Toward a Modular Approach for Type Systems and LSP generation

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Problem Statement
Programming Language Implementation

The implementation of a programming language is a complex task that involves several implementation aspects, such as:

- Syntax and semantics definition
- Type system definition
- Code generation
- Error handling and recovery
- IDE support
- Documentation

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It is usually done in a monolithic way, where all the aspects are tightly coupled.

This makes the maintainability, extensibility and reusability of the implementation difficult.

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Type Systems and IDEs Support

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Often some parts of compilation, such as code generation, makes use of feature-oriented programming to support different architectures.

However, the type system and the IDE support are usually implemented using a top-down approach.

Software Product Lines

Problem Statement

SPLs

LPLs

LWs

LSP

The Reductions of Combinations In a Nutshell

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Type System Components

LSP in Action

LSP in Action

Since 1990s, researchers have been working on the concept of Software Product Lines (SPLs) to move towards a more modular world.

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- SPLs defines a family of software products.
- SPLs is described by a Feature Model.
- A Feature Model describes the variability of the software.
- SPL variants are generated by selecting a set of features.
- A feature (or artifact) is a first-class entity in SPLs.

Software Product Lines
Language Product Lines

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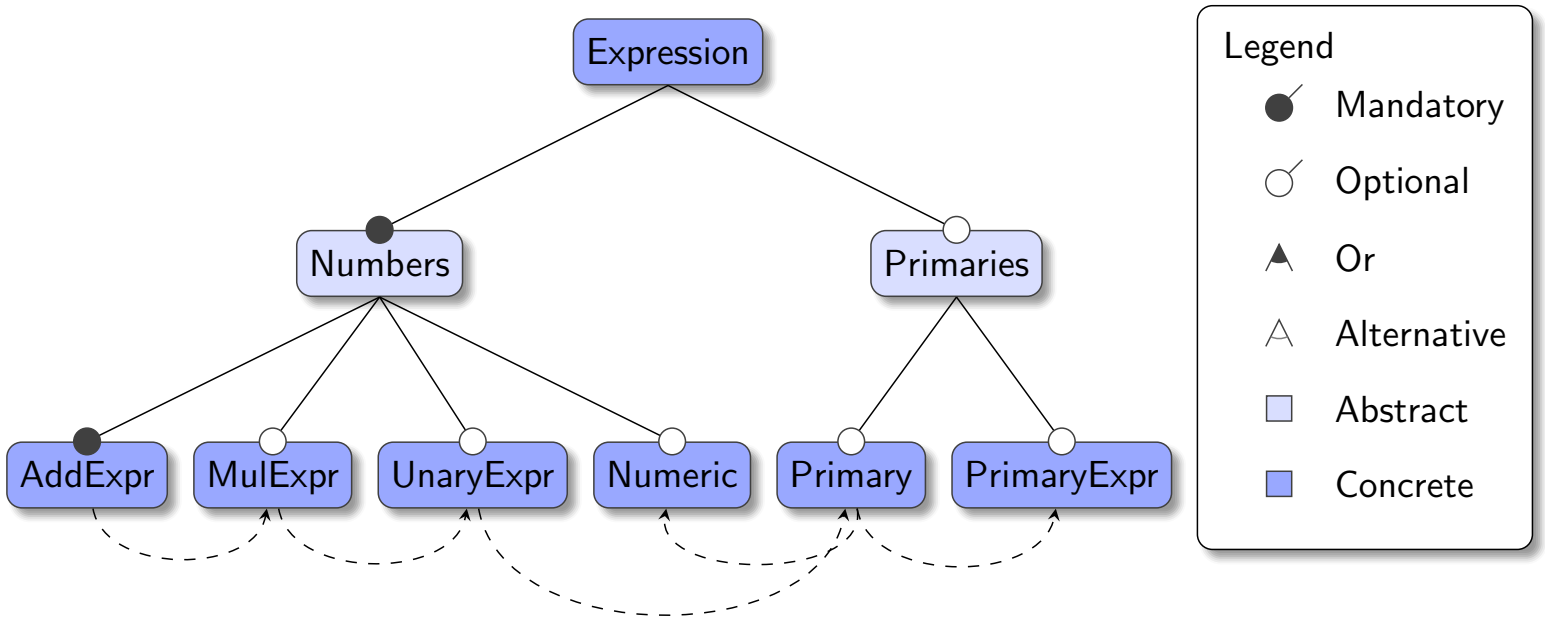
Applying the concept of SPLs to programming languages, we obtain the concept of Language Product Lines (LPLs).



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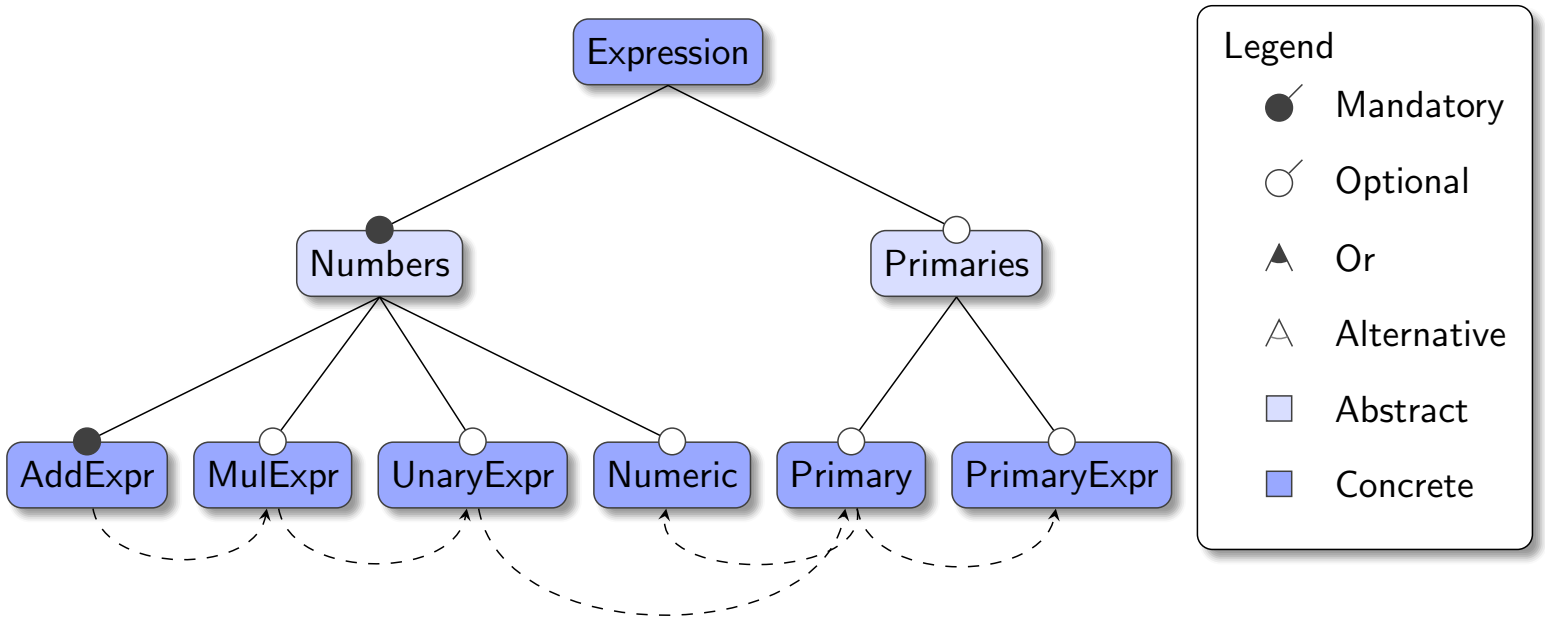

Some achievements:

- **Bottom-up** approach to language implementation
- **Reusability** of language artifacts
- Multiple **variants** of the same language
- **Language Workbenches** come to the rescue

Software Product Lines
Language Workbenches and Neverlang

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Language Workbenches (LWs) are tools that allow the development of programming languages, both GPLs and DSLs.
Some LWs allow the development of LPLs.

Language Workbench	Modularization Supp.	Precompiled Feature Supp.	Native IDE gen.	LSP Gen.	LSP Mod.
JustAdd	◐	○	○	○	○
Melange	⍓	○	2rd party (EMF)	☆	☆
MontiCore	◐	◐	●	○	○
MPS	⍓	○	●	☆	☆
Rascal	○	○	●	○	○
Spoofax	⍓	◐	●	☆	☆
Xtext	○	◐	●	●	○
Neverlang	⍒	●	○	★	★

● Full support

○ No support

◐ Limited support

⍒ Fine-grained mod.

⍓ Coarse-grained mod.

★ My contribution

☆ Future Work

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Neverlang	⍒	●	○	★	★

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- ○ No support
- ◐ Limited support
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- ★ My contribution
- ☆ Future Work

Neverlang is a language workbench, developed by the ADAPT lab, that supports the development of LPLs.

Language Server Protocol
The Reduction of Combinations

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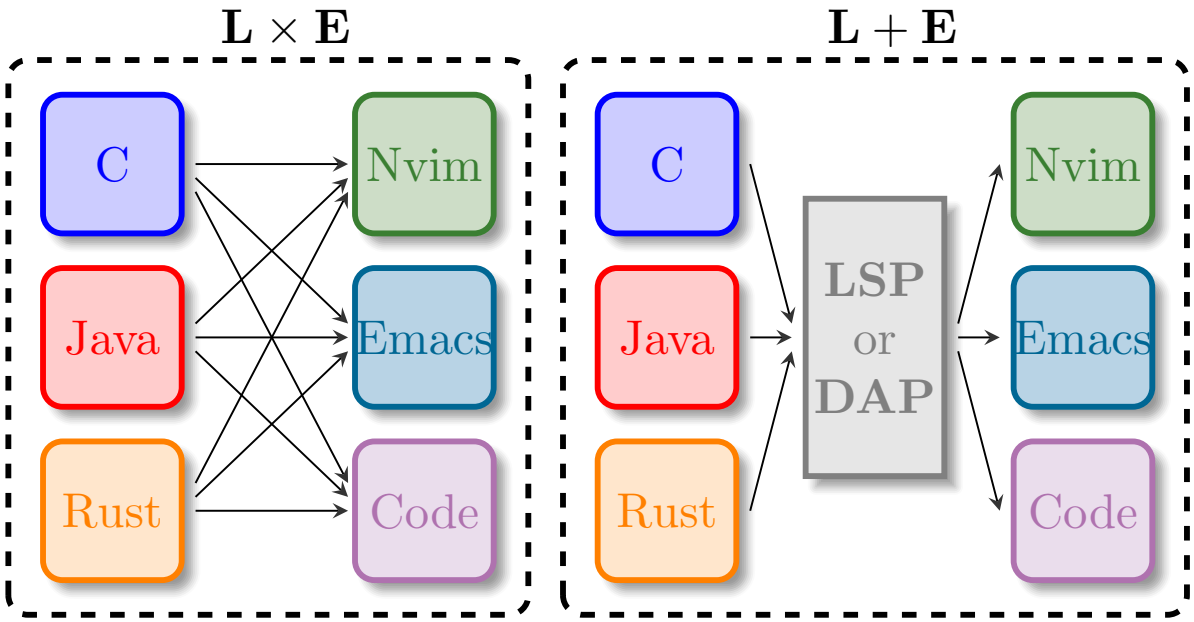

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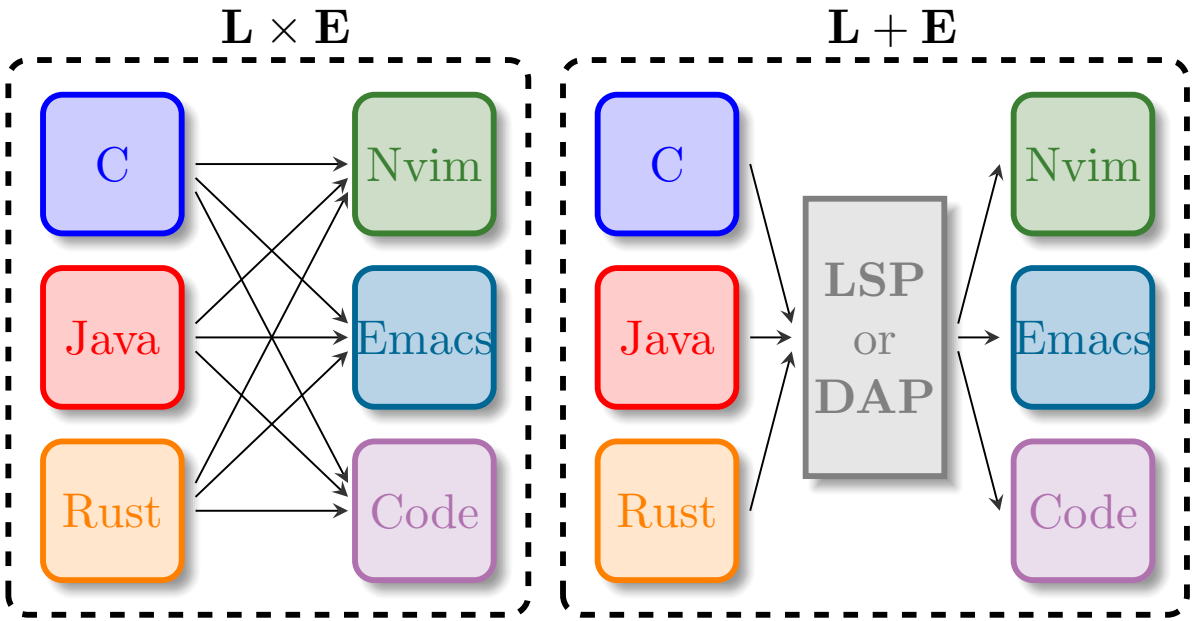

Spoiler: We have reduced the number of combinations from $\mathbf{L} \times \mathbf{E}$ to $\mathbf{N} \times \mathbf{1}$ where $\mathbf{N} \ll \mathbf{L}$.

Language Server Protocol
LSP In a Nutshell

The Language Server Protocol (LSP) is a protocol that allows the communication between a Language Server and an IDE.

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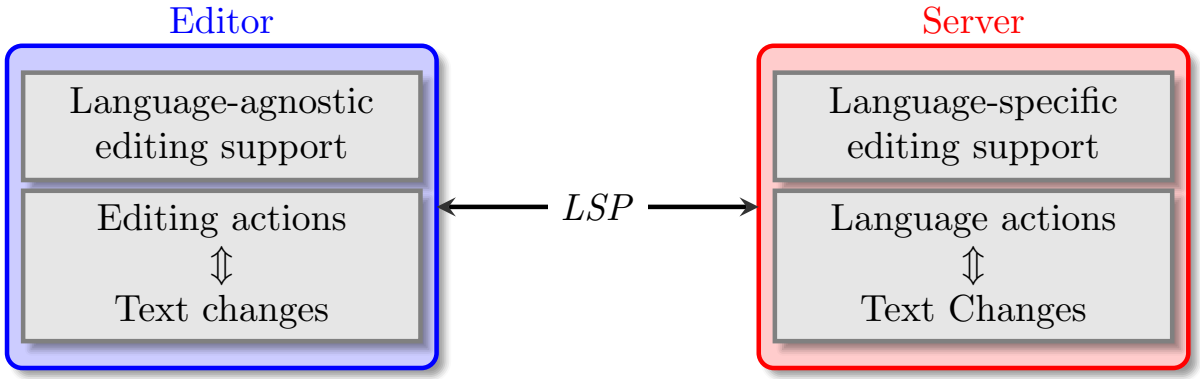

Intrinsic properties:

- Language-agnostic
- IDE-agnostic
- Asynchronous
- Text-based

Features:

- Diagnostics
- Hover
- Go to definition
- Find references
- Inlay hints

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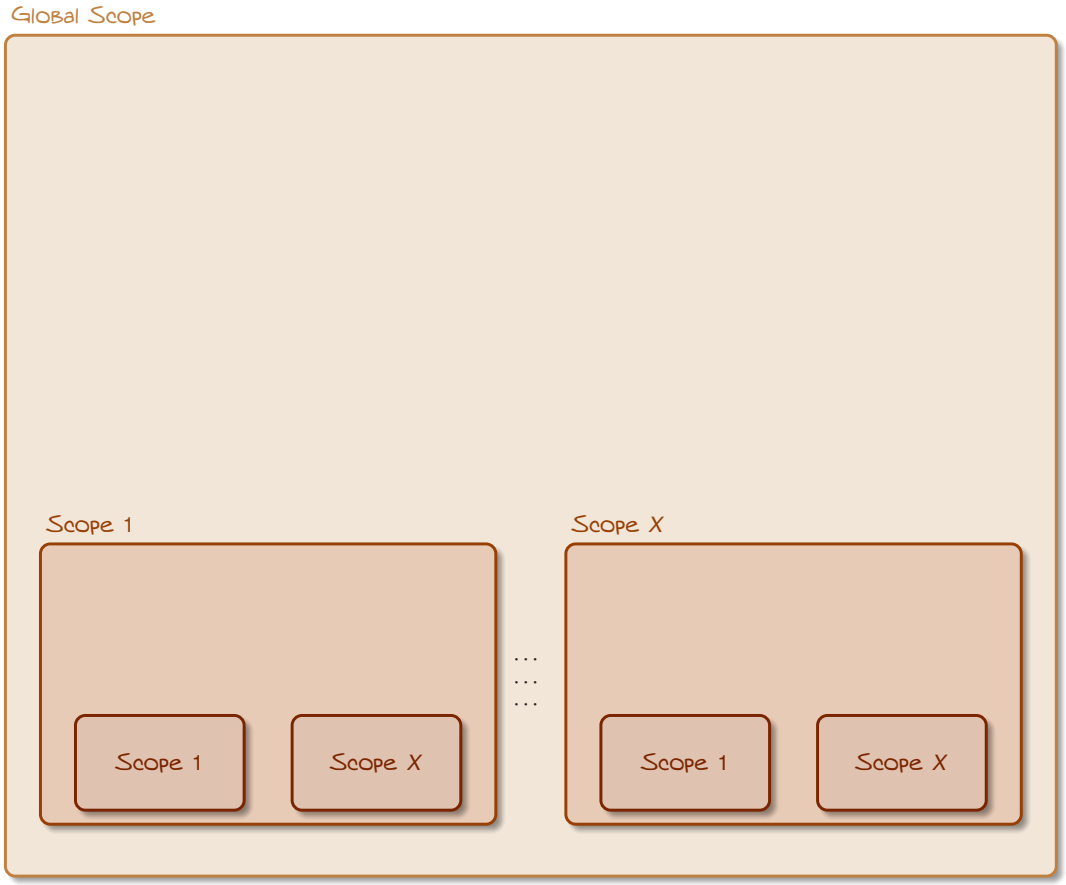

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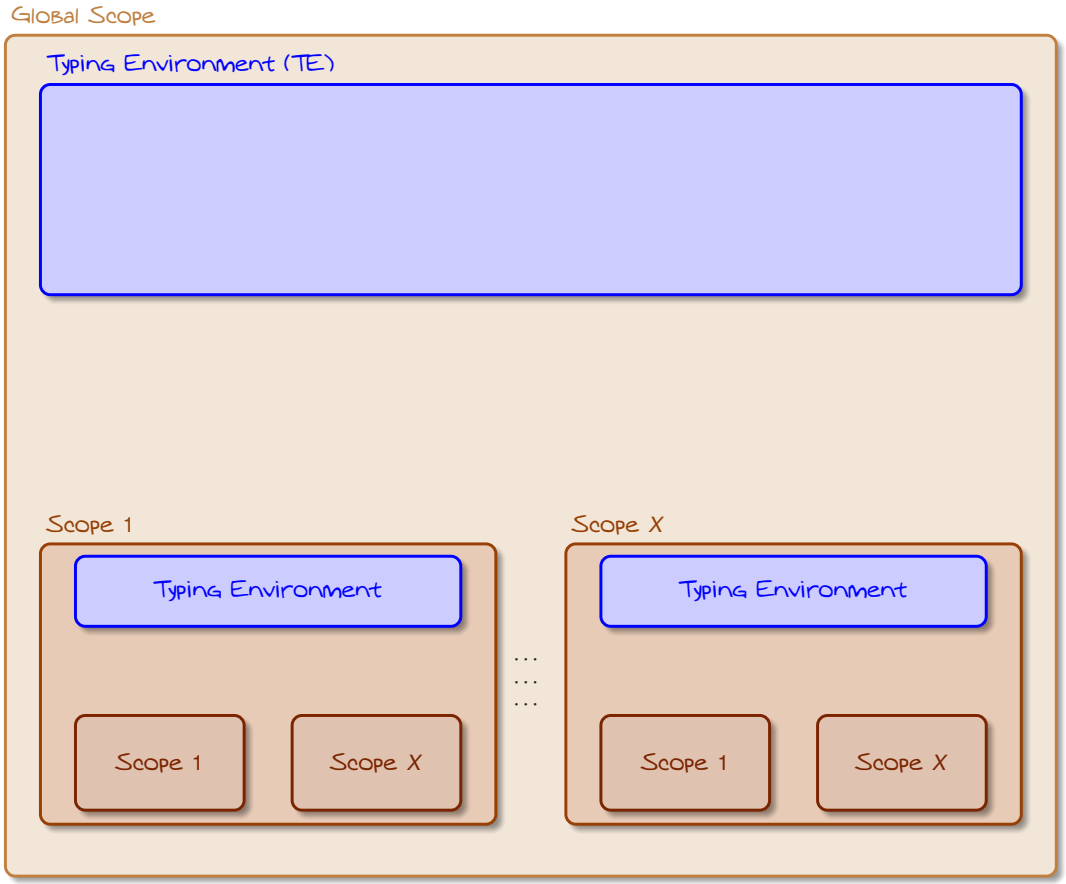

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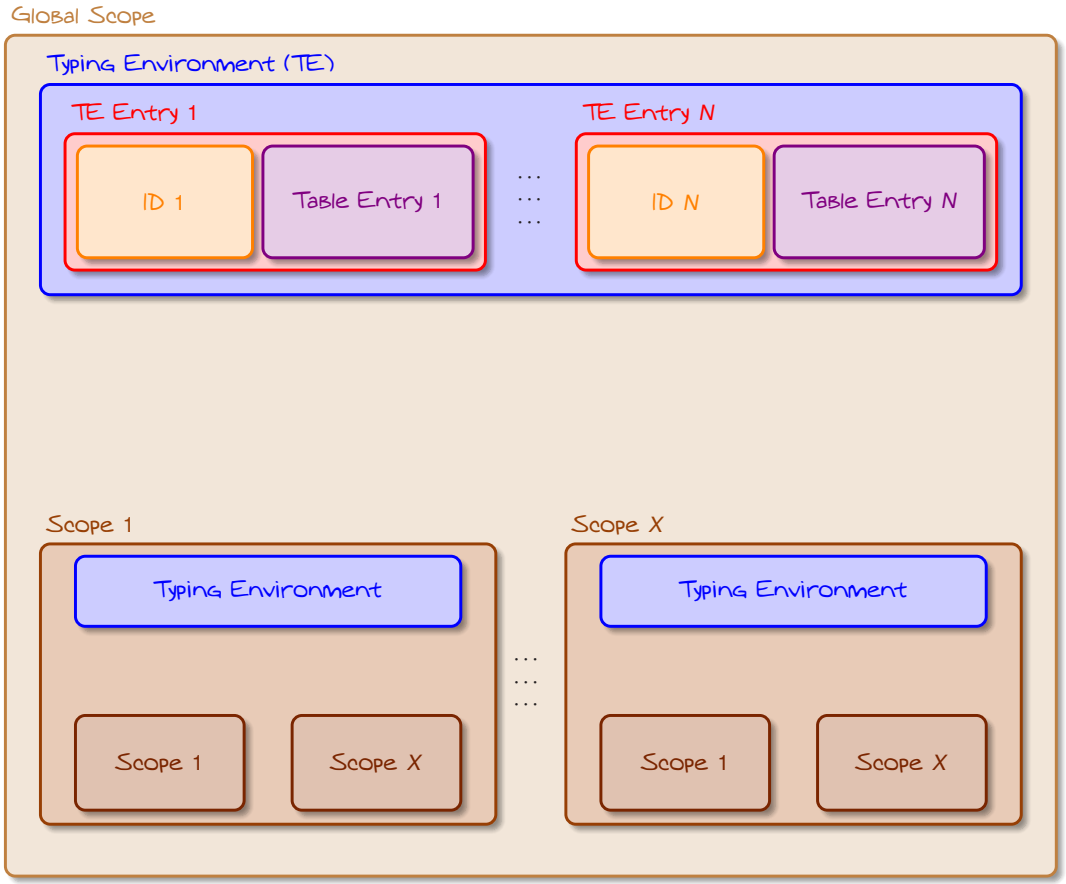

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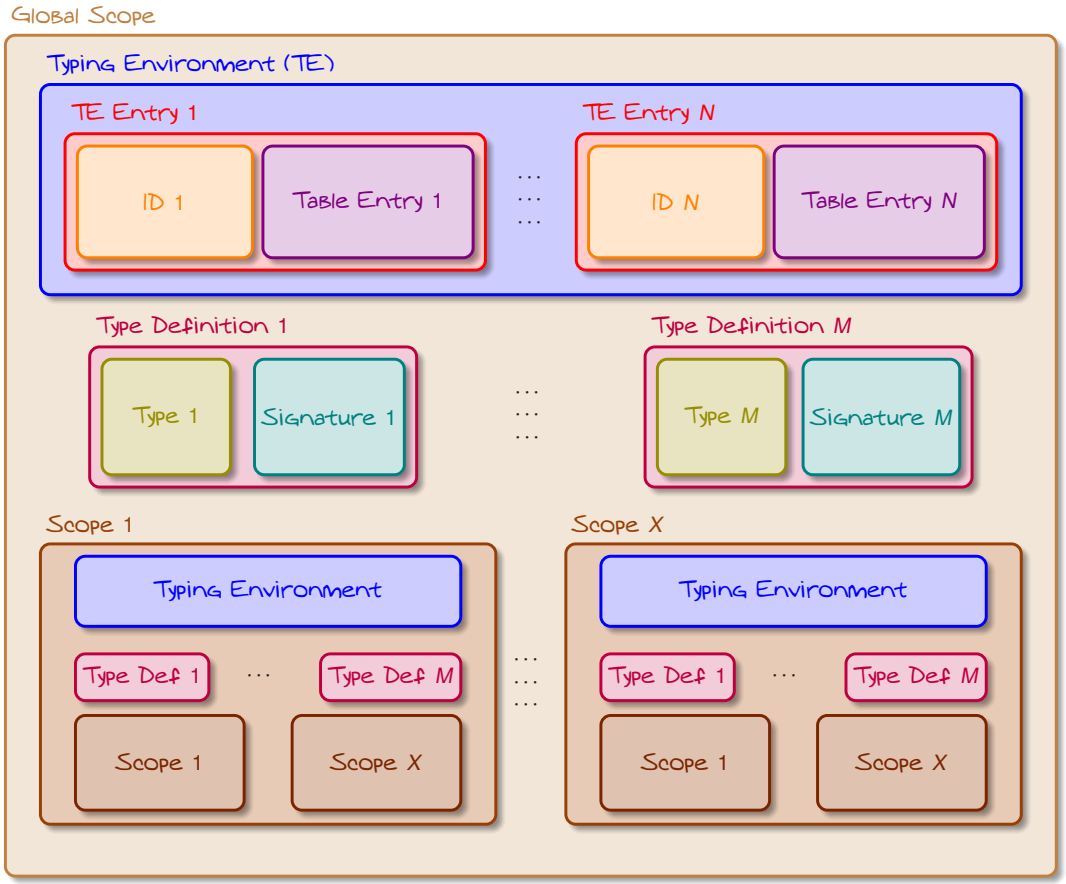

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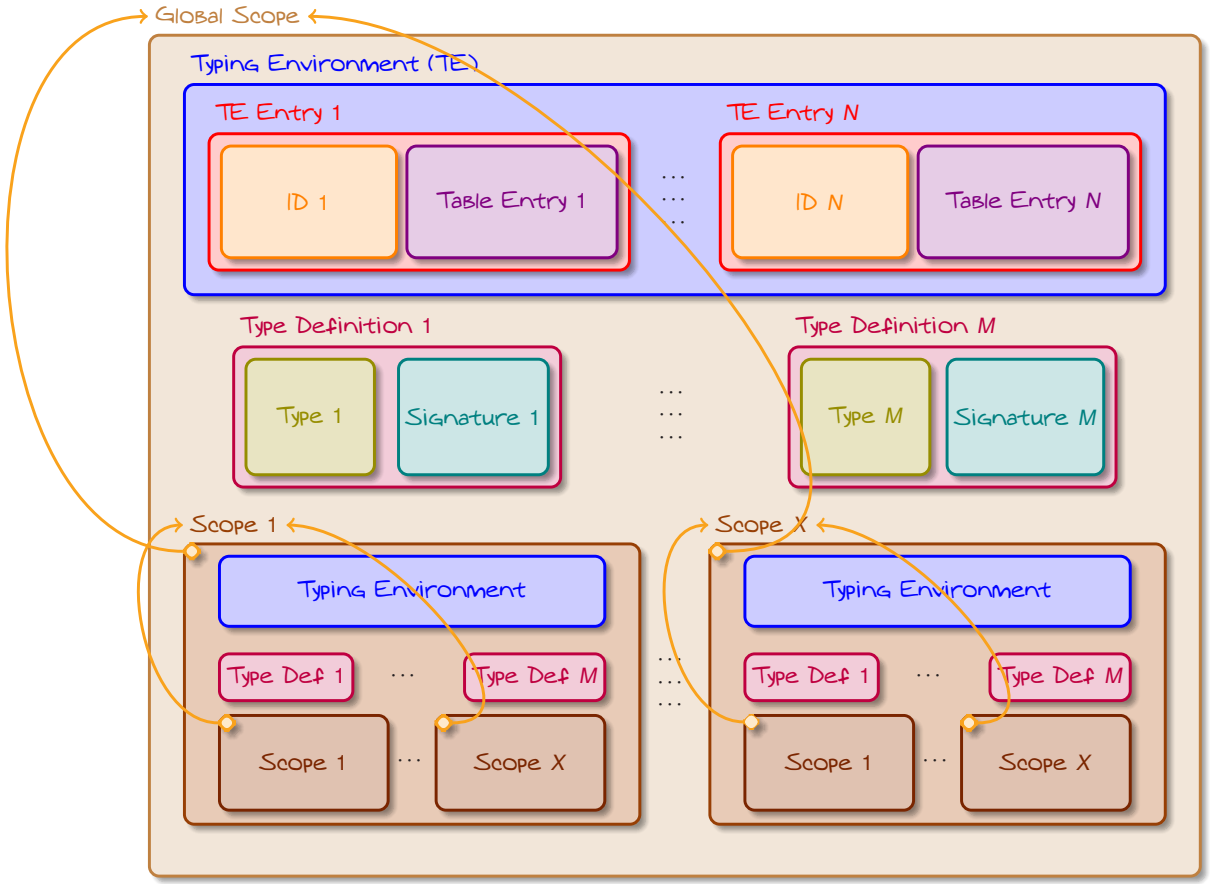

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HELLO