Høgskulen på Vestlandet

Towards refactoring meta-models into multi-level models

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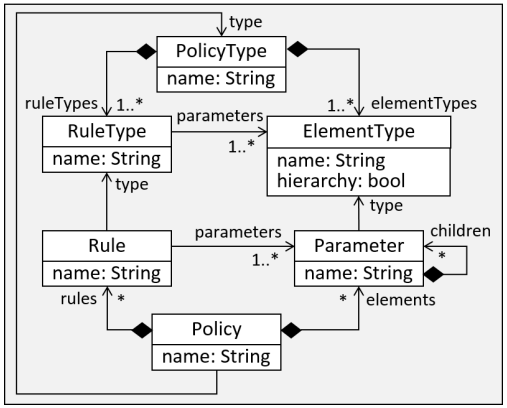
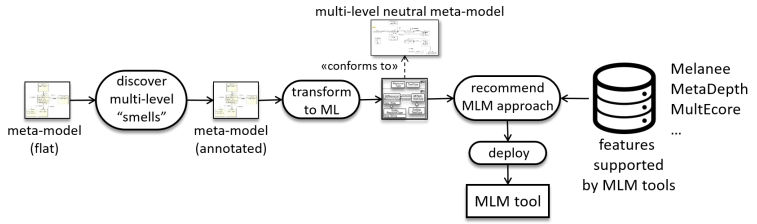
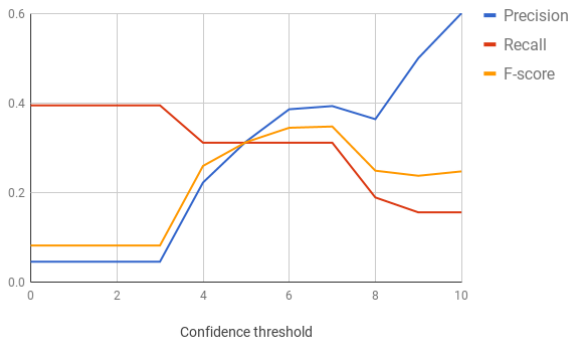
This work: What, how and why



Two-level limitations



Multi-level refactoring process



Evaluation and experiments

Juan de Lara, Esther Guerra, and Jesús Sánchez Cuadrado. "When and How to Use Multilevel Modelling". In: *ACM Trans. Softw. Eng. Methodol.* 24.2 (Dec. 2014), 12:1–12:46. ISSN: 1049-331X. DOI: 10.1145/2685615

What is MDSE?

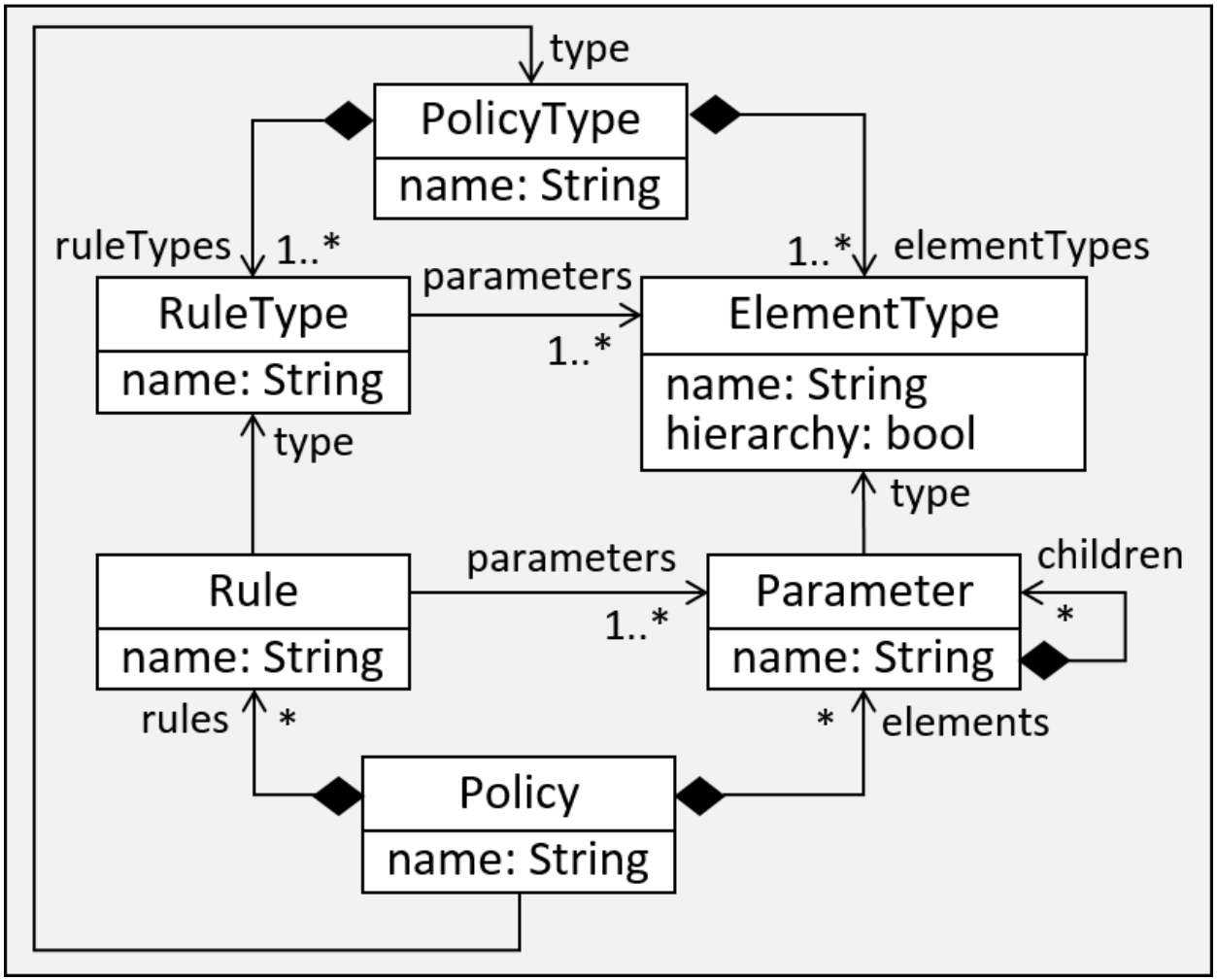
Model-Driven Software Engineering.

Representing information in a structured way.

Uses:

- Code generation
- Simulation
- Documentation
- ...

Example: Security Policies

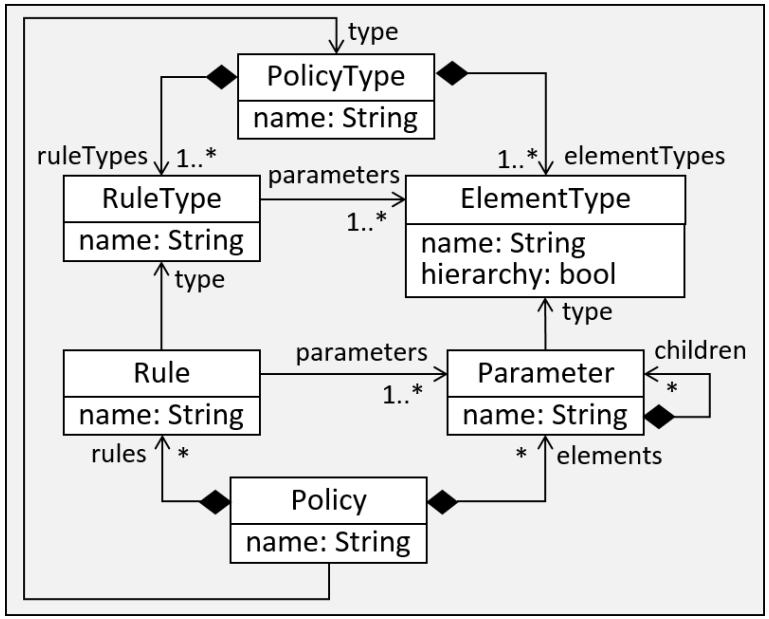


Tejeddine Mouelhi, Franck Fleurey, and Benoit Baudry. "A Generic Metamodel For Security Policies Mutation". In: *Proc. ICST*. IEEE Computer Society, 2008, pp. 278–286

Limitations of traditional approaches

Complexity tends to grow pretty fast.

- Difficult to read
- Complex maintenance
- Low reusability



Multi-level modelling (MLM)

The good:

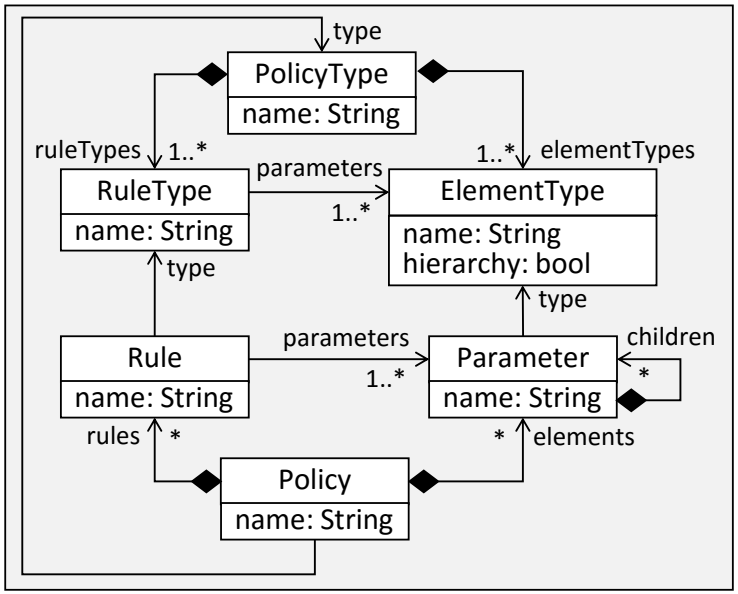
- Unbounded levels of abstraction
- Richer semantics
- Cleaner structures

The bad:

- Lack of consensus on foundations
- Technology lock-in
- Tool isolation

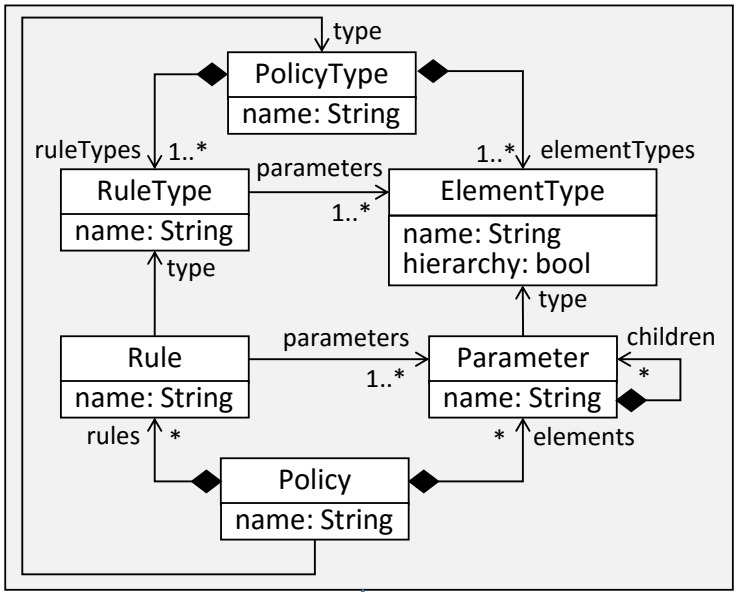
Security Policies with MLM

(a) "flat" meta-model

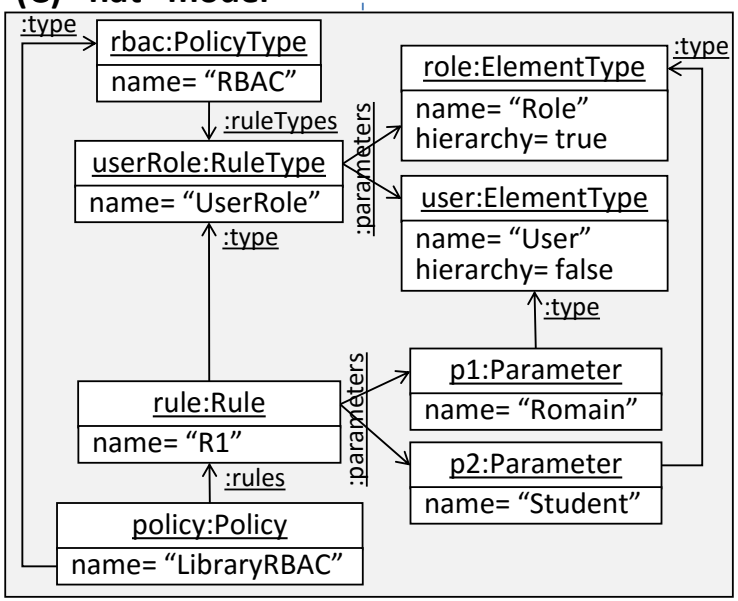


Security Policies with MLM

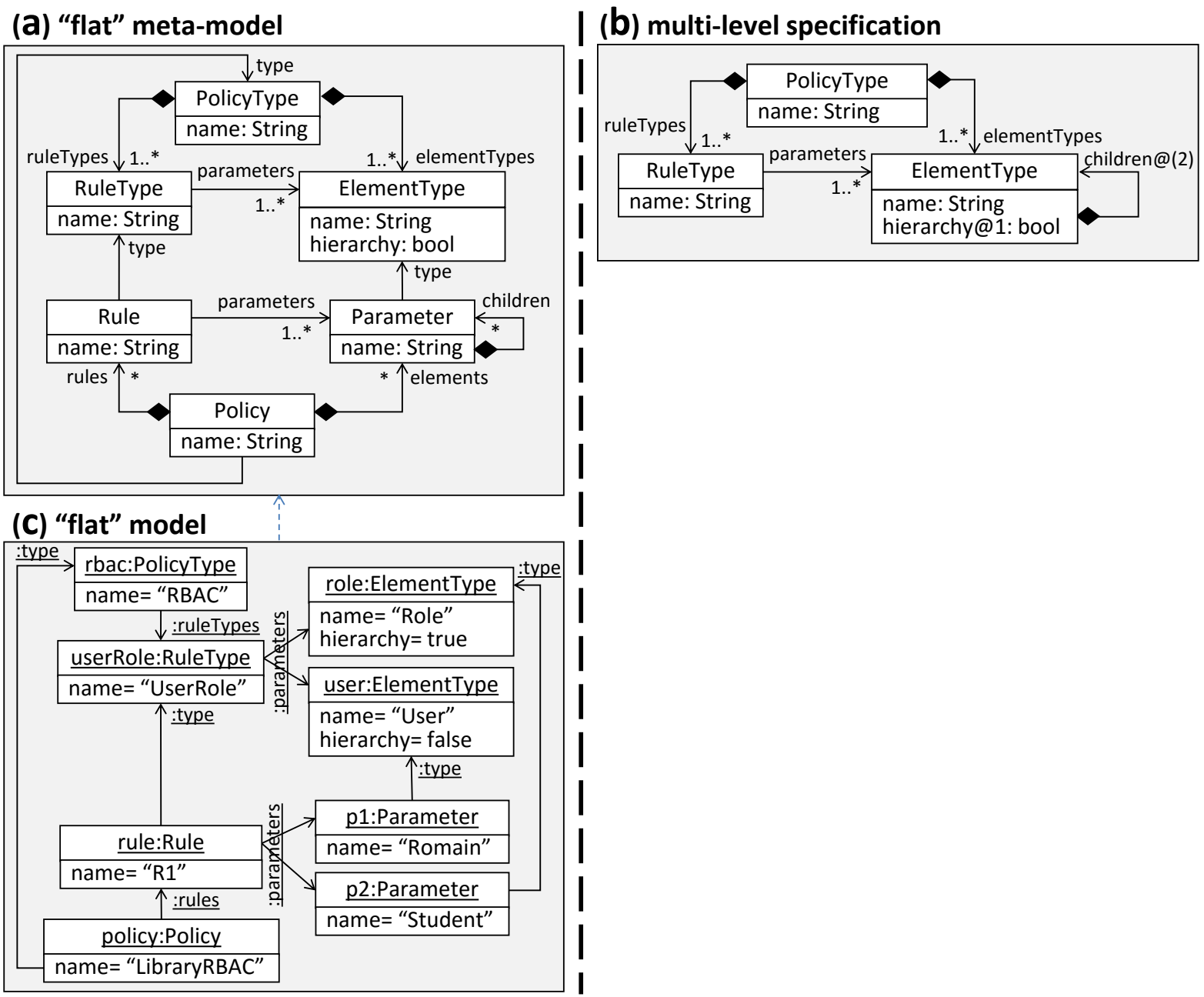
(a) "flat" meta-model



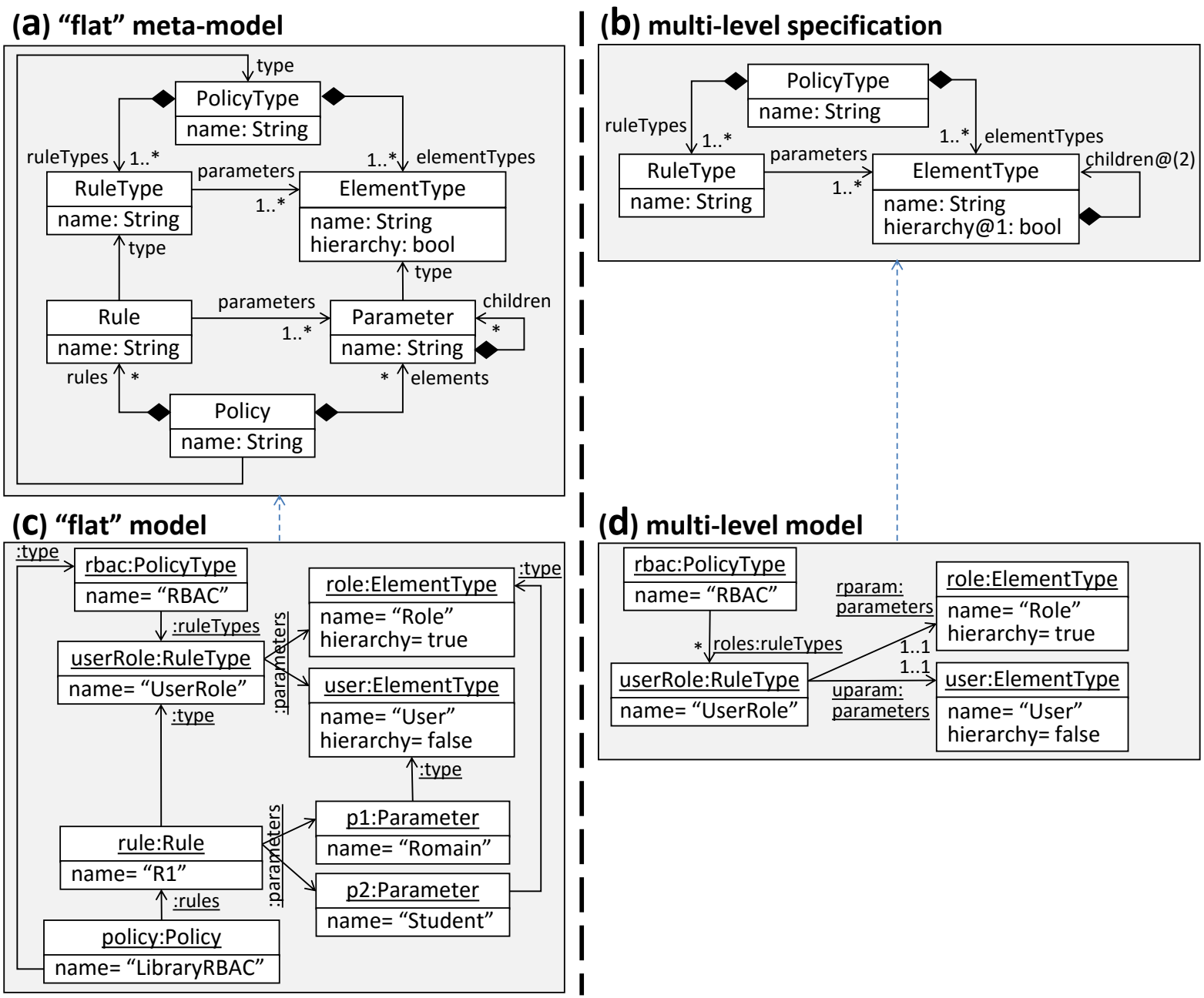
(c) "flat" model



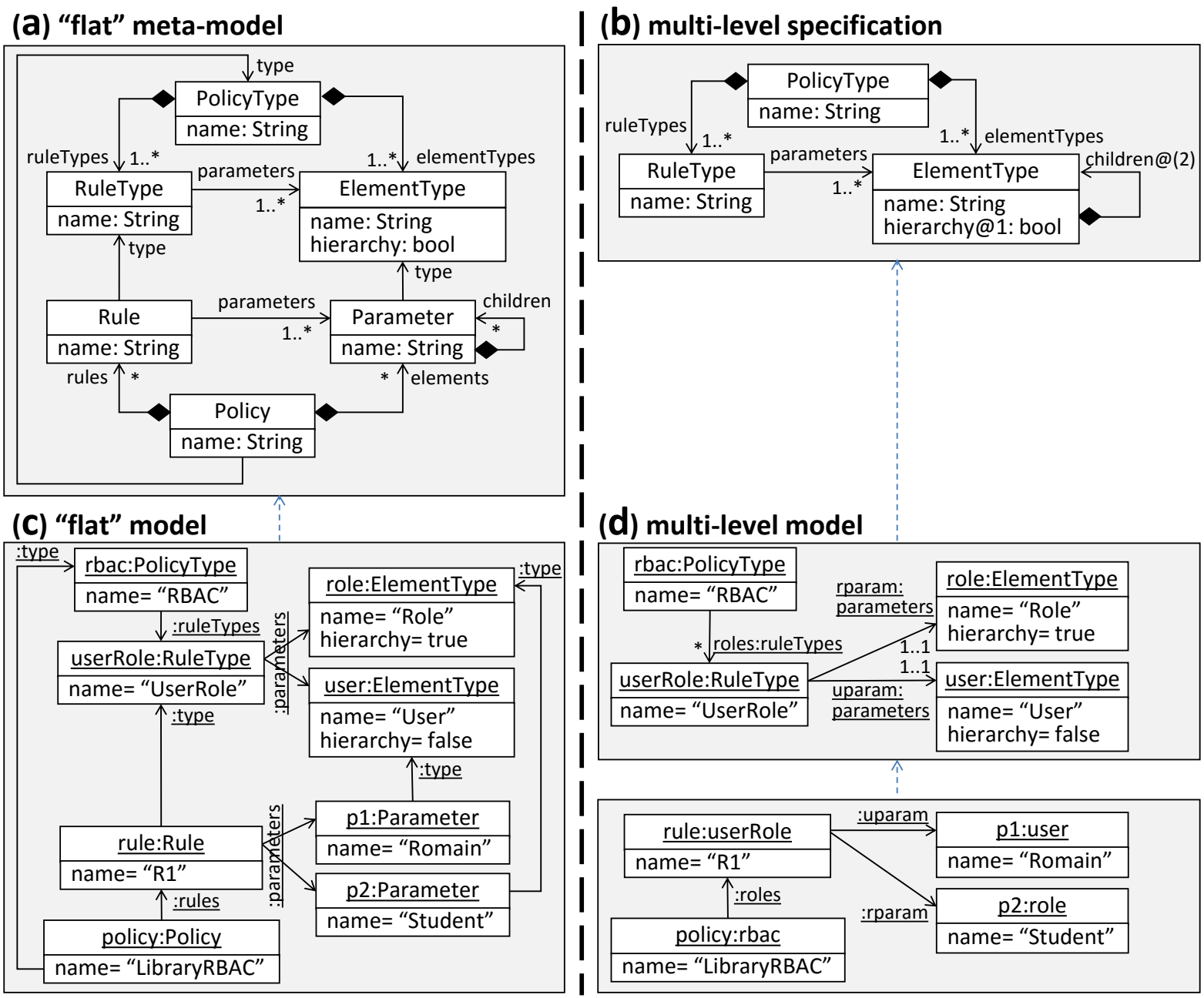
Security Policies with MLM



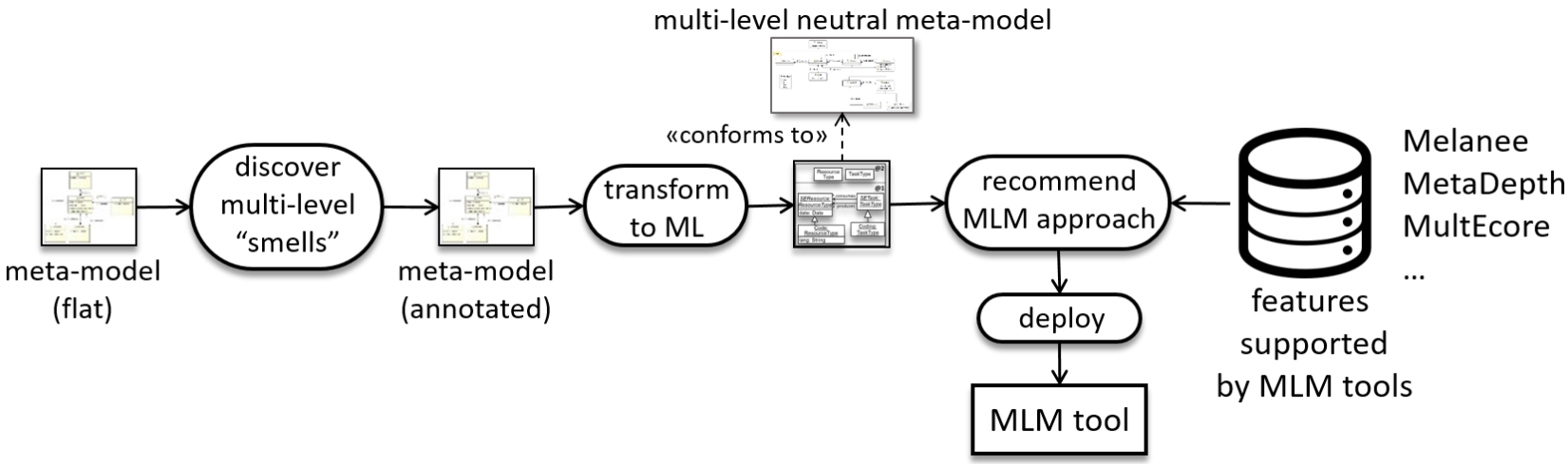
Security Policies with MLM



Security Policies with MLM



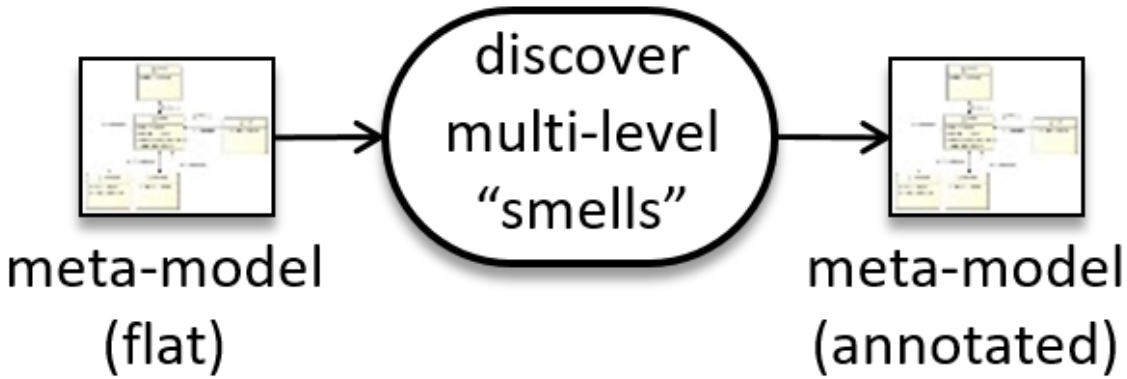
Refactoring into MLM



Goals:

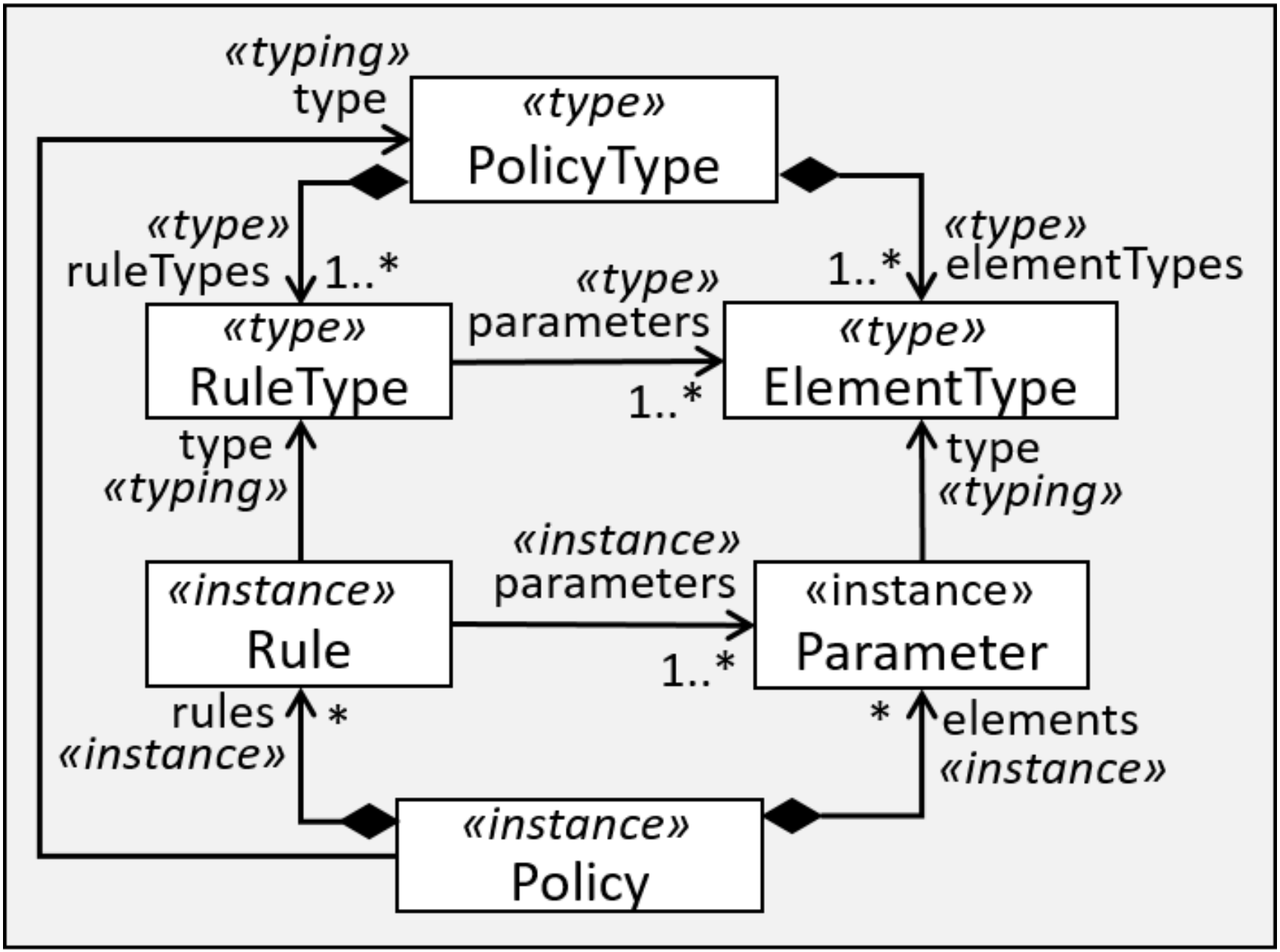
- Empirical data about MLM improvement
- Automatic refactoring tool
- Convergence of MLM frameworks

Step 1: Detecting smells

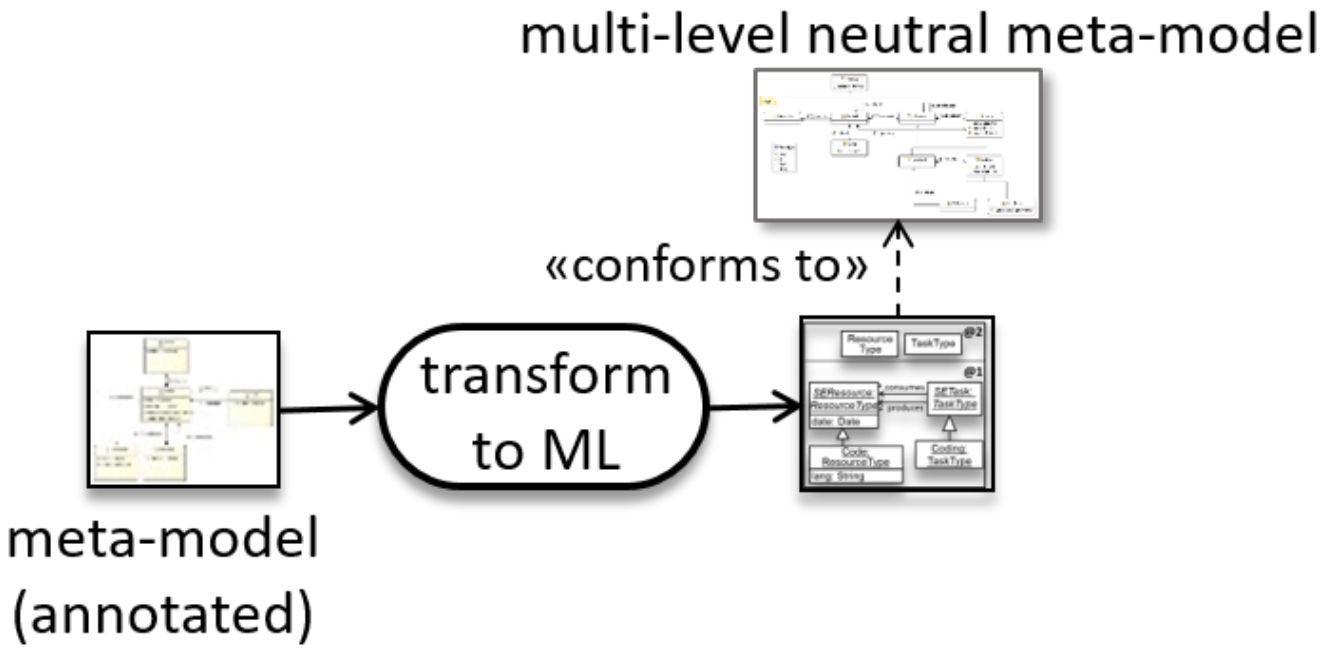


- Heuristic-based annotation
- Based on structure and name similarity
- Adjustable confidence threshold
- Open to human intervention (i.e. semi-automatic)

Step 1: Detecting smells

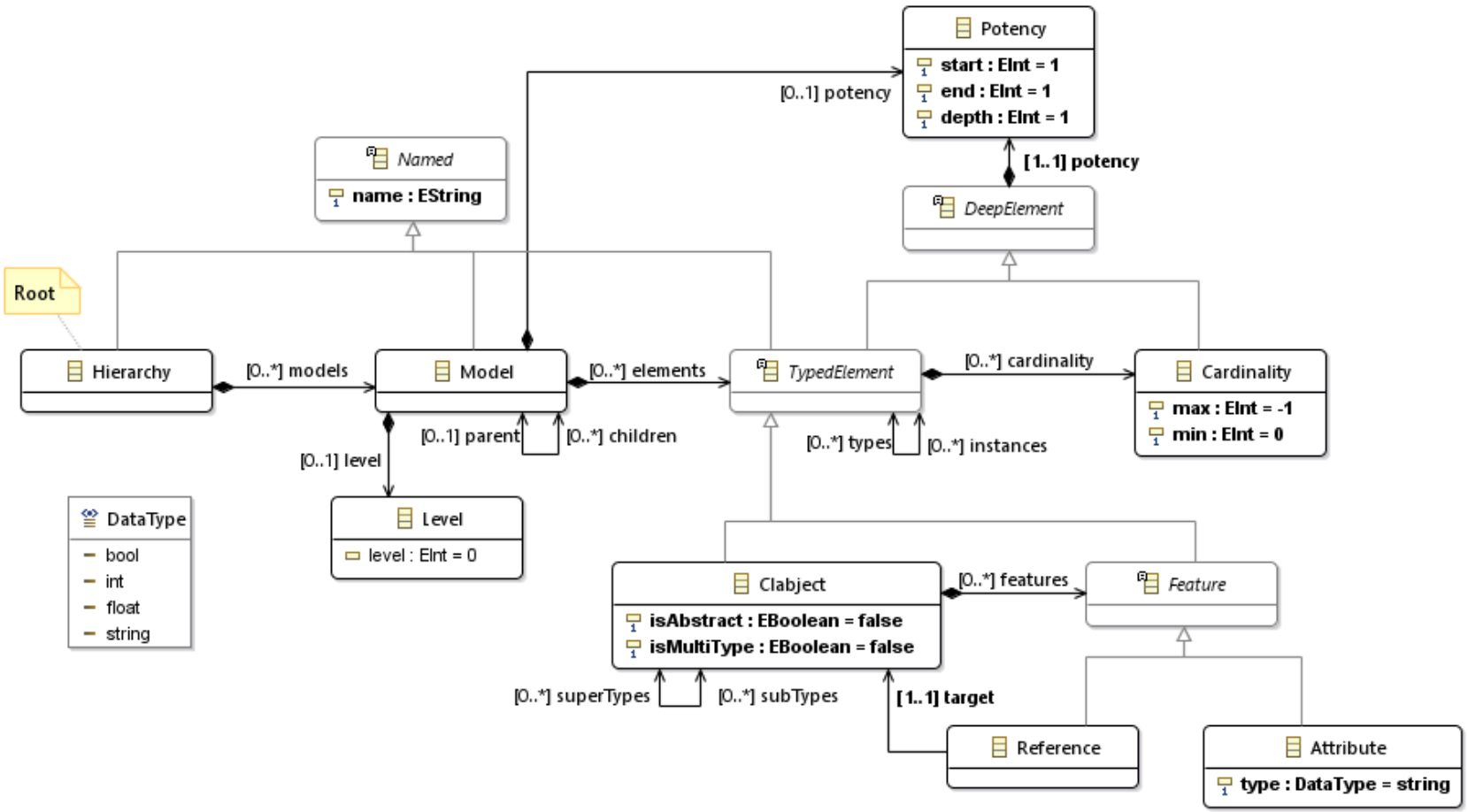


Step 2: Refactoring

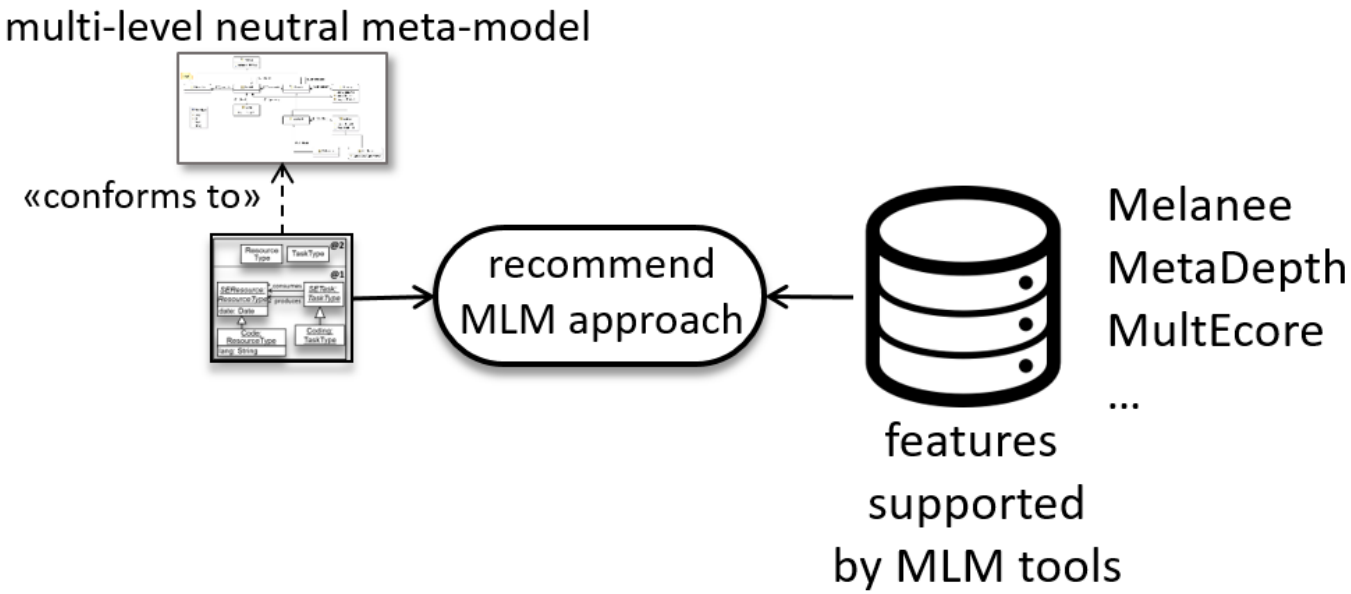


- Transformation applied to each annotated pattern
- Based on annotations from previous step
- Single-model output (for now)
- Automatic

Step 2: Refactoring



Step 3: Recommendation



- Based on framework support for MLM features
- Three degrees of support: *supported*, *emulated*, *unsupported*
- Scores and ranking output
- Automatic

Step 3: Recommendation

dimension	multi-level feature	start	end	depth	MetaDepth
potency in clabjects and references	standard potency	1	1	n (n≥1)	+
	leap potency	n (n>1)	n	1	+
	replicability	n (n≥1)	m (m>n)	1	− (m=n)
	deep leap potency	n (n>1)	n	o (o>1)	− (o=1)
	deep replicability	n (n≥1)	m (m>n)	o (o>1)	− (m=n,o=1)
potency in attributes	attribute durability	1	n (n≥1)	1	+
	attribute mutability	n (n≥1)	m (m>n)	1	∼ (m=n)
instantiation	shallow ref. cardinality	1	1	1	+
	deep ref. cardinality	n (n>1)	m (m>n)	o (o>1)	∼ (OCL)
	multiple typing	-	-	-	+ (a-posteriori)
	abstract types	-	-	-	+

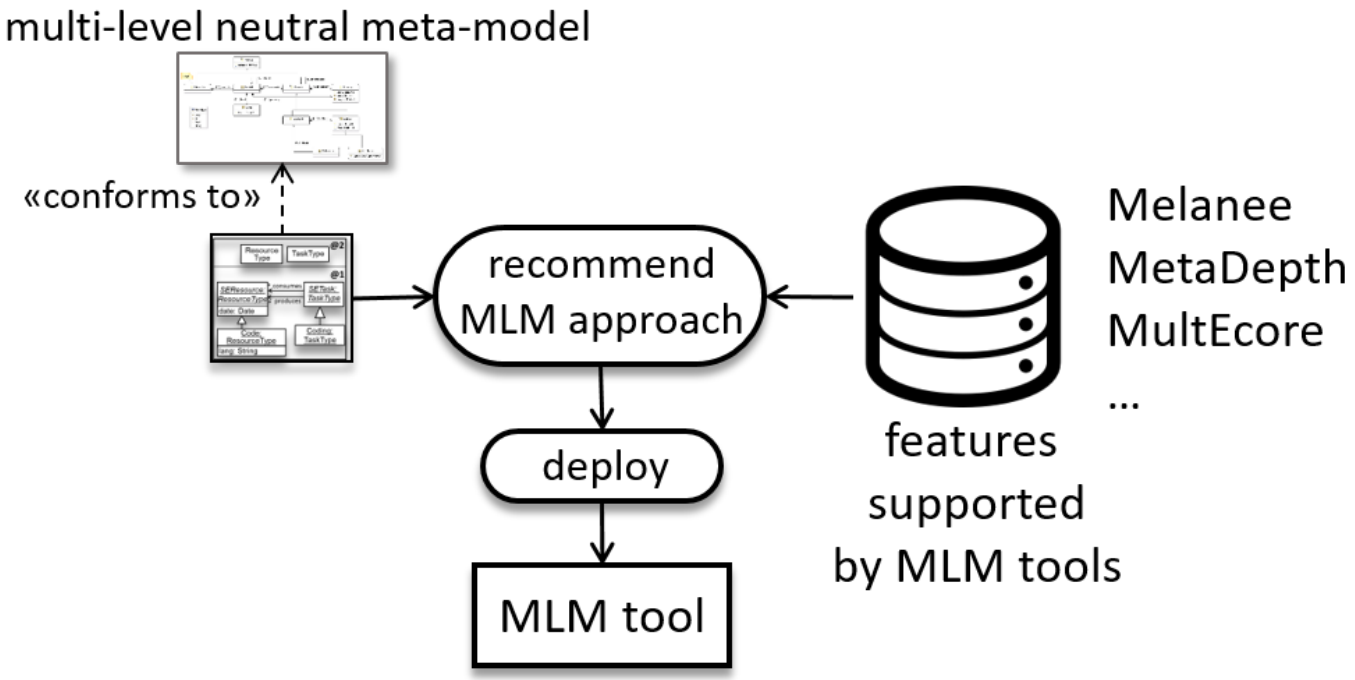
Step 3: Recommendation

dimension	multi-level feature	start	end	depth	MultEcore
potency in clabjects and references	standard potency	1	1	n ($n \geq 1$)	$\sim$ ($n=\infty$)
	leap potency	n ($n>1$)	n	1	$\sim$ ($n=\infty$)
	replicability	n ($n \geq 1$)	m ($m>n$)	1	+
	deep leap potency	n ($n>1$)	n	o ($o>1$)	$\sim$ ($o=\infty$)
	deep replicability	n ($n \geq 1$)	m ($m>n$)	o ($o>1$)	$\sim$ ($o=\infty$)
potency in attributes	attribute durability	1	n ($n \geq 1$)	1	$\sim$ ($n=\infty$)
	attribute mutability	n ($n \geq 1$)	m ($m>n$)	1	− (always mutable)
instantiation	shallow ref. cardinality	1	1	1	+
	deep ref. cardinality	n ($n>1$)	m ($m>n$)	o ($o>1$)	−
	multiple typing	-	-	-	+ (supplementary)
	abstract types	-	-	-	+

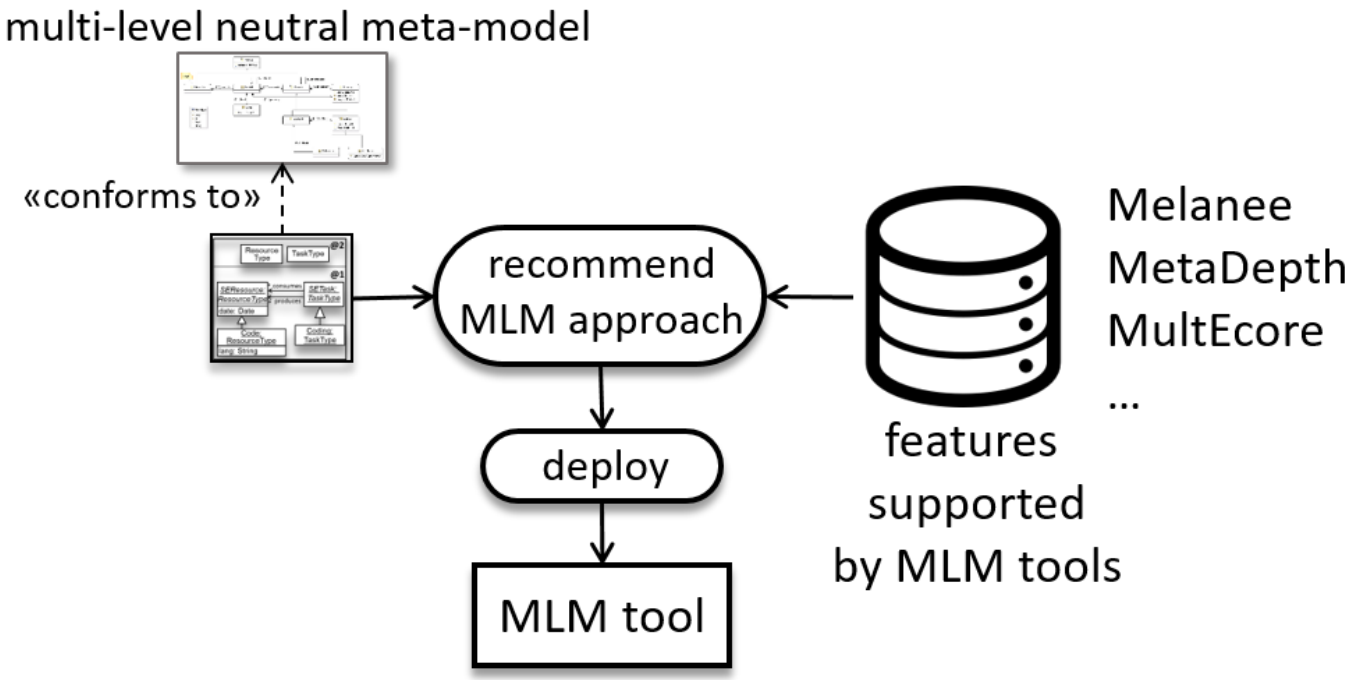
Step 3: Recommendation

dimension	multi-level feature	start	end	depth	Melanee
potency in clabjects and references	standard potency	1	1	n ($n \geq 1$)	+
	leap potency	n ($n > 1$)	n	1	~ ($n=1$)
	replicability	n ($n \geq 1$)	m ($m > n$)	1	− ($n=1, m=n$)
	deep leap potency	n ($n > 1$)	n	o ($o > 1$)	− ($n=1, o=1$)
	deep replicability	n ($n \geq 1$)	m ($m > n$)	o ($o > 1$)	− ($n=1, m=n, o=1$)
potency in attributes	attribute durability	1	n ($n \geq 1$)	1	+
	attribute mutability	n ($n \geq 1$)	m ($m > n$)	1	+
instantiation	shallow ref. cardinality	1	1	1	+
	deep ref. cardinality	n ($n > 1$)	m ($m > n$)	o ($o > 1$)	−
	multiple typing	-	-	-	−
	abstract types	-	-	-	~ (potency=0)

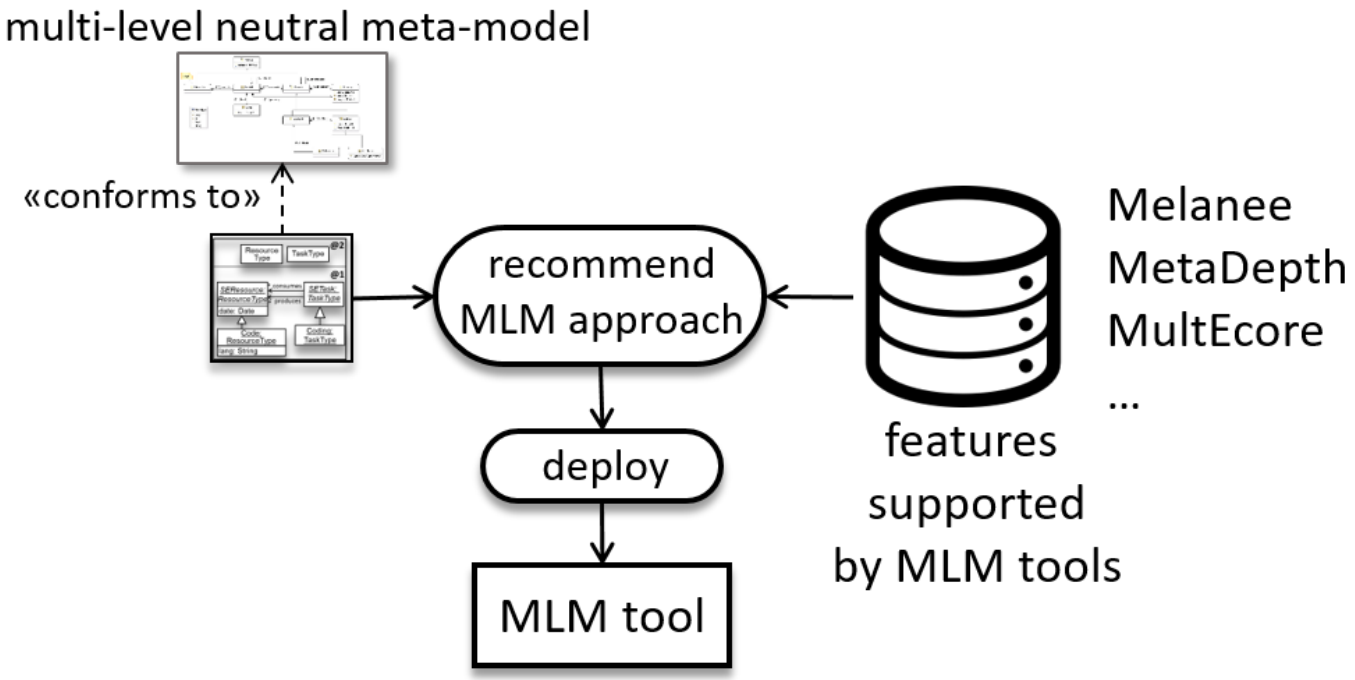
Step 4: Deployment

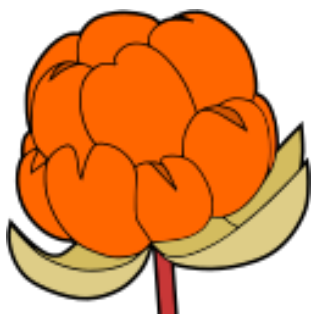


Step 4: Deployment



Step 4: Deployment

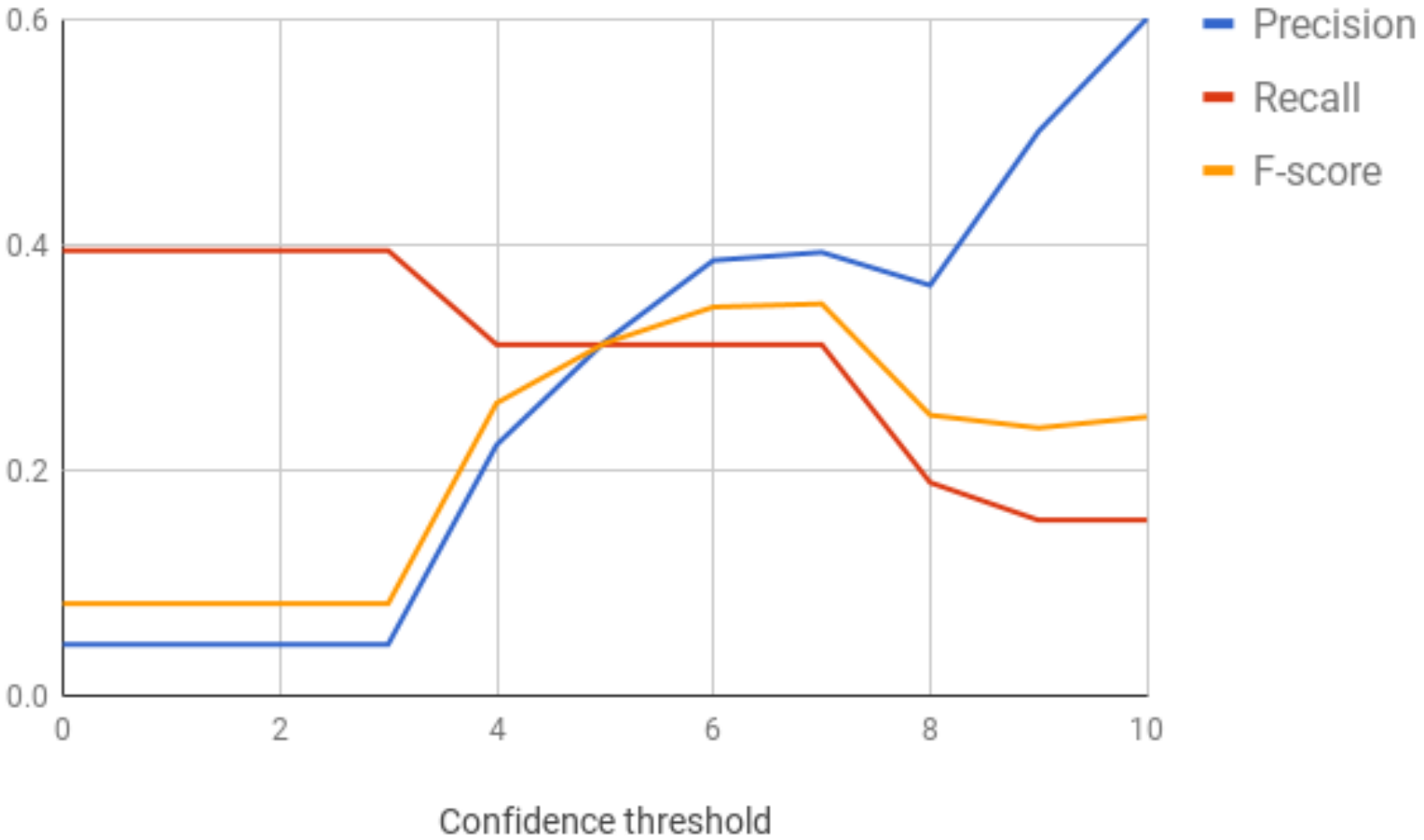




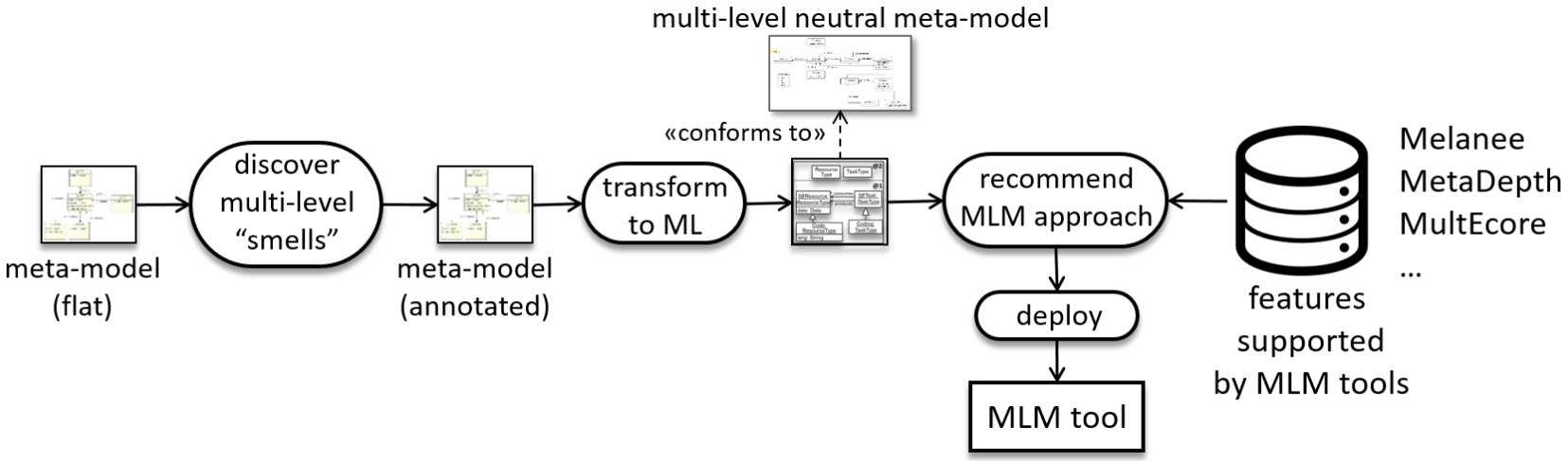
Evaluation: Gain

meta-model	flat meta-model			multi-level version			
	classes	refs.	attrs.	classes	refs.	attrs.	reduc.
Security Policies	7	12	7	4	5	4	50%
Agate	69	123	81	64	118	81	4%
CloudML	21	28	26	15	17	26	23%
CloudML-2.0	33	50	44	21	40	44	18%
HAL	42	16	72	41	15	72	2%

Evaluation: F-score optimization

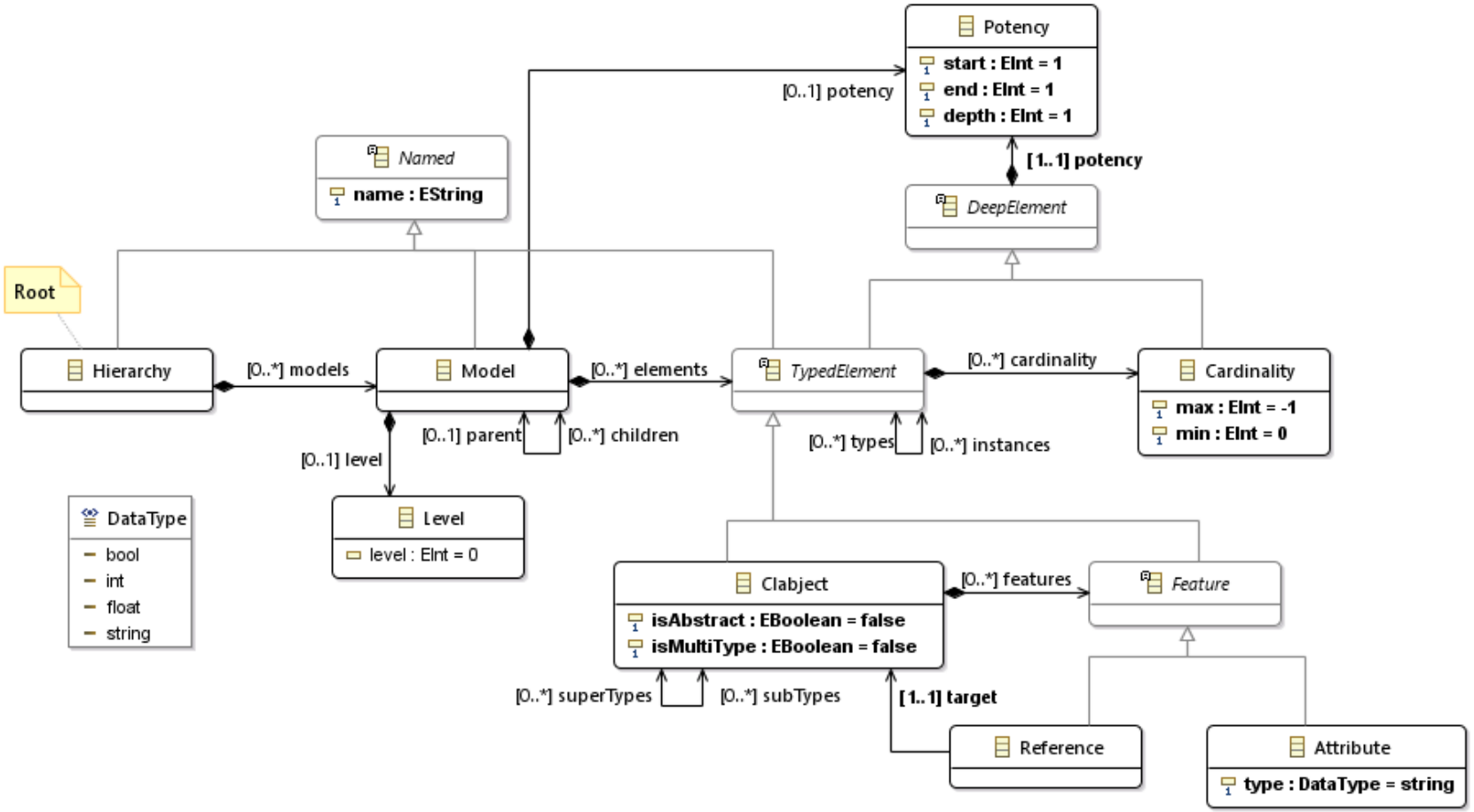


Conclusions



- Empirical evaluation of MLM with third-party data
- Prototype tool support
- Tool-independent representation of MLM hierarchies

Future work



- Support more scenarios
- Large-scale evaluation (Github)
- Crystallize tool-independent metamodel as exchange format

References

- Fernando Macías, Esther Guerra, and Juan de Lara. "Towards rearchitecting meta-models into multi-level models". In: *International Conference on Conceptual Modeling*. Springer. 2017, pp. 59–68
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