Semantics & Type Checking

CSE 401 Section 7

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Announcements

- Midterm grades have been released
  - If you have any questions, feel free to drop by office hours
  - If it really looks like we goofed, submit a regrade request
- Semantics Project Part due November 14th (1 week away!)
  - If you haven’t already, start early! There are plenty of weird edge cases to think about

Agenda

- **Semantics & Type Checking**
  - **Review: Semantics vs. Type Checking**
  - **Type Checking for MiniJava**
- Objects & vtables
  - MiniJava object and vtable layouts
  - Review: Java inheritance

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

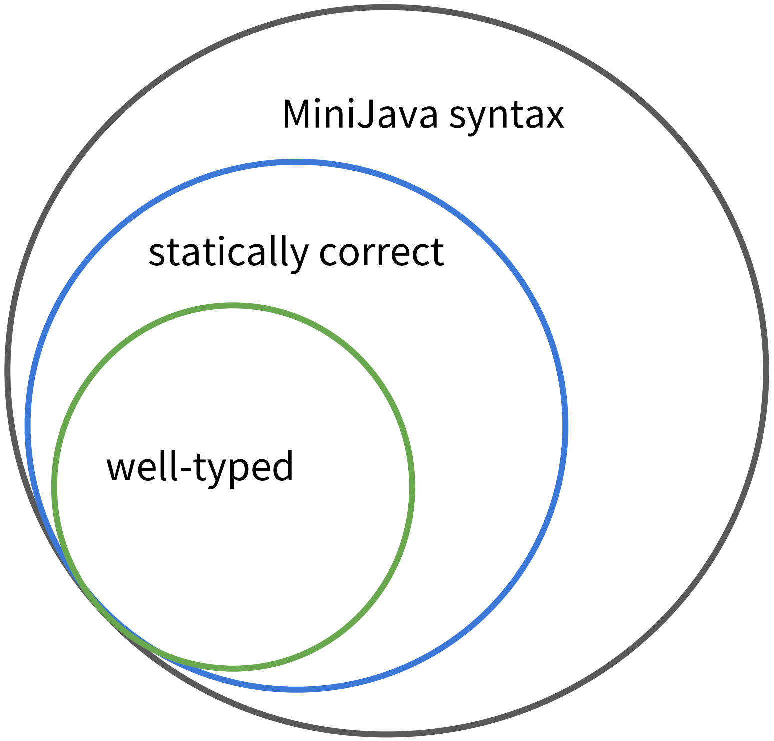
The type checker's goal is to verify that a source program is statically correct.

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 MiniJava expressions have type `int`? Why (not)?

```
56              x+(new Foo()).f      x+this.m()

2+x             x+y                  x+z.m(y)

this.f          (new Bar()).f        x+this.m(true)
```

Scopes and Symbol Tables

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

Some guiding observations from today:

- All classes 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 Take-Away

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 1: Static Semantics & Type Checking

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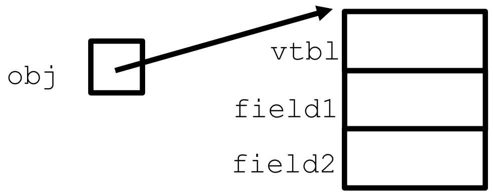
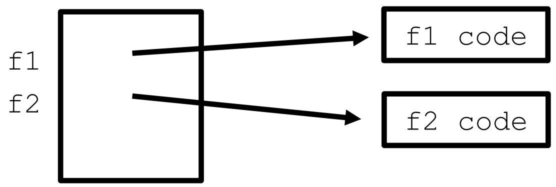
Objects & Vtables

Objects



- An instance of a class
- Contains reference to class vtable
- Also contains reference to its <u>state</u> (fields)
  - Order is important!

Vtables

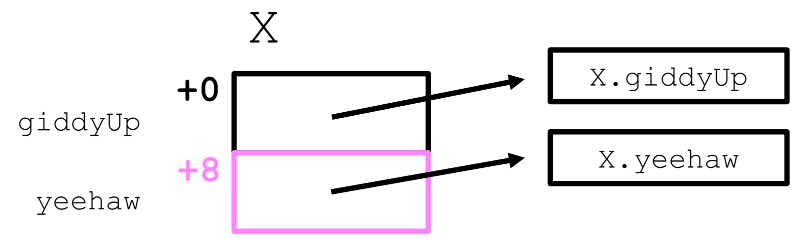


- One per class
- Contains reference to code body for each method in the class
  - Order is important!
  - May be inherited from superclass

Vtables (and object fields!): Why does order matter?

```
X obj = new X();
obj.yeehaw();
```

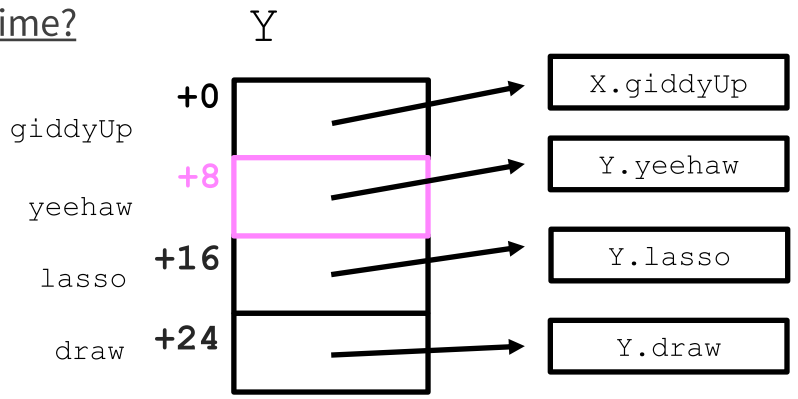
Compile method call to an offset in the vtable *based on the variable type!*



What if the `obj` variable refers to instance of a *subclass* at runtime?

```
X obj = new Y();
obj.yeehaw();
```

Need to correspond to same offset in the subclass vtable!



Problem 2: Vtables & Objects