Domain-Specific Languages and Language Extensions

Minnesota Extensible Language Tools

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Motivation

- Domain-specific languages (DSLs) provide high-level notations for solving problems.
- Advantages of DSLs include conciseness, robustness, and, in many cases, high-performance.
- Our research aims to find ways to let programmers add domain-specific language features to mainstream languages such as Java and C.

Process

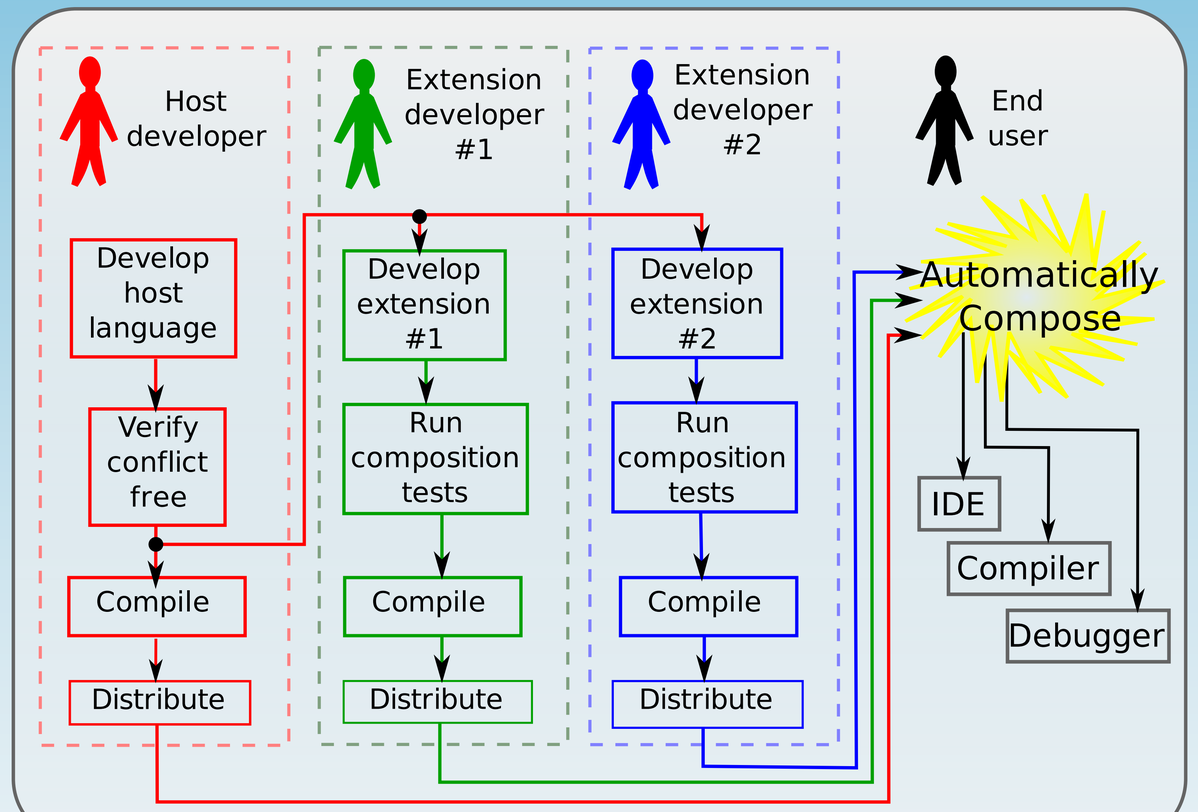
- A host language is developed using Copper to specify its concrete syntax and Silver to specify its semantics.
  - The host language developer is an expert in language design.
- Language extensions are developed independently by different parties. They may add new constructs (syntax), semantics, optimizations, and translations to the host language.
  - Extension developer has some knowledge of language design.
- End-user programmers acquire language extensions that apply to their problem domain and use the Silver and Copper tools to automatically create their custom extended language.
  - End-user programmers need to have no knowledge of language design.

Challenges

- Automatically composing concrete syntax specifications. Solution: context-aware scanning and analysis of extension syntax used in Copper.
- Automatically composing specifications of sophisticated language semantics. Solution: attribute grammars with forwarding as seen in Silver.
- Tool support for compilation, debugging, and IDE support as seen in Eclipse.

Applications

- SQL database queries.
  - Syntax checking of the SQL at compile time.
  - Type checking between program and DB schema.
  - Comparable to LINQ.
- Dimension analysis. Use to ensure that physical measurement values are used correctly; e.g. a time value is not added to a length value.
- Map Reduce. Provide language support, especially optimizations, to functional constructs used in imperative languages.
- Computational geometry for fast and robust computations.



Example

```
connection db c with table person ;
class Demo {
  boolean demo ( ) {
    rs = using db c query { SELECT age, zip
                            FROM person
                            WHERE state = "NY" } ;
    res = res && table ( a > 18       : T F
                        z == 10001  : F * ) ;
    return res ;
  }
}
```

- Java host language
- SQL extension
- Boolean table extension
- Independently developed extensions

Challenges:

- Keyword conflicts
- Parsing embedded languages
- Semantic analysis
  e.g. typing SQL
- Optimizing new constructs

Silver

- An extensible attribute grammar system.
- Used to specify the semantics of host languages and language extensions.
- Modern attribute grammar features such as forwarding and higher-order attributes.
- Attribute grammar specifications easily compose, making them suitable for use in extensible languages.

Van Wyk, Bodin, Gao, Krishnan. *Silver: an Extensible Attribute Grammar System*. LDTA '07

Van Wyk, Krishnan, Schwerdfeger, Bodin. *Attribute Grammar-based Language Extensions for Java.* ECOOP '07

Copper

- Context-aware scanner and parser generator.
- Provides verifiable composition of grammars and parse tables.
- Gracefully handles many scanning problems from other languages (C++'s >> in templates)

Schwerdfeger, Van Wyk. *Verifiable Composition of Deterministic Grammars*. PLDI '09

Van Wyk, Schwerdfeger. *Context-Aware Scanning for Parsing Extensible Languages.* GPCE '07

People

- Eric Van Wyk — evw@cs.umn.edu
- August Schwerdfeger — schwerdf@cs.umn.edu
- Ted Kaminski — tedinski@cs.umn.edu
- Derek Bodin — bodin@cs.umn.edu
- Lijesh Krishnan — krishnan@cs.umn.edu

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