DEPARTMENT OF CIVIL, ENVIRONMENTAL & GEOMATIC ENGINEERING

UCL

Data Ontology for Digital Twins: supporting research and operations

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DAFNI launch: bridging the physical divide with digital
5 Jul 2021

Science and Technology Facilities Council

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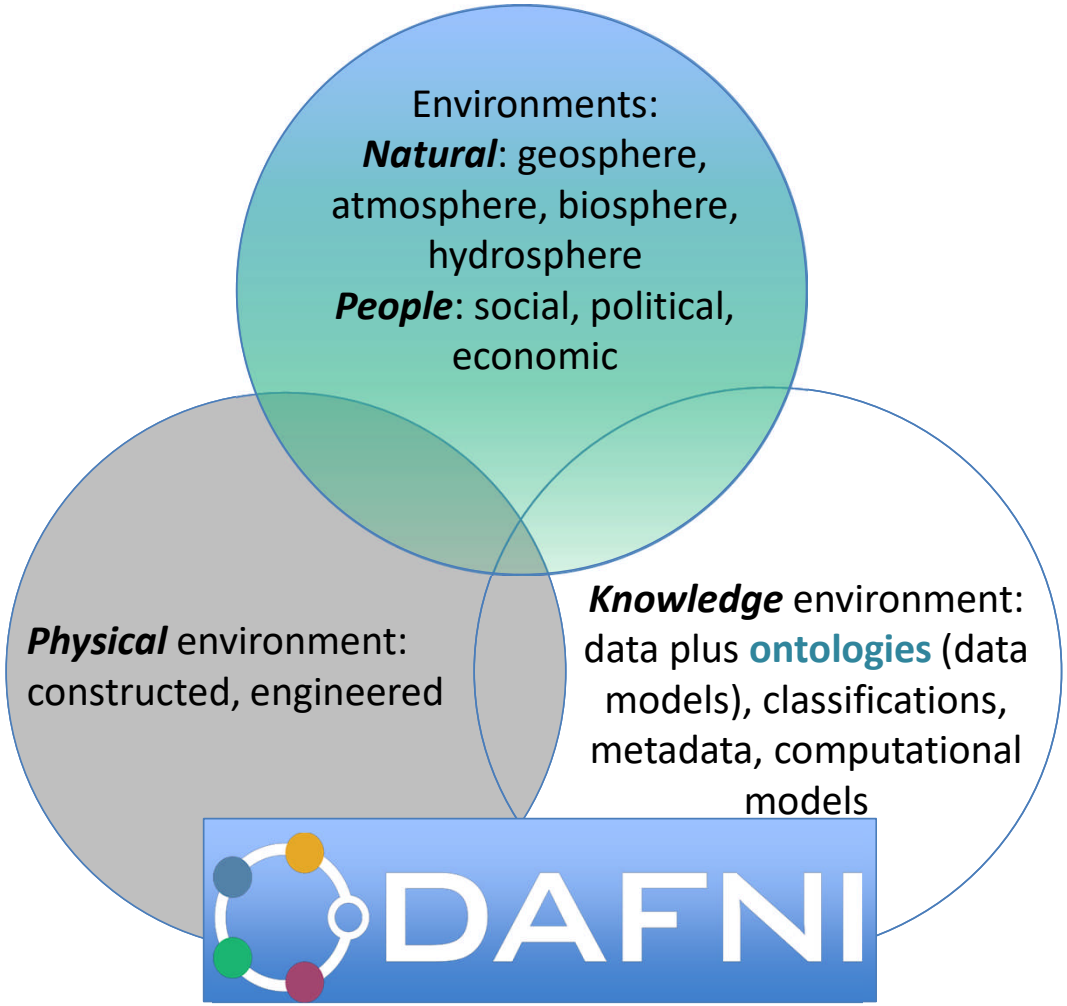
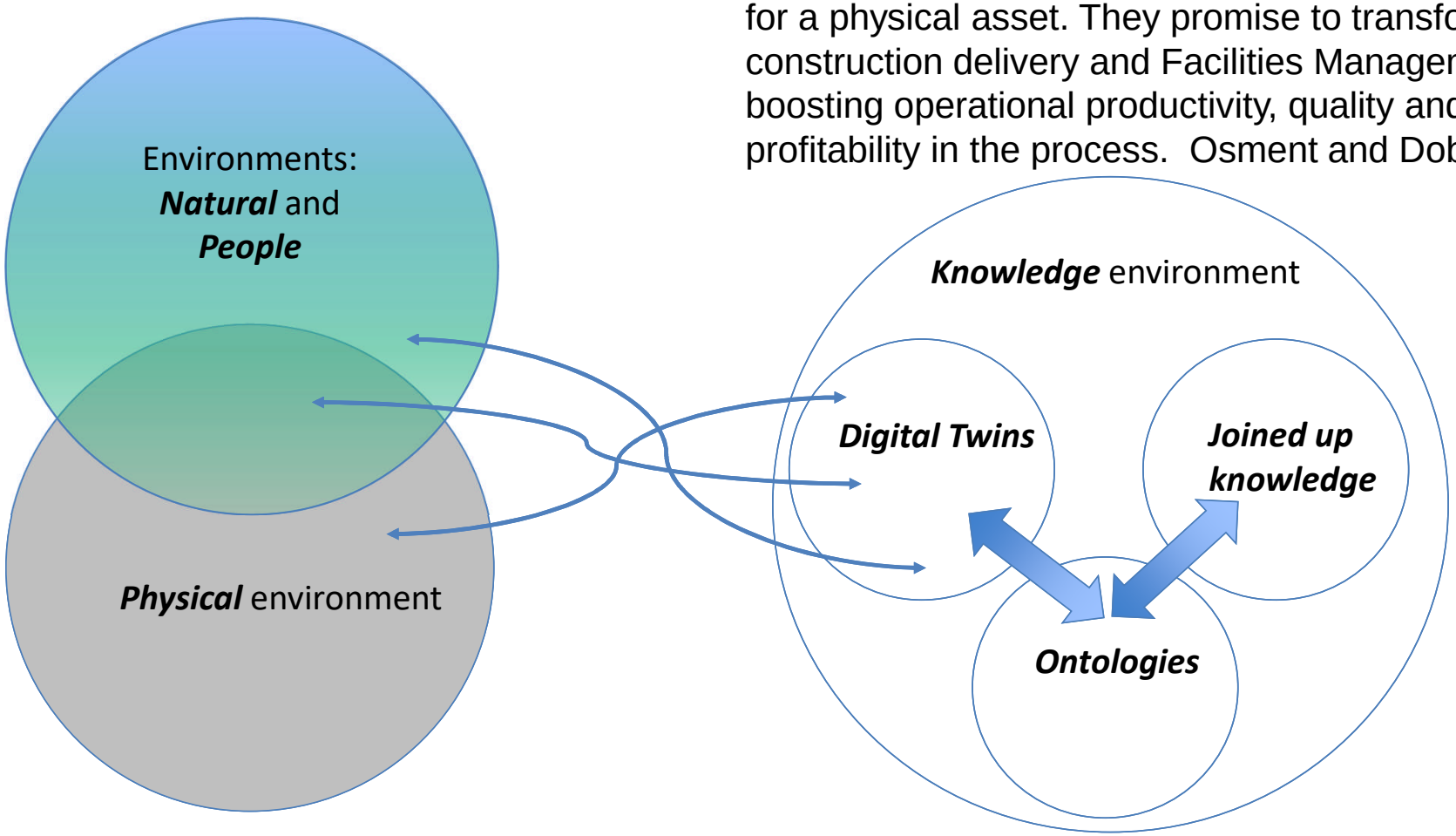
Locating ontologies



Ontologies to Digital Twins

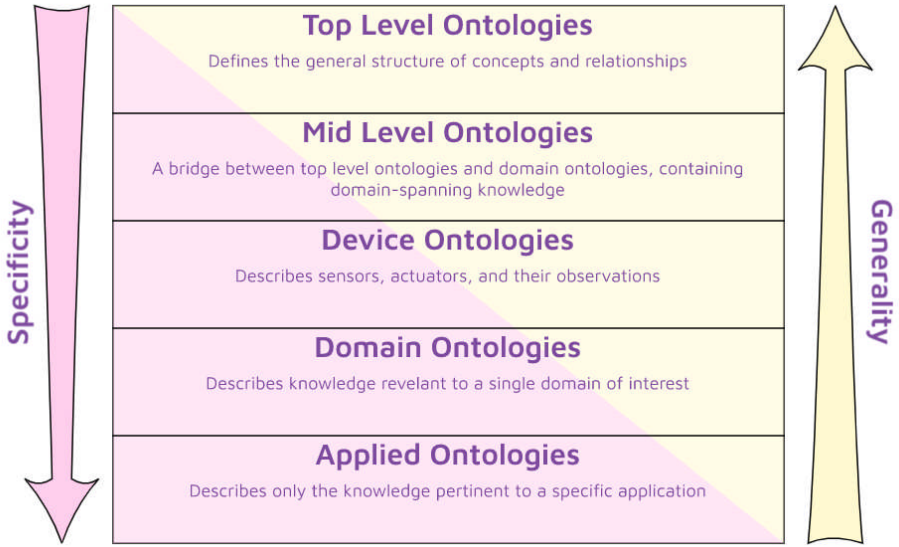
"Digital Twins (DTs) provide a form of a digital counterpart for a physical asset. They promise to transform construction delivery and Facilities Management (FM), boosting operational productivity, quality and ultimately profitability in the process. Osment and Doboš (2021, p3)



- Robust
- Reliable
- Responsible
- …

The value of ontologies for infrastructure planning, investment, construction, operations, maintenance, circular economy, …

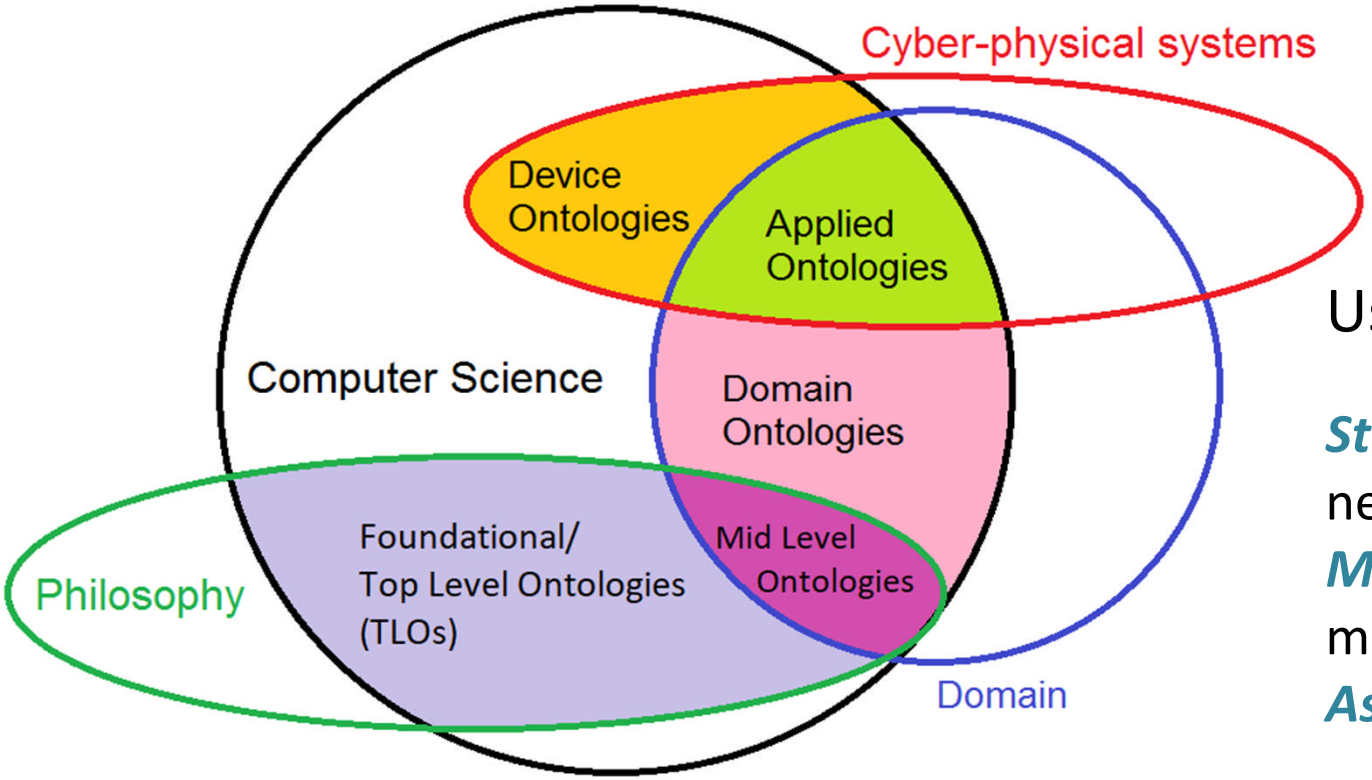
An ontology is "***the set of things whose existence is acknowledged by a particular theory or system of thought***" (Lowe, 1995)



(Varga et al, 2021)

- Descriptive clarity and quality
  - of 'what' is in a system
  - digitalised
- Transparency and engagement
- Plurality and diversity
- Knowledge discovery
  - analysis and automated inferencing
- Knowledge integration
  - inter and intra systems
  - across built, natural and people environments

Ontology types and use cases



(Varga et al, 2021)

Use case types and examples:

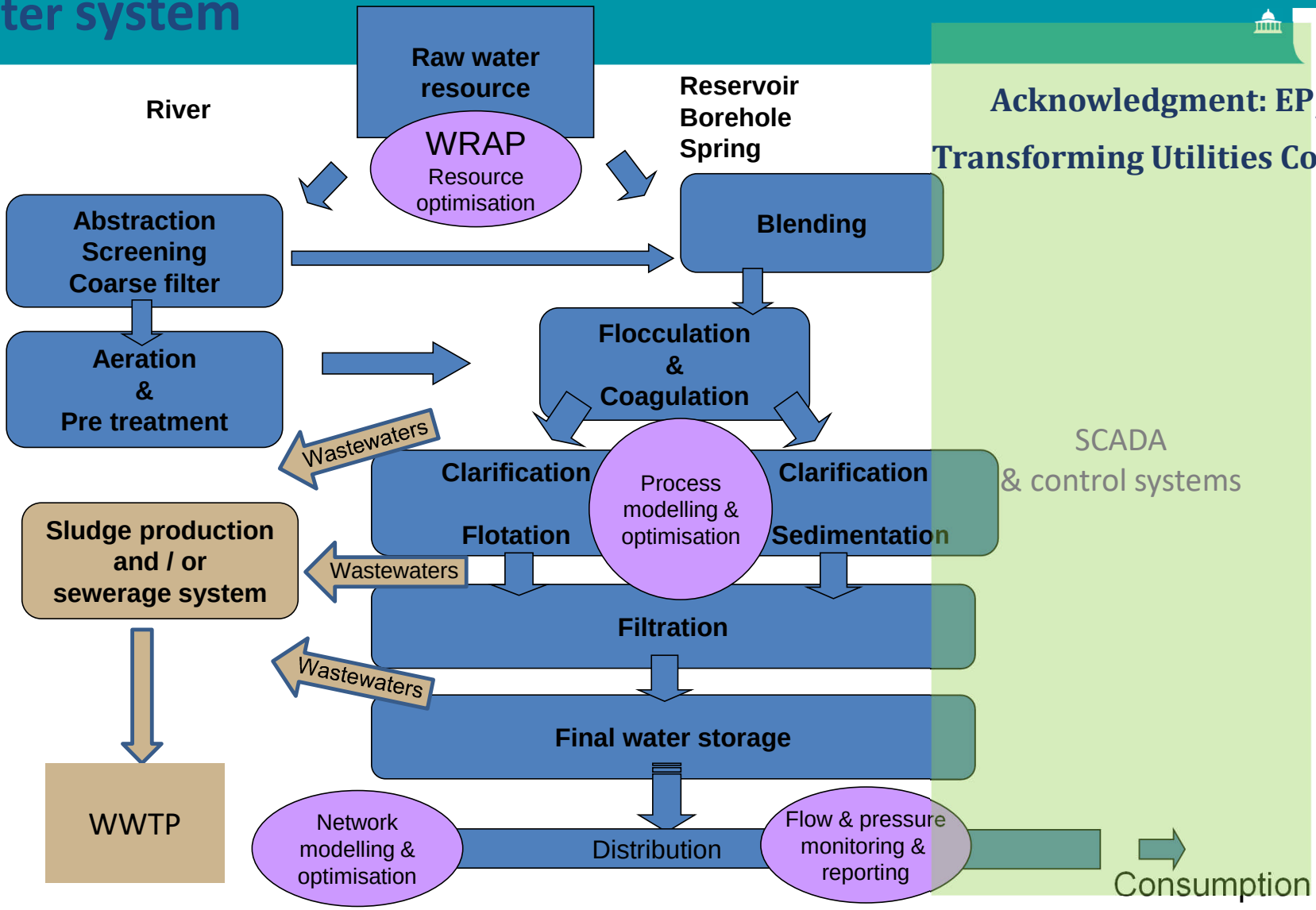
Strategy and Planning: road network improvement

Managing Assets: asset maintenance prioritization

Assurance: Risk assessment

Types based on CDBB Digital Twin Toolkit, 2021

The water system

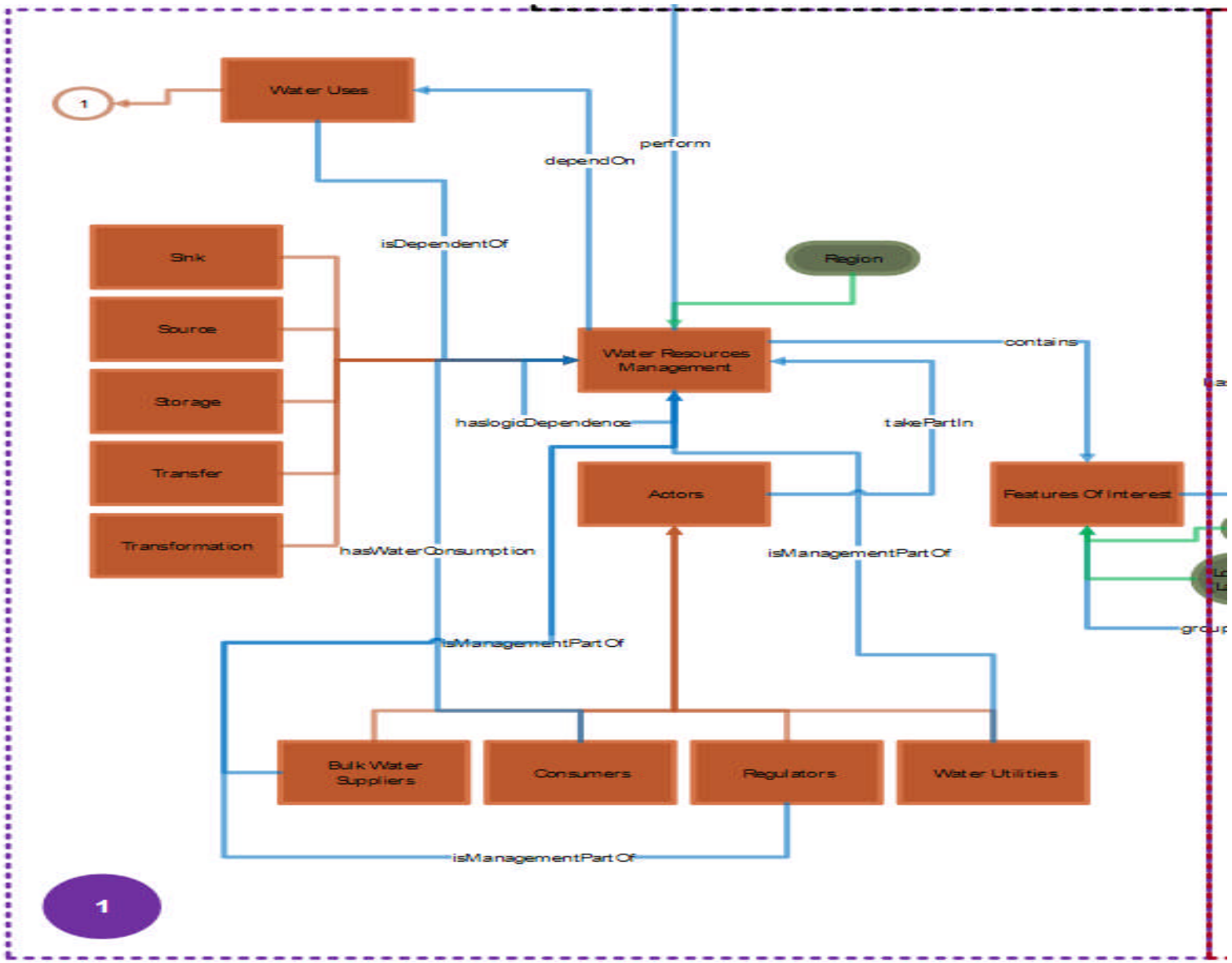


Acknowledgment: EP/J005649/1

Transforming Utilities Conversion Points

WATERP (1): Generic ontology for water supply distribution

Varas, (2013, p26)

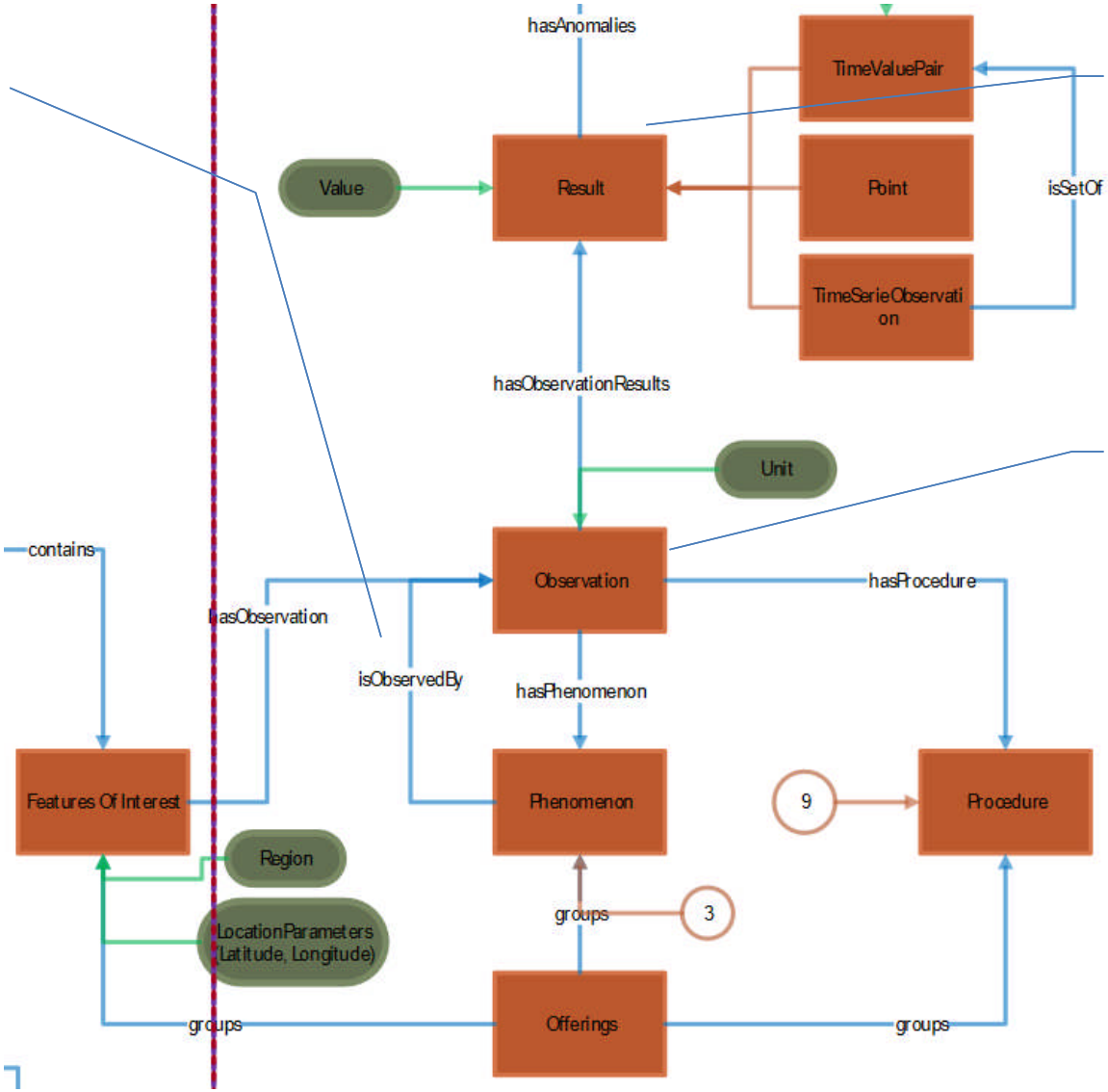


WATERP – Descriptive clarity

- Differentiate concepts definition inside WatERP ontology in order to create ***consistent knowledge*** managing
- Include synonyms into the ontology in order to ***enrich the vocabulary*** where it is desirable
- Define the coverage in the terms needed for the ontology in order to ***avoid ambiguity*** in instances definition

Varas, (2013, p27)

Explicit top level ontological commitments



Increasingly automated: AI/data science, or reference to models

Increasingly digitalized: cyber physical systems

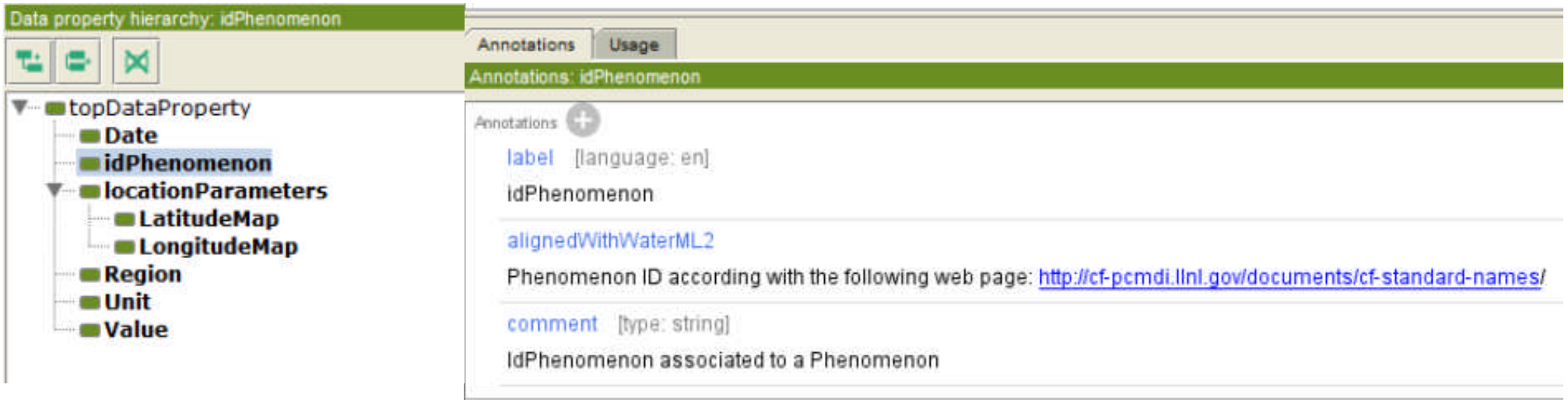
WATERP (2): Generic ontology for water supply distribution chain

Varas, (2013, p26)

Ontological commitments

- Necessary conditions:
  - conditions to be met by a member of a specific class
- Necessary and sufficient conditions:
  - conditions to be met by a member of a specific class which are ***enough to infer*** that the individual is a member of a specific class
- Universal classes: natural classes that abstract or generalize over similar particular things: Person, Location, Process
- Entities – either «Continuants» and «Occurrents »

Semantic meaning via mapping



Ontological mapping is the mechanism to link the ontological resources with to other ontological resources. Mappings offer the benefit of

(i)***standardize the concepts*** defined in the ontology by the linkage between representative organization such as NASA, National Institute of Standards and Technology (NIST), etc;

(ii)***share ontological resources*** with the aim of enhancing other ontological resources; and

(iii)improve understanding of ***data provenance*** by linking the ontology to the rest of the semantic world.

Ontologies: a mechanism enabling the golden thread to solving societal challenges

- Climate change and net zero
- Resilience of critical services
- Reduced waste and raw materials use
- Equity, diversity, inclusion
- Environmental risks management
- …

Joined up knowledge

Call for support

- DAFNI ROSE
  - Support modelers who are increasingly writing digital twins
  - Provide a resource in DAFNI to describe and discover ontologies
  - Provide a digital twins service (akin to the NIMS) which supports the identification of ontologies in order to facilitate digital twin workflow (integration)
- Contact Liz Varga or Brian Matthews if you want to contribute

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Thanks

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