Discussion of Part 3 & Programming Languages

Lecture 7
CS 212 – Spring 2007

Announcements

- Part 2 is due tomorrow (Thursday) evening
  - We have an AMS.jar file (Assignment Management System) for submitting your assignment
  - Instructions for its use will appear on the website later this evening
- *Do not* alter the files we provide
  - We run your code with the original versions of these files
- Make use of Office Hours!
- If your Part 2 does not compile or if it fails many tests
  - The graders are *not expected* to determine the exact nature of any problems with your code
  - If there is some small error, you can request a regrade
    - Describe the problem
    - Describe the fix
    - Provide working code

Grammar for Bali (Part 3)

```
program -> [declarations ] : function*

function ->
    type name ( [declarations] ) :
    [ declarations ] : statement* end

declarations -> type name ( , type name )*

type -> int | boolean | void
```

- There must be a *main function*
- A function has a return-type and 0 or more parameters
- Valid types are *int*, *boolean*, and *void*
  - *void* can only be used as a function return-type

More Grammar for Bali (Part 3)

```
statement -> reference = expression ;
statement -> reference ;
statement ->
   if expression then statement*
   [ else statement*] endif
statement ->
   loop statement*
   ( while | until ) expression ;
   statement* endloop
statement -> return expression ;
statement -> print expression ( , expression )* ;

reference -> name [ functionArgs ]
functionArgs -> ( [ expression ( , expression )* ] )
```

- The Part 3 sam-code for statements should be nearly the same as for Part 2
- The *reference statement* is executed for its side-effects (it might modify a global variable, for instance)
- To parse an *assignment statement*, pretend it's a *reference statement* until you reach the equal sign (=)

Rest of Grammar for Bali (Part 3)

```
expression -> [ + | - | not ] term ( binaryOp term )*
binaryOp -> arithmeticOp | comparisonOp | booleanOp
arithmeticOp -> + | - | * | / | %
comparisonOp -> < | <= | == | != | > | >=
booleanOp and | or
term -> literal | ( expression ) | inputValue | reference
literal -> integer | true | false
subscript -> [ expression ]
literal -> integer | true | false | null
inputValue -> readInt
```

The Major Tasks for Part 3

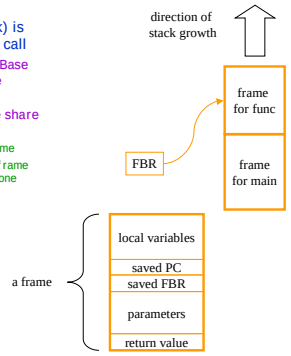
- The "hard stuff"
  - Implementing functions
    - Stack frames
  - Global variables
    - Use of multiple namespaces (i.e., multiple symbol tables)
  - Error handling
- **Warning**: finish this stuff before messing with the bonus work
- Bonus work
  - Multiple error reporting

Global Variables & Namespaces

- At each point in the Bali-code, there are at most two active namespaces
  - A global namespace
    - Always exists
    - Holds names for global variables and for functions
  - A local namespace
    - Exists only within a function
    - Holds local variable names and parameter names
- Each namespace corresponds in a natural way to a symbol table
  - To find a name your code should
    - First check the local symbol table
    - Then, if not found, check the global symbol table
- Once you have created the sam-code for a function, the function's symbol table can be discarded

Recall: Stack Frames for Functions

- A new *frame* (on the stack) is created for each function call
  - We use the FBR (Frame Base Register) to indicate the current frame
  - The caller and the callee share responsibility for
    - Creating the stack frame
    - Cleaning up the stack frame when the function is done



Signatures for Functions

- You need to check that each function argument is of the correct type
  - To do this, you need to remember the function's *signature*
- A *function signature* includes
  - The function name
  - The number and types of all parameters
  - The return type of the function
- The natural place to record this information is in the symbol table
  - You can encode a function's signature in any way you want

Bonus: Multiple Error Reporting

- Error Handling
  - We *will* test your Part 3 compiler's response to errors in supplied Bali programs
  - Two kinds of errors
    - *Syntax errors*: code that violates the rules of the Bali grammar
    - *Semantic errors*: code that violates the rules of Bali semantics
- For bonus, use the *MultipleBaliException* class to accumulate and report multiple errors
- Which kind of error (syntax error or semantic error) is easier to deal with if we're trying to accumulate all errors?

Reference Statement vs. Assignment Statement

- According to Bali's grammar
  - A reference statement and an assignment statement both start out looking like a reference
  - No way to tell that you are parsing an assignment statement until you get to the equal sign (=)
- Suggestion
  - Start parsing as if you are parsing a reference
  - Once the reference is complete, you check for the equal sign (=) to see if within an assignment statement
  - If in an assignment statement
    - You need to re-examine the AST you just built (for the reference) to see if it can be the target of an assignment statement
    - Your compiler should throw a BaliSemanticException if the reference is inappropriate as a target

So Many Languages

- *For*mula *Tran*slation (FORTRAN) in 1954 led to…
  - Over 2000 computer languages
- How many languages in use today?
  - Difficult to say
  - Legacy software (using outdated languages) is everywhere
- Why can't we just use one language?

Computer/Human Languages

- Computer/Human language matching game!

Character Set	Paragraphs
Tokens	Words
Token Separators	Chapters
Expressions	Book
Statements	Phrases
Functions	Alphabet
Classes	Sentences
Programs	Whitespace

Compiled vs. Interpreted

- Compiled
  - Parse code (typically create an abstract syntax tree)
  - Create assembly code for entire program
  - Run the assembly code
- Interpreted
  - Run each statement as the statement is parsed
- Examples
  - Compiled: Fortran, Java, C
  - Interpreted: Matlab, Python, Logo, some versions of Basic
- Advantages/Disadvantages?

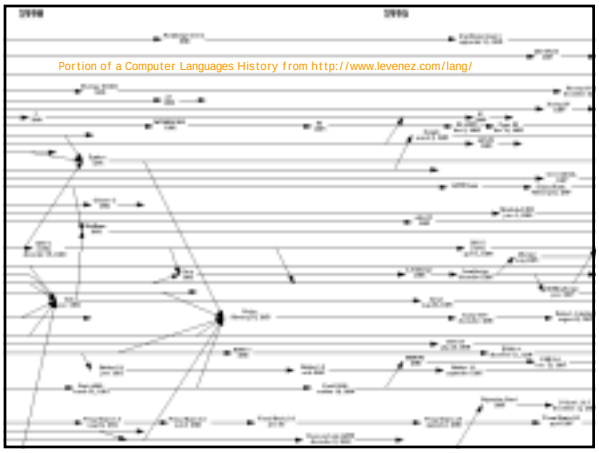
Imperative vs. Declarative

- Imperative/Procedural
  - Statements tell the computer what to do
  - Think "commands" or "recipe"
  - Examples
    - Java, C, Fortran, Python
- Declarative
  - Describe what something "is like" (state what you know)
  - Examples
    - Logic programming (Prolog)
    - Constraint programming (later versions of Prolog)

Prolog Example

```
sendmore(Digits) :-
  Digits = [S,E,N,D,M,O,R,Y],     % Create variables
  Digits :: [0..9],               % Associate domains to variables
  S #\= 0,                        % Constraint: S must be different from 0
  M #\= 0,
  alldifferent(Digits),           % All elements must take different values
        1000*S + 100*E + 10*N + D     % Other problem constraints
      + 1000*M + 100*O + 10*R + E
  #= 10000*M + 1000*O + 100*N + 10*E + Y,
  labeling(Digits).               % Start the search
```

(from Wikipedia)



Portion of a Computer Languages History from http://www.levenez.com/lang/

A List of Language Categories

from The Language List
(http://people.ku.edu/~nkinners/LangList/Extras/langlist.htm)

- Procedural Language
- Imperative Language
- Declarative Language
- Applicative Language
- Functional Language
- Definitional Language
- Single Assignment Language
- Dataflow Language
- Logic Language
- Constraint Language
- Object-Oriented Language
- Concurrent Language
- Fourth Generation Language (4GL)
- Query Language
- Specification Language
- Assembly Language
- Intermediate Language
- Metalanguage

Some Advice

- Use the language that best fits your task
- Think small!!
  - Write little programs that test various concepts
  - Test them!
  - Comment them!
  - Collect these little programs together
  - Reuse your own code (templates!)