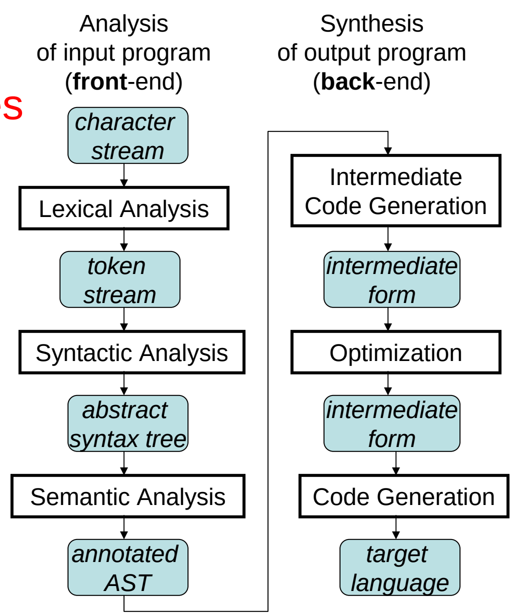
CSE 401
Building An Interpreter

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

Compiler Passes



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

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

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

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

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

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
```

MiniJava Interpreter [continued]

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

```
...

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