LL Parsing & Semantics

CSE 401/M501

Adapted from Spring 2021

Announcements

- Parser + AST due **TONIGHT**!
- Homework 3 (LL grammars) due Monday 10/28 @ 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

what interpretation or code generation implements

dynamic semantics: systematic rules to define runtime behavior

static semantics: systematic rules to define *statically correct* behavior

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

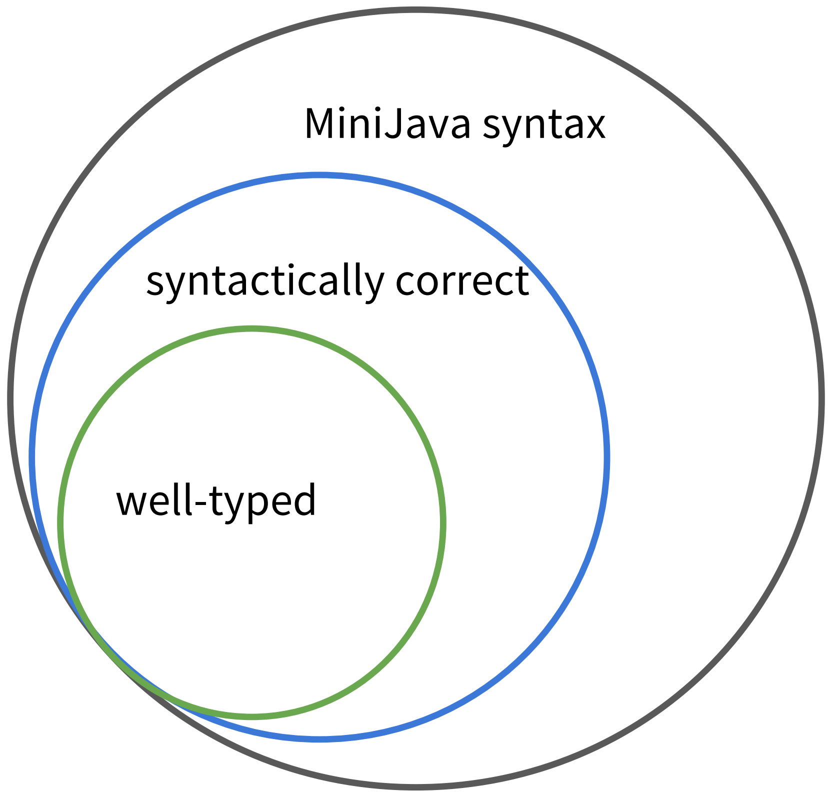
The type checker's goal is to verify that a source program is statically correct.

We can't check that directly, but we can 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