LL Parsing & Semantics

CSE 401/M501

Adapted from Spring 2021

Announcements 📢

- Parser + AST due **TONIGHT**!
- Homework 3 (LL grammars) due Monday, May 5th @ 11:59pm
  - Only one late day, smaller assignment
  - Solutions released Wednesday to review for midterm
- Next section: midterm review
  - Bring your conceptual questions and past midterm questions!

Agenda 🗓️

- LL parsing worksheet
- Semantics & Type Checking
  - Review: Semantics and Type Checking
  - Type Checking for MiniJava

Problem 1: LL parsing

Canonical LL(1) Problems and their Solutions

FIRST Conflict:
Both productions of A have α in their FIRST sets
0. A ::= αβ | αγ

Solution:
Factor out the prefix (α)
0. A ::= α Tail
1. Tail ::= β | γ

FIRST FOLLOW Conflict:
B is nullable, α in FIRST & FOLLOW
0. A ::= B α
1. B ::= α | ε

Solution:
Substitute B into A
0. A ::= αα | α
Factor out the prefix (α)
0. A ::= α Tail
1. Tail ::= α | ε

Left Recursion:
Special FIRST conflict: β in FIRST for both productions
0. A ::= A α | β

Solution:
Create recursive tail from suffix of recursive production
1. Tail ::= α Tail
Append Tail to non-recursive productions
0. A ::= β Tail
1. Tail ::= α Tail
Add empty string (ε) as a rhs for the tail production
0. A ::= β Tail
1. Tail ::= α Tail | ε

Indirect Left Recursion:
Recursively alternates between A & B
0. A ::= B β
1. B ::= A | α

Solution:
Substitute B into A
0. A ::= A β | α β
Solve like normal Left Recursion
0. A ::= α β Tail
1. Tail ::= β Tail | ε

Semantics & Type Checking

Semantics, Dynamic and Static

semantics: precise meaning of program syntax.

Linguistics equivalent: *Sentences can be grammatically correct but make no sense!*

what interpretation or code generation implements

dynamic semantics: Well-defined rules to check during runtime

static semantics: Well-defined rules to check during compile time

what type checking implements

Static Semantics of MiniJava

Every language has its own idea of "statically correct,"
but in MiniJava, statically correct code must...

1. *never* add, subtract, multiply, or print non-integers

2. *never* call a non-existent method

3. *never* access a non-existent field

***n*.** … and so on (see the assignment page for more)

How do type checks relate to these conditions?

Type Checking for MiniJava

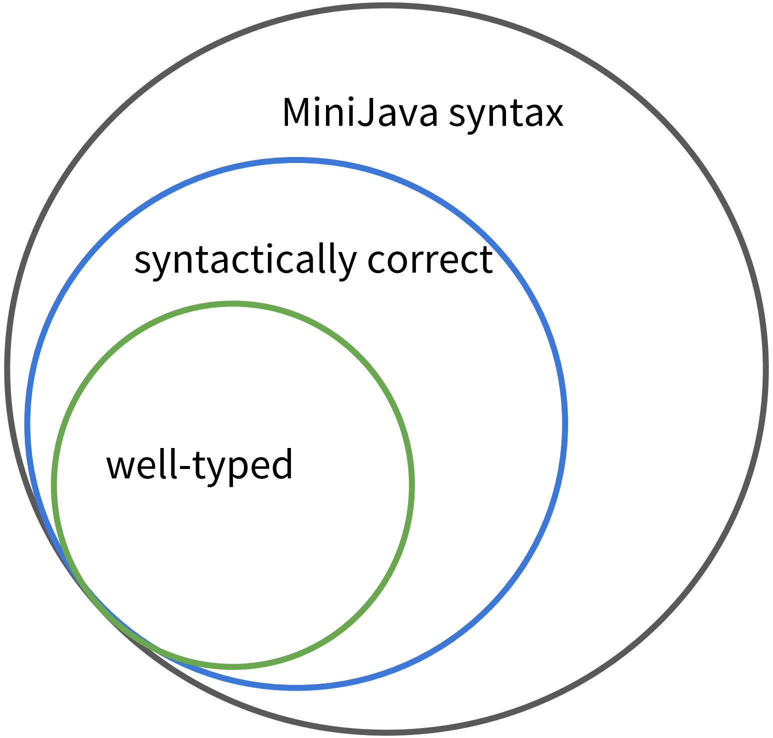
The type checker's goal is to verify that a source program is statically correct.

Thus, we need to build a checkable type system so that:

well-typed $\Longrightarrow$ ***statically correct***

Note: type checking depends on context – an implementation will depend on keeping track of types across different contexts (a scoped symbol table)

Type Checking for MiniJava



Examples

Suppose the following declarations are in effect:

Global scope: `class Foo { int f; int m(boolean b); }`

Local scope: `Foo this (implicit); int x; boolean y;`

In these scopes, which Java expressions have type `int`? Why (not)?

`56` yes	`x+(new Foo()).f` yes	`x+this.m()` no ☹
`2+x` yes	`x+y` no ☹	`x+z.m(y)` no ☹
`this.f` yes	`(new Bar()).f` no ☹	`x+this.m(true)` yes

Scopes and Symbol Tables

Accurately tracking scope information, via symbol tables, is critical to type checking.

Some guiding observations from today:

- All classes and methods in MiniJava will need symbol tables
  - When looking for a symbol, start in method table, then enclosing class, then global
- To generate symbol tables, it will make your life easier to go layer-by-layer
  - Global information needed everywhere! Makes sense to do that first
  - Easier to check a method body once global information is already computed

- Implementation tip:
  - Add pointers in your AST nodes to relevant type/symbol table information

The Takeaway

Static semantics is usually about what code must ***not*** do.

∴ ruling out ill-behaved traces is a useful mental model

∴ implementing and debugging a type checker is all about **edge cases**

∴ need to consider all names in scope, with their type (signatures)

Problem 2: Static Semantics & Type Checking