

MULTI Vector Industry Challenge 2026

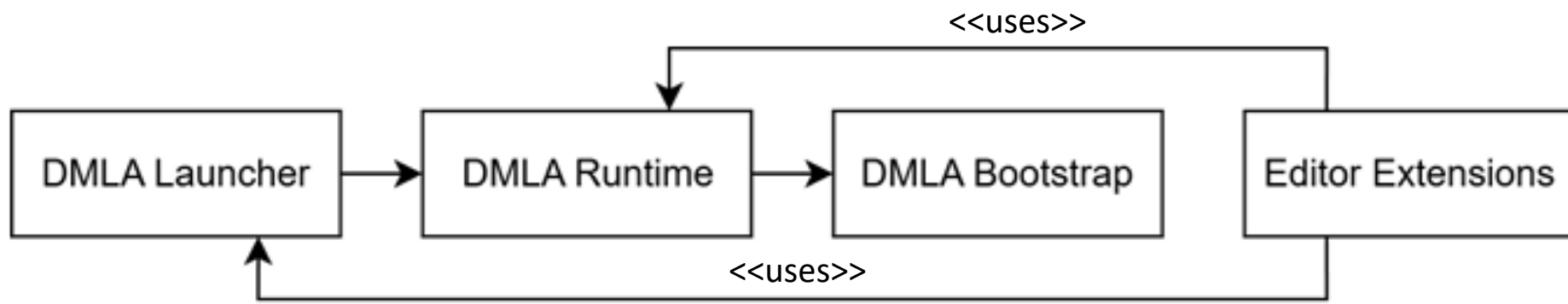
Contractual Type-Square pattern

And its lack of necessity in DMLA

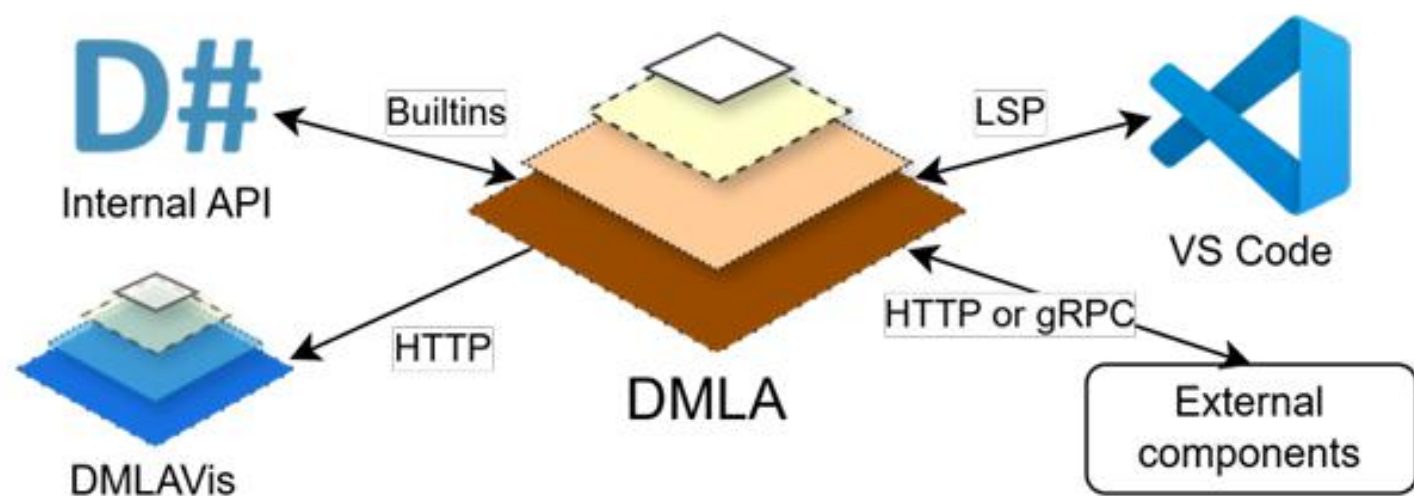
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1. The Framework

The current version 3.5 Dynamic Multi-Layer Algebra (DMLA) solidifies its language semantics [1] and supporting toolchain [2].



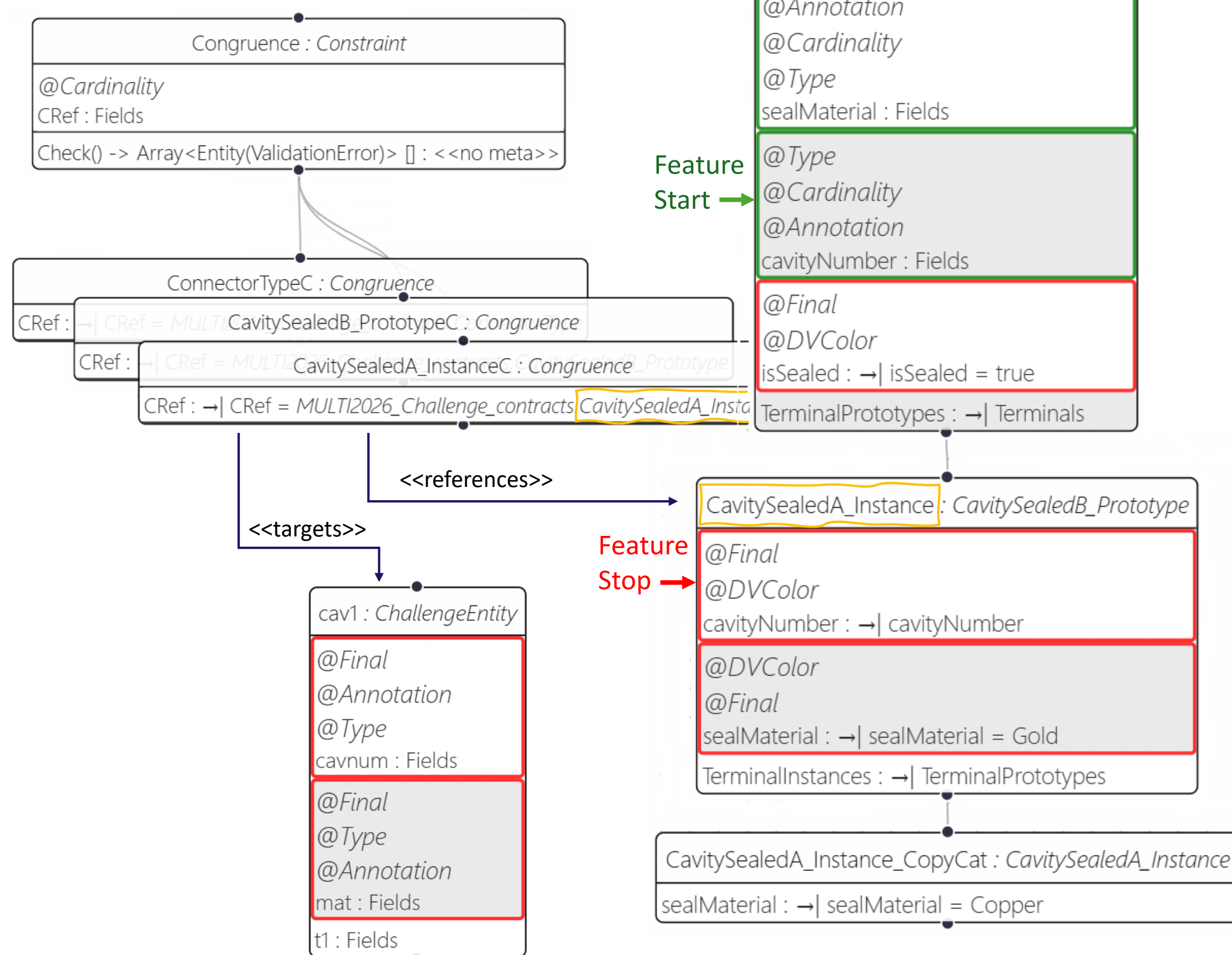
Framework extensions: *Language Server Protocol*, *visualization* over HTTP, *built-in functions* offered via an automatically generated API, and a *Model Context Protocol* (still Work-In-Progress).



In DMLA the key relationship between entities is the *gradual refinement* along the meta-chain introducing new features and restricting existing ones via *constraints*.

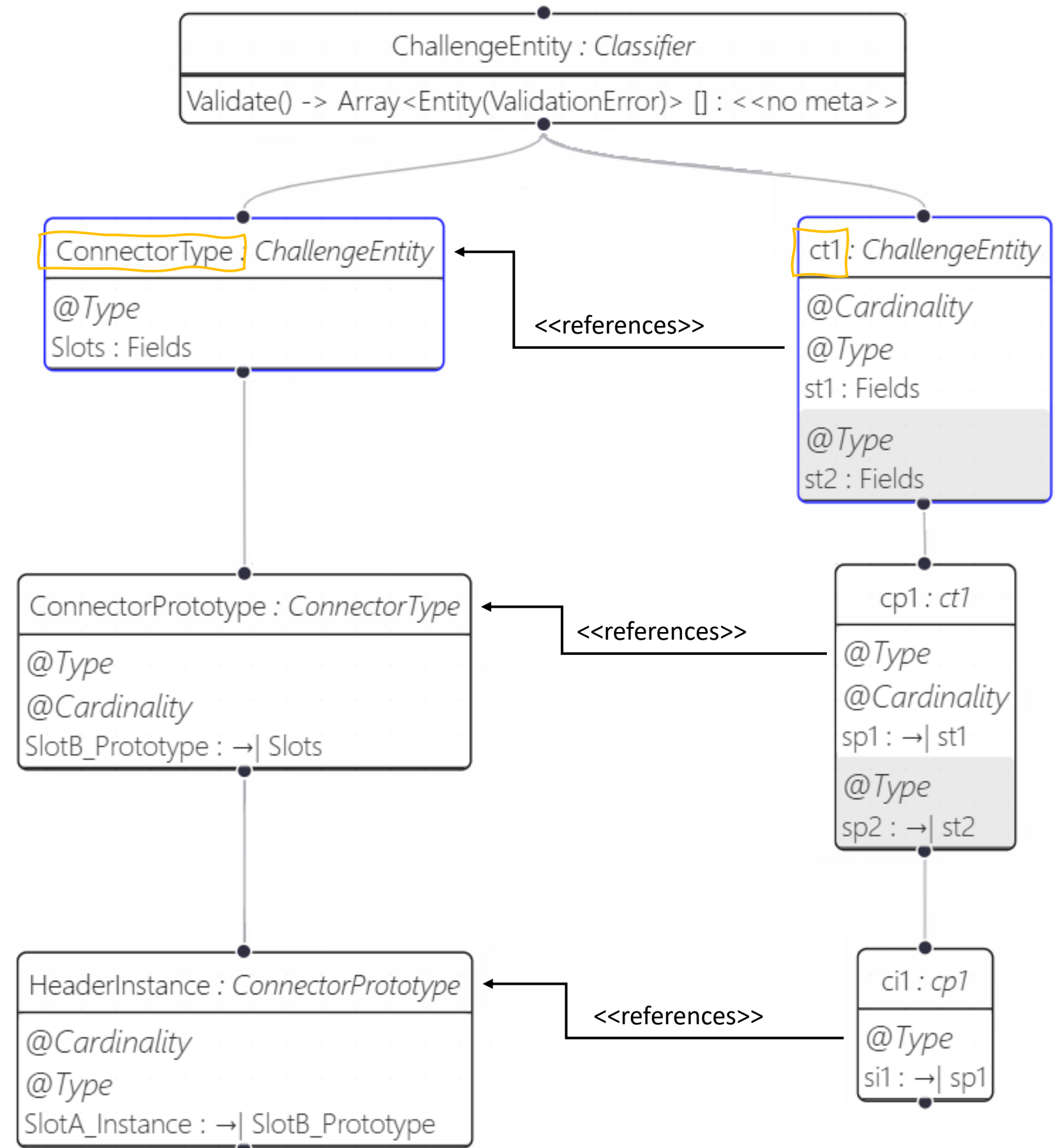
2. The explicit Type-Square pattern

A straightforward *Type : Prototype : Instance* flow originates in a common root *ChallengeEntity* injecting basic bijection requirements via a domain specific *Validate* operation. Typing *Congruence* then may be an elaborate constraint annotation where *Constraints*, like *Type* and *Cardinality* are checked, akin to *Contracts*. [3,4]



3. The implicit Type-Square pattern

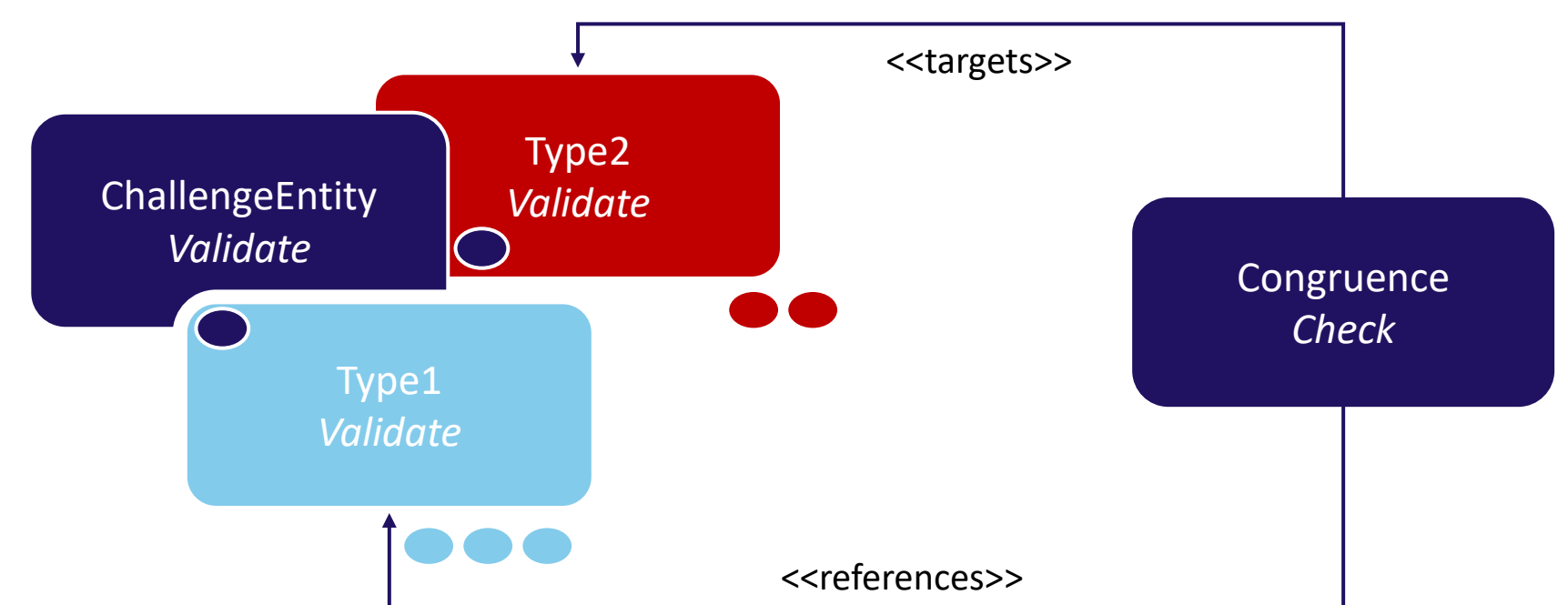
We can omit the *Congruence* constraint if we move the integrity constraints to the meta-chain to formalize the inherent type-square pattern of DMLA. What we loose is the ability to connect arbitrary abstraction levels.



4. Discussion

While the Type-Square pattern can be applied automatically and seamlessly in level-blind gradual refinement, this flexibility of the DMLA-native approach poses its main problem for complex designs – embedding the meta-model as a *@Type* annotation makes it is hard for the modeler to follow through the many interim refinement layers, or even the “layer jumping” allowed by these solutions.

Luckily, these type-instance relations can be formalized via contract-like *Congruence* constraints. These help us navigate and enforce the structural conformity w.r.t. *Type*, *Cardinality* and any other *Constraint* derived annotation in case of each *Field* of a typing-typed entity pair. However, validating all the bijection and congruence requirements between distinct meta-chains impose a high complexity in the domain specific logic which needs to be programmed by experts, and results in ~30% extra validation time compared to the native solution.



Repository

Artefacts made available at <https://github.com/dmlaorg/multi-vector-industry-challenge-2026>
The validation, visualization commands are all invocable in VS Code within the Dev Container.



References

- [1] G. Gembela, G. Mezei, F. A. Somogyi, and A. Furmann, “Revisiting the foundations of dynamic multi-layer algebra 3.5,” in *Proceedings of the Automation and Applied Computer Science Workshop 2026 (AACS'26)* (I. Vajk and D. Dunaev, eds.), (Budapest, Hungary) Budapesti Műszaki Egyetem, Automatizálási és Alkalmazott Informatikai Tanszék, 2026.
- [2] G. Gembela, G. Mezei, “A Queryable Model Store Architecture for Dynamic Multi-Layer Algebra,” (AACS'26)
- [3] A. Furmann and G. Mezei, “Towards Concept-to-Software Spanning Heterogeneous Multi-level Modeling,” (AACS'26)
- [4] S. Bacsí and G. Mezei, “Bridging requirements and configurations: A multi level approach to system design,” in *Proceedings of the ACM/IEEE 28th International Conference on Model Driven Engineering Languages and Systems*, (New York, NY, USA), pp. 780–784, Association for Computing Machinery, 10 2025.

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Acknowledgements

The project supported by the Doctoral Excellence Fellowship Programme (DCEP) is funded by the National Research Development And Innovation Fund of the Ministry of Culture and Innovation and the Budapest University of Technology and Economics. Special thanks to the valuable support of Knorr-Bremse R&D Center Hungary, Budapest.