A Feature-based Categorization of Multi-Level Modeling Approaches and Tools

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Multi-level modelling

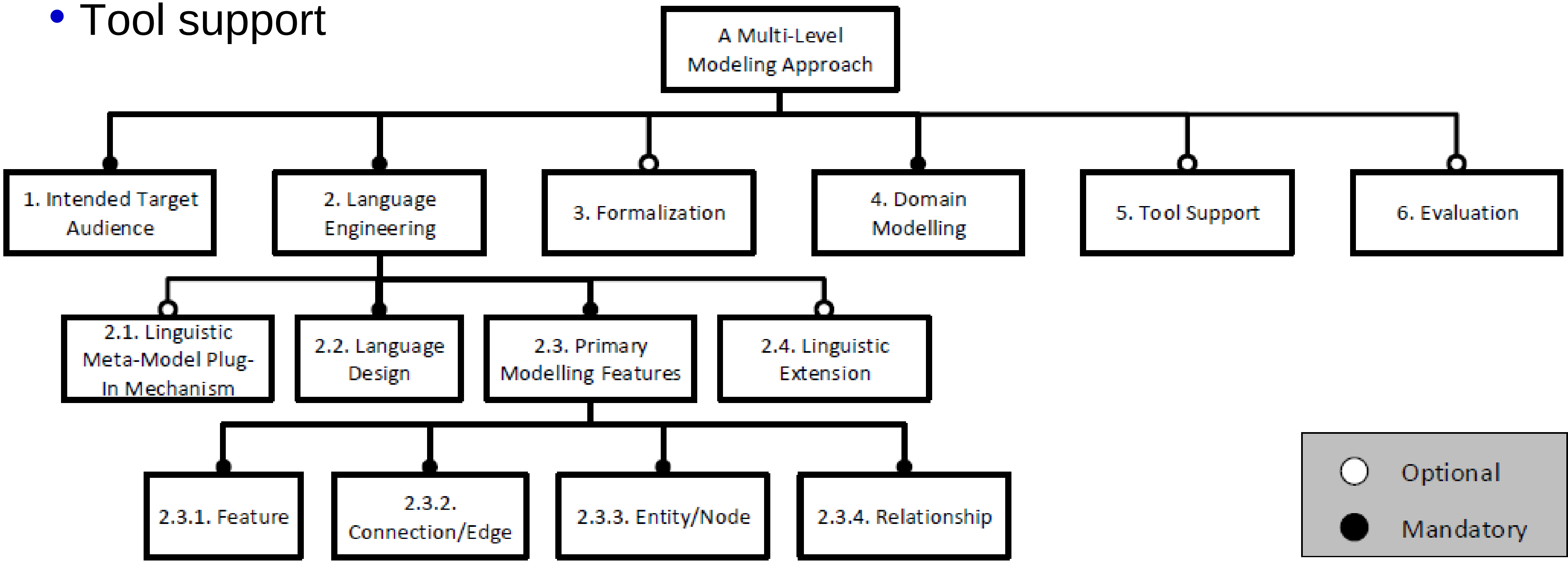
- **Different approaches and formalism:**
  Orthogonal Classification Architecture (OCA), Deep meta-modeling, Dual Deep Instantiation/modeling, Multi-level Theory (MLT), Diagram Predicate Framework (DPF) , M-objects and M-relationships, Powertype, Materialization

- **Different tools:**
  Melanee, MetaDepth, DPF, DDM, OMLM/MULLER, VIATRA, VMTS, Nivel, OMME, XLM

- **Different languages:**
  LML, MetaDepth, ConceptBase, OMLM & DDM (Flora-2), M-SQL, DeepJava, FOML

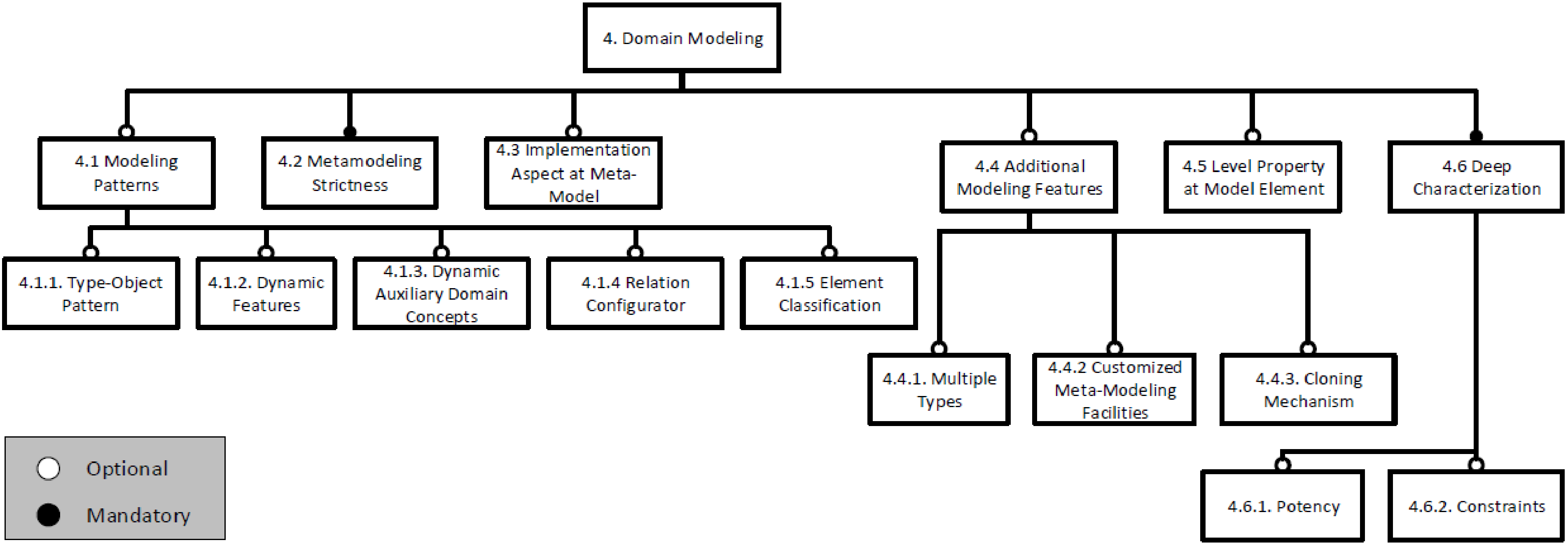
Multi-Level Modelling feature model

- Linguistic engineering
- Domain modelling
- Tool support



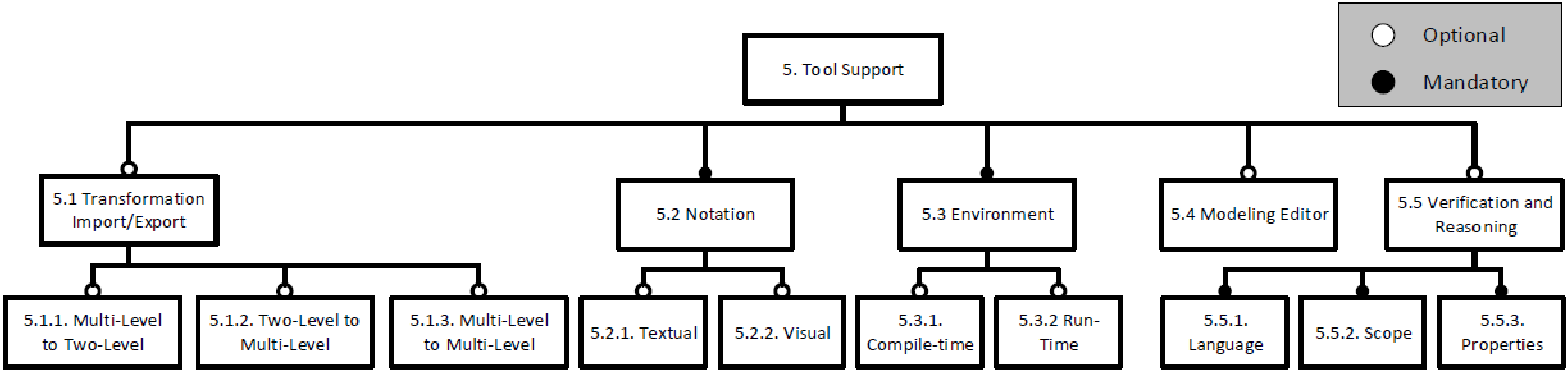
Domain modeling perspective

- Modeling patterns
- Meta-model strictness
- Implementation @ meta-model
- Deep characterization



Tool support perspective

- Transformations, Import/Export
- Notation
- Development environment
- Verification & reasoning



Comparison of approaches and tools

Approach	Tools	2. Lang. eng.				3	4 Domain modeling												5 Tool support								6
		2.1	2.2	2.3	2.4		4.1 Mod. patterns				4.2	4.3	4.4 Add. m.			4.5	4.6 Deep		5.1	5.2	5.3		5.4	5.5 Verif			
				2.3.1			4.1.2	4.1.3	4.1.4	4.1.5			4.4.1	4.4.2	4.4.3		4.6.1	4.6.2			5.3.1	5.3.2		5.5.1	5.5.2	5.5.3	
Telos [27]	Telos		D	MA	●	●	●				L							●		T	Conceptbase	JRE	●	N	S	F	
VODAK [20]	VODAK		D	●	~	●					L							●		T	VODAK	~		N	A	F	
OCA [7]	Melanee		D	MA	●	●	●		●	●	S			◓		●	M	●	M2	VT	EMF	JRE	●	O	S	F	
SKIF [18]	SKIF		A	MA	●	●	●				S					N/A				T	SKIF	First-order		N	S	F	
Materialization [12]	Metaclass impl		~	MA			●		●		S					N/A				T	~	~				F	
VPM [36]	VIATRA		D	MA	●	●	●				L							●	2M	V	UML	Prolog,XSB	●	N	S	F	
VMTS [26]	VMTS		A	MA		●	●				S					N/A				T	C#	.NET	●	O	S	F	
Powertype [17]				MA							L																
DeepJava [22]	DeepJava		A	MA	●		●				S					●	M	●		T	Polyglot, javac	JRE	●			F	
Nivel [2]	Nivel		A	A	●	●	●		●		S						M	●	M2	T	Nivel	WCRL	●	N	M	F	
Aschauer et al. [1]	Traversal algorithm		D	A							L					N/A	M			T	Algorithm						
M-Objects [28]	M-SQL		A	MA	●	●	●				S					●	M			T	M-SQL	SQL		O	S	F	
Deep meta-modeling [34]	MetaDepth		D	MA	●	●	●		●	●	S			◓			SM	●	2M	T	MetaDepth	JRE		O	S	FQ	
OMME [37]	OMME		A	MA			●				S					N/A				V	EMF/Ecore	JRE					
XLM [13]	XLM		A	MA			●				S					N/A				VT	EMF	JRE	●	O	S	F	
DPF [23]	DPF workbench		A	MA		●	●				S						M	●		V	EMF	JRE	●	O	S	F	
DDI [29]	Conceptbase		A	MA		●	●		●		L			◓			M	●		T	ConceptBase	JRE	●	N	S	FQ	
DesignSpace [14]	Model Analyzer		A	MA		●		●			S					●	M	●		VT	RSM,EMF	JRE	●	O	S	F	
MLT [10]			D	MA		●					L					N/A											
OMLM [19]	OMLM, MULLER	●	A	A	●	●	●			●	S	●		◓			SM	●	2M	T	Flora-2	XSB		N	A	FQ	●
DDM [32]	DDM		A	A	●	●	●		●	●	L			◓			SM	●		T	Flora-2	XSB		N	A	F	

Features: ● - supported, ◓ - semi-supported, empty - not supported. ~ - unknown. N/A - not applicable.
Language engineering: 2.2 (D)efined,(A)dapted. 2.3 (M)ethod,(A)ttribute.
Domain modeling: 4.2 (S)trict, (L)oose. 4.6.1 (S)ingle, (M)ulti-potency.
Tool Support: 5.1 2M - two-level to multi-level, M2 - the opposite. 5.2 (T)extual, (V)isual. 5.5.1 (O)CL, (N)on-OCL. 5.5.2 Single & All levels. 5.5.3 (F)unctional & (Q)uality properties.

Comparison results

- **Design choices:**
  - Modeling based on existing vs a new language
  - **Strict vs loose meta-modeling**
  - Single vs multi-potency
  - **Textual vs visual (GUI) notation**
  - **OCL vs non-OCL verification**
  - Single vs all ontological scope
  - **Functional vs quality properties**

- **Challenges & trends:**
  - **Linguistic meta-model extension**
  - **Real-life industry models, applications**
  - Element classification pattern
  - **Addressing implementation at meta-model level**
  - Additional modeling features
  - **Multi-level constraints**

Comparison results (cont.)

- **User guidance & support:**
  - Import and export features
  - Visual too notation (GUI)
  - OCL and non-OCL for model verification

- **Application area of the categorization.**
  - Discover and exchange features between approaches and tools
  - Guidance for new users
  - A starting point for the evaluation criteria for a multi-level modeling tool contest

Conclusion & Future work

- **Conclusion**
  - a categorization for multi-level modeling based on the standard feature-diagram notation
  - compared MLM approaches and tools to map/visualize research challenges and trends
  - support users in their decisions
- **Future work**
  - comparison criteria are regarded as a course-grained representation of the domain, the fine-grained version can be elaborated by zooming in the specific criterion
  - feature model limits the range of comparison results into the `supported', `semi-supported' and `not supported' options only.
  - **a multi-level modeling tool contest** in the context of the MULTI workshop