The Language of Languages Research Project: Unifying Concepts Expressed Across Different Notations

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Abstract
Maintaining the consistency of multiple notations used in large projects is daunting. Language of Languages(LoLs) is our experimental language workbench that fulfills a frequently overlooked but important role: unify the different notations so developers can better understand and evolve a project. Due to the impossibility of anticipating all the notations that may be used in a project, LoLs adopts a language agnostic view and supports different notations from free-form text to graphical forms and shapes. Our demo begins by illustrating the fundamental ideas of LoLs through building a calculator that supports multiple notations; the demo concludes with more advanced projects that exemplify the extent of our multi-notation support.

Categories and Subject Descriptors D.2.2 [Software Engineering]: Design Tools and Techniques; D.3.3 [Programming Languages]: Language Constructs and Features

General Terms Design, Languages

Keywords Language Workbench, Modeling, Smalltalk

1 Introduction
Different programming languages, libraries and frameworks provide different notations for representing components. For instance, state machines, a common component used in many engineering disciplines, can be expressed using VHDL code (text) or state diagrams (graphics). Large projects seldom, if ever, commit to just a single notation. Instead, multiple notations are used, with developers choosing the most expressive one for the task at hand.

Using multiple notations creates several challenges: (i) communication – how would my colleagues understand the notations that I have chosen? (ii) correctness – how would we verify that notations are consistent with one another? LoLs [1] has an ambitious goal: distill the core concepts from each component and attempt to unify these underlying concepts across different notations.

This unification maintains consistency and facilitates virtual integration of components as the project evolves. Virtual integration, done early and continuously, enables prompt detection of problems and reduces the cost of fixing them. Virtual integration is a key component of the System Architecture Virtual Integration (SAVI) project [3], and we see LoLs as one feasible approach for supporting it.

2 Language of Languages Approach
Consider the simple expression “3 + 4”. There are different notations to represent this expression: in Western Numerals, Roman Numerals, or even using graphics. Regardless of the notation, the underlying concept remains the same: we are adding two numbers together. How can we represent this concept across different notations?

The fundamental building block of LoLs is the Language Element. Everything has a corresponding Language Element. In Figure 1, the symbols “3”, “+” and “4” have corresponding Language Elements. These Language Elements form a Language Element Tree. Each Language Element has a corresponding Concept. In our example, we have two Concepts: Addition and Number. Each Concept, in turn, has several Language Definitions that it can select from. In our example, we have three Language Definitions: Western, Roman and Graphical. The Western Definition is being used in our example (indicated by the check mark).

The fundamental idea of LoLs is thinking in terms of reusable Concepts that apply across different notations. Each notation is supported by a particular Language Definition. Language Definitions do not stand alone; they can reference other Concepts. For instance, it is necessary for the Addition Concept to reference and use the Number Concept. Each Language Definition supports three operations: checking, parsing and projecting.

Checking The checking operation validates if a Language Definition is applicable for the current context.
Parsing The parsing operation recognizes the notation that is being used and builds a Language Element Tree from each construct of interest.

Projecting The projecting operation interprets or transforms Language Elements. This operation can take a Language Element Tree and reduce it to a single value e.g. the tree in Figure 1 is reduced to the value 7. Or, it can transform a Language Element Tree from one notation (Western Numerals) to a different notation (Graphical).

Our approach allows us to easily “plug-n-play” different concepts. New Concepts and Language Definitions can easily be written by the developer or extended from existing ones. Judicious use of Concepts and Language Definitions in LoLs affords the developer a lot of freedom in expressing the underlying domain knowledge. It is an open research question to catalog the common concepts that apply to various projects.

3 Agenda for Demo

We begin by showing how to build a basic calculator in LoLs. We start with a calculator that only understands Western Numerals and show how to add support for graphical notations in a modular fashion. Starting with a simple example provides the audience with both a high-level overview of LoLs and also a deeper understanding of how our tool is implemented. Figure 2 shows the preliminary user interface for our tool. After familiarizing the audience with the basic ideas, we will demonstrate how to support projects that require the use of multiple notations. These projects illustrate the extent of our support for multiple notations.

The SPLASH community has always been at the forefront of new ideas and would be a befitting audience for LoLs. LoLs is a novel idea that presents not only a new way of thinking about programming but also a minimalistic yet flexible approach that is easily extensible. Our current bootstrap implementation in Squeak Smalltalk [2] makes good use of metacircularity (LoLs is defined in terms of itself) and well-known design patterns for its core. We leverage the Morphic graphic system in Squeak to support graphical notations. LoLs has a small core that is easy to understand and extend for different purposes.

The LoLs bootstrap and examples presented will be available for download from www.LanguageOfLanguages.org after our demo. LoLs is an open source project under the MIT license and we encourage participation and contributions from the community.

4 Presenters

Jamie Douglass and Nicholas Chen are the main developers of LoLs. Jamie Douglass is an Architect and Associate Technical Fellow within the Office of IT Chief Engineer at the Boeing Company. His research interests include language based integration, modeling and software development. Nicholas Chen is a PhD candidate in the Software Architecture Group at the University of Illinois. His research interest lies in mining patterns of software evolution and creating flexible software engineering tools to support them.

Acknowledgments

The authors thank Jeff Overbey, Kathleen Chalas and Eric Reed for feedback on earlier drafts of this manuscript.

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