50. Software Factories - Metamodelling in Heterogeneous Technical Spaces

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TU Dresden
http://st.inf.tu-dresden.de/teaching/most
Version 21-0.3, 29.01.22

1) Heterogeneous technical spaces

Obligatorische Literatur

- Uwe Aßmann, Steffen Zschaler, and Gerd Wagner. Ontologies, meta-models, and the model-driven paradigm. In Coral Calero, Francisco Ruiz, and Mario Piattini, editors, Ontologies for Software Engineering and Technology. Springer, 2006.
  - http://www.springer.com/computer/swe/book/978-3-540-34517-6?cm_mmc=Google-_-Book%20Search-_-Springer-_-0
- Steffen Staab, Tobias Walter, Gerd Gröner, and Fernando Silva Parreiras. Model driven engineering with ontology technologies. In Uwe Aßmann, Andreas Bartho, and Christian Wende, editors, Reasoning Web, volume 6325, Lecture Notes in Computer Science, pages 62-98. Springer, 2010.
  - http://www.uni-koblenz.de/~staab/Research/Publications/2010/reasoningweb2010.pdf

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Other Literature

- Kurtev, I., Bezivin, J., Aksit, M.: Technological Spaces: An Initial Appraisal. In: International Symposium on Distributed Objects and Applications, DOA Federated Conferences, Industrial track, Irvine. (2002)
- Model-based Technology Integration with the Technical Space Concept. Jean Bezivin and Ivan Kurtev. Metainformatics Symposium, 2005.

- Gaševic, Dragan, Djuric, Dragan, Devedžic, Vladan. Model Driven Engineering and Ontology Development, 2nd ed., 2009, ISBN 978-3-642-00281-6
  - http://www.springer.com/computer/swe/book/978-3-642-00281-6?cm_mmc=Google-_-Book%20Search-_-Springer-_-0
- [Kendall] D. T. Chang and E. Kendall. Metamodels for RDF Schema and OWL. Proceedings of the First International Workshop on the Model-Driven Semantic Web (MDSW 2004), Monterey, USA, September 21, 2004.

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- Jendrik Johannes. Component-Based Model-Driven Software Development. PhD thesis, Technische Universität Dresden, Fakultät Informatik, December 2010. http://nbn-resolving.de/urn:nbn:de:bsz:14-qucosa-63986
  - This PhD thesis lays the ground for component models and composition technology for modeling languages.
  - www.reuseware.org
- Birgit Grammel. Automatic Generation of Trace Links in Model-driven Software Development. PhD thesis, Technische Universität Dresden, Fakultät Informatik, February 2014

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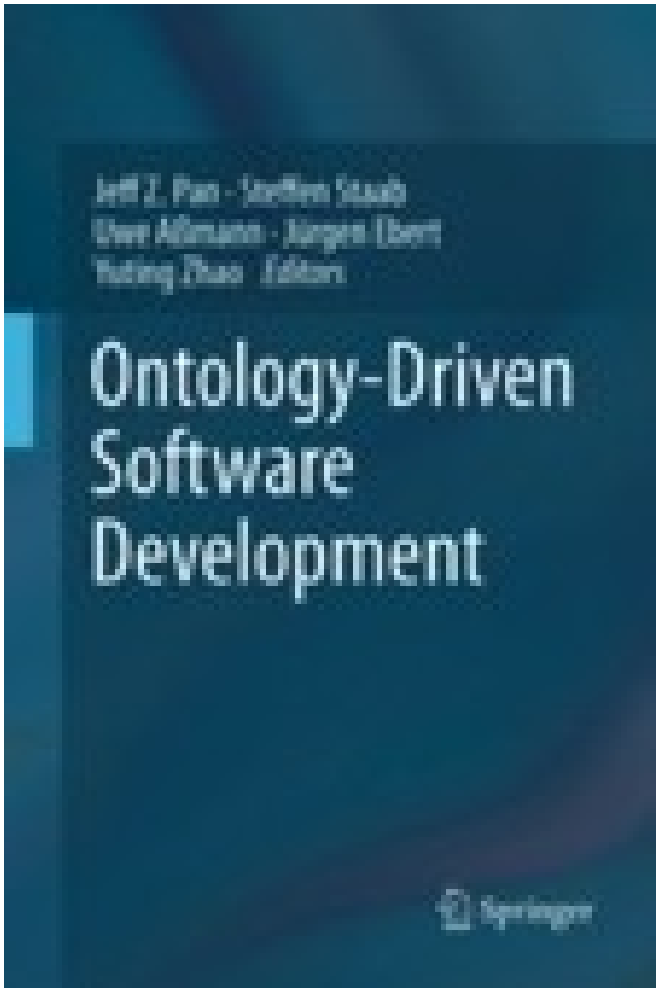
The Book of the MOST Project for Multi-TS Development



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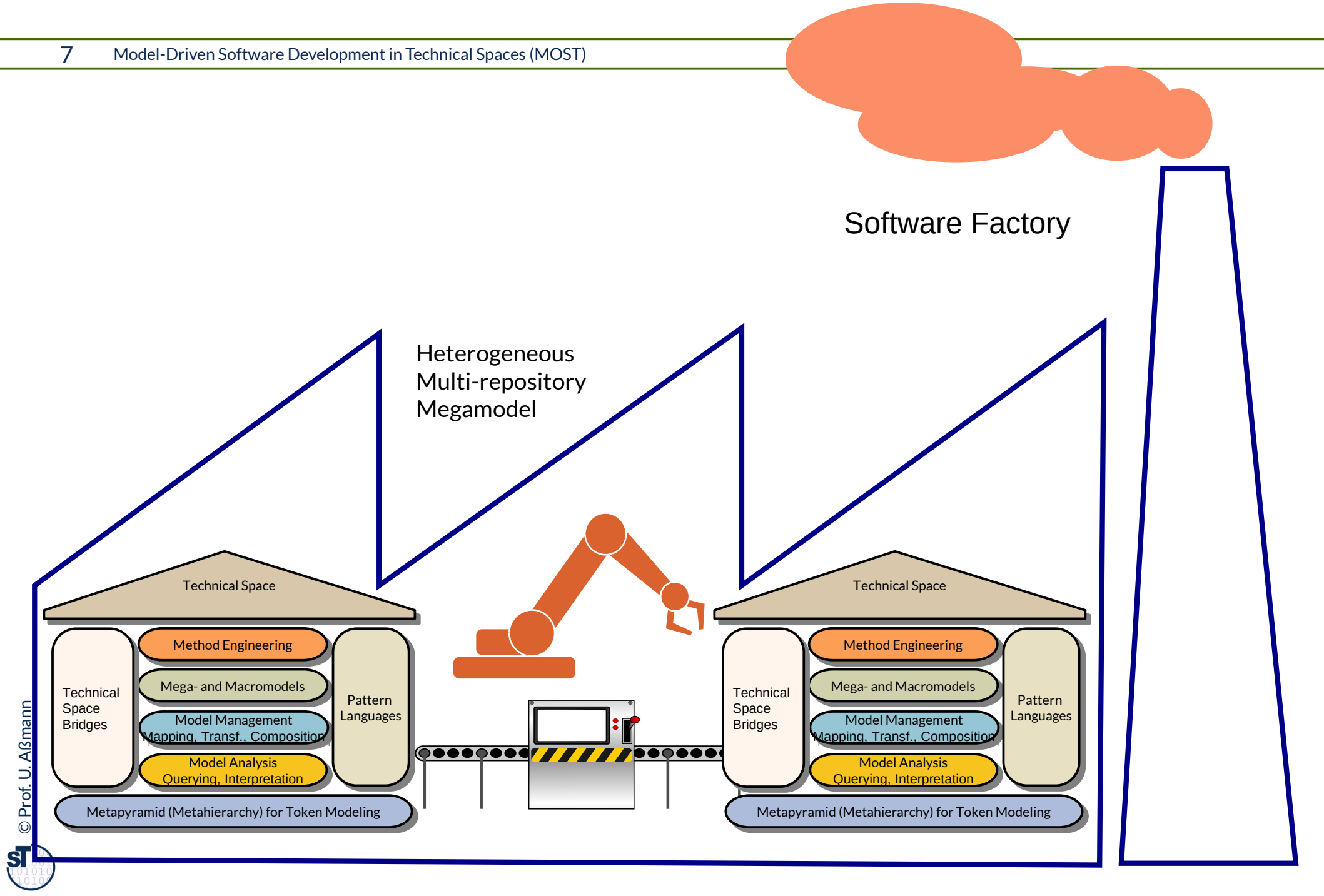
50.1 MDSD in Multiple Technical Spaces (Multi-TS Development)

Q13: A Software Factory's Heart: the Multi-TS Megamodel



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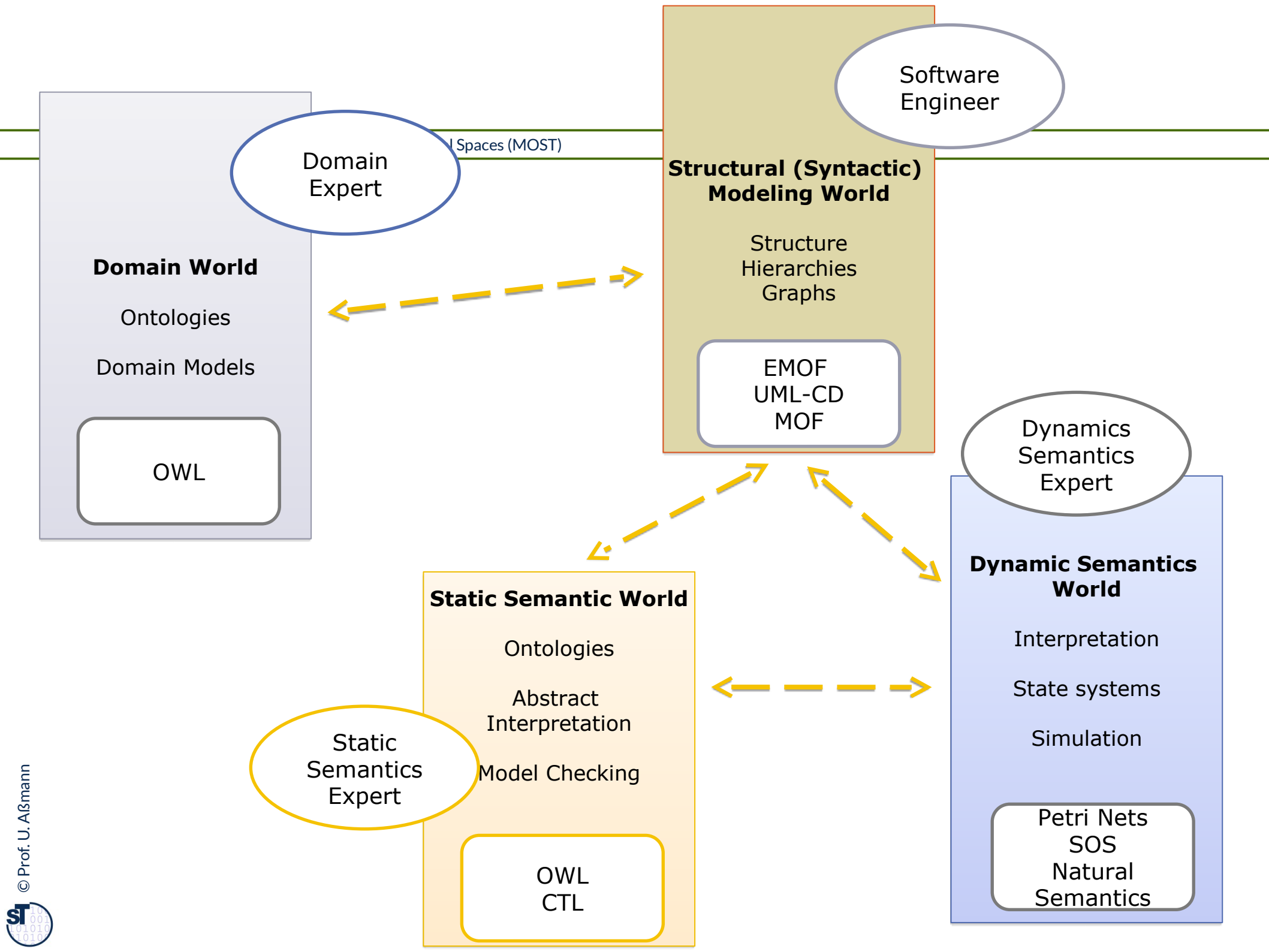

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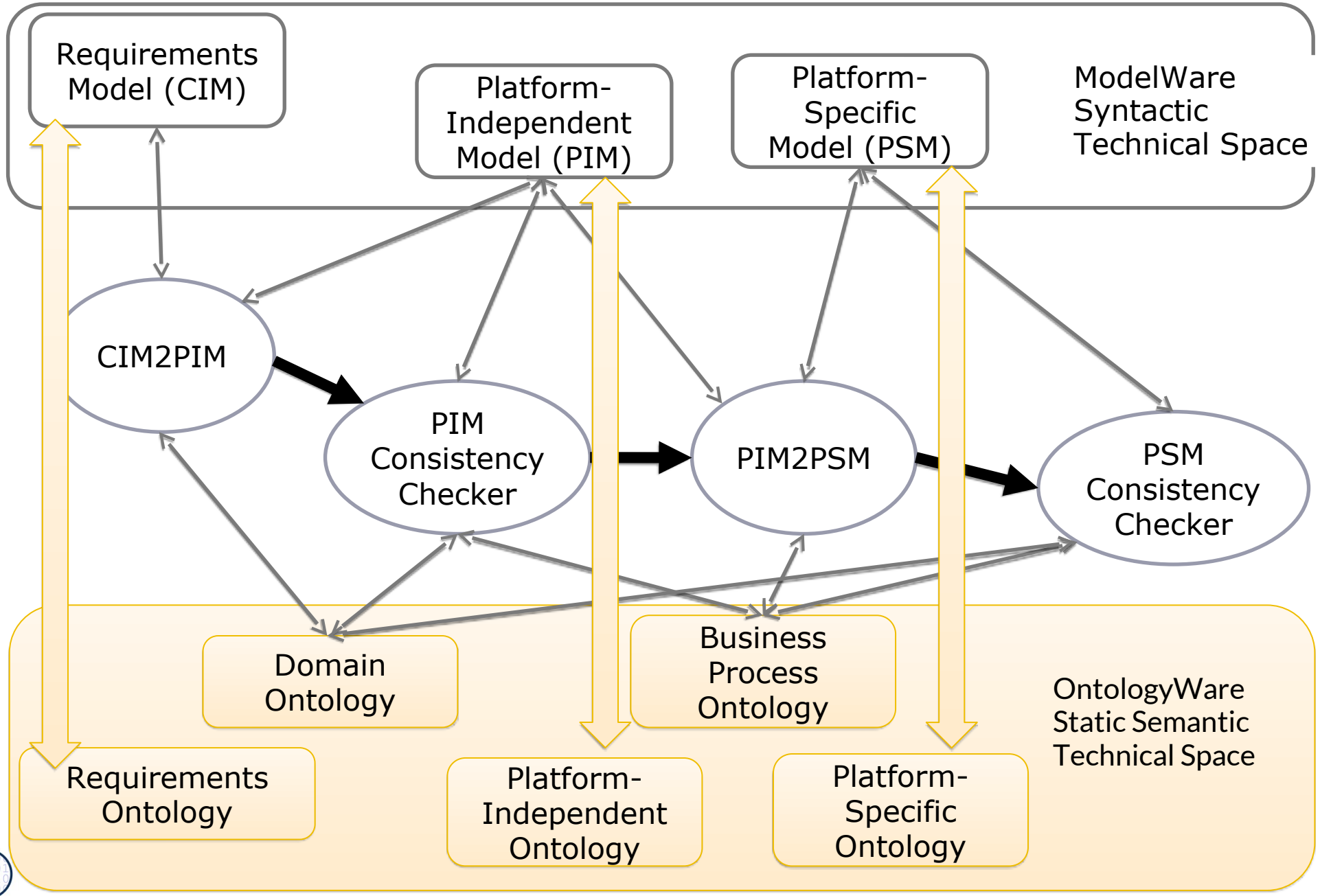
Example: A Heterogeneous MDA (From MOST Project)



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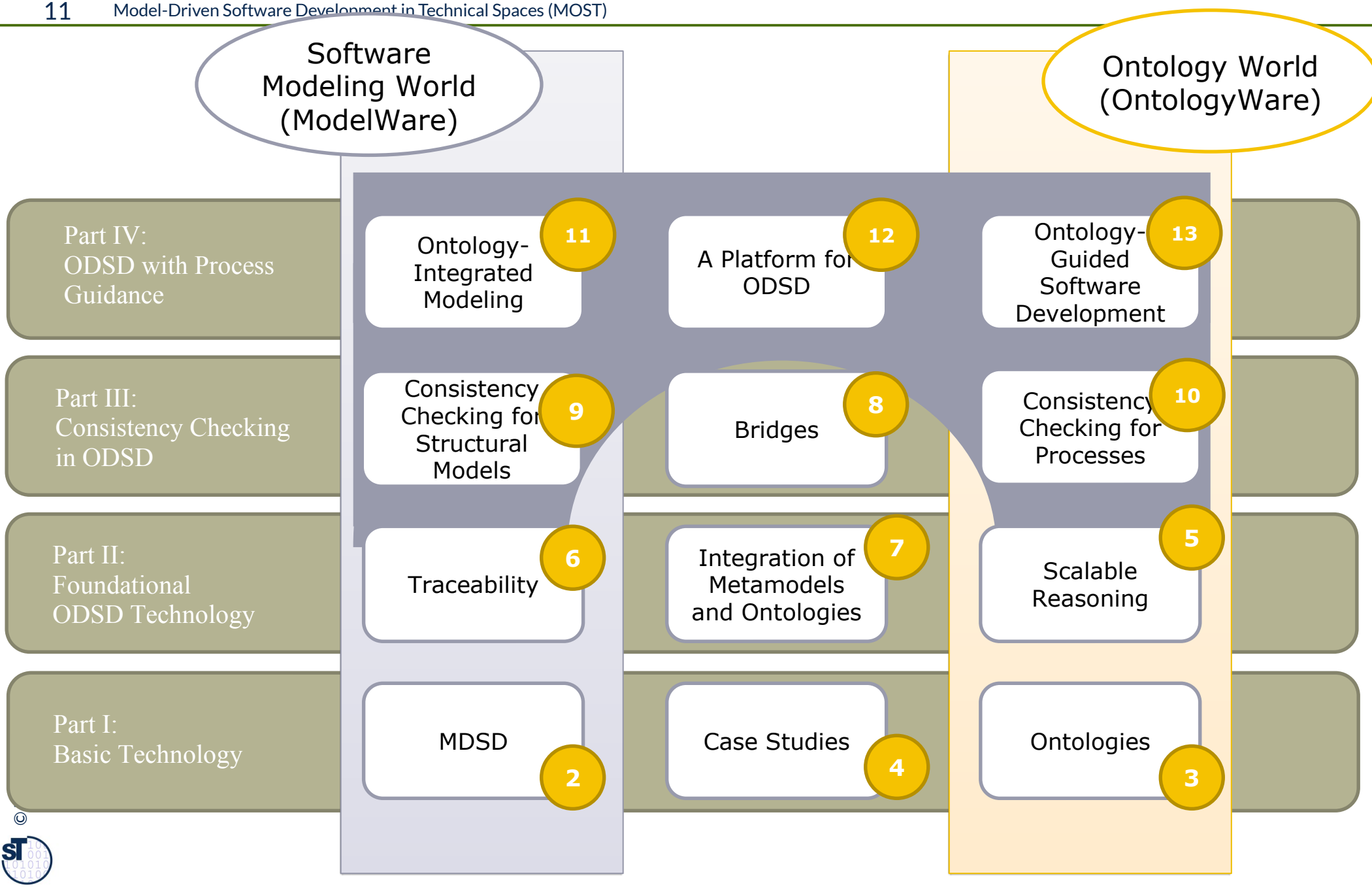
MOST: Tasks for Bridging between Syntactic and Semantic TS



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50.2 Applications Working in Multiple Technical Spaces

Language Mapping between Several TS via XML
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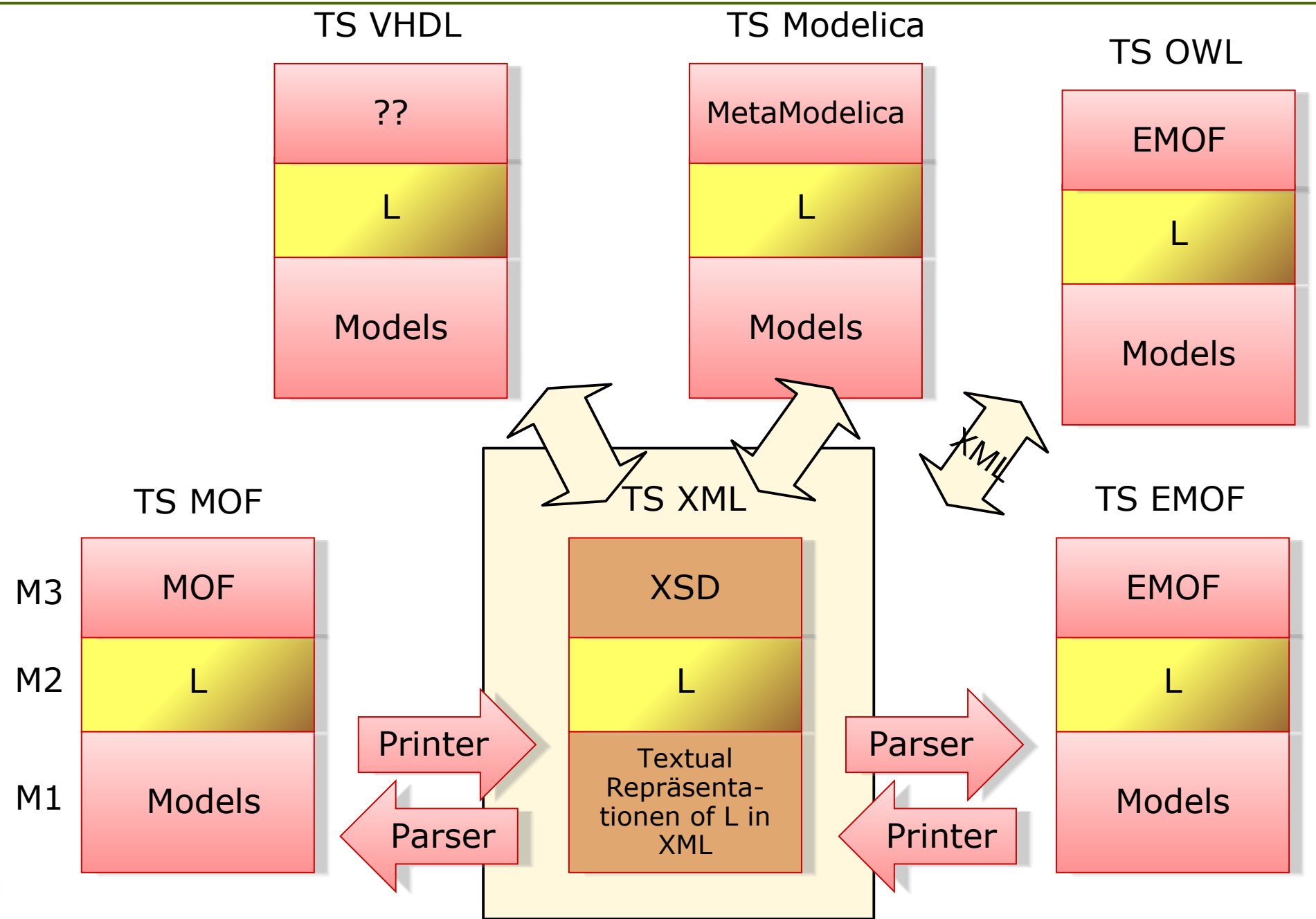

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Multi-Technical-Space MDSD Tools (Software Factories)

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- However, industrial software development usually is heterogeneous and several technical spaces must be used (XML, Java, C++, UML, csv, …)
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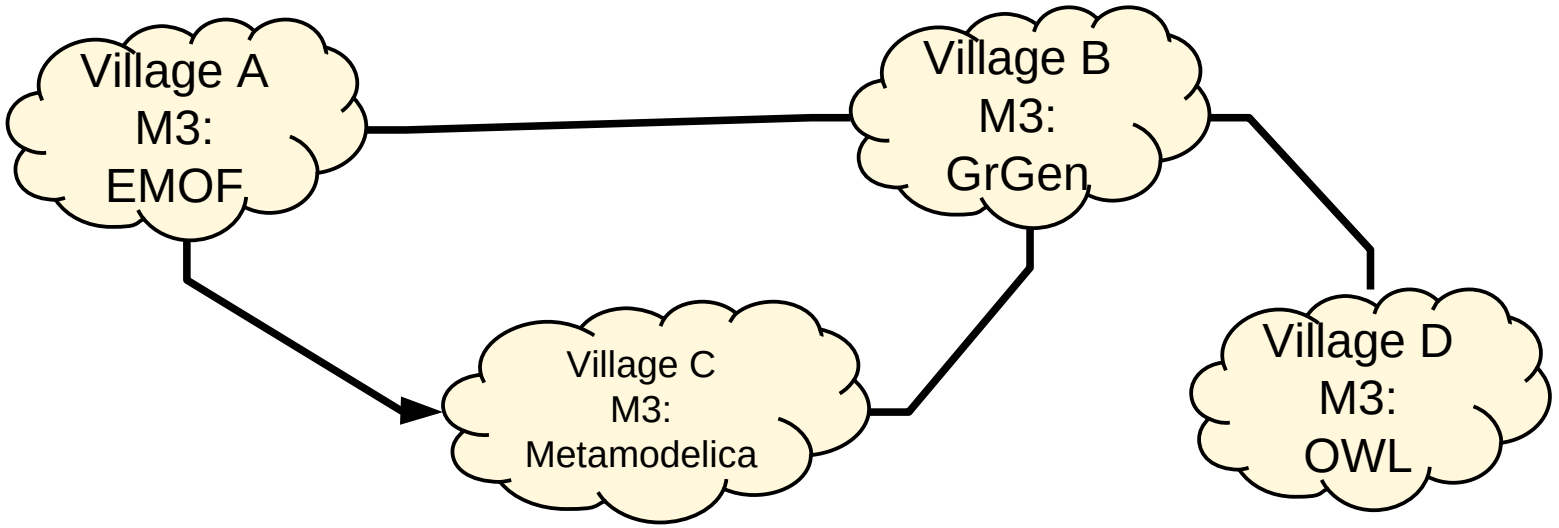

Model Engineering is is the engineering of software factories – the engineering with several technical spaces in multiple technological spaces

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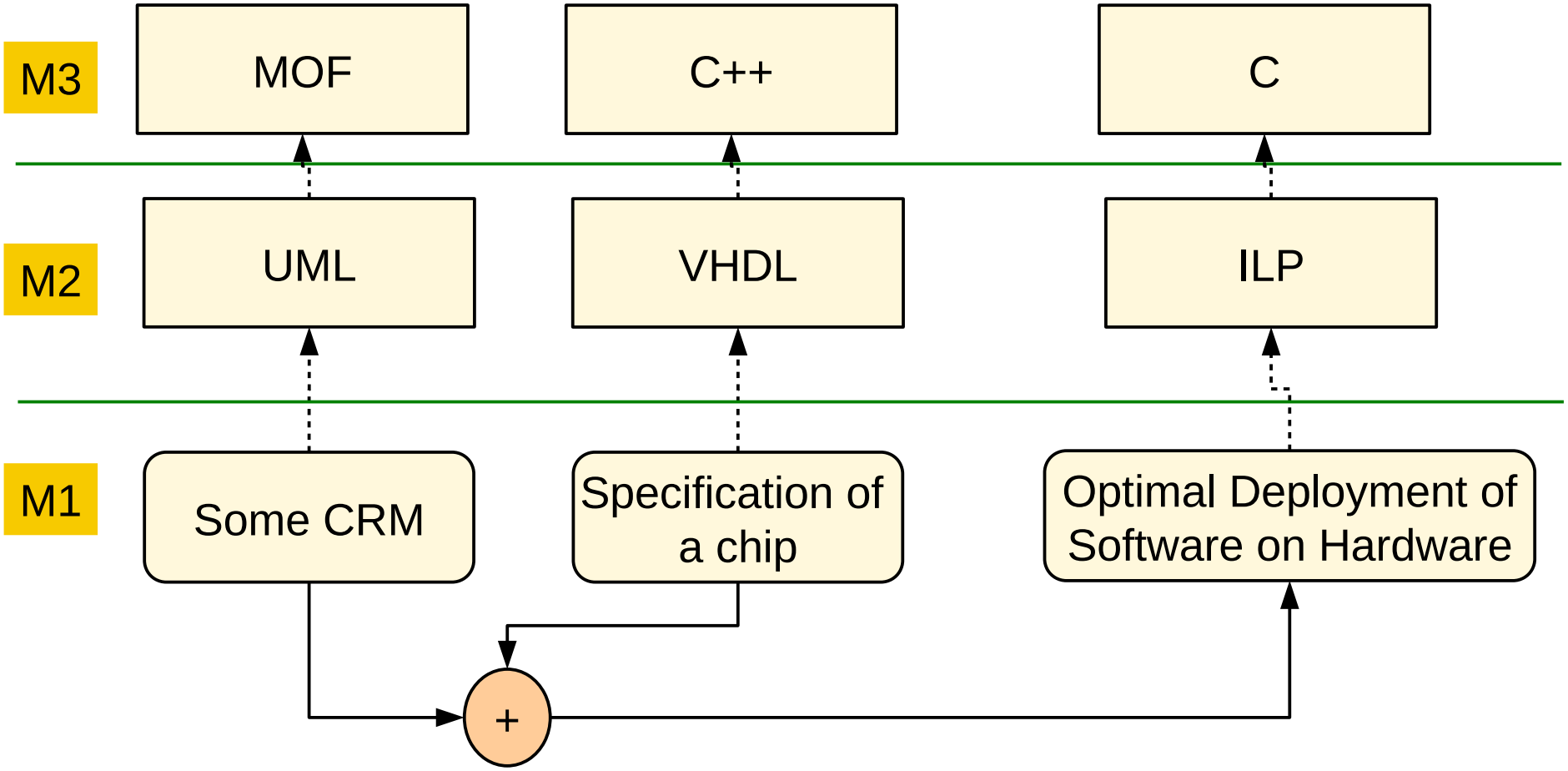

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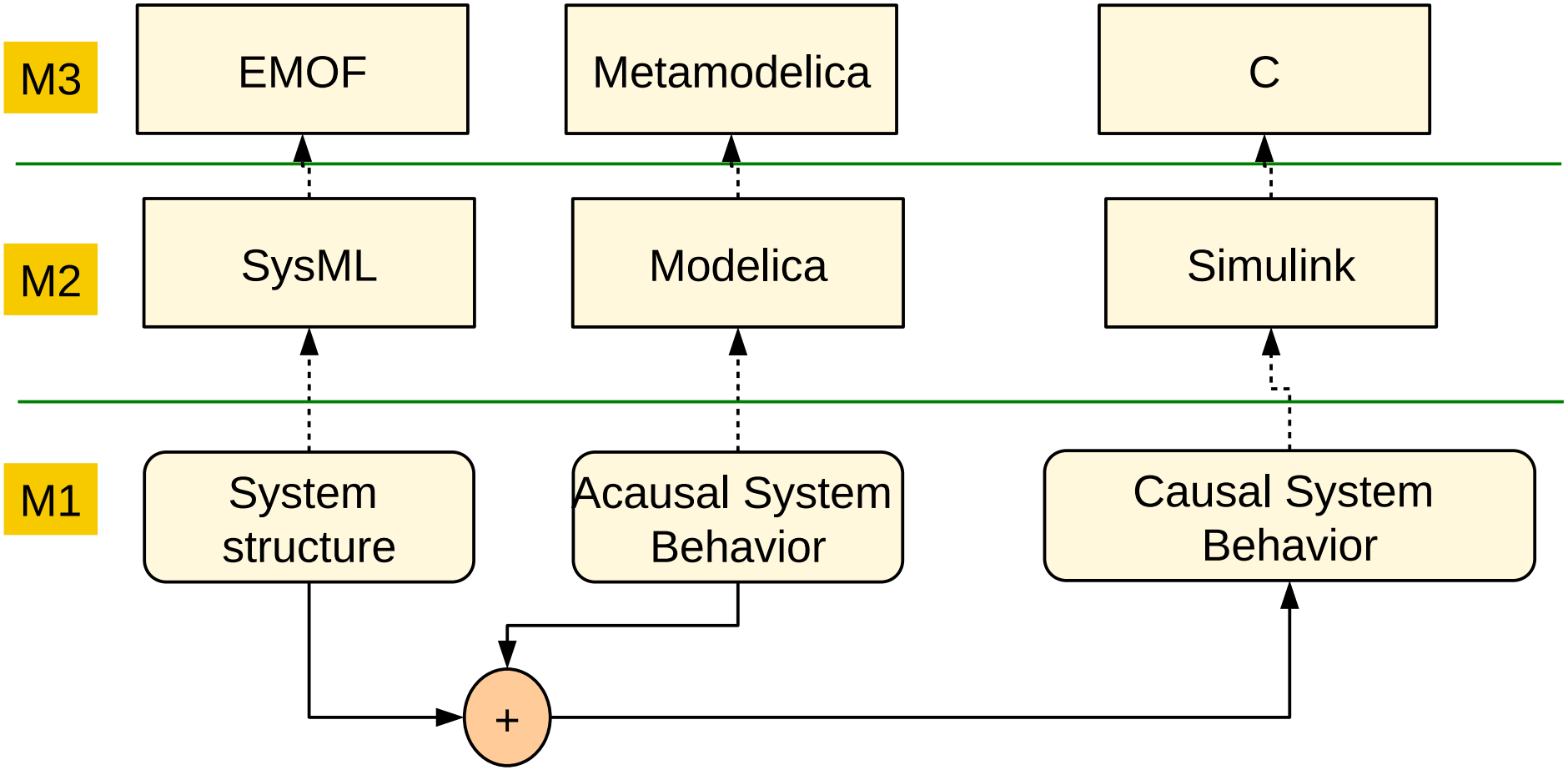

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50.2 Software Factories (Wrapup)

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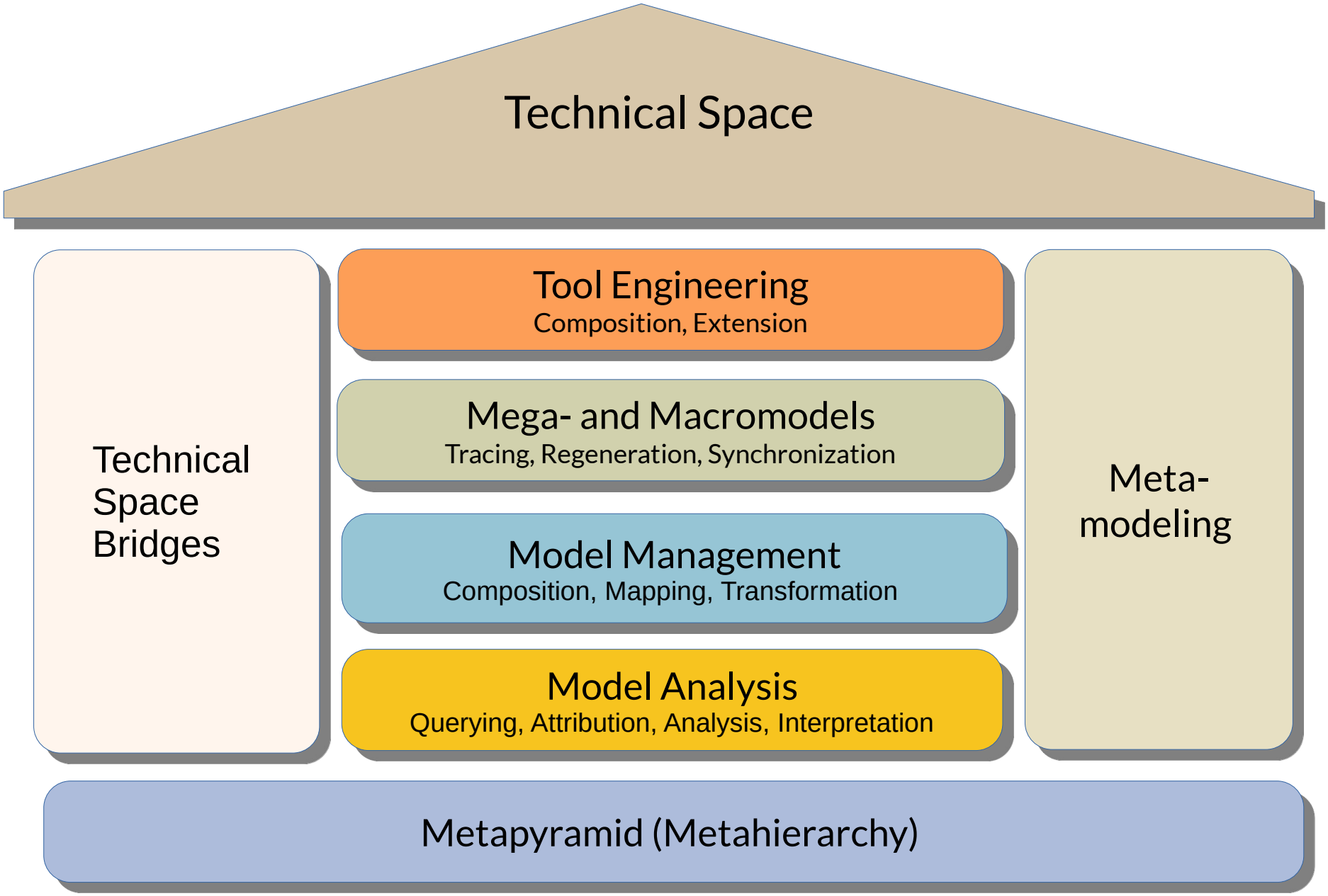

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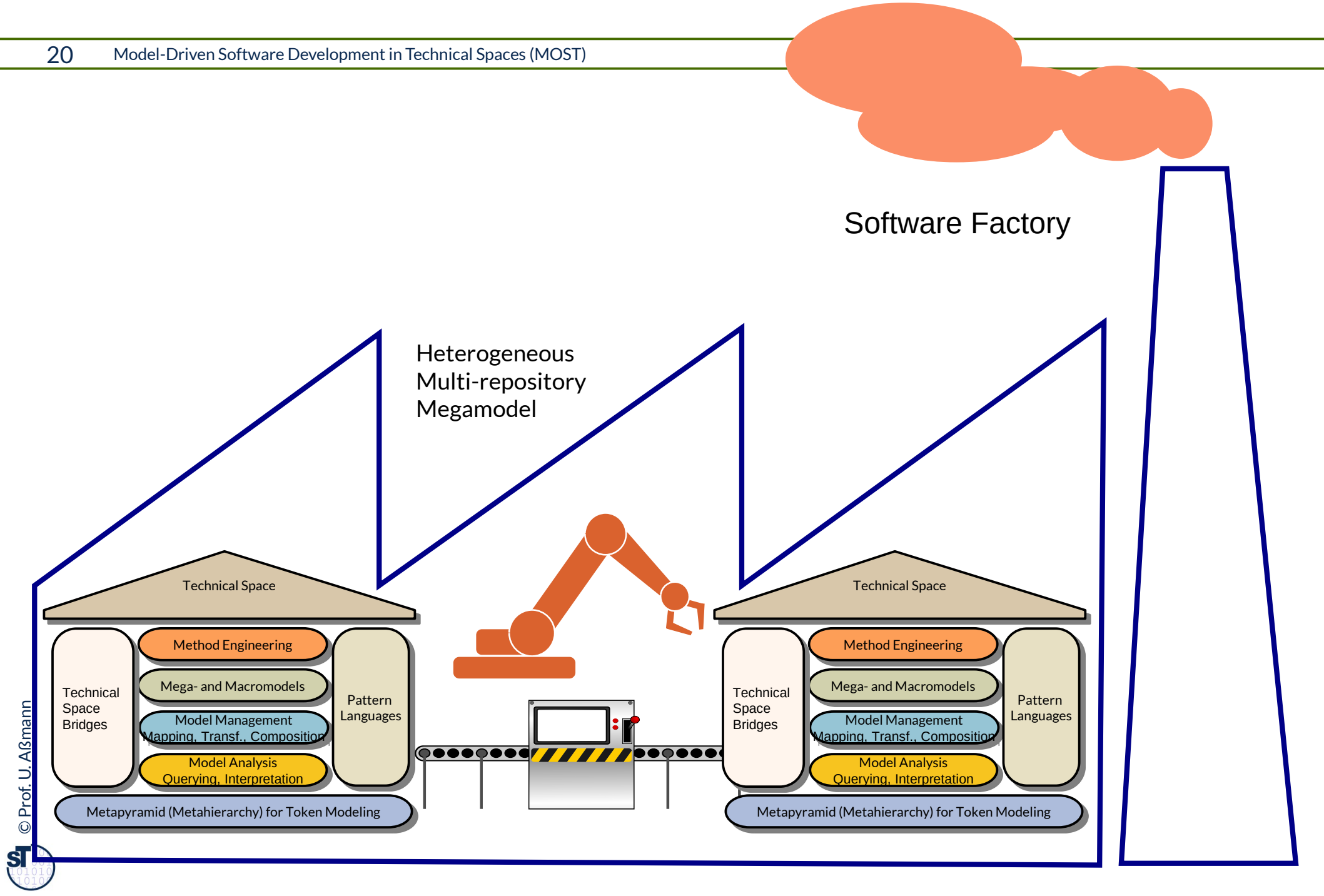

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Remember the Big Example: Car Design with PREEVision (Vector): Interoperability with XML Link Trees

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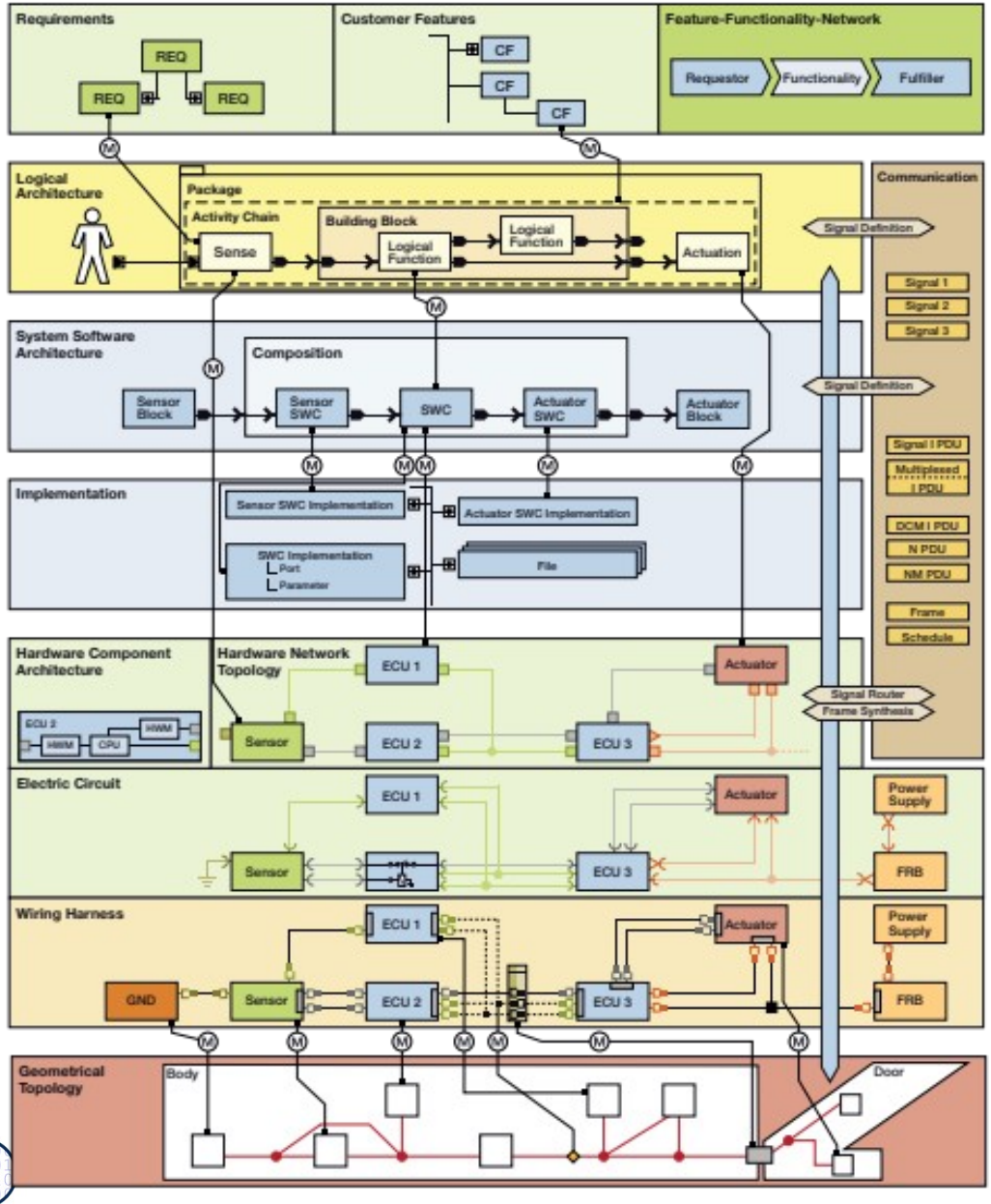

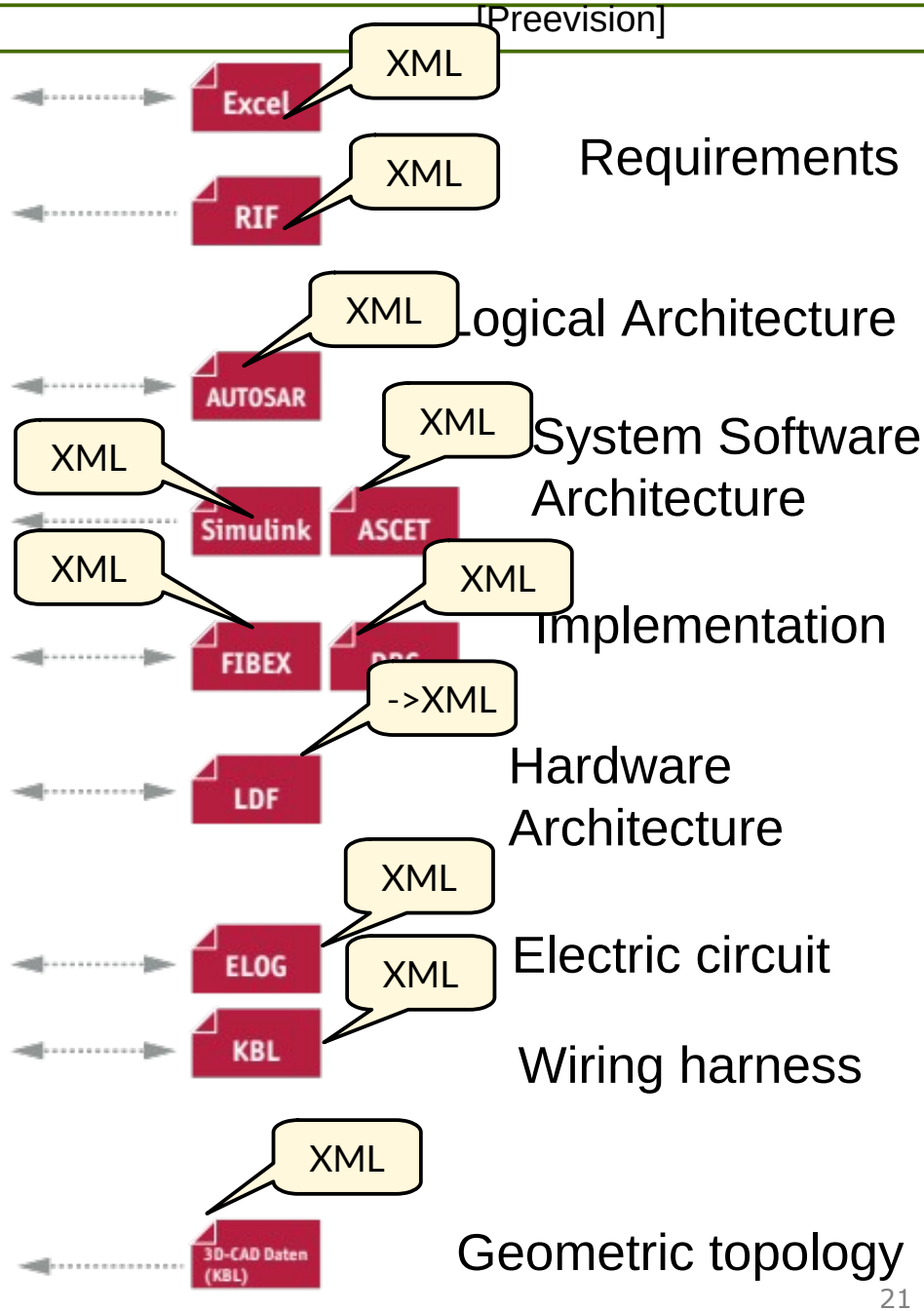

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Engineering of Multi-Technical Space Macromodels

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The End

- Explain why future toolkits to design complex things will be multi-TS software factories
- What is different in the handling of a multi-TS megamodel compared to a 1-TS megamodel?
- Which technical space would you choose to exchange data in a software factory? Why?
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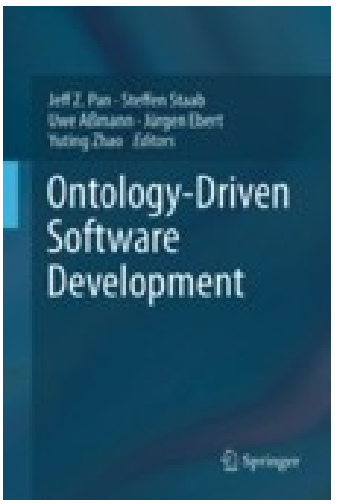

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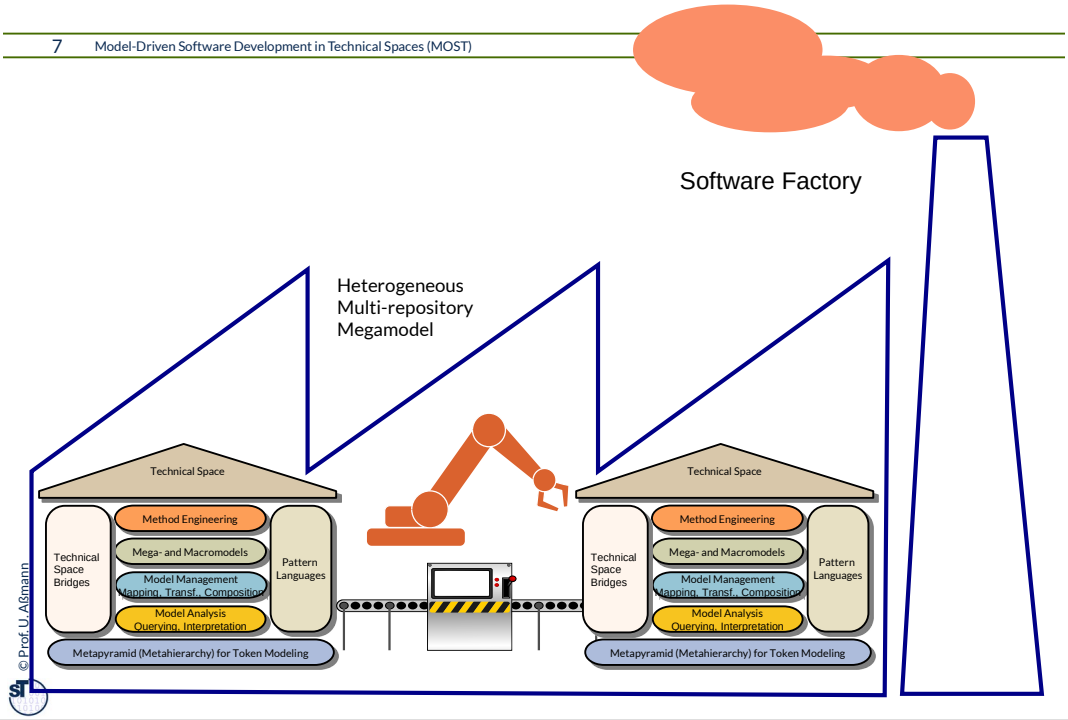

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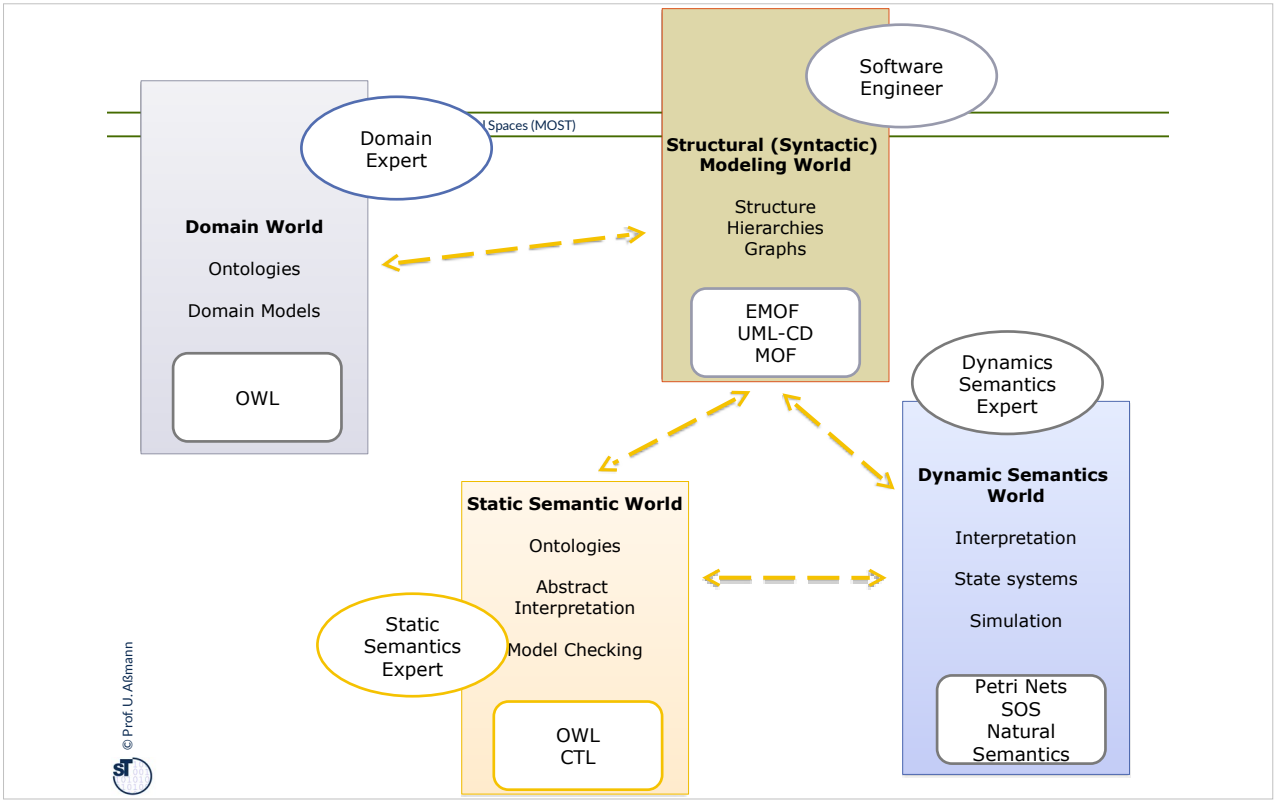

Bridging.all-the-technical-spaces

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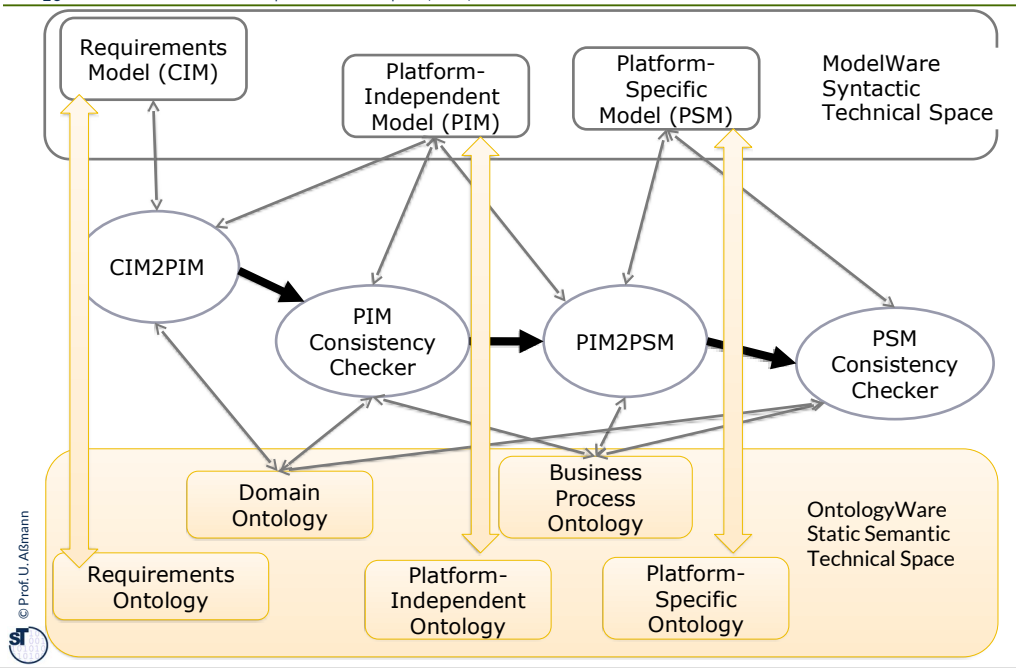

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MDSD-Integrated-Services

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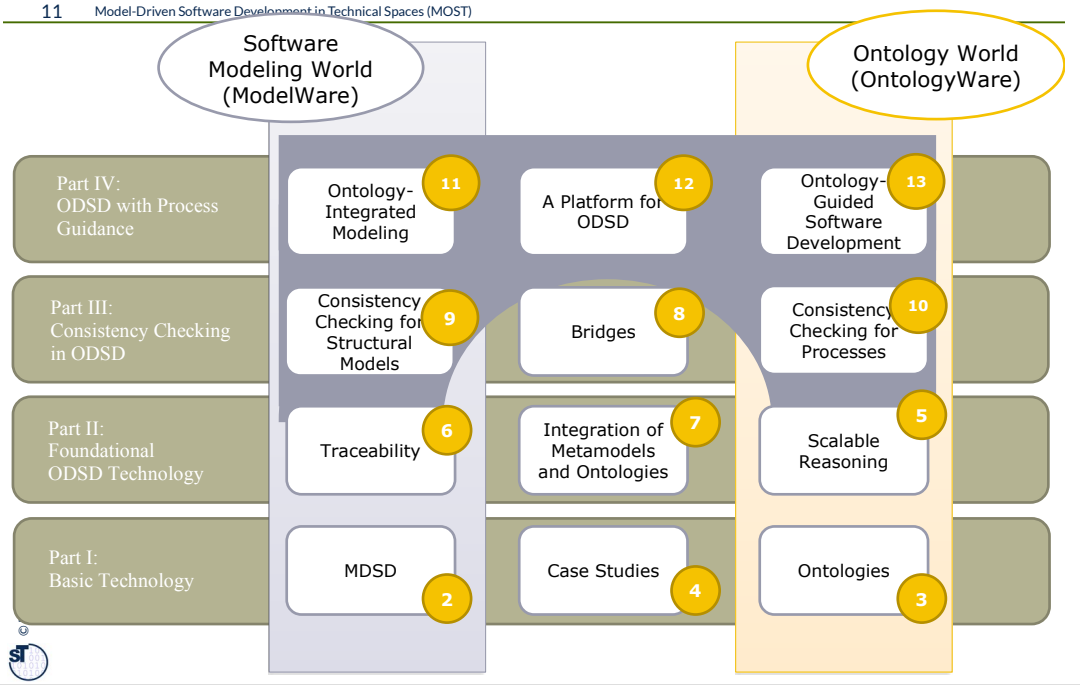

BookRoadmap

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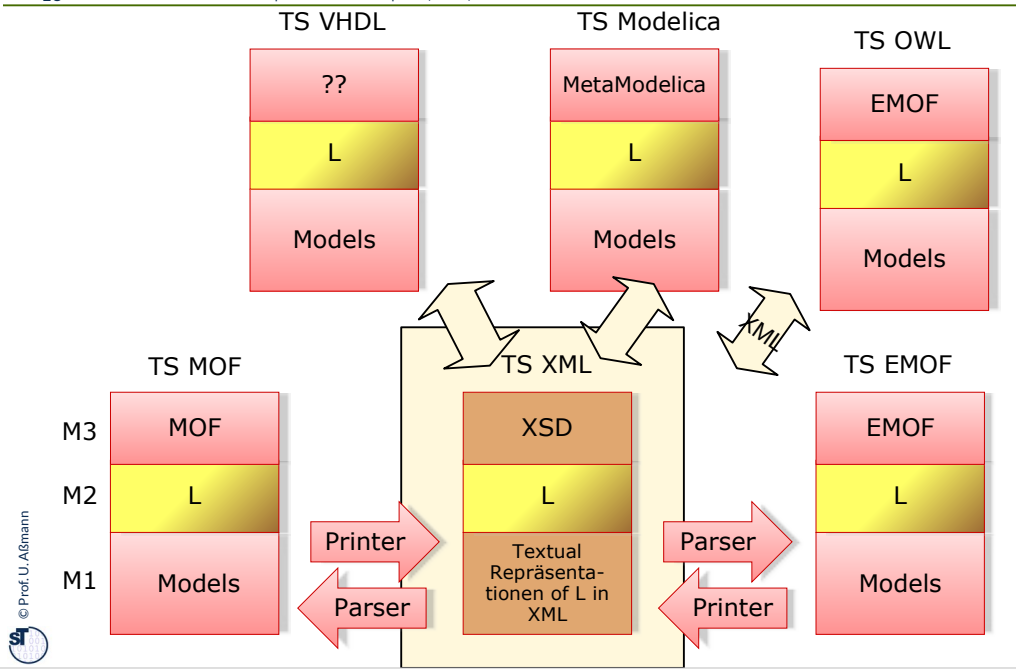

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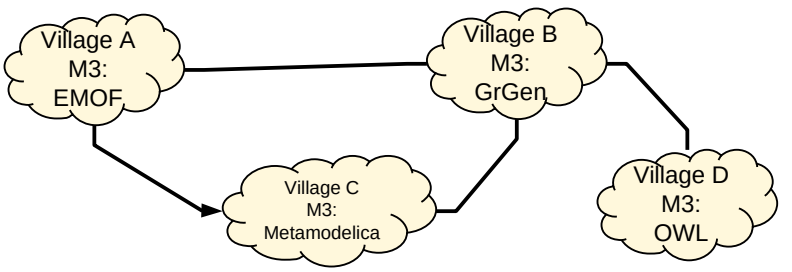

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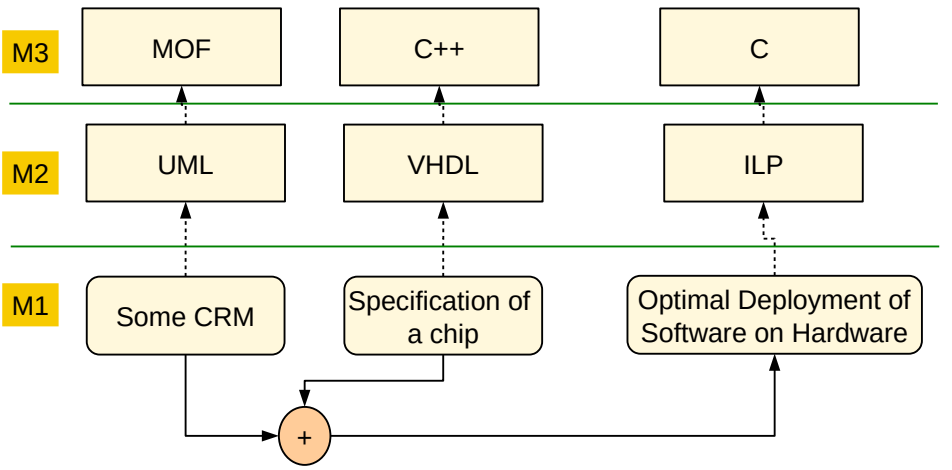

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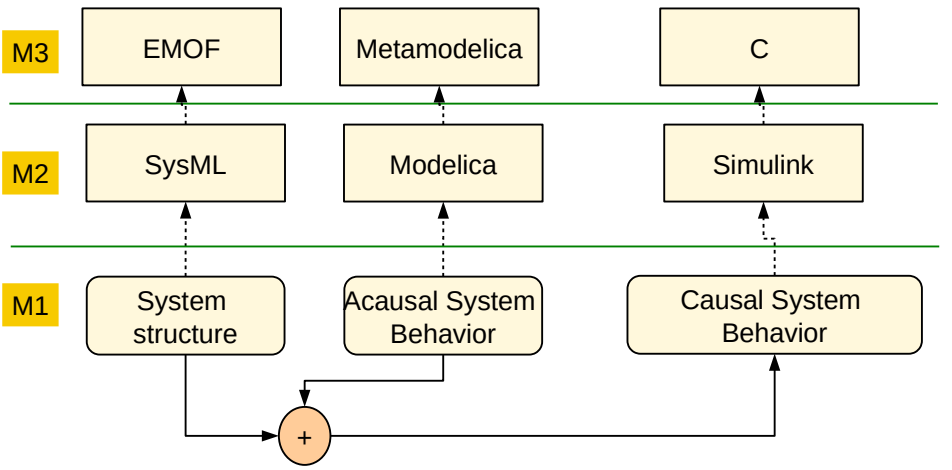

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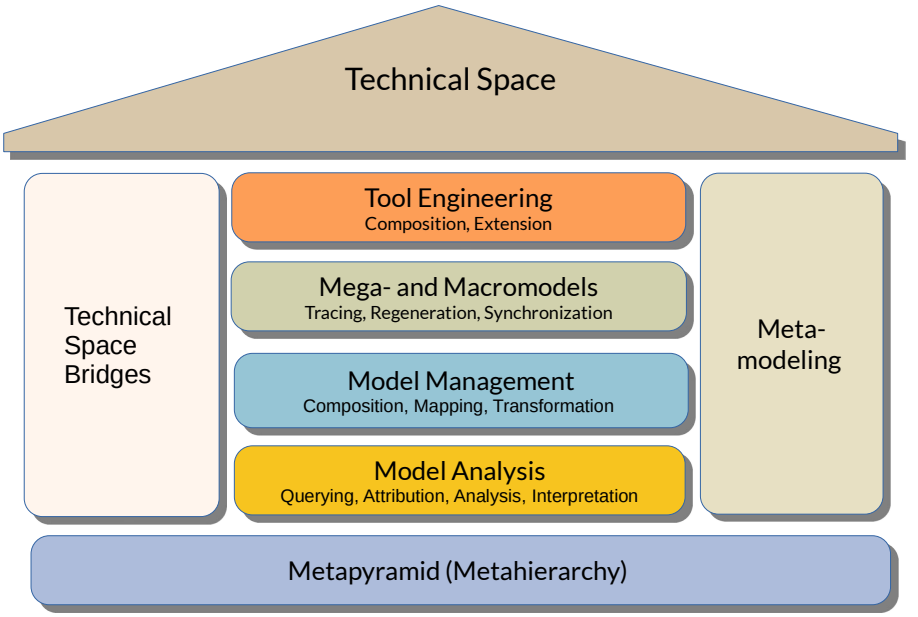

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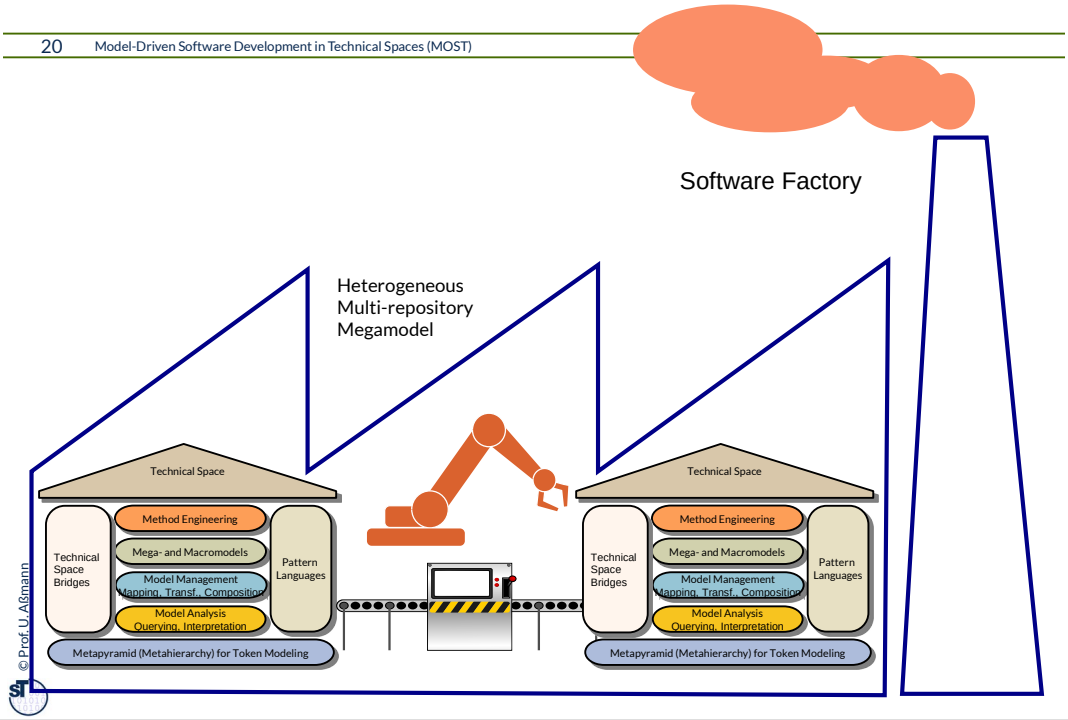

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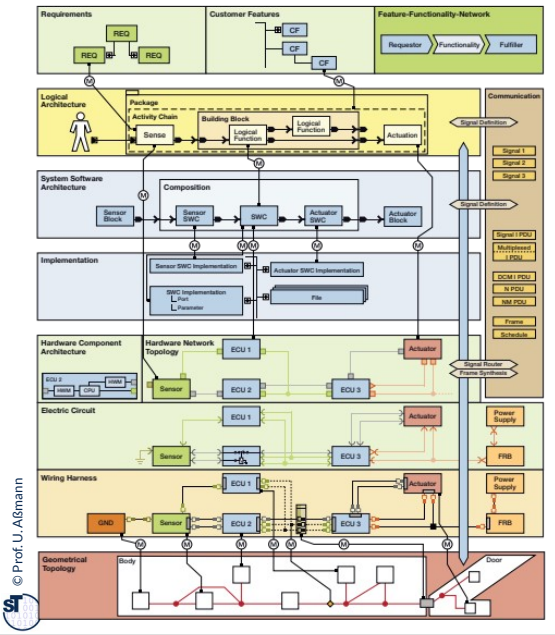

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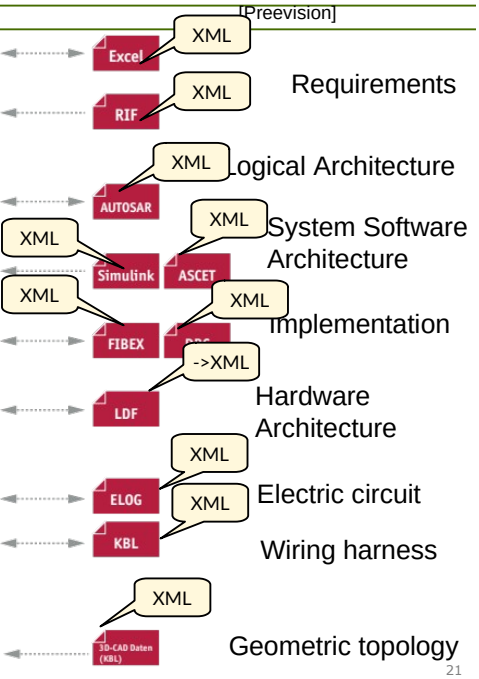

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