triples pointing to resources that are not effectively hosted on the Pod in this hierarchy
  - (alternative: DCAT: use *dcat:dataset* to aggregate datasets into dcat:Catalog-s (*rdfs:subClassOf dcat:Dataset))*

API DISCOVERY

- DCAT services registered in “project access point”
- Endpoint URL
- Standard number

```
# [... Pointers to partial projects etc. ]

<>              dcat:service              <#f20dd53e> .

<#f20dd53e>     a                         <http://www.w3.org/ns/dcat#DataService>;
                dcat:endpointURL          <https://icdd.my-api.org/7712c210/>;
                dcterms:conformsTo        “ISO 21597” .
```

USE CASES

ISO 19650 – STAGES OF PUBLICATION

- Trivial example: can be defined by a single property
- “Satellite”: SPARQL CONSTRUCT a “virtual container” which is served as a classic LDP container
- User Interface: SPARQL SELECT

```
CONSTRUCT {?virtualContainer ldp:contains ?downloadURL }
WHERE {
        #_____Dataset discovery starting from Project Access Point____
        #initial source: project access point
        ?aggr dcat:dataset ?partial .

        #link traversed source: partial project
        ?partial lbds:hasDatasetRegistry ?dsr .

        #link traversed source: dataset registry
        ?dsr dcat:dataset ?ds .

        #_____Subquery for dataset filtering____
        #link traversed source: dataset
        #aggregate all resources with status "shared" (example ontology)
        ?ds ex:publicationStatus "shared";
        dcat:distribution/dcat:downloadURL ?downloadURL .

        BIND(UUID() as ?virtualContainer)
}
```

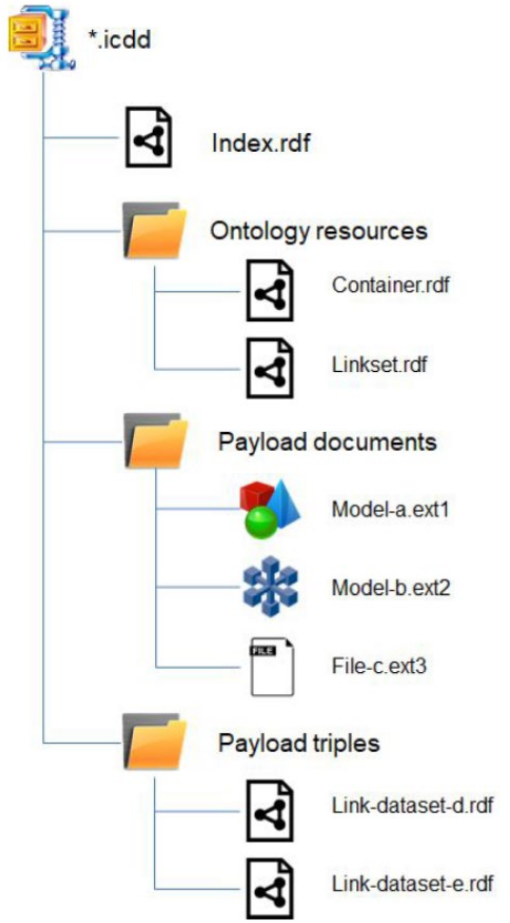
ISO 21597: ICDD

1. “Payload Triples”

```
CONSTRUCT {?virtualContainer ldp:contains ?download }
WHERE {

        # [...dataset discovery patterns starting from Project Access Point (cf. Listing 4)]
        # link traversed source: Dataset registry
        ?dsr ldp:contains ?ds .

        ?ds dcat:distribution ?dist .
        ?dist dcat:downloadURL ?download;
        dcat:mediaType ?mt .

        FILTER(?mt IN (
        <https://www.iana.org/assignments/media-types/text/turtle>,
        <https://www.iana.org/assignments/media-types/application/rdf+xml>,
        <https://www.iana.org/assignments/media-types/application/ld+json>
        # [... other RDF serialisations ...]
        ))

        BIND(UUID() as ?virtualContainer)
}
```

2. “Payload Documents”

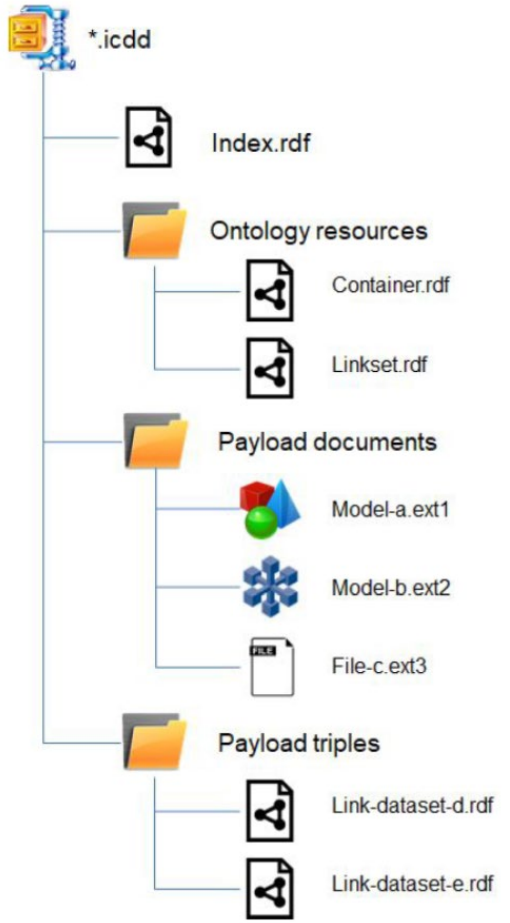
FILTER (?mt NOT IN(…))



ISO 21597: ICDD

3. Ontology resources

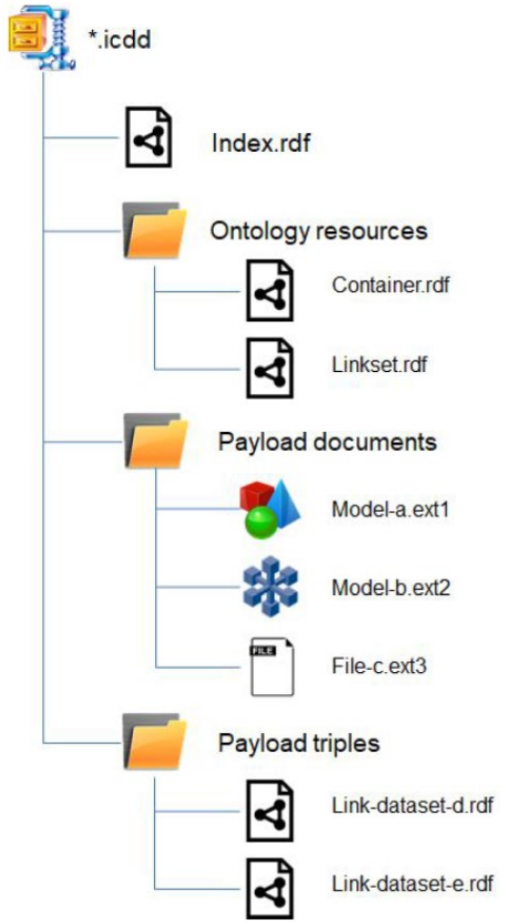
```
CONSTRUCT {?virtualContainer ldp:contains ?vocabulary }
WHERE {

        #  [...reference registry discovery patterns (lbds:hasReferenceRegistry)]
        # link traversed source: Reference registry
        ?dsr ldp:contains ?ds .

        ?ds void:vocabulary ?vocabulary .
        BIND(UUID() as ?virtualContainer)
}
```



ISO 21597: ICDD

4. Links.rdf

```
CONSTRUCT {
        ?concept a ls:Link ;
                ls:hasLinkElement ?le .
        ?le a ls:LinkElement ;
                 ls:hasDocument ?distribution ;
                ls:hasIdentifier ?id .
        ?id ls:identifier ?identifier .
} WHERE {
        #  [...reference registry discovery patterns (lbds:hasReferenceRegistry)]
        # link traversed source: Reference registry
        ?concept a lbds:Concept ;
                lbds:hasReference ?le .
        ?le lbds:hasIdentifier ?id ;
                lbds:hasDocument ?distribution .
        ?id lbds:hasIdentifier ?identifier .
}
```

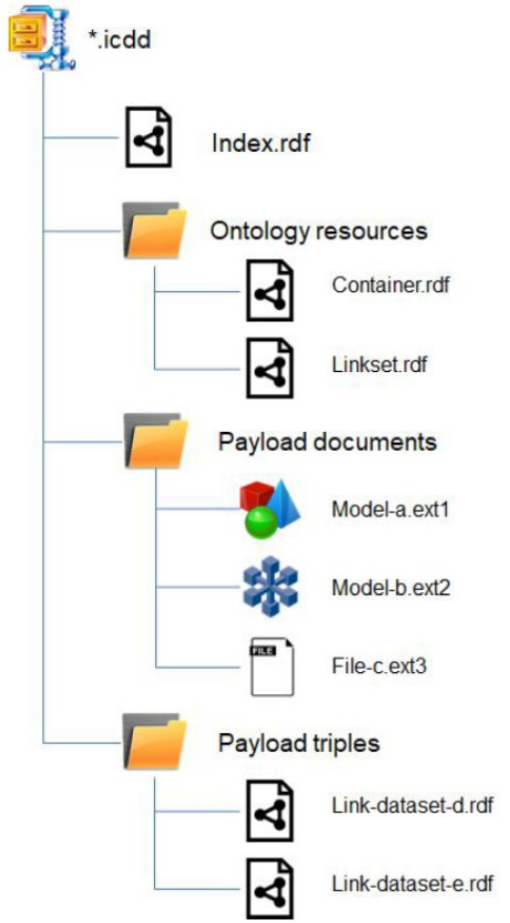


Use of LBDserver Reference Registry (see [4])

ISO 21597: ICDD

5. Index.rdf

```
CONSTRUCT {
        ?index ct:containsDocument ?dist ;
                ct:creator ?creator ;
                ct:description ?projectDescription .
        ?dist a ct:InternalDocument ;
                ct:description ?dsDescription ;
                ct:format ?format ;
        ct:filename ?filename .
} WHERE {
        # [...dataset discovery patterns starting from Project Access Point (cf. Listing 4)]
        # link traversed source: Dataset registry
        ?dsr ldp:contains ?ds .

        ?ds dct:creator ?creator ;
                rdfs:comment ?dsDescription ;

        BIND(UUID() as ?index)
        BIND(replace(str(?mt), str("https://www.iana.org/assignments/media-types/"),  str("")) as ?format)
}
```



NON-LDP-BASED MAPPING

- Standardised API responses as JSON
- JSON-LD = JSON + context
- Example: BCF API
  - Bundle federated LBDserver projects and present as (one or multiple) BCF-API endpoints
  - (https://github.com/BuildingSMART/BCF-API)

BCF API

GET /bcf/{version}/projects/{project_id}/topics

LBDserver Query

```
CONSTRUCT {
        ?ds dct:identifier ?identifier ;
        dc:creator ?creator ;
        dct:title ?title ;
        rdfs:label ?label ;
        dct:created ?creationDate .
} WHERE {
        # [...dataset discovery patterns starting from Project Access Point]
        ?ds a bcfOwl:Topic ;
        dct:identifier ?identifier ;
        dc:creator ?creator ;
        dct:title ?title ;
        rdfs:label ?label ;
        dct:created ?creationDate .
}
```

Standard BCF API Response

```
[...otherTopics,
        {
                "guid": "A211FCC2-3A3B-EAA4-C321-DE22ABC8414",
                "server_assigned_id": "ISSUE-00078",
                "creation_author": "Architect@example.com",
                "title": "Example topic 2",
                "labels": ["Architecture", "Heating", "Electrical"],
                "creation_date": "2014-11-19T14:24:11.316Z"
        }
]
```

JSON-LD context

```
{
        "@context": {
                "guid": "http://purl.org/dc/terms/identifier",
                "creation_author": {"@id": "http://purl.org/dc/terms/creator", "@type": "@id"},
                "title": "http://purl.org/dc/terms/title",
                "labels": "http://www.w3.org/2000/01/rdf-schema#label",
                "creation_date": "http://purl.org/dc/terms/created"
        }
}
```

CONCLUSION

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- Metadata-based, “virtual views” avoid the need to re-allocate LDP resources on a Solid Pod and modify their URL
- LBDserver storage patterns are discipline/topic-agnostic – this is covered semantically in the metadata documents
- Virtual views allow compatibility with existing industry standards, in a federated LD-environment
- The end user / client uses Pod-external services to see project data through a specific lens

FUTURE WORK

- The “dynamic views” are read-only; data manipulation happens directly at storage level
- Ontological mappings – e.g. base IFC (or ifcOWL) file, but satellite presents a view “as if LBD”
- Complex configurations – e.g. viewing BCF Topics as discussion threads
- “Blurry” differences between metadata and actual knowledge graph
- Dynamic access-rights management

READ MORE

[1] Werbrouck, J., Pauwels, P., Beetz, J., & Mannens, E. (2022). Mapping Federated AEC projects to Industry Standards using dynamic Views. In *10th Linked Data in Architecture and Construction Workshop*. CEUR-WS. org.

[2] Werbrouck, J., Pauwels, P., Beetz, J., & van Berlo, L. (2019). Towards a decentralised common data environment using linked building data and the solid ecosystem. In *36th CIB W78 2019 Conference* (pp. 113-123).

[3] Werbrouck, J., Pauwels, P., Beetz, J., & Mannens, E. (2021). Data patterns for the organisation of federated linked building data. In *9th Linked Data in Architecture and Construction Workshop.* CEUR-WS. org.

[4] Werbrouck, J., Pauwels, P., Beetz, J., & Mannens, E. LBDserver-a Federated Ecosystem for Heterogeneous Linked Building Data. *Under review.*

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THANK YOU!