A Linked Data Primer

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Acknowledgements

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Outline

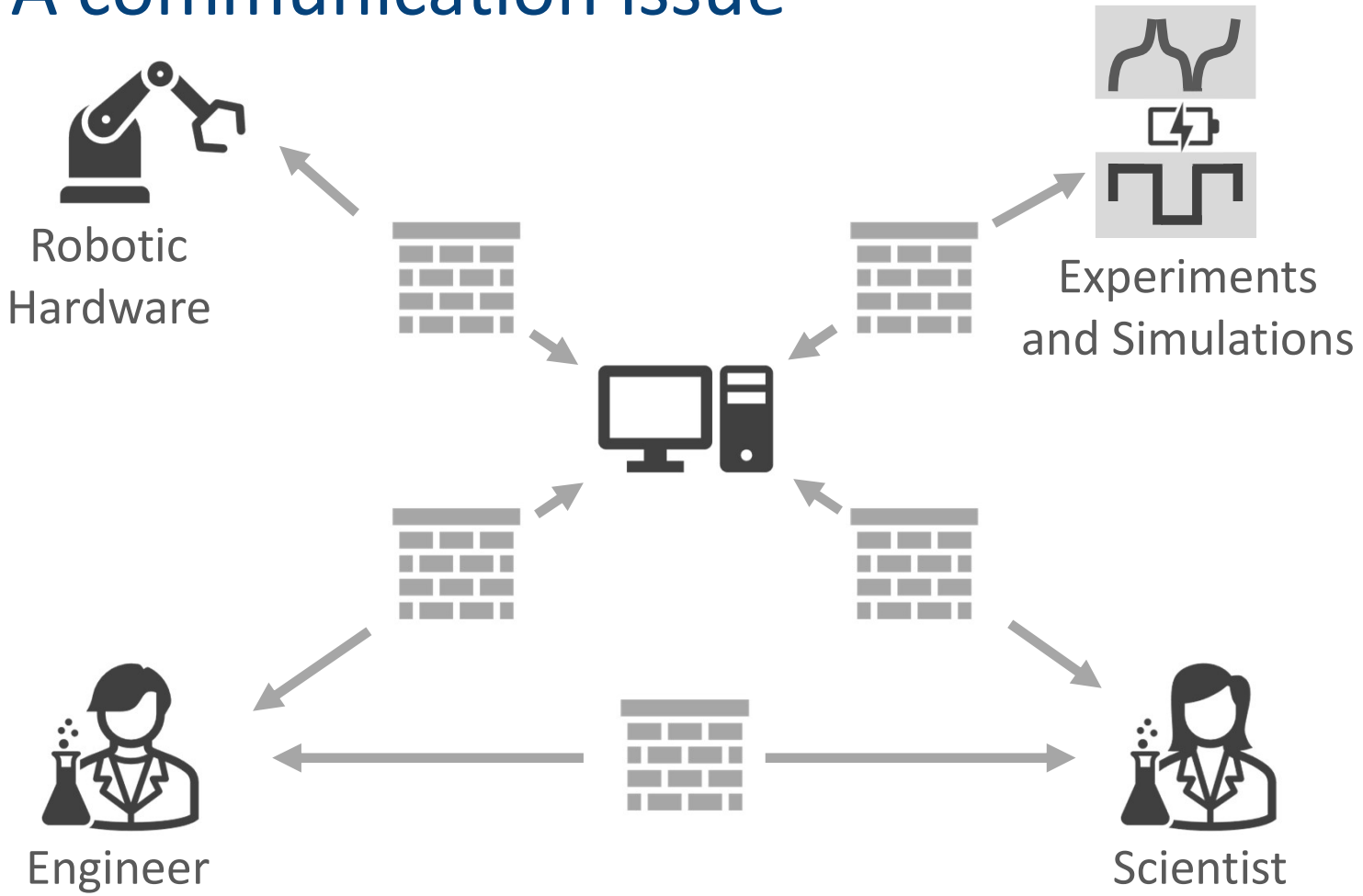
What are we trying to solve with linked data

How to link data

What can we do with linked data

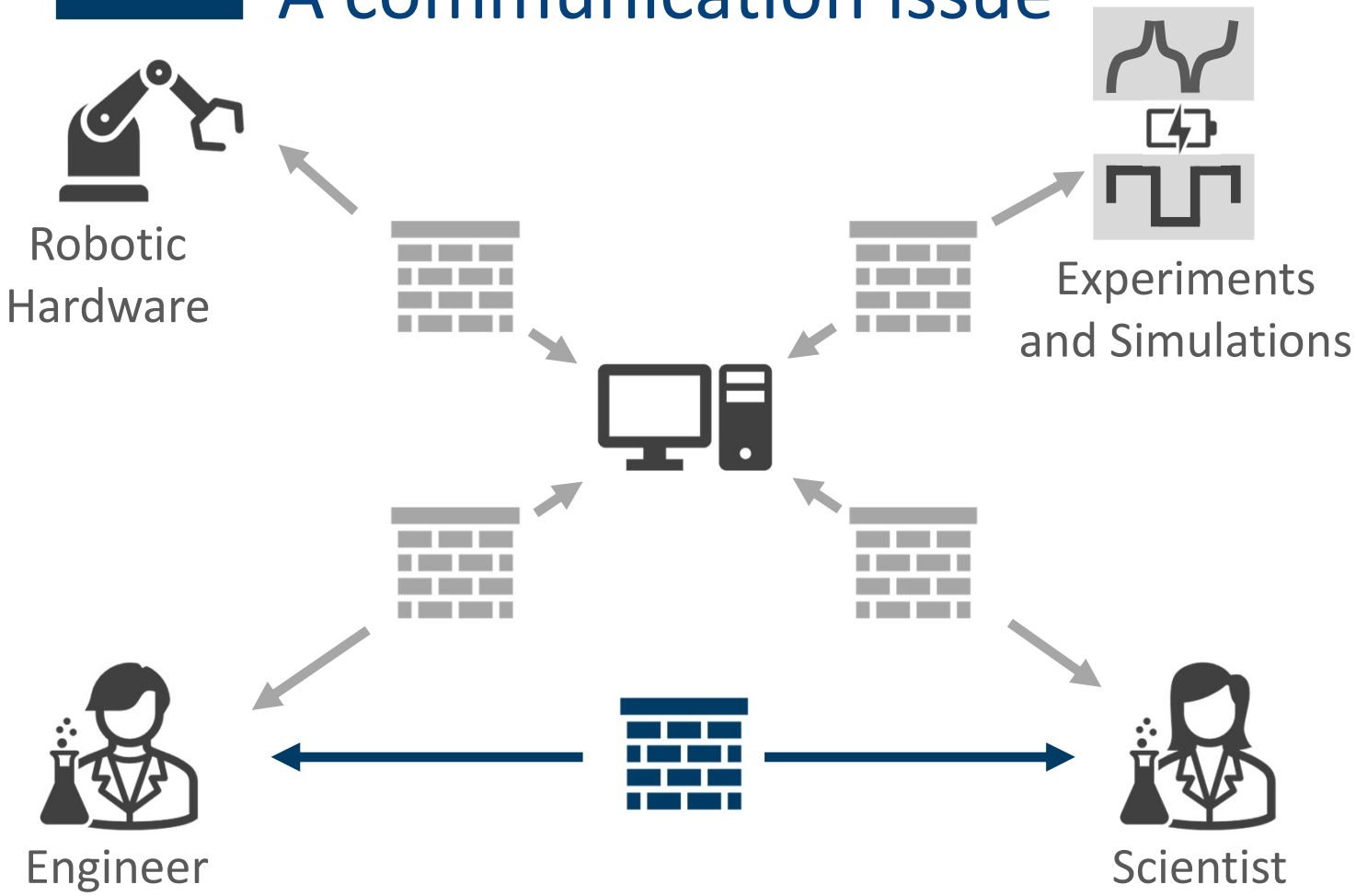
What are we solving?

A communication issue



What are we solving?

A communication issue

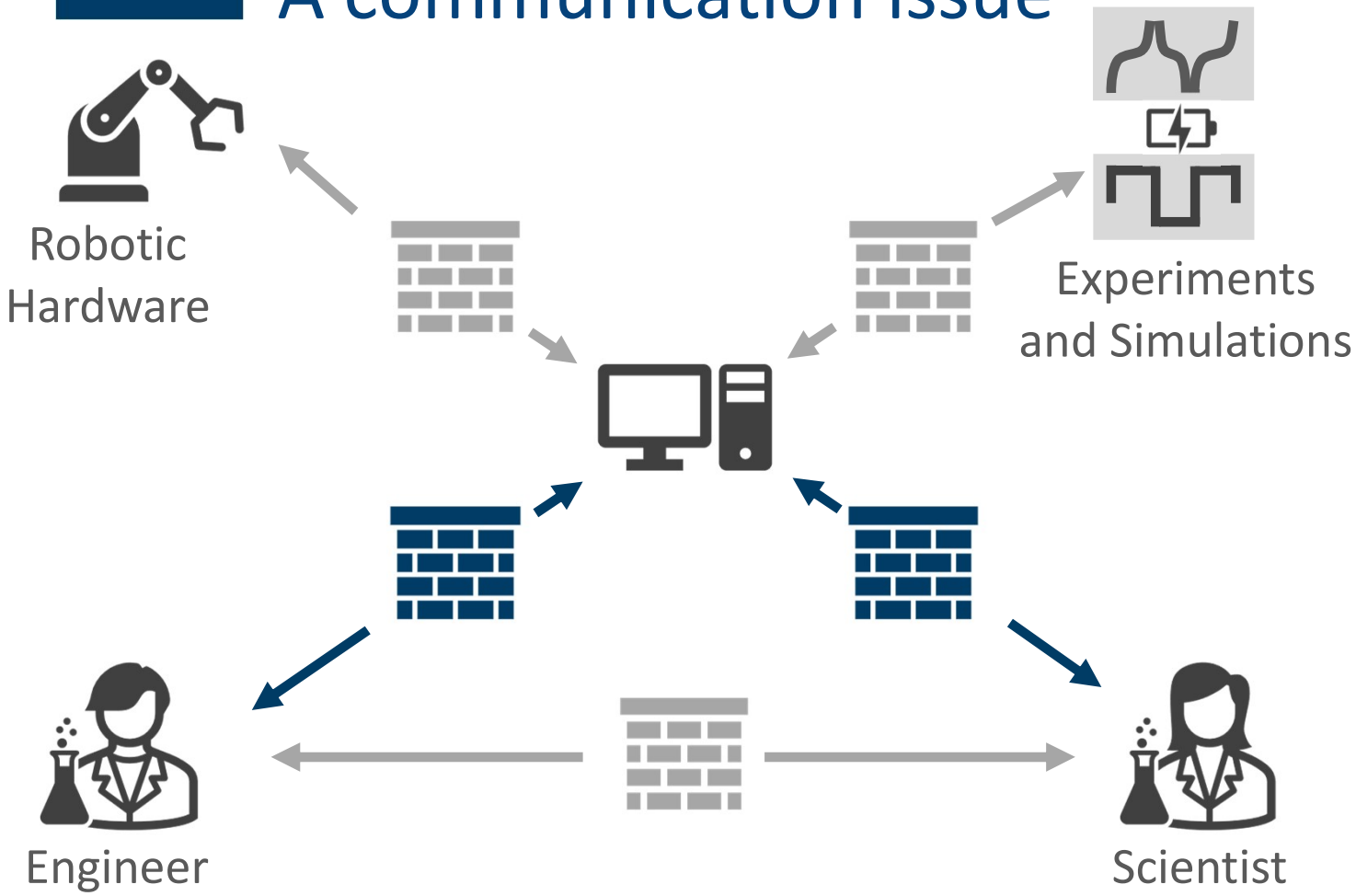


Interaction between human actors

- Terminology
- Languages
- Requirements
- Technical background

What are we solving?

A communication issue

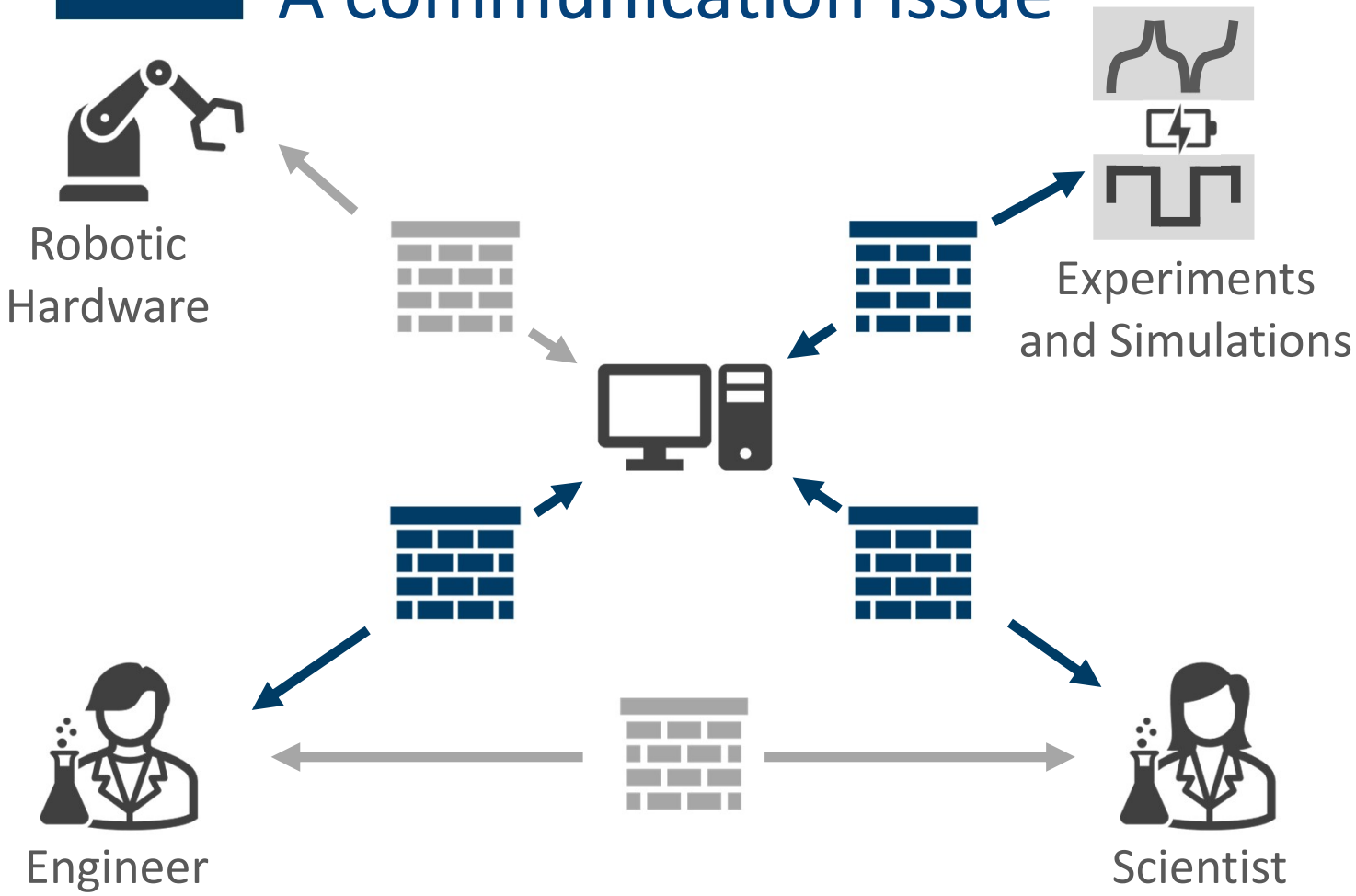


Exchange of data

- Formats
- Metadata
- Methodology
- Postprocessing
- Access

What are we solving?

A communication issue

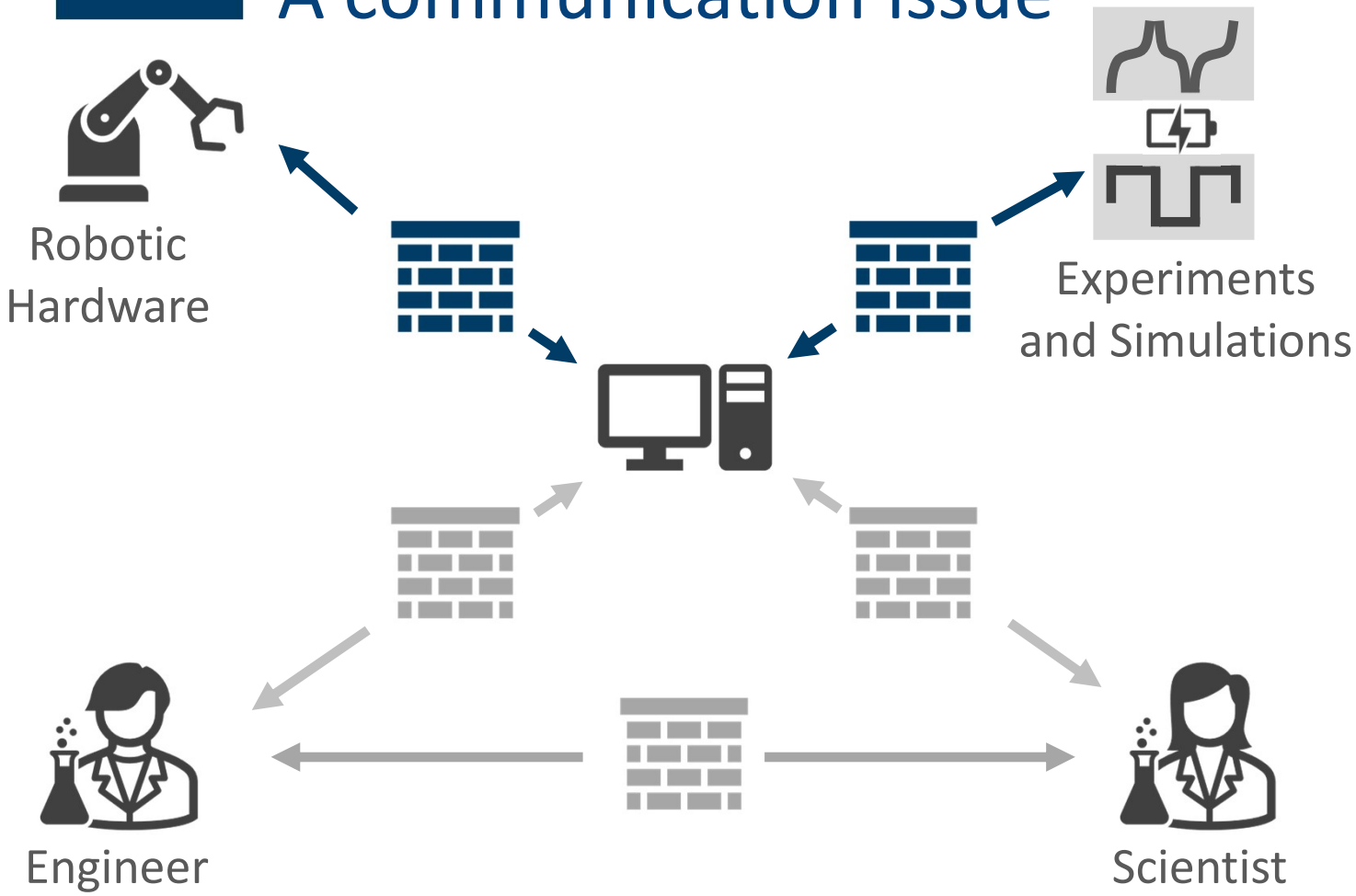


Reproducibility

- Scope
- Inputs
- Methodology
- Pre-/post-processing
- Comparison
- Provenance

What are we solving?

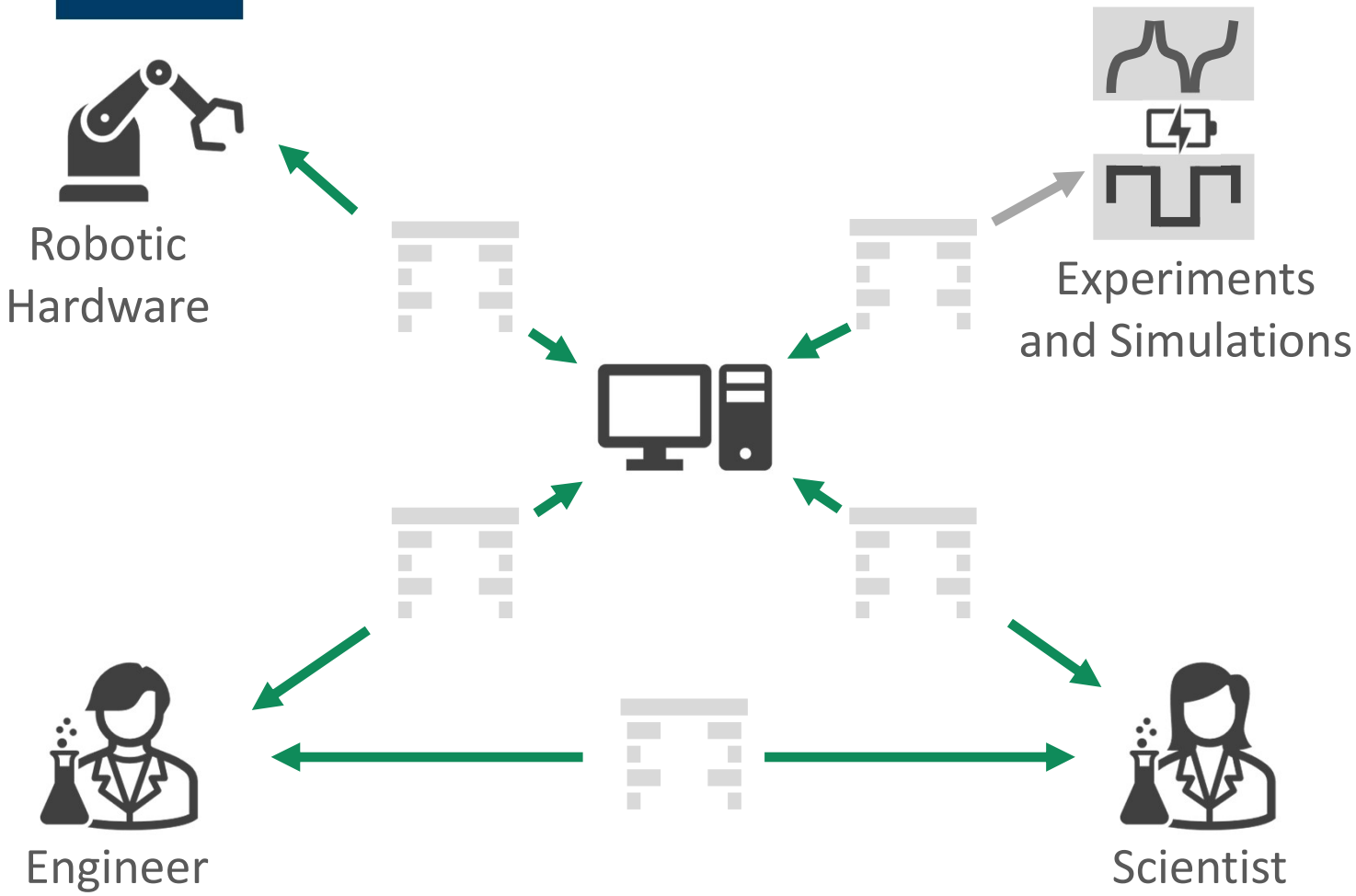
A communication issue



Interaction with autonomous machines

- Data Exchange format
- Metadata
- Safety and security
- Robustness

What are we solving?



Linked data breaks barriers down by ensuring

- Enough context to understand data
- Enough information to reproduce results
- Streamlined interactions with hardware
- Streamlined exchange and access

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How to link data

In 3 ~~easy~~ steps

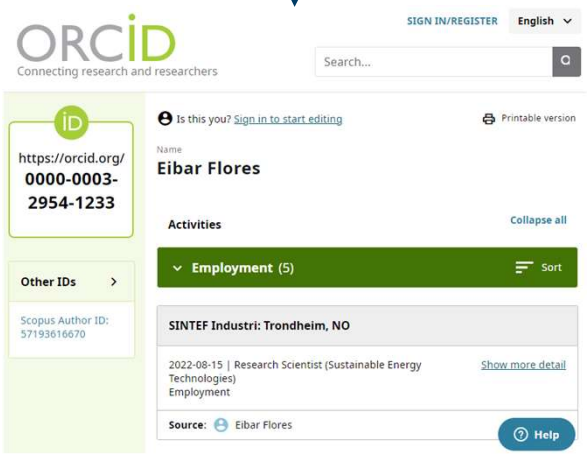
How to link data
1. Assign unique identifiers

Unique identifier: Sequence of characters uniquely identifying a resource used in the web. IDs must resolve to a document offering further data about the resource.

Person

https://orcid.org/0000-0003-2954-1233

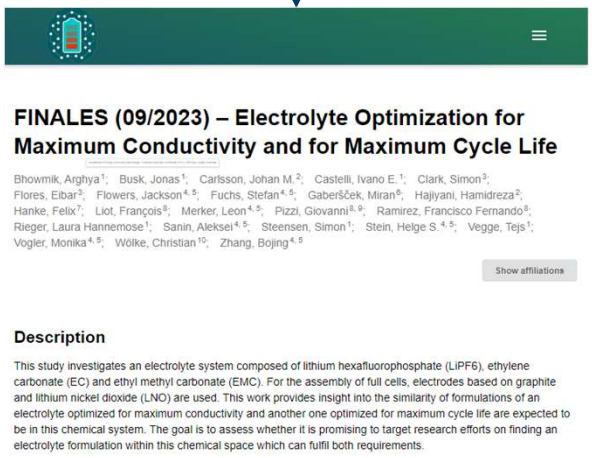
resolve



Dataset

https://archive.big-map.eu/records/vzm2s-m5484

resolve



Publication

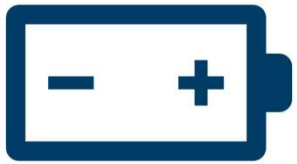
https://doi.org/10.1002/batt.202100117

resolve

How to link data
2. Use open, controlled vocabularies

Controlled vocabulary: List of concepts of predefined, agreed and curated terms with unambiguous meaning. Concepts themselves must be uniquely identified (URLs).

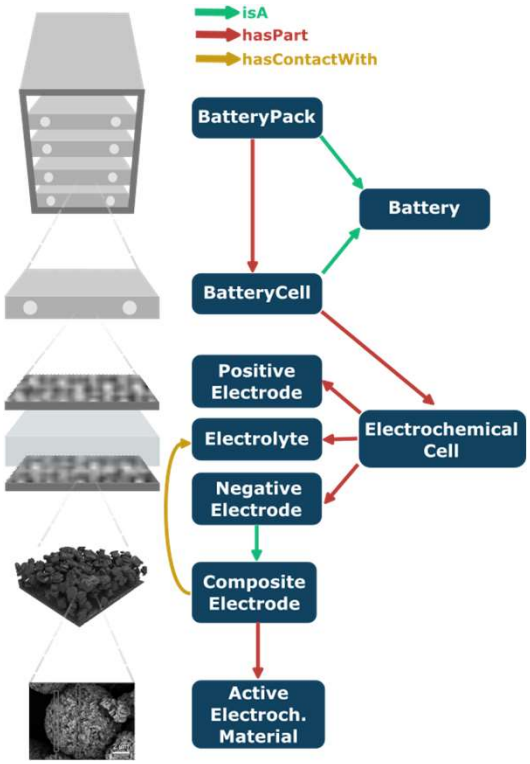
Web vocabularies: digital resources
Datasets, file formats, images, multimedia, events, locations, persons, software, …



BattINFO: batteries + electrochemistry
Voltage, current, EIS, CCCV, Battery, Electrode, Active Material, LFP, NCM, SEI, Lithium Plating …

How to link data
2. Use open, controlled vocabularies

BattINFO: a machine-readable description of concepts in batteries and electrochemistry.



Concepts are organized as a network:

Nodes: Battery Concepts

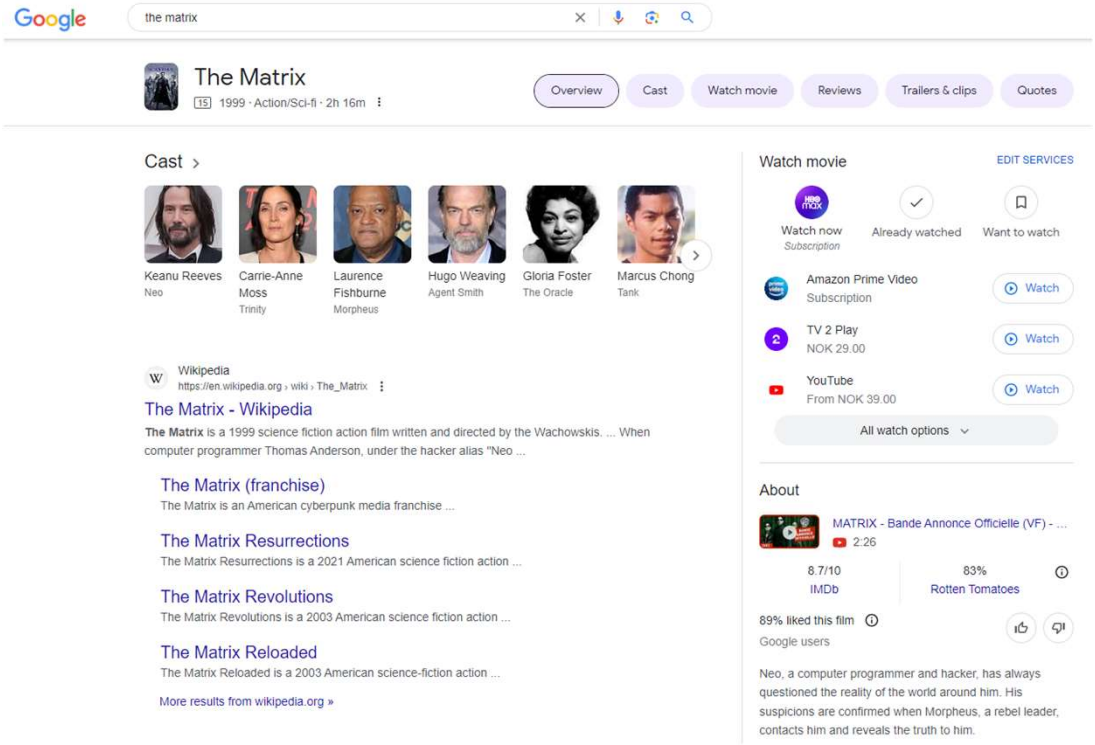
Edges: relations among concepts

Provides:

- The vocabulary to index battery data
- The connections representing battery knowledge

How to link data
2. Use open, controlled vocabularies

Schema.org: a machine-readable description of web resources



Concepts are organized as hierarchy:

Nodes: Web Concepts

Edges: Relations among concepts

Provides:

- The vocabulary to describe and index web resources
- Interoperability for search engines (e.g. google)

How to link data
2. Use open, controlled vocabularies

Additional vocabularies: tailored to some domains.

CSVW Namespace Vocabulary Terms
W3C Document 06 June 2017

Describes: CSV (tabular) files
Maintainer: W3C
Prefix: “csvw”

CHAMEO

Describes: Characterization of materials
Maintainer: EMMC Task Force
Prefix: “chameo”

DublinCore

Describes: Web resources
Maintainer: The Dublin Core™ Metadata Initiative
Prefix: “dc”

EUropean Research Information Ontology (EURIO)

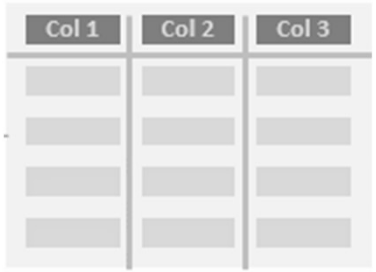
Describes: Research projects
Maintainer: European Union Vocabularies
Prefix: “eurio”

How to link data

3. Describe and link data in open format

JSON-LD: Method of annotating and linking data with the widely-used, machine-readable JSON format.

Test.csv



Test_metadata.jsonld

```
"@context": "https://mydomain.com/context.json"
"csvw:tableSchema": {
                "csvw:columns": [
                 {
                  "csvw:name": "time",
                  "csvw:titles": "Time / s",
                  "csvw:propertyUrl": {
                    "@type": "Time",…},…}
                 {
                  "csvw:name": "voltage",
                  "csvw:titles": "Voltage / V",
                  "csvw:propertyUrl": {
                    "@type": "CellVoltage"
                  },
            …
```

Annotations become entries in the hierarchy of JSON fields

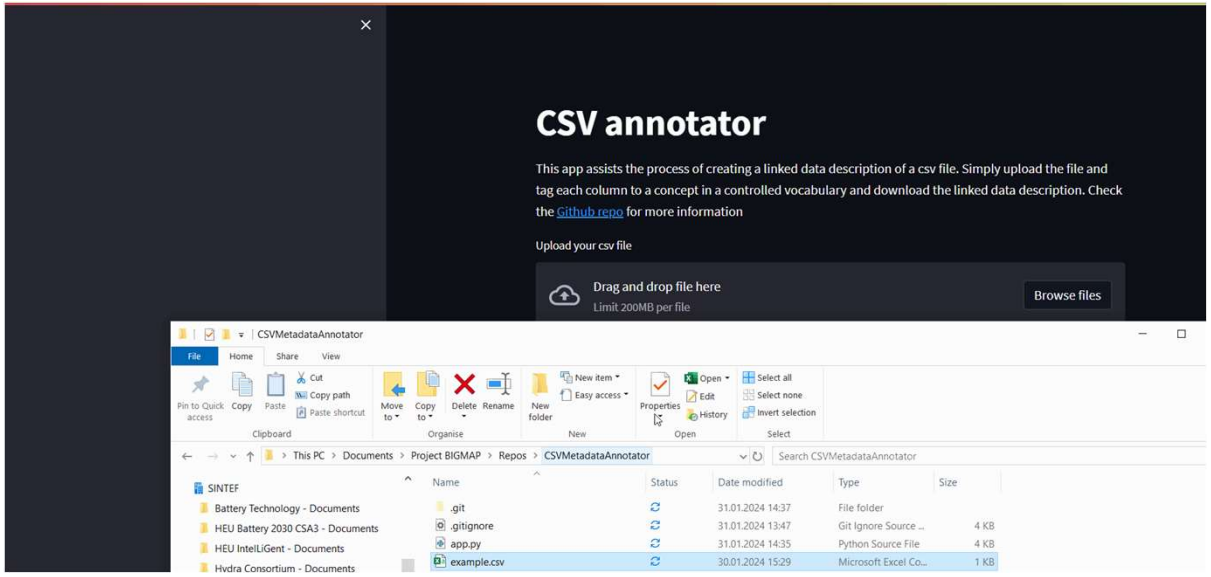
Annotations might live:

- Within the same data file (e.g. HDF5)
- As a separate accompanying file to the data
- All data, metadata and annotations in single JSON file

How to link data
3. Describe and link data in open format

Do I have to write all these annotations manually?

Hopefully NOT: we build User Interfaces to make annotations user-friendly



Test_metadata.jsonld

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"@context": “https://mydomain.com/context.json”
"csvw:tableSchema": {
                "csvw:columns": [
                 {
                  "csvw:name": "time",
                  "csvw:titles": "Time / s",
                  "csvw:propertyUrl": {
                    "@type": "Time“,…},…}
                 {
                  "csvw:name": "voltage",
                  "csvw:titles": "Voltage / V",
                  "csvw:propertyUrl": {
                    "@type": "CellVoltage"
                  },
              …
```

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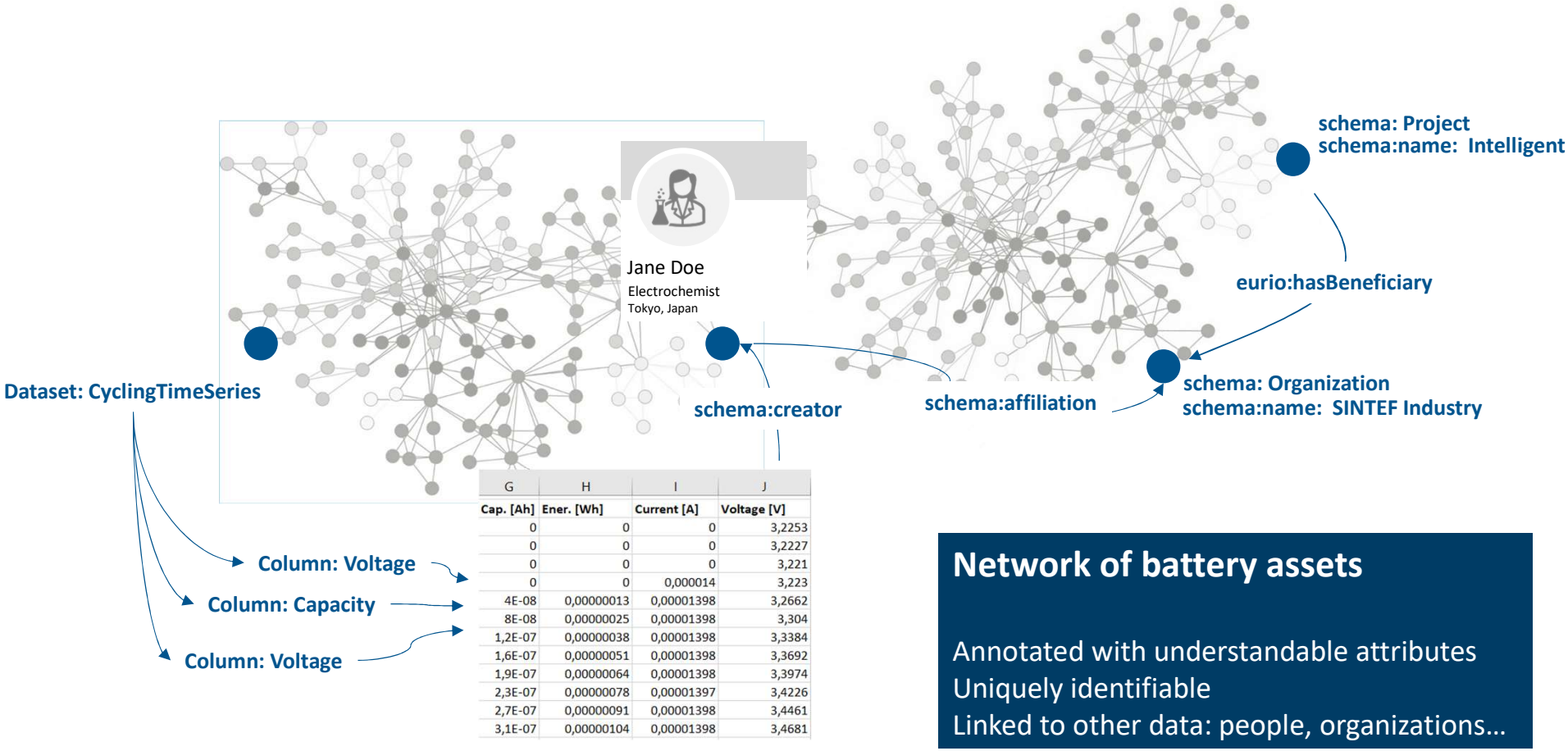
Linked data:
what can we do with it?

What can we do with Linked Data

Build a network of battery assets



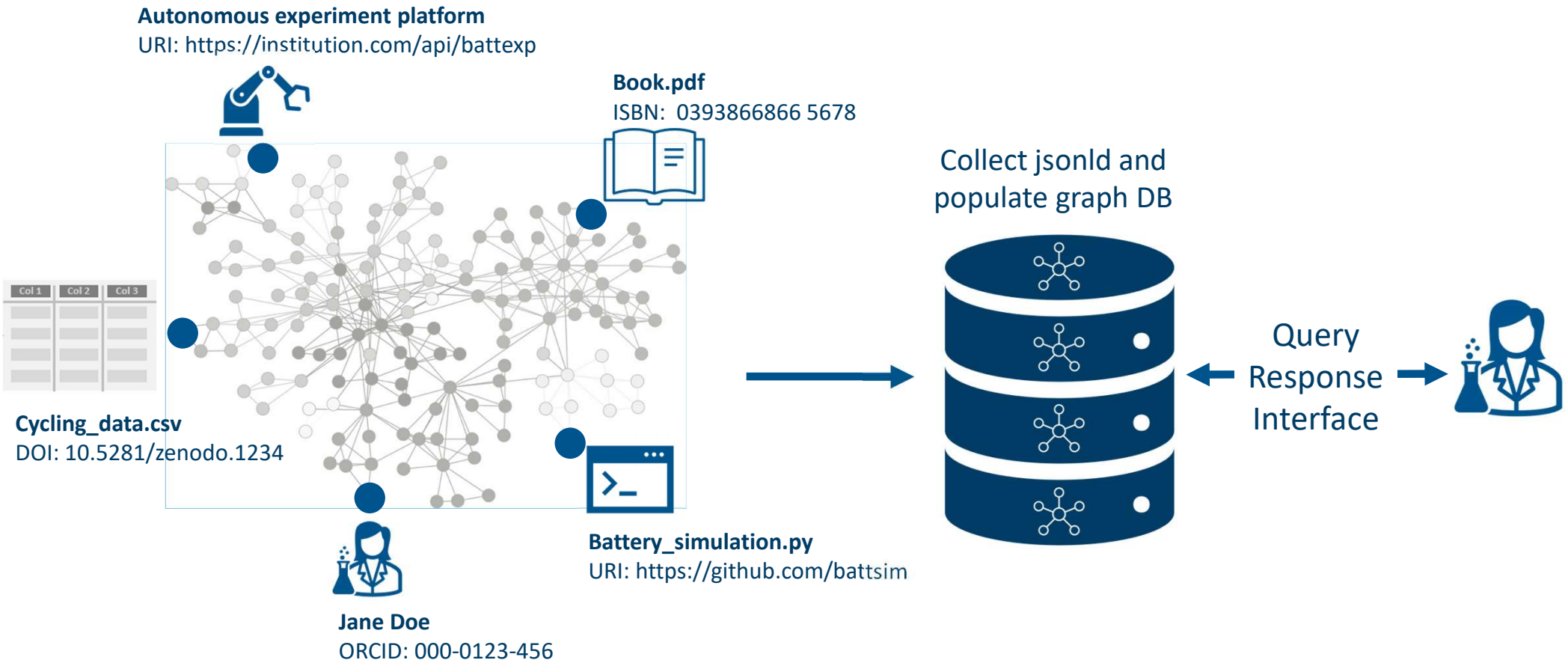
G	H	I	J
Cap. [Ah]	Ener. [Wh]	Current [A]	Voltage [V]
0	0	0	3,2253
0	0	0	3,2227
0	0	0	3,221
0	0	0,000014	3,223
4E-08	0,00000013	0,00001398	3,2662
8E-08	0,00000025	0,00001398	3,304
1,2E-07	0,00000038	0,00001398	3,3384
1,6E-07	0,00000051	0,00001398	3,3692
1,9E-07	0,00000064	0,00001398	3,3974
2,3E-07	0,00000078	0,00001397	3,4226
2,7E-07	0,00000091	0,00001398	3,4461
3,1E-07	0,00000104	0,00001398	3,4681

Network of battery assets

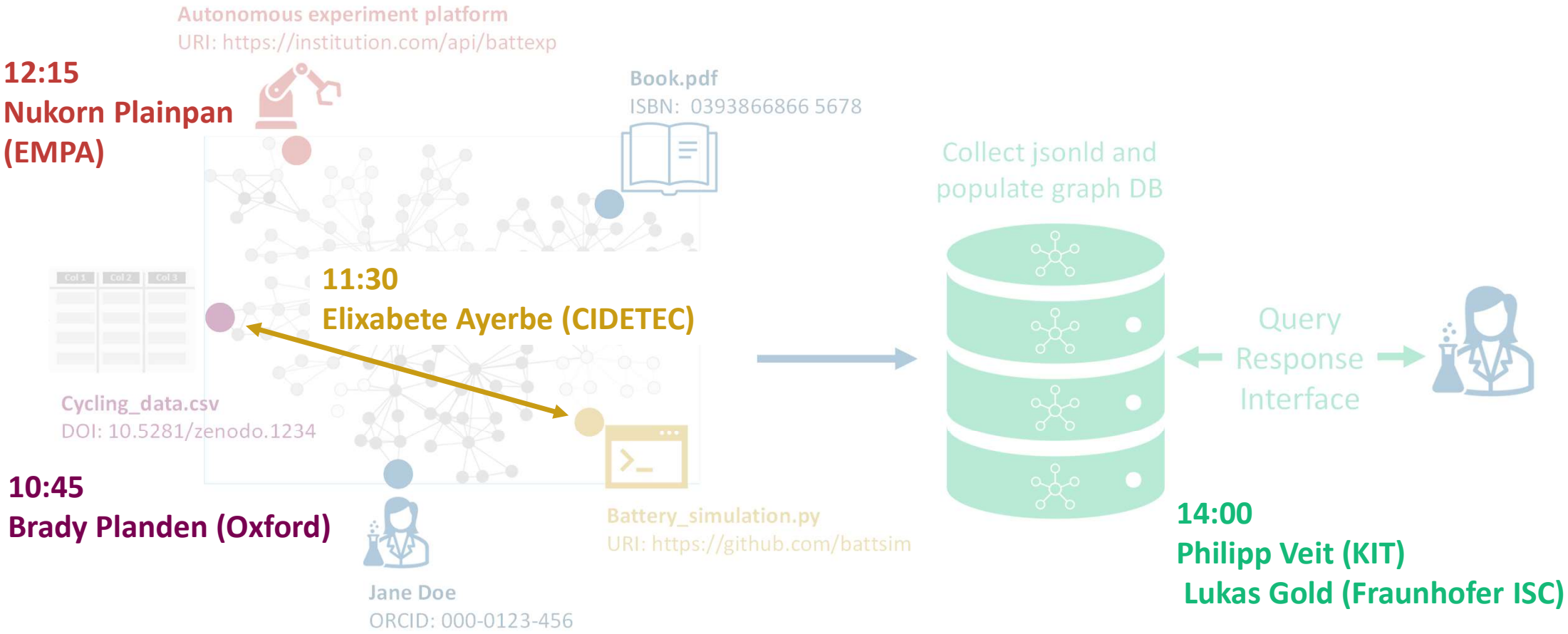
Annotated with understandable attributes
Uniquely identifiable
Linked to other data: people, organizations…

What can we do with Linked Data

Make network accessible in Knowledgebase



Upcoming exciting talks



12:15
Nukorn Plainpan (EMPA)

11:30
Elixabete Ayerbe (CIDETEC)

10:45
Brady Planden (Oxford)

14:00
Philipp Veit (KIT)
Lukas Gold (Fraunhofer ISC)

Linked data

1. Uniquely identified and referencing other data (URLs)
2. Annotated with controlled vocabularies (Ontologies)
3. In a machine-readable format supporting annotations (JSON-LD)

Linked data enables reproducing, exchanging and automating battery research.

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Technology for a better society