Building An Interpreter

After having done all of the analysis, it's possible to run the program directly rather than compile it ... and it may be worth it

Implementing A Language

Given type-checked AST program representation:
• might want to run it
• might want to analyze program properties
• might want to display aspects of program on screen for user

To run program:
• can interpret AST directly
• can generate target program that is then run recursively

Tradeoffs:
• time till program can be executed (turnaround time)
• speed of executing program
• simplicity of implementation
• flexibility of implementation

Pros and Cons of Interpretation

+ 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

Interpreters

Create data structures to represent run-time program state
• values manipulated by program
• activation record (a/k/a 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

Compilation

Divide interpreter work into two parts:
• compile-time
• run-time

Compile-time does preprocessing
• perform some computations at compile-time once
• produce an equivalent program that gets run many times

Only advantage over interpreters: faster running programs
Compile-time Processing

Decide representation of run-time data values

Decide where data will be stored
- registers
- format of stack frames
- global memory
- format of in-memory data structures (e.g., records, arrays)

Generate machine code to do basic operations
- just like interpreting expression, except generate code that will evaluate it later

Do optimizations across instructions if desired

Compile-time vs Run-time

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Static Link vs Dynamic Link

class C {
  int x;
  boolean y;
  int f(int i) {
    int z;
    boolean x;
    C z;
    int f;
    ...f(...)... f(...)...
  }
  ...f(...)...
}

An Interpreter for MiniJava

In Environment subdirectory, two data structures:

Data structure to represent run-time values:
- Value hierarchy
  - analogous to ResolvedType hierarchy

Value
- IntValue
- BooleanValue
- ClassValue
- NullValue

Data structure to store Values for each variable:
- Environment hierarchy
  - analogous to Symbol Table hierarchy

Environment
- GlobalEnvironment
- NestedEnvironment
- ClassEnvironment
- CodeEnvironment
- MethodEnvironment

- evaluate methods for each kind of AST class

Activation Records

Each call of a procedure allocates an activation record
(instance of Environment, somewhat poorly named)
- Activation record stores:
  - mapping from names to Values, for each formal and local variable in that scope (environment)
  - lexically enclosing activation record (static link)
- Method activation record: also
  - calling activation record (dynamic link)
- Class activation record: also
  - methods (to support run-time method lookup)
  - instance variable declarations, not values
  - values stored in class instances, i.e., 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 activation records have same “shape,” described by single symbol table

Example

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