A Survey of Federative Approaches for Model Management in MBSE

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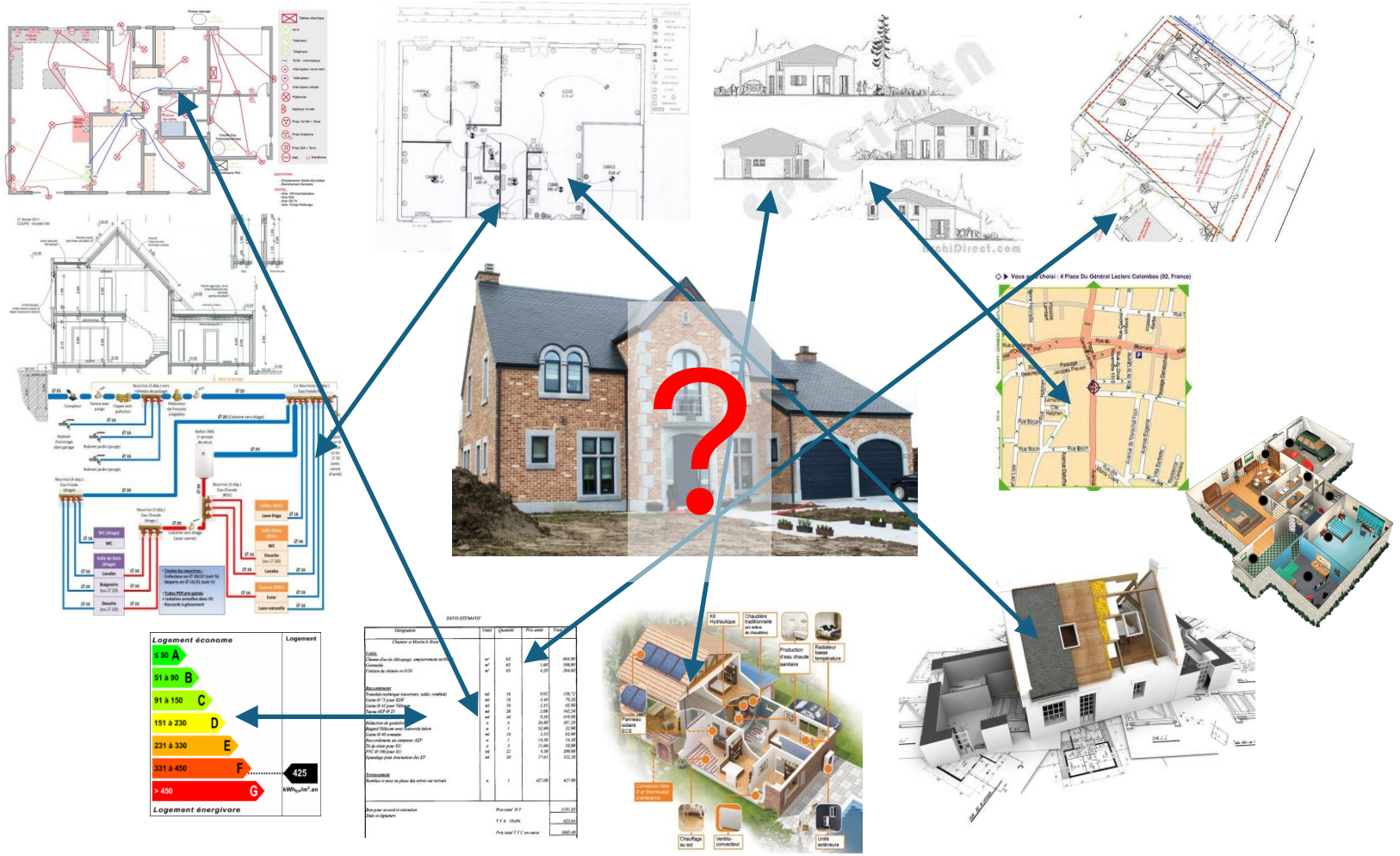
Plethora of Models !!! ...



Background

Information Systems

"... feel the need to build Model Management systems, emerging from the central use of data and decision models, which both need dedicated tools and workflows to extract valuable information efficiently ..."

Robert Blanning. 2003. Encyclopedia of Information Systems. Academic Press

Business Processes

discussed the same need, although naturally more oriented towards "dynamic" models representing processes, decisions, analyses, etc., and emphasising the crucial need for collaboration

Fred A. Cummins. 2016. Building the Agile Enterprise, With Capabilities, Collaborations and Values

Databases

"Model Management comprises technologies and mechanisms to support the integration, transformation, evolution, and matching of models"

"a Model Management System (MMS) has to provide definitions for models [...], mappings (i.e. relationships between different models), and operators (i.e. operations that manipulate models and mappings)"

Philip A. Bernstein. 2003. Applying Model Management to Classical Meta Data Problems. In Conference on Innovative Data Systems Research

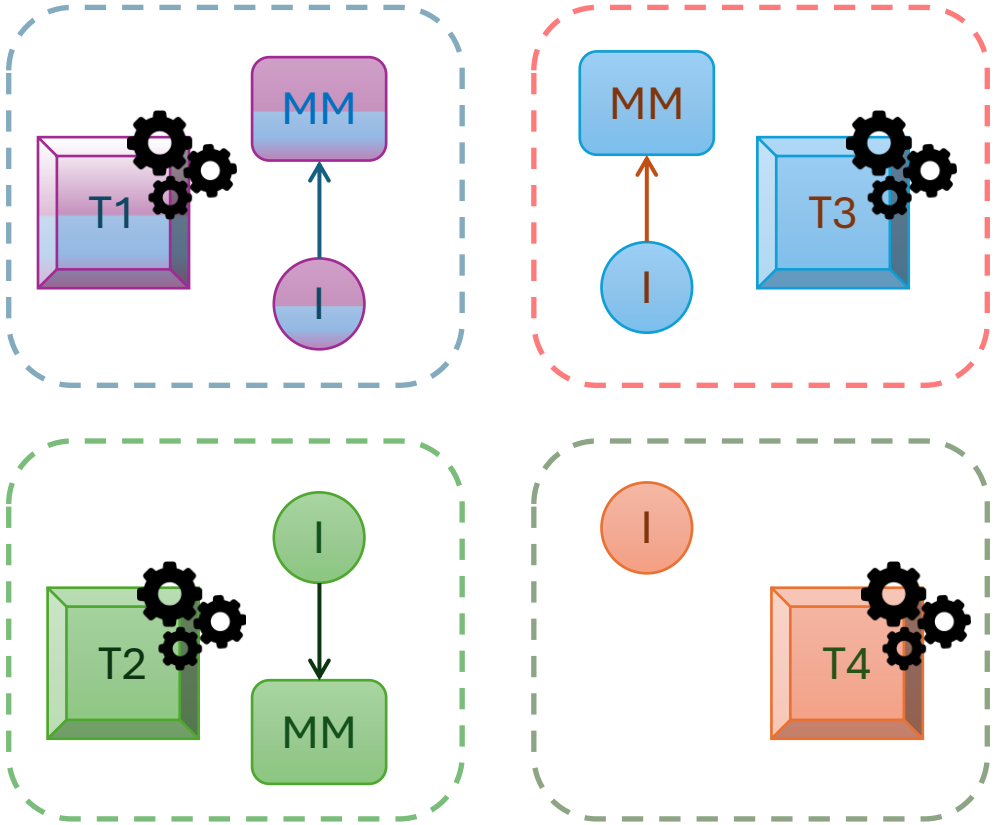
Background

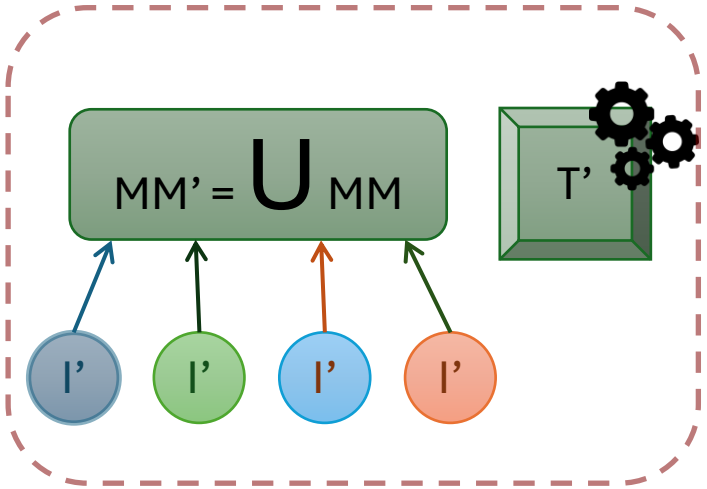
Model-Driven Engineering

models may represent a physical or computational reality with different scales of fidelity, and are consequently, often updated along real-life evolutions. In turn, engineers (or other models) may query these models, and collaboratively perform operations and analyses on the repository.

Yentl Van Tendeloo and Hans Vangheluwe. 2017. The Modelverse: A tool for Multi-Paradigm Modelling and simulation. In Winter Simulation Conference

Model Integration



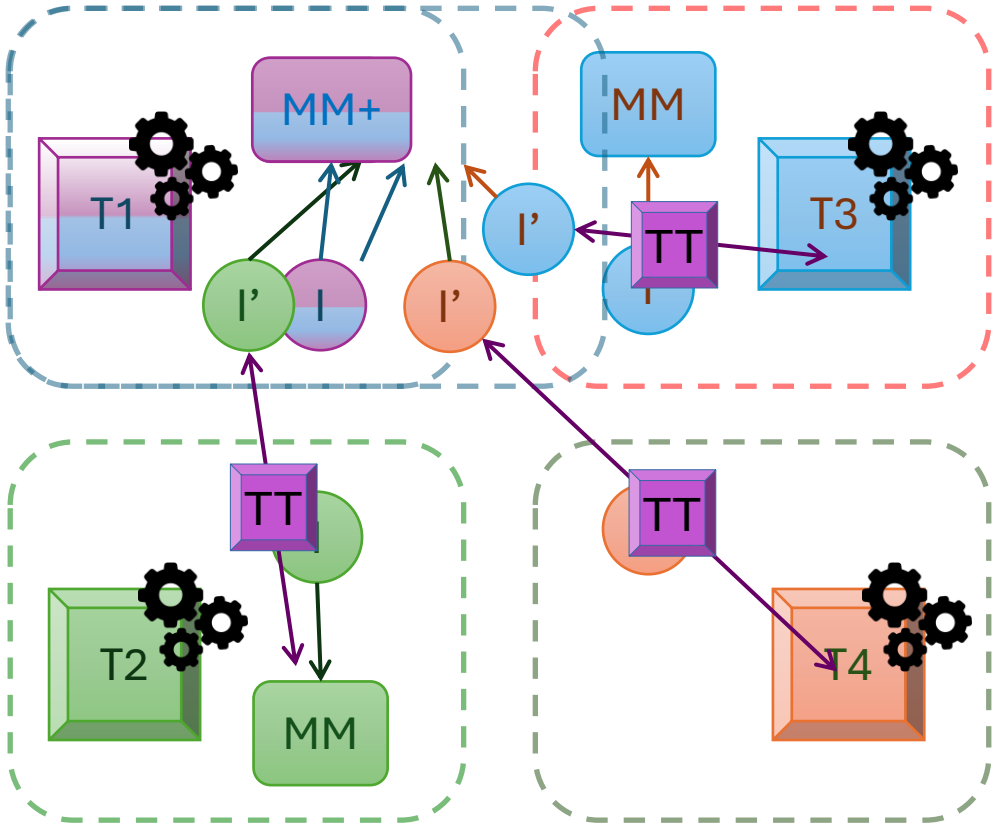


Construct a union meta-model from all the utilized meta-models.

Needs a new tool T'. If something changes, needs change in T'

Standard ISO 14258 : Interoperability, integration, and architectures for enterprise systems and automation applications committee, 1998

Model Unification



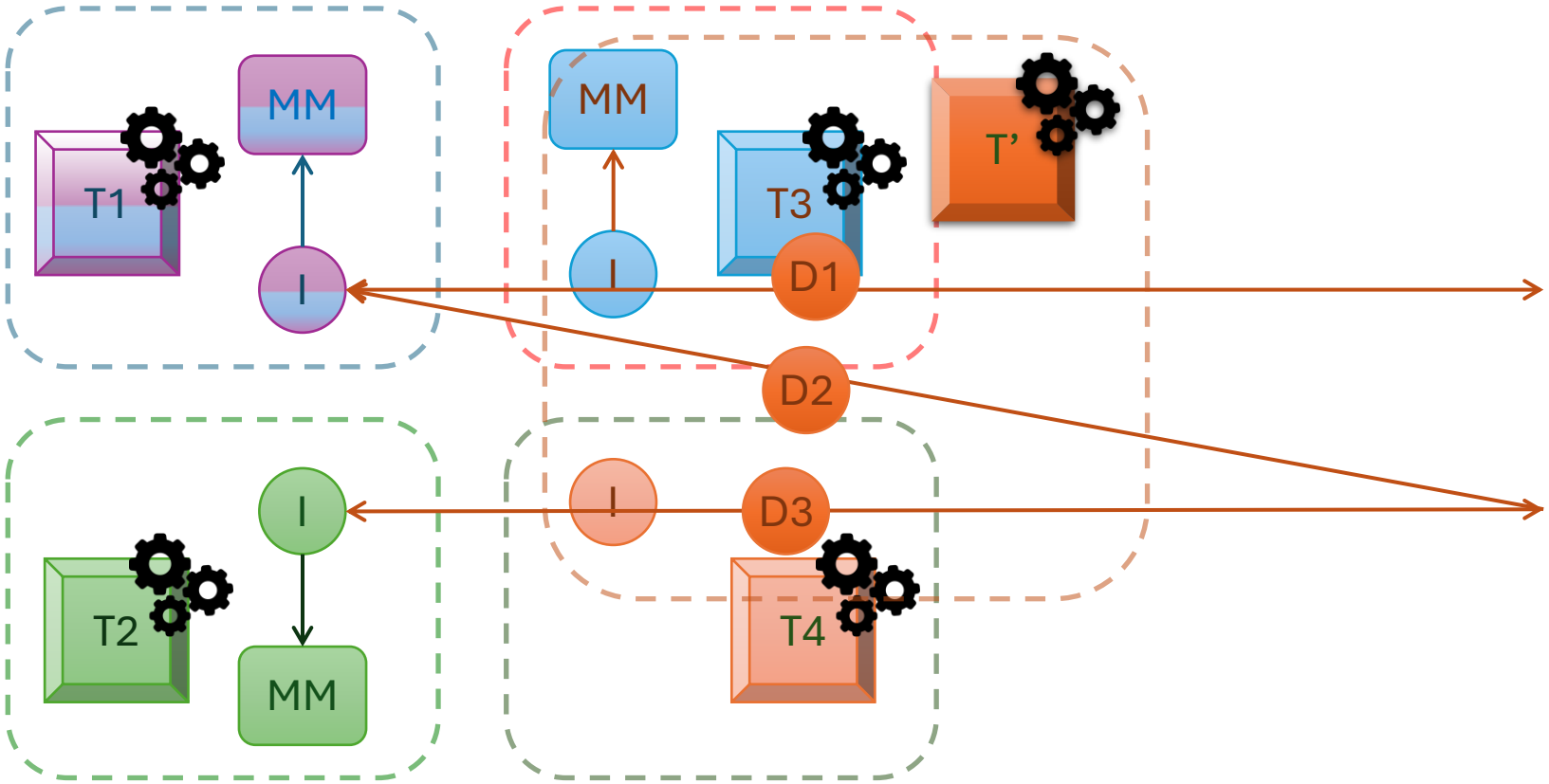
Choose one meta-model that becomes the pivot.

Needs transformations from all meta-models to this pivot.

How to choose pivot? Maybe meta-models cannot be related easily? Also lose information..

Standard ISO 14258 : Interoperability, integration, and architectures for enterprise systems and automation applications committee, 1998

Model Federation



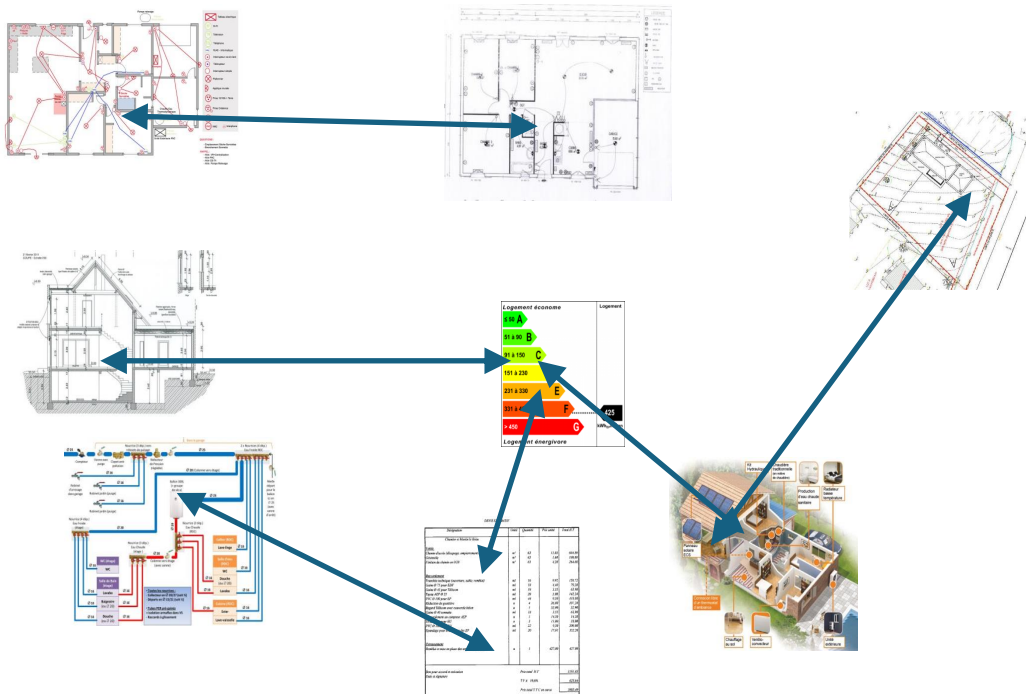
Identify and reify all the links.

Needs a dedicated tool to handle all these links.

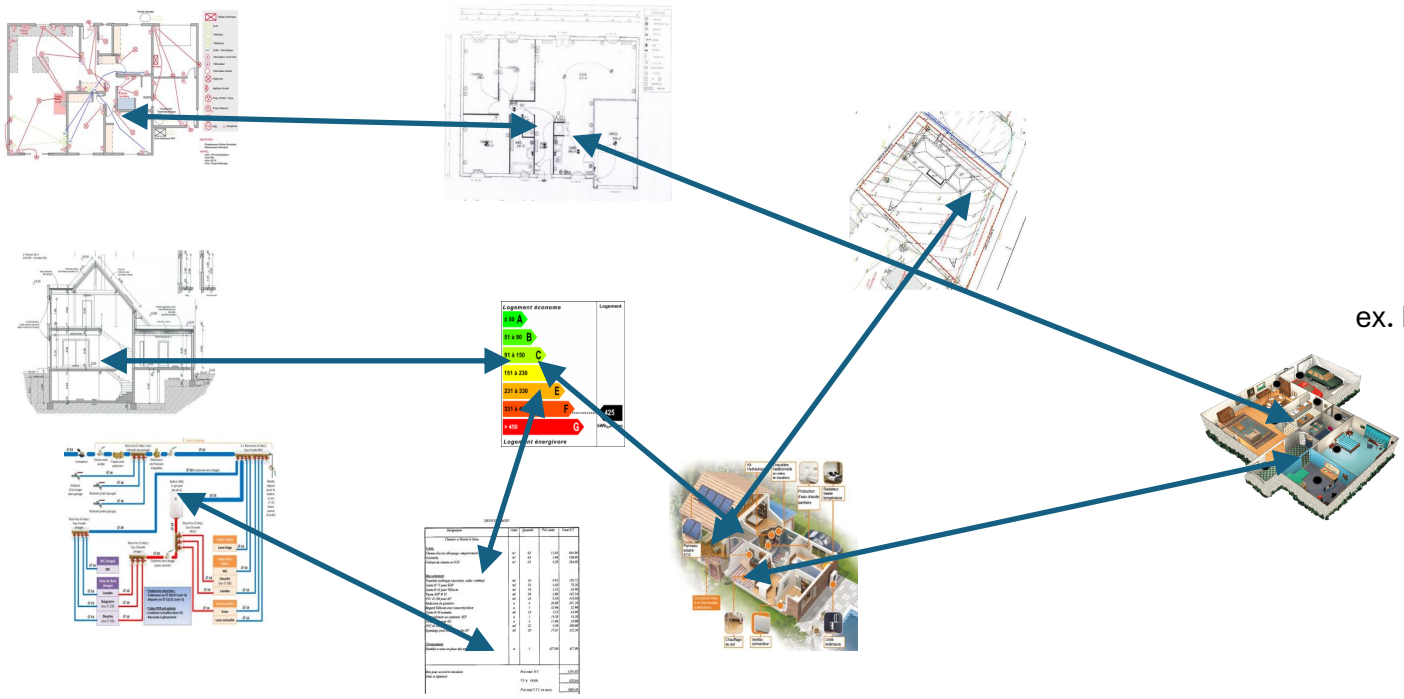
Contributions

- Feature Model of Model Federation
- Preliminary Classification of literature
- Available open-source in a Zenodo repo

Model Federation - Structure

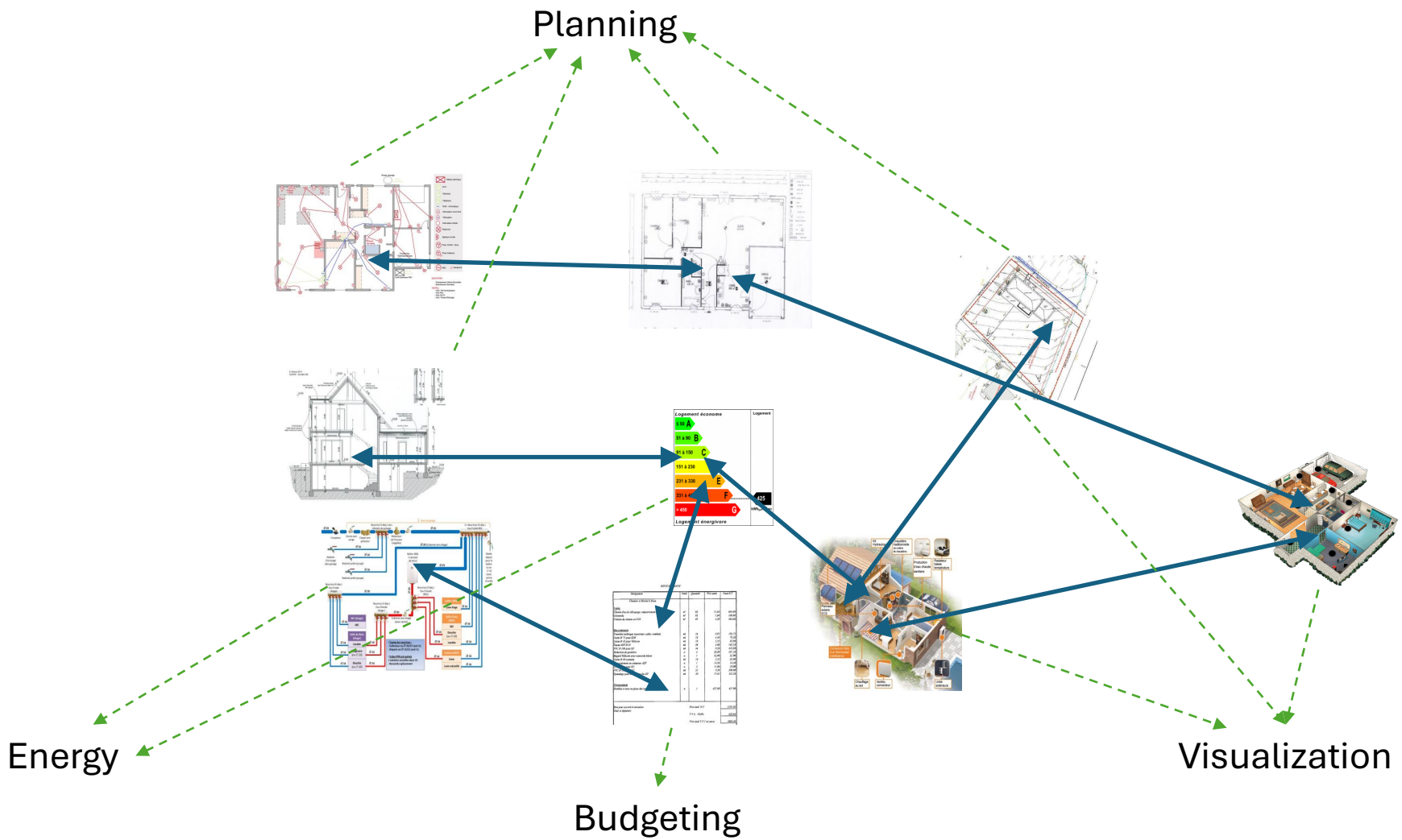


Model Federation - Operation



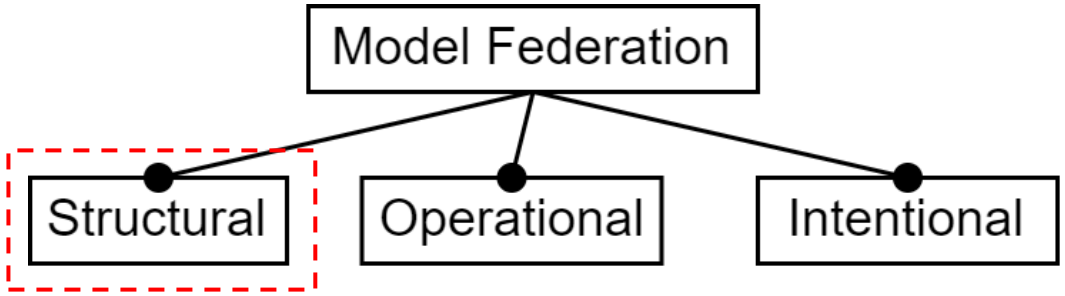
ex. Model-transformation

Model Federation - Intention



Classification / Feature Model

A Model Federation (MF) can be seen as a graph of links connecting artefacts.



- the nature of vertices
- how edges are organised
- what they represent

Directly inspired from Sylvain Guerin. 2023. FML: A Model Federation Language For Semantic Interoperability of Heterogeneous Information Sources. Ph. D. Dissertation. École Nationale Supérieure de Techniques Avancées Bretagne

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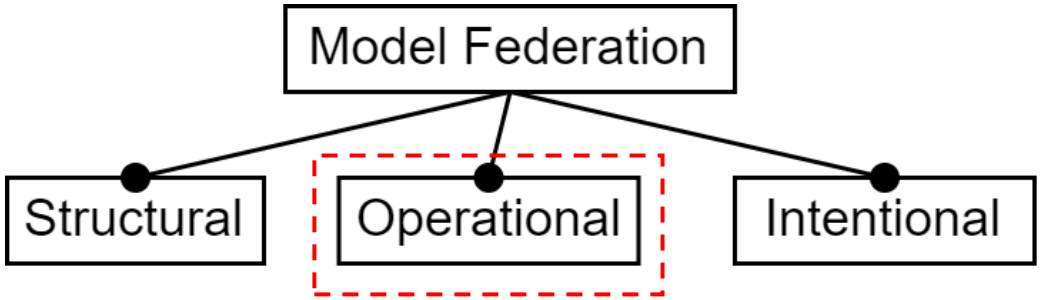

- the possible processes and operations,
- explicitly or implicitly defined
- how they compare with each other

Directly inspired from Sylvain Guerin. 2023. FML: A Model Federation Language For Semantic Interoperability of Heterogeneous Information Sources. Ph. D. Dissertation. École Nationale Supérieure de Techniques Avancées Bretagne

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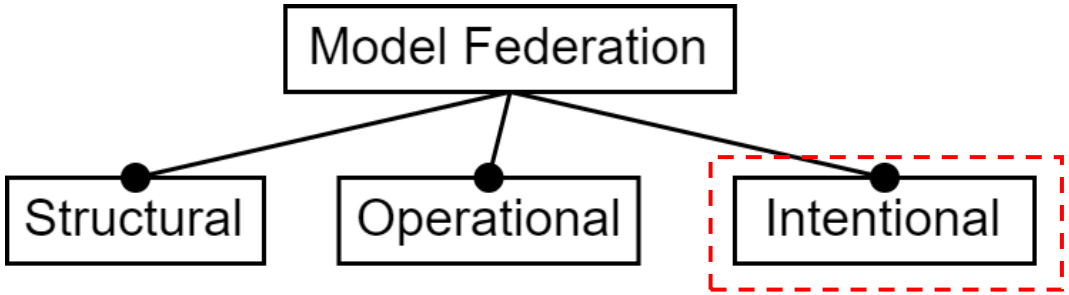
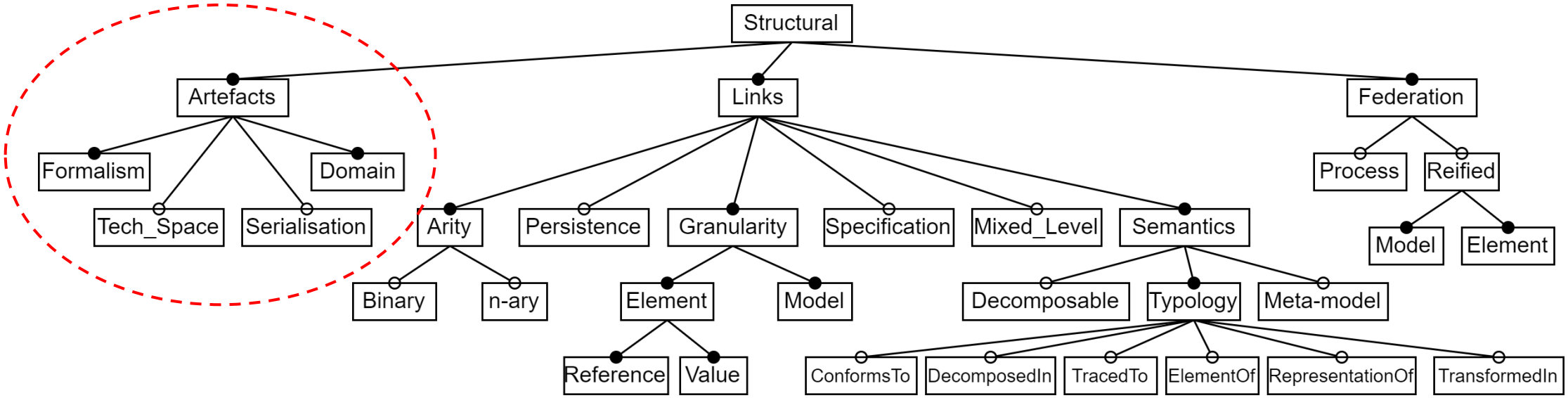


- the goals or purposes of creating the MF

Directly inspired from Sylvain Guerin. 2023. FML: A Model Federation Language For Semantic Interoperability of Heterogeneous Information Sources. Ph. D. Dissertation. École Nationale Supérieure de Techniques Avancées Bretagne

Structural Features

Federation is structurally a graph



Structural Features - Artefacts

- Formalism: Most are agnostic
- Domain: Most are agnostic
- Tech_Space: Most work with EMOF/EMF ;
  except ModelVerse and DesignSpace (ad-hoc)
- Serialisation: Many use XMI/XML;
  OpenFlexo is agnostic

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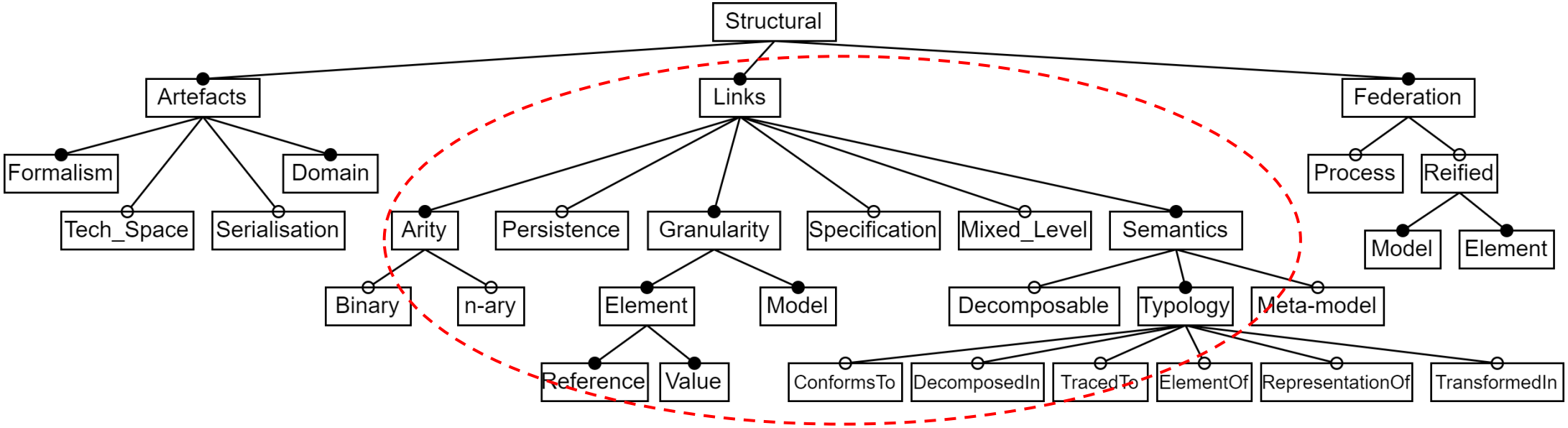
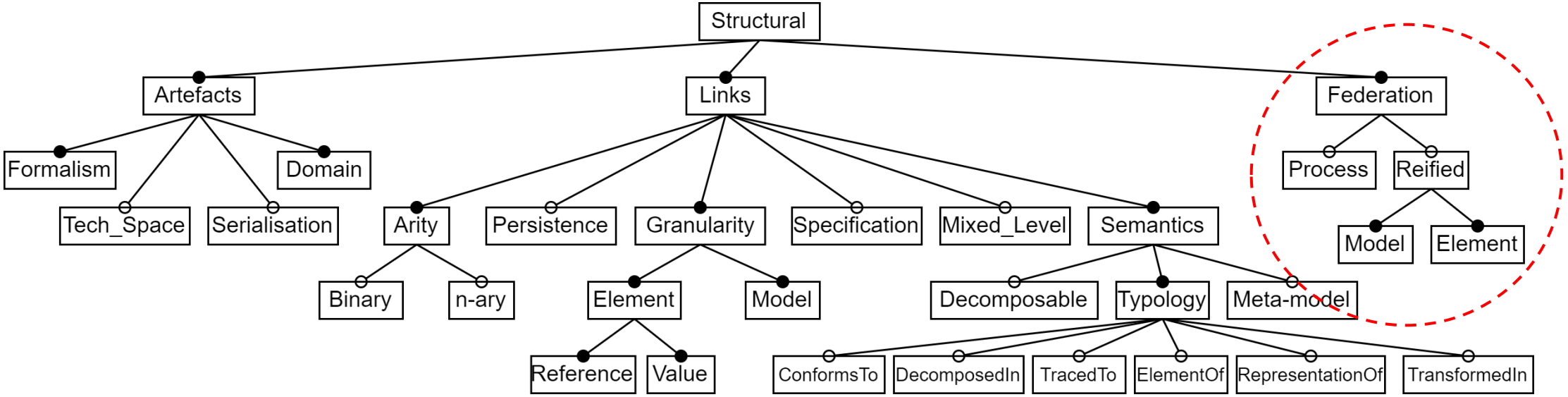


Structural Features - Links

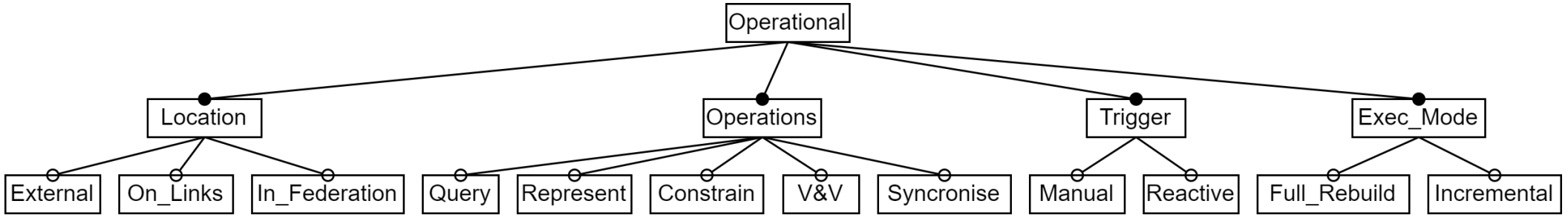
- Arity: Majority use binary links
- Granularity: Most allow fine-grained manipulation
- Semantics: Not always explicitly stated
  - Most explicitly meta-modelled
  - Most use decomposable links
- Persistance: Most persist links
  - Some only persist specification

Structural Features

Federation is structurally a graph

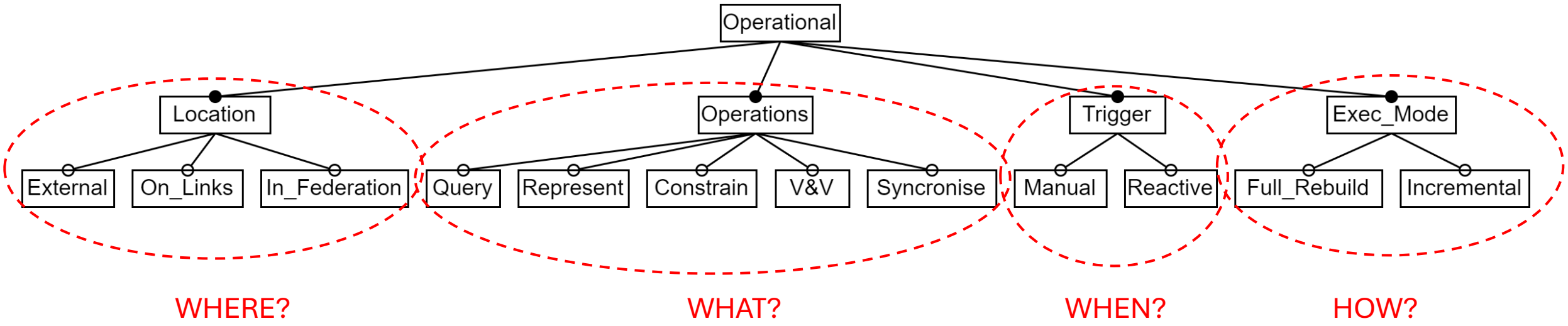


Operational Features



- An MF is only useful when it enables execution of Operations and (complex) processes on it.
- Usually, an MF tool, is not responsible for creating, deleting, or updating the Artefacts; each Artefact has dedicated domain-specific tooling for that purpose.
- The MF tool is however responsible for creating, deleting, and updating the Links

Operational Features



Operational Features

Difficult to extract from papers.

- How: Most performed with classical MDE transformations or GPLs
- What: Most for synchronisation, consistency check, trace-ability
- Location: Most on Links or External
- Trigger: Few allow manual and reactive
- Exec_Mode: Clear tendency towards Incremental

Intentional Features

- Traceability
- Unified Transformation Management
- Model consistency, checking and repair
- Model Composition
- Cross-domain analysis
- Artefact co-design
- Model edition
- Conceptual elicitation / reverse engineering

Intentional Features

- Most are generic
- Major focus on Trace-ability
- Many on consistency checking
- Cross-domain analysis usually coupled with other intentions
- Co-design poorly represented

Gaps

- Model-versioning
- Access Control
- Authoritative Source of Truth
- Model validity !!!
- Digital-Twin / Run-time model substitution

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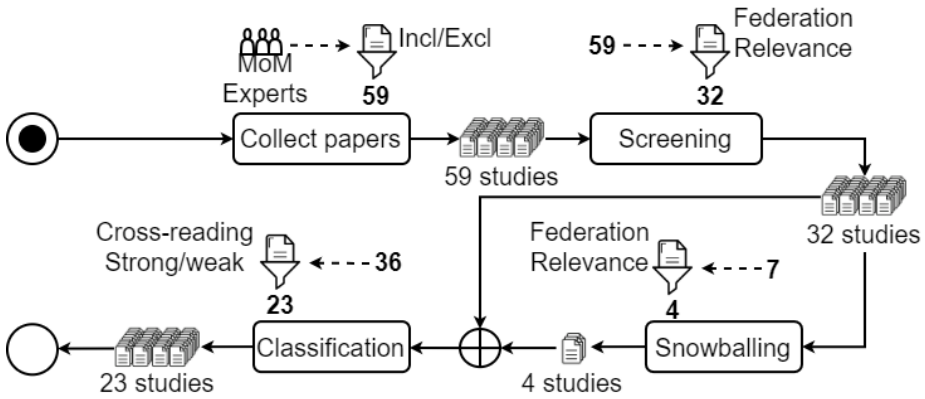
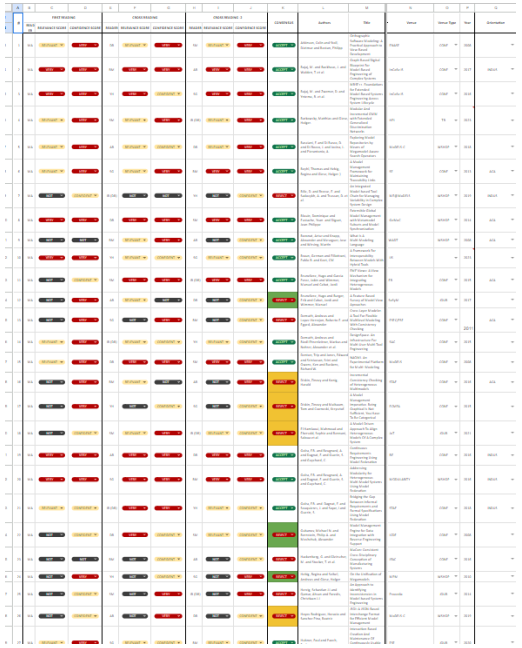
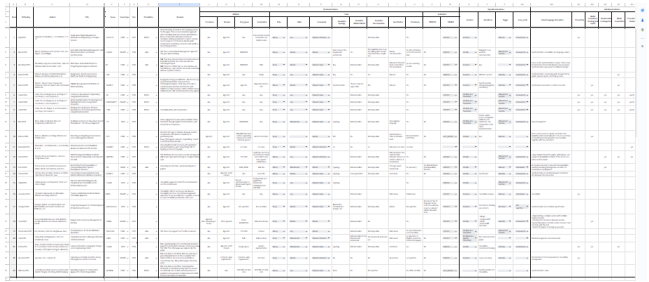
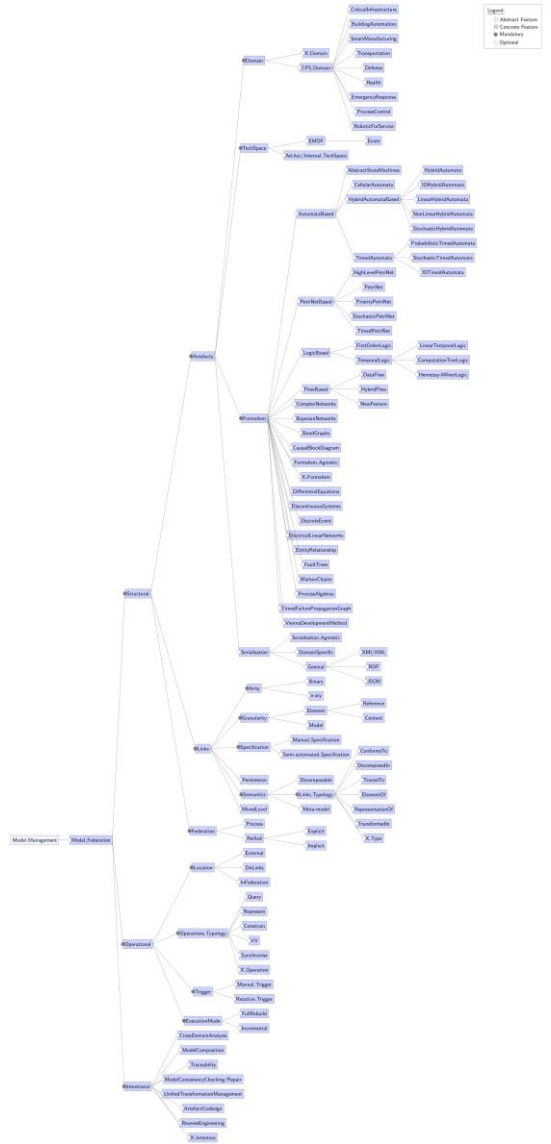
Survey Methodology









All transparency artefacts available at:

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Conclusion and Future Work

Not a systematic study ; to be improved in a future study

Designing a benchmark

What features do you think are missing?

Any relevant comments?

Future work: extended (systematic) study beyond federation
Not just reading papers, but testing tools

Is your federation approach/tool not mentioned in the paper? Sorry … please speak up

Thanks! Questions? Contact.

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Paper:
https://doi.org/10.1145/3652620.3688221

Artefact: