CSE 401 – Compilers

Interpreting MiniJava

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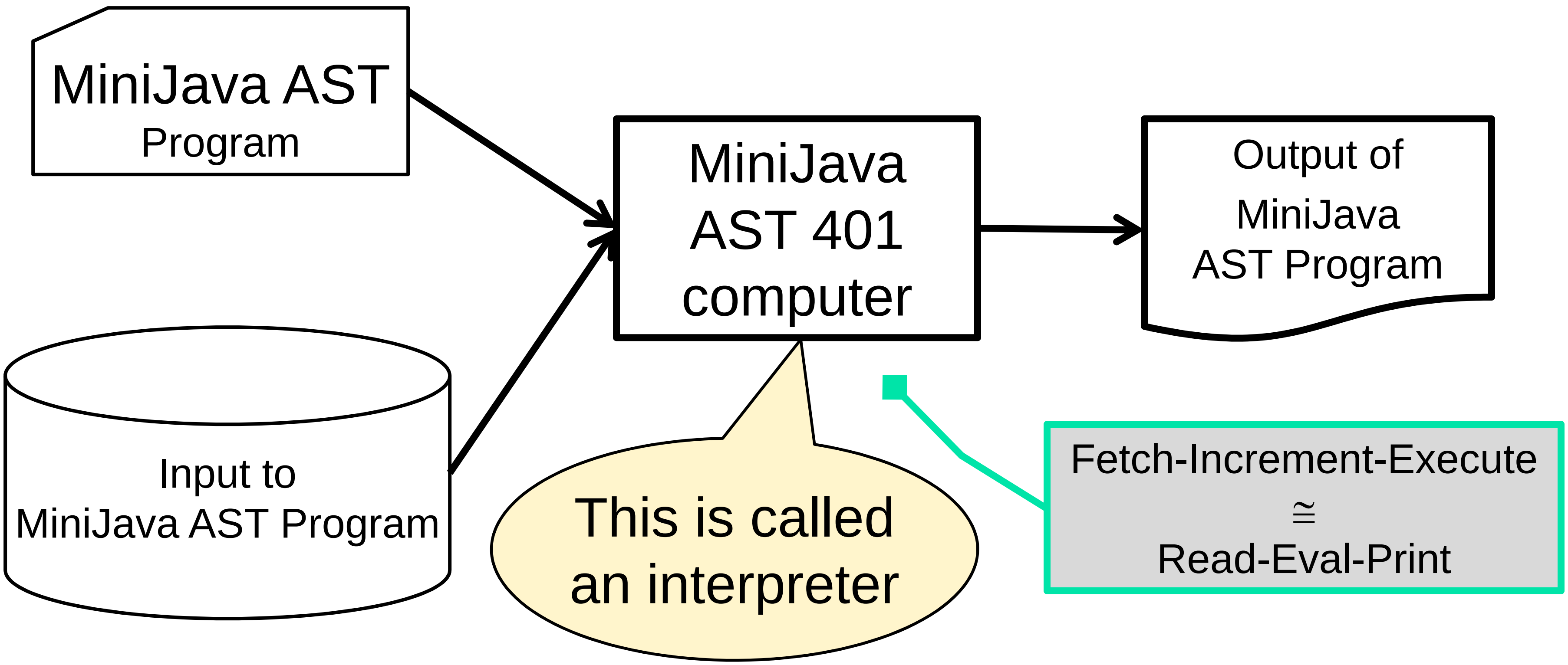
We have...

- ...scanned and parsed and type checked and built an abstract syntax tree with a symbol table...
- So we know we have
  - a correct program, and
  - we have a useful representation of that program
- Now what?
  - Generate equivalent code in a lower-level language ... (so we can later run it)
  - Perform further analysis .. (such as?)
  - ...what else?

We can execute it immediately...

- To do so, we need to implement a MiniJava-AST computer interpreter



Why interpret vs. generate code?

- Time until program can be executed
- Speed of executing program
- Simplicity of implementation
- Flexibility of implementation

TRADEOFFS

Interpreters

- Create data structures to represent run-time program state
  - values manipulated by program
  - activation record (i.e., stack frame) for each called method
  - environment to store local variable bindings
  - pointer to lexically-enclosing activation record/environment (static link)
  - pointer to calling activation record (dynamic link)
- EVAL loop executing AST nodes

An Interpreter for MiniJava:

- The MiniJava project contains the infrastructure to implement an interpreter
  - We won’t use this code in the actual project*, but it’s worth a look

*And interpreting could be an interesting project extension later...

An Interpreter for MiniJava:
~readme (**`Evaluator`** subdirectory)

- The main data structure is the **`environment`**, which keeps track of the values of local variables declared in a given scope, plus some information about declarations in classes.
- **`Environments`** closely parallel **`SymbolTables`**
  - "compile-time" information computable before running the program (e.g. declarations and types)
  - "run-time" information representing the program’s running state
- Only one symbol table for each program scope, while there can be zero or more environments created for (most) scopes

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- There are *environments* for different kinds of scopes (global scope, class scope, and code scope…), as they have different declarations and run-time state.
  - An *activation record* is an instance of an environment
- The (only) global environment maps names of classes to the corresponding class environments…
- A class environment maps the names of locally declared methods to their declarations and the names of locally declared instance variables to their resolved types. Also stores a reference to the environment of its superclass (if any).

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- The values of the instance variables are not stored in the class environment because each instance of the class stores its own values of its instance variables.
- A code environment maps the names of local variables to their current values.
- A method code environment additionally remembers the environment of its caller, for use in printing stack traces during evaluation.
- Each kind of nested environment stores a reference to its lexically enclosing scope's environment.

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- The evaluation values are represented by instances of **`Value`** classes, organized into a class hierarchy
- Each kind of **`ResolvedType`** (**`Int, Boolean, Class, and Null`**) has a corresponding kind of **`Value`** to use in representing values
- **`Int`** and **`BooleanValues`** store their value
- **`ClassValues`** store the environment for the instantiated class as well as a table that maps instance variable names to the current values for that instance
- **`NullValue`** represents null pointers.

Activation Records

- Each call of a procedure allocates an activation record that stores
  - mapping from names to **`Values`**, for each formal and local variable in that scope (*environment*)
  - lexically enclosing activation record (*static link*)
- An activation record for a method also stores the calling activation record (*dynamic link*)
- A class activation record also stores
  - methods (to support run-time method lookup)
  - instance variable declarations, not values
  - values stored in class instances (**`ClassValues`**)

Activation Records vs Symbol Tables

- For each method/nested block scope in a program:
  - exactly one symbol table, storing types of names
  - possibly many activation records, one per invocation, each storing values of names
- For recursive procedures,
  - can have several activation records for same procedure on stack simultaneously
  - All of these activation records have same “shape,” described by single symbol table

Example

```
class Fac {
  public int ComputeFac(int num) {
    int numAux;
    if (num < 1) {
      numAux = 1;
    } else {
    numAux = num * this.ComputeFac(num-1);
  }
  return numAux;
  }
}
```

Interpretation tradeoffs: reprise

- simple conceptually, easy to implement
  - fast turnaround time
  - good programming environments
  - easy to support fancy language features
- slow to execute
  - data structure for value vs. direct value
  - variable lookup vs. registers or direct access
  - EVAL overhead vs. direct machine instructions
  - no optimizations across AST nodes

Compile-time vs Run-time

Compile-time	Run-time
Procedure	Activation record/stack frame
Scope, symbol table	Environment (contents of stack frame)
Variable	Memory location or register
Lexically-enclosing scope	Static link
Calling Procedure	Dynamic link