An extension of Thing Descriptions from the Web of Things for Digital Twins

Ontology Engineering Group,
Universidad Politécnica de Madrid

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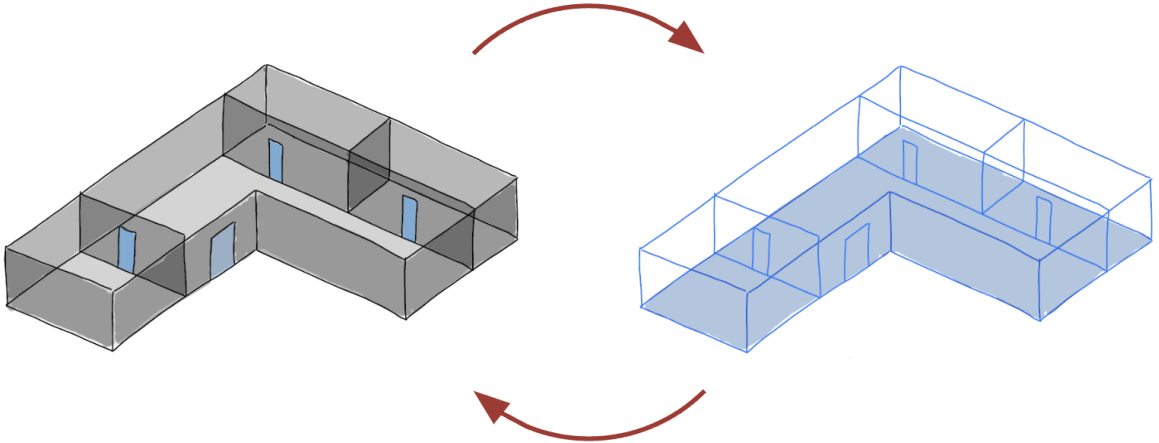
09/09/2022

What are Digital Twins?

Physical entity

Virtual entity

Real-world actions



Simulations

Bi-directional information flow

What are Digital Twins?

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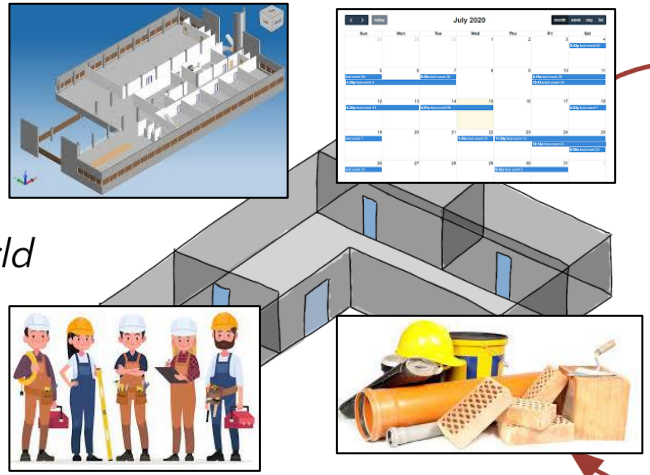
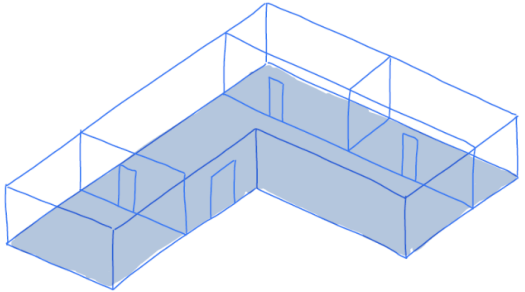
Virtual entity



Real-world actions



Simulations

Bi-directional information flow

COGITO

COnstruction-phase di**GI**tal **T**win m**O**del

Project Partners

HYPERTECH energy labs · UCL · AARHUS UNIVERSITET · THE UNIVERSITY of EDINBURGH · BOC group · iti · POLITÉCNICA · QUE TECHNOLOGIES · Novitech · ASM · ferrovial construction · OLYMPIA ODOS · RHOMBERG SERSA RAIL GROUP

www.cogito-project.eu

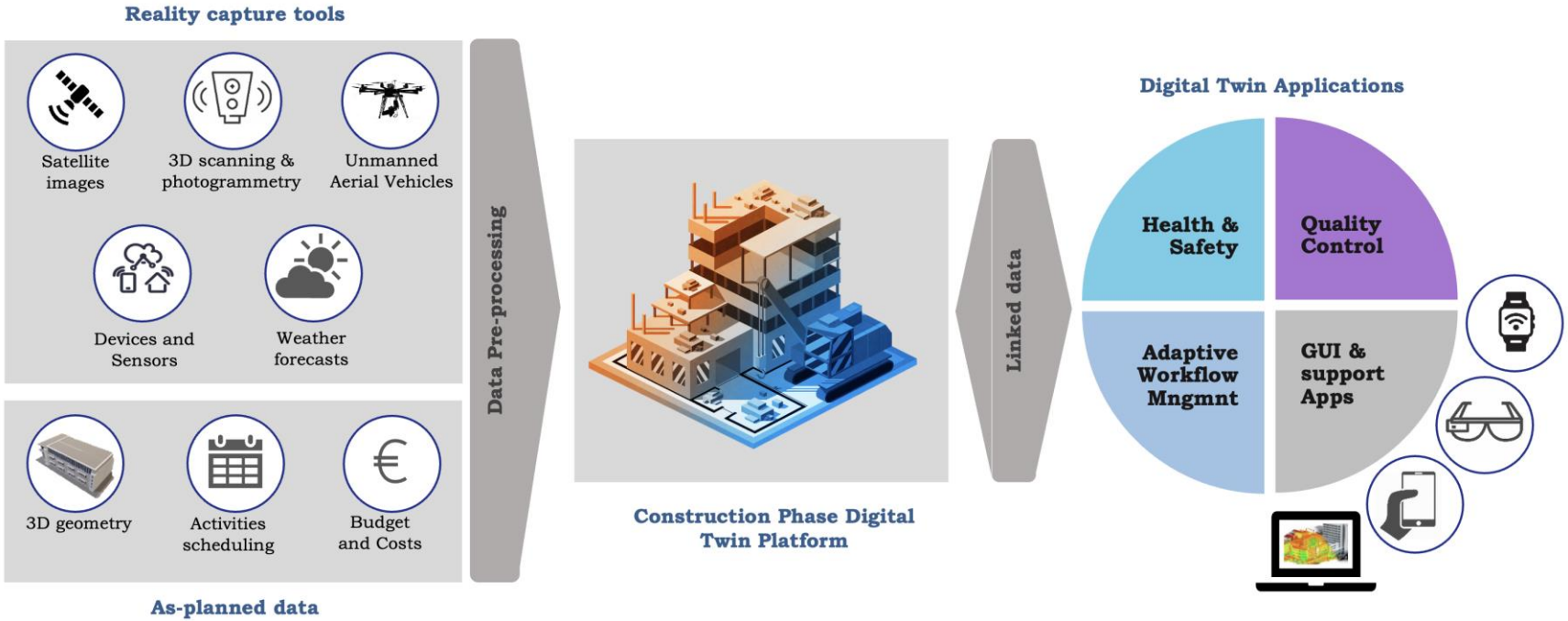
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958310

COGITO

Testlab - Austria

Pilot Site I - Denmark

Pilot Site II - Spain



OPEN STANDARDS

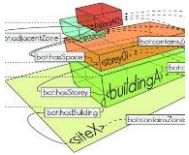
W3C Semantic Web

W3C OWL

W3C RDF

W3C SPARQL

ETSI SAREF



BOT

BRICK

WEB OF THINGS

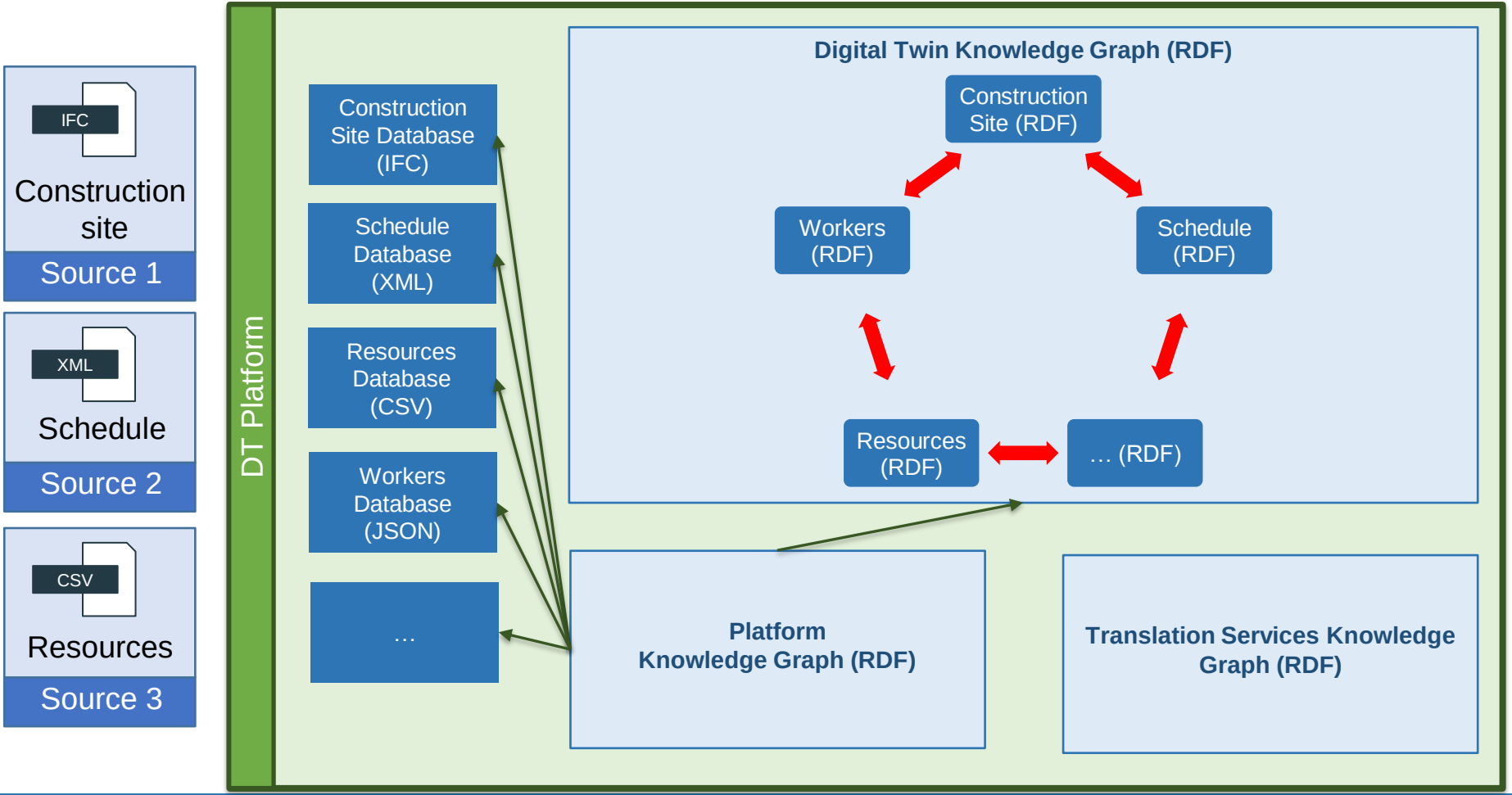
COGITO Challenges

- **Lack of semantic interoperable data** due to the heterogeneity of the APIs of the **physical layer**

- The difficulty of **orchestrating** the **translation services of the semantic interoperability approach**

- Complexity involved in **managing** the **COGITO related data for grouping it in Digital Twin processes within the digital model**

Data layers in COGITO



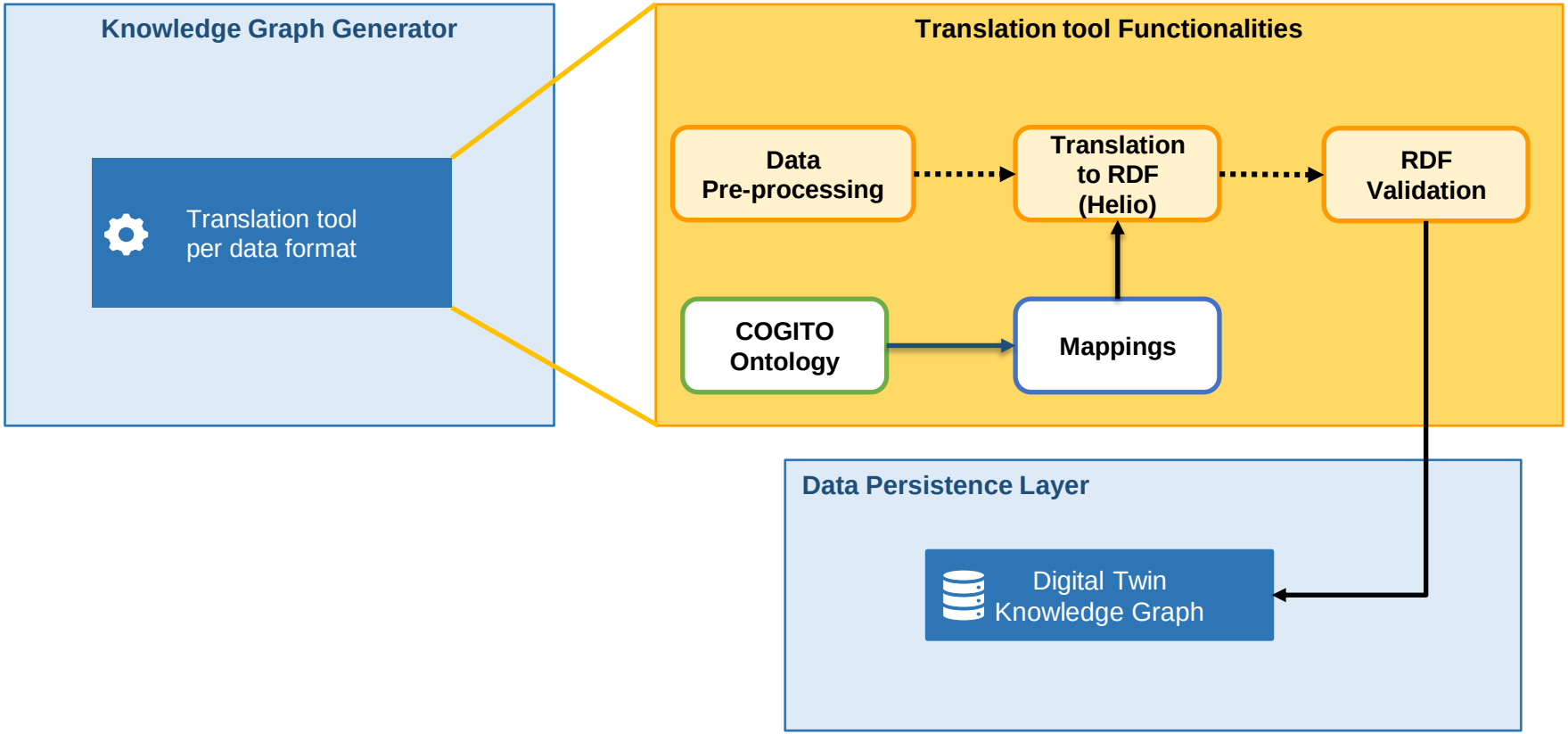
Challenge 1: Lack of semantic interoperable data

- **Hinders, limits or cancels** the **exchange of data** between different applications
- Data do **not have any kind of meaning**
- Data has **no** information that **describes and references them to each other**

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.

Challenge 1: Solution



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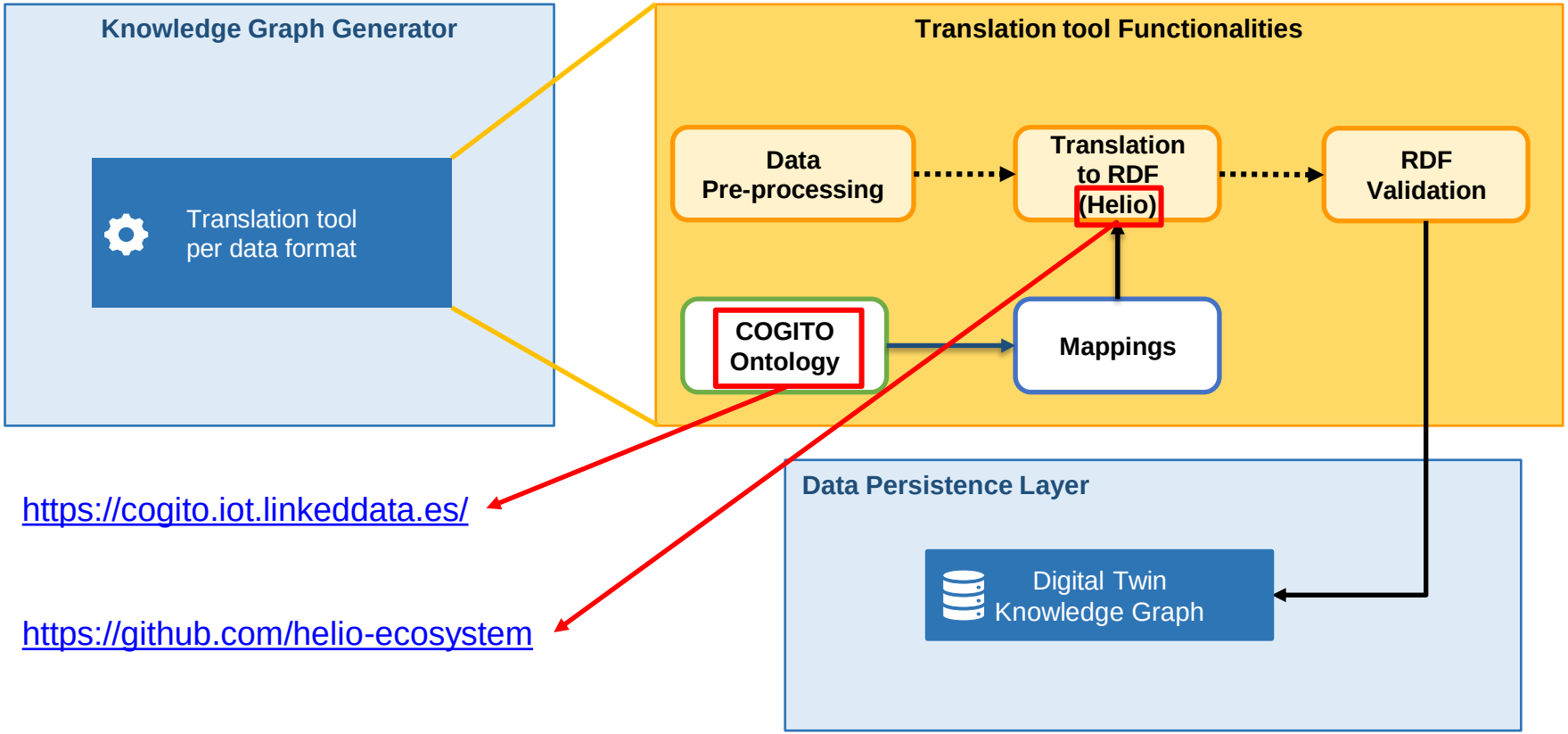
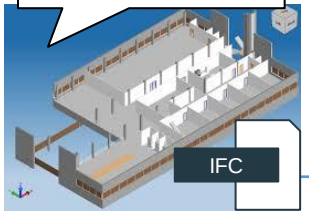
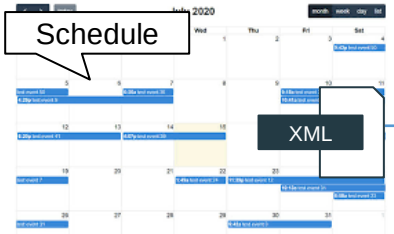


https://cogito.iot.linkeddata.es/

https://github.com/helio-ecosystem

Challenge 1: Example





Knowledge Graph Generation

- Construction site in IFC Translation tool → RDF
- Schedule in XML Translation Tool → RDF
- Workers in JSON Translation Tool → RDF
- Resources in CSV Translation tool → RDF

Knowledge Graph Validation

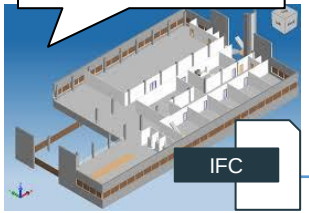
- IFC Validation tool
- Schedule Validation tool
- Workers Validation tool
- Resources Validation tool

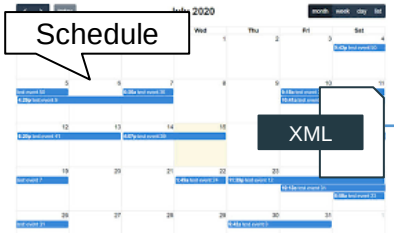
Digital Twin Knowledge Graph

- Construction site RDF
- Schedule RDF
- Workers RDF
- Resources RDF

Knowledge Graph Linking

Challenge 1: Example





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- IFC Validation tool (SHACL)
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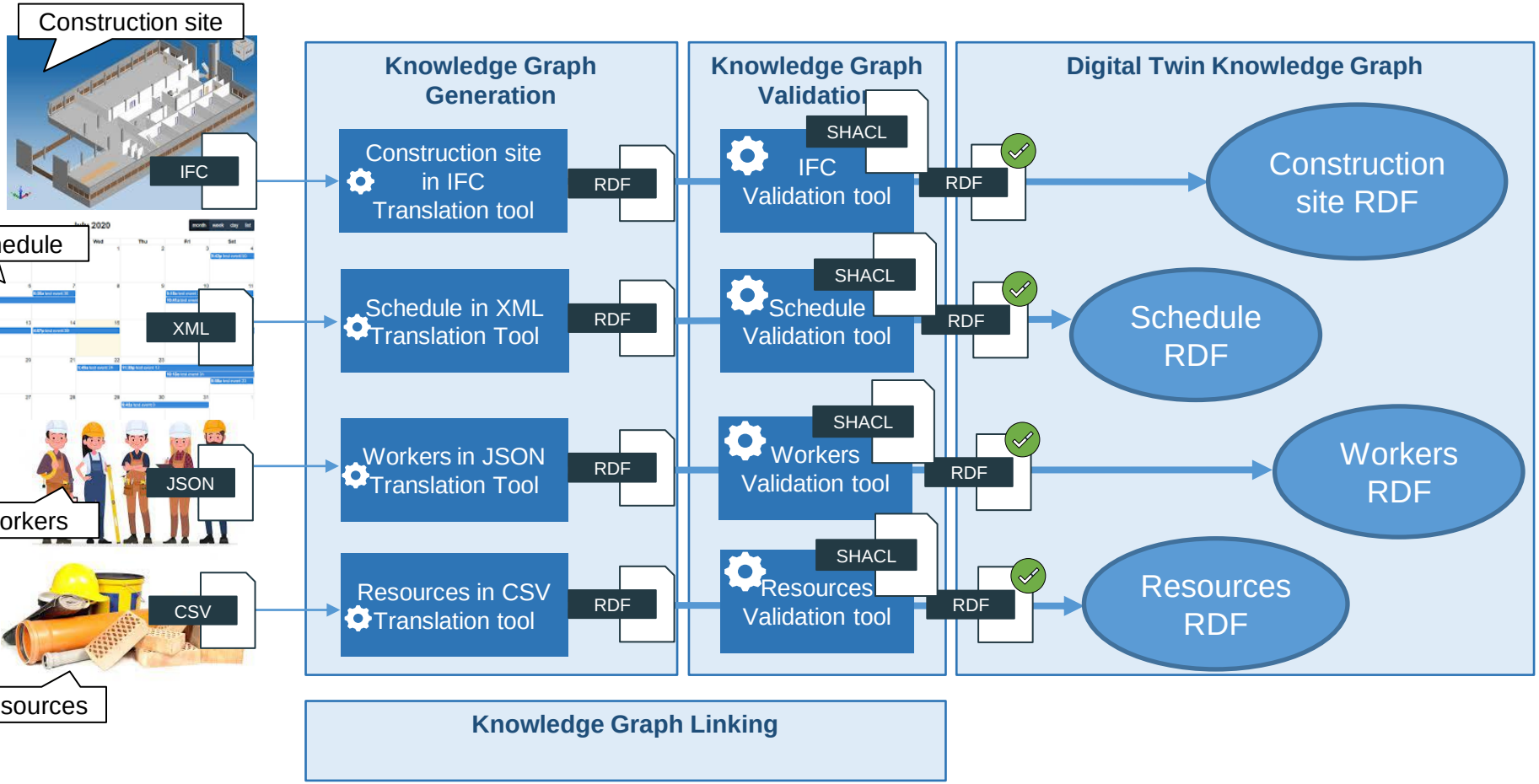

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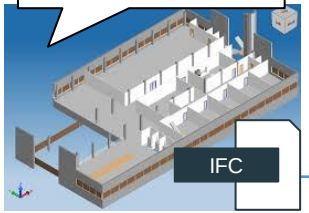

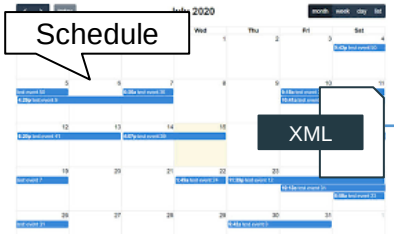

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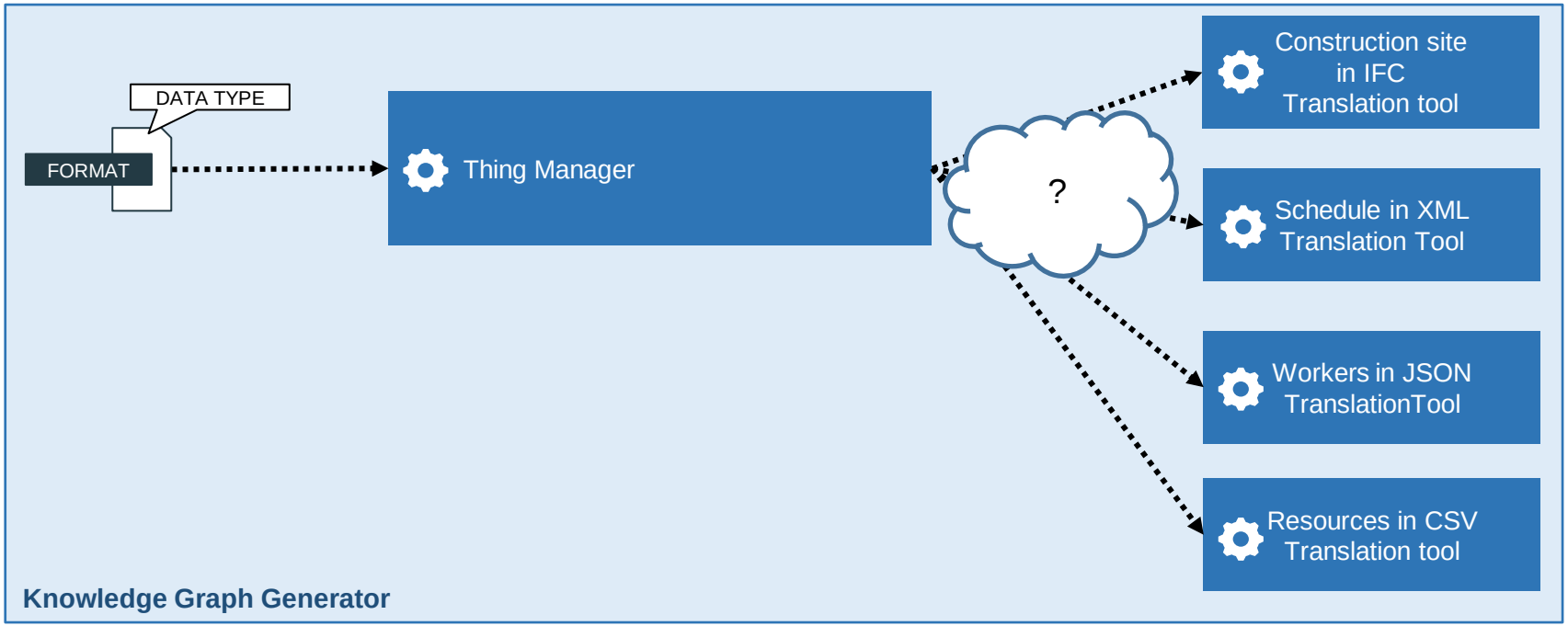
Knowledge Graph Linking

Challenge 2: Orchestration translation services

- Data is expressed in **different formats and can not be translated** into interoperable data **using any translation services and need to be translated with one that is “compatible”**

- The **increment of different types of data and formats can be unmanageable** because each type of format must use its own translation rules to get the correct translation to semantic interoperable data

Decentralized system orchestrated by Thing Descriptions



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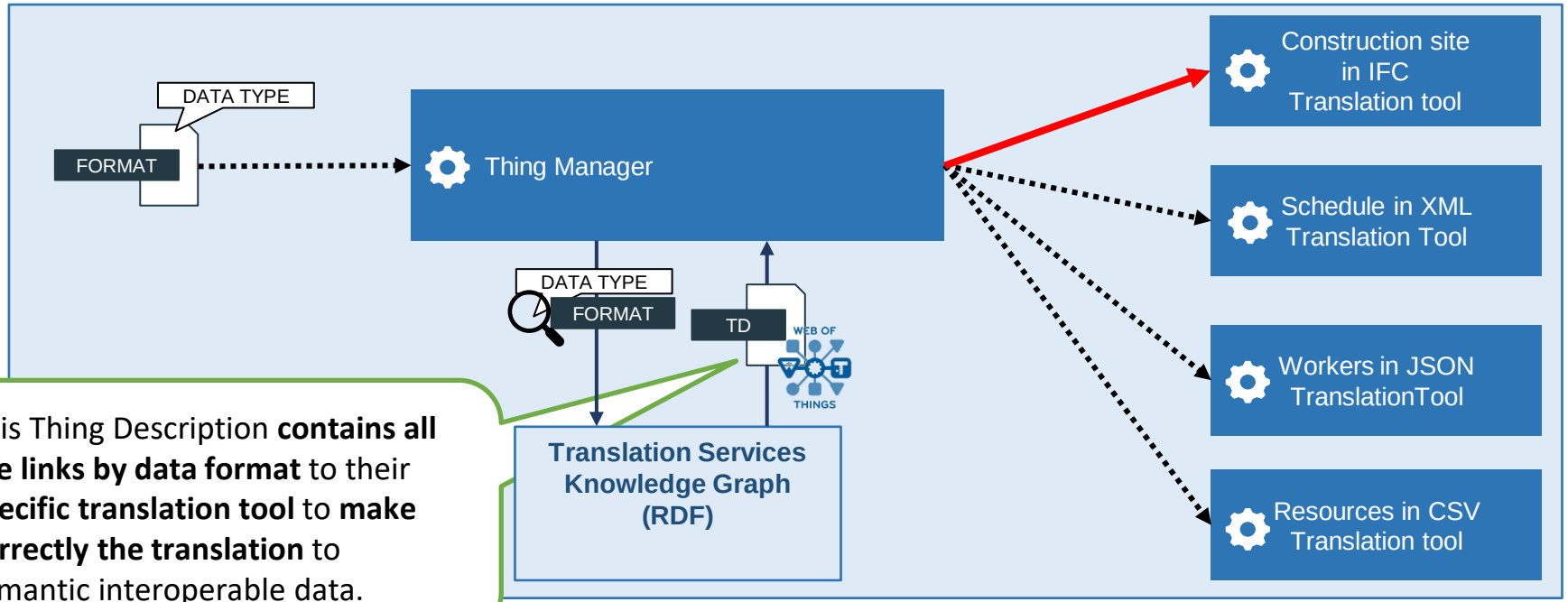
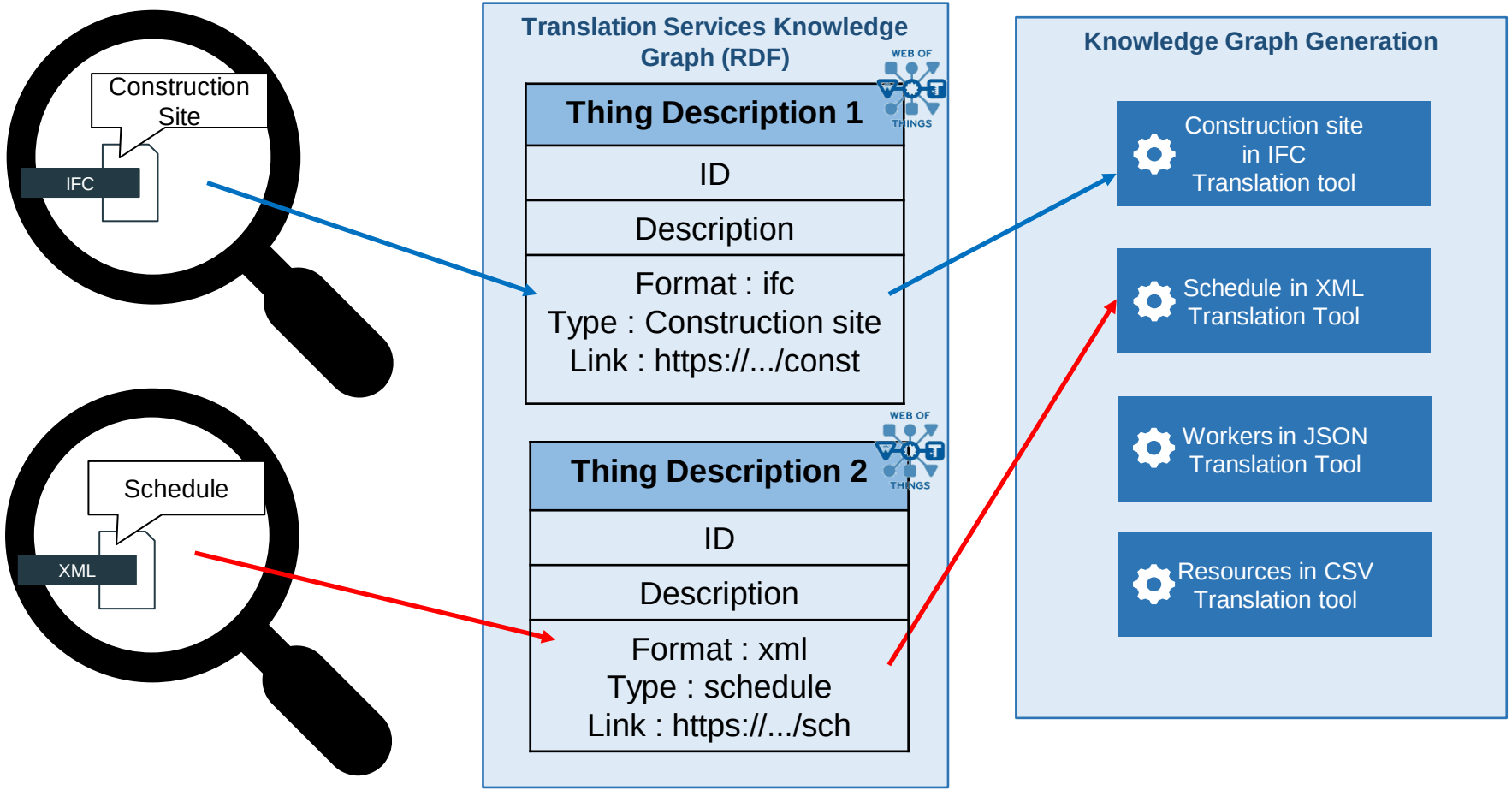


This Thing Description **contains all the links by data format** to their **specific translation tool** to **make correctly the translation** to semantic interoperable data.

Challenge 2: Example



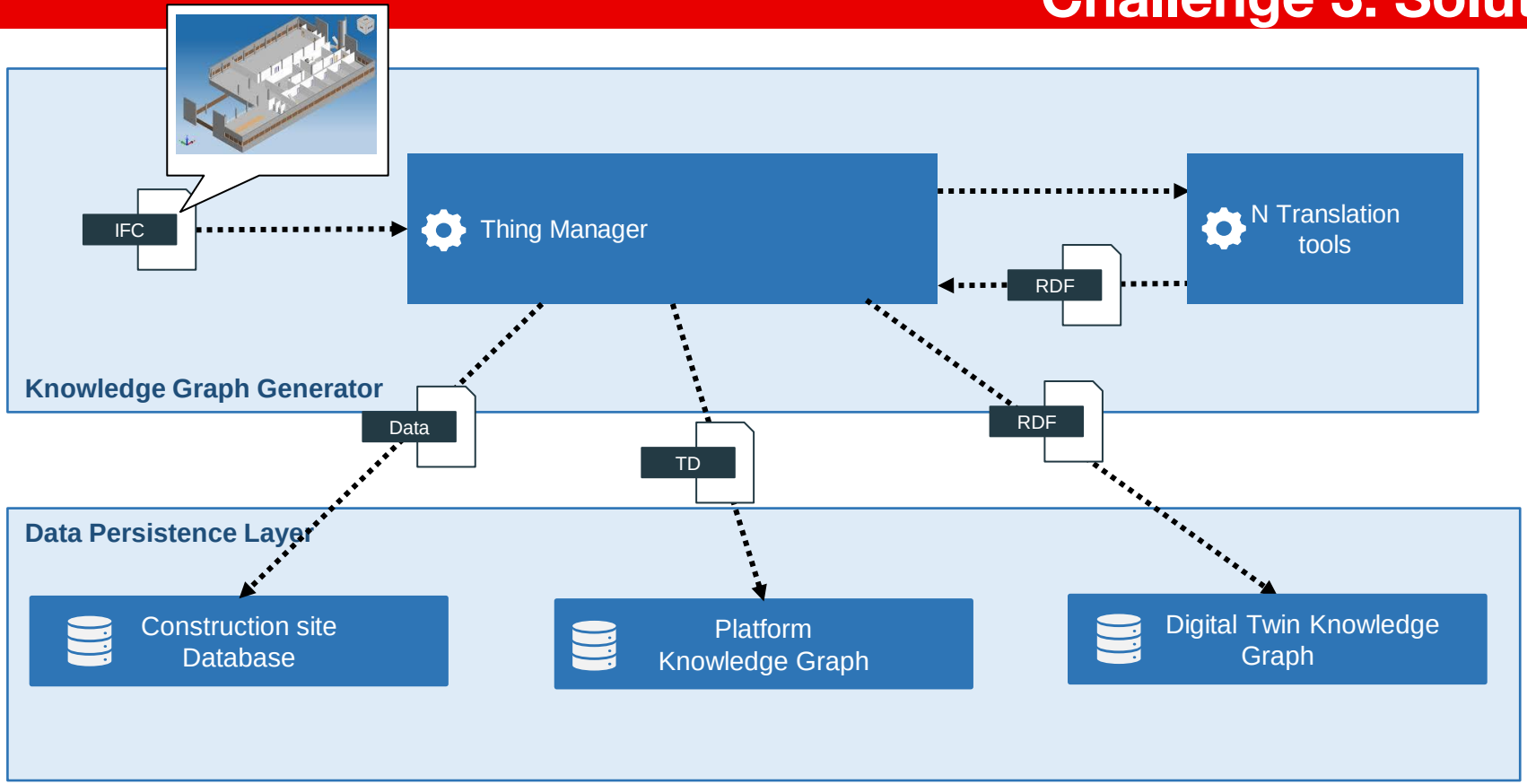
Challenge 3: Management of data

- **Complex** due to the amount of data available, in terms of finding specific data

- Provenance, if the **heterogeneous data is needed**, there is **no link that references to the information** once the information is translated to interoperable data

- The **data is not referenced to a particular process** belonging to the Digital Twin, so it is **not possible to extract information from the same process**, as the data are not associated with any other data

Challenge 3: Solution



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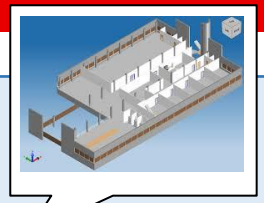


IFC

Thing Manager

N Translation tools

RDF

Knowledge Graph Generator

Data

TD

RDF

Data Persistence Layer

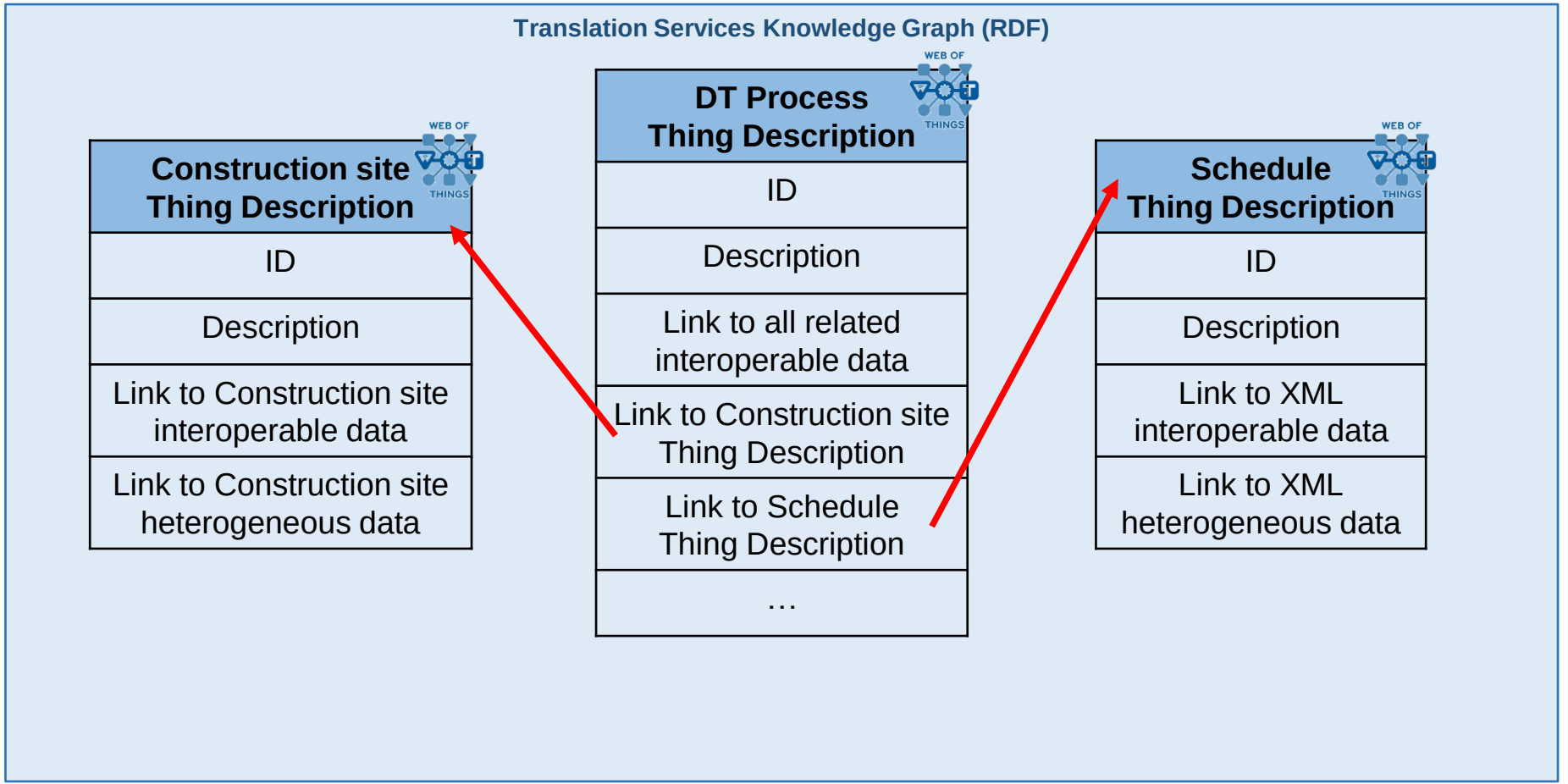
Construction site Database

Plat
Knowled

Creates Thing Description of data linked to a process with…

- **Data information** (identifier and description)
- **Link** to **heterogeneous data**
- **Link** to **semantic interoperable data**
- **Link** to **process Thing Description**

Challenge 3: Example



Conclusions

- Digital Twins have **lots of data** and has **to be handled**.

- A **semantic interoperable based approach** has been created, to handle the problem of describing and exchanging information between different systems.

- Also, to **manage and orchestrate data** between internal Digital Twins tools has been made, with the option of **managing all the data by digital twin processes**.

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