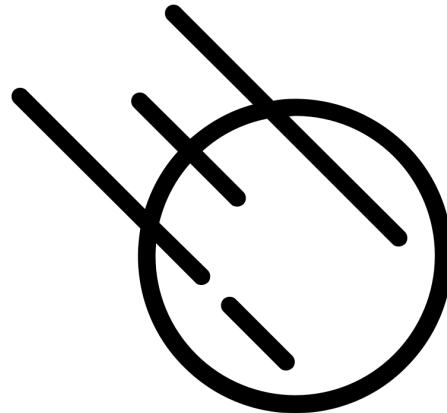


Welcome - CSC 301

CSC 301- Fundamentals of Programming Languages

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- (for more details see BrightSpace)



Why Study Programming Languages?

- Amazing variety
 - ~2300 different programming languages discussed on online forums*.
- “Strange” controversies
 - Should a programming language have a ‘goto’ statement?
 - Should an OO language support inheritance?
 - Terminology: argument vs. actual parameter.
- Many connections
 - Programming languages touch upon virtually all areas of computer science: from the mathematical theory of **formal languages** and **automata** to the implementation of **operating systems**.
- Intriguing evolution
 - Programming languages change!
 - New ideas and experiences trigger new languages.
 - New languages trigger new ideas, etc.

Programming Language Classes

There are many different programming language classes, but three classes or paradigms stand out:

- Imperative Languages
- Functional Languages
- Logic/Rule Based Languages

What Happened to OOP?

- Object-orientation is really a property of the type system of a language.
- OO features have traditionally been added to imperative languages (C++, Java, Python)
- Object-oriented features have also been added to:
 - Functional programming languages like Lisp (CLOS)
 - Logic languages like Prolog (Logtalk)
- Here we look at object-based programming within the multi-paradigm language Asteroid

Meet Our Languages

- Asteroid – An object-based, imperative, and functional programming language being developed right here at URI
 - asteroid-lang.org
- Prolog – A logic programming language, most famously used in IBM Watson
 - The IBM Watson knowledge base was filled with 200 million pages of information, including the entire Wikipedia website. To parse the questions into a form that IBM Watson could understand, the IBM team used Prolog to parse natural-language questions into new facts that could be used in the IBM Watson pipeline. In 2011, the system competed in the game *Jeopardy!* and defeated former winners of the game.
 - www.swi-prolog.com

Example Computation

- Recursive definition of the factorial operator

$$x! = \begin{cases} 1 & \text{if } x = 1, \\ x(x-1)! & \text{otherwise.} \end{cases}$$

for all $x > 0$.

Imperative Languages

- Hallmarks: assignment and iteration
- Examples: C, FORTRAN, Imperative sublanguage of Asteroid
- Example Program: factorial program in (imperative) Asteroid

```
function fact with n:%integer do
  ..let val = 1.
  ..while n > 1 do
    ...let val = val*n.
    ...let n = n-1.
  ..end
  ..return val.
end
```

Imperative Languages

Observations:

- The program text determines the order of execution of the statements.
- We have the notion of a '*current value*' of a variable – accessible state of variable.

This is not always true in other languages.

Imperative Asteroid

```
1  -- compute the factorial-  
2  -  
3  load system "io".-  
4  load system "type".-  
5  -  
6  function fact with n:%integer do-  
7  ..let val = 1.-  
8  ..while n > 1 do-  
9  ....let val = val*n.-  
10  ....let n = n-1.-  
11  ..end-  
12  ..return val.-  
13  end-  
14  -  
15  let x = tointeger(input("Enter a positive integer: ")).-  
16  println ("The factorial of "+x+" is "+(fact x)).-
```

Functional Languages

- Hallmarks: recursion, multi-dispatch, single valued variables.
- Examples: ML, Lisp, Haskell, Functional sublanguage of Asteroid
- Example Program: factorial program in (functional) Asteroid

multi-dispatch {

```
function fact~  
  ··with 1 do~  
    ···return 1~  
  ··orwith n:%integer do~  
    ···return n*fact(n-1).~  
end~
```

} n is single valued variable.

recursion

Functional Languages

Observations:

- There are **no** explicit assignments.
- The name stems from the fact that programs consist of *recursive* definitions of **functions**.

Functional Asteroid

```
1  -- compute the factorial-  
2  -  
3  load system "io".-  
4  load system "type".-  
5  -  
6  function fact-  
7  ..with 1 do-  
8  ....return 1-  
9  ..orwith n:%integer do-  
10  ....return n*fact(n-1).-  
11  end-  
12  -  
13  let x = tointeger(input("Enter a positive integer: ")).-  
14  println ("The factorial of "+x+" is "+(fact x)).-
```

Logic Programming Languages

- Hallmarks: programs consist of **rules** that specify the problem solution.
- Examples: Prolog, Maude, Isabelle
- Example Program: factorial program written in Prolog

rules {

```
fact(1,1).  
fact(X,F) :-  
    X1 is X-1,  
    fact(X1,F1),  
    F is X*F1.
```

fact(in,out)

'and'

unification

Logic Programming Languages

Observations:

- Rules do *not* appear in the order of execution in the program text.
- No specific order of execution is given – rules ‘fire’ when necessary.

Prolog

```
% factorial program
```

```
fact(1,1).
```

```
fact(X,F) :-
```

```
    X1 is X-1,
```

```
    fact(X1,F1),
```

```
    F is X*F1.
```

```
compute :-
```

```
    X is 3,
```

```
    fact(X,F),
```

```
    writeln(F).
```

Object-Based Languages

- Hallmarks: bundle data with the allowed operations ➞ Objects
- Asteroid takes an interesting approach here – structures with functions.

```
1  -- simple object-based program~
2  ~
3  load system "io".~
4  ~
5  -- define our rectangular structure with member functions~
6  structure Rect with~
7  ..data xdim.~
8  ..data ydim.~
9  ~
10 ..-- return the area of the rectangle~
11 ..function area with none do~
12 ....return this@xdim * this@ydim.~
13 ..end~
14 end~
15 ~
16 let r = Rect(4,2).~
17 println ("The area of rectangle <"+r@xdim+", "+r@ydim+"> is "+r@area()).~
```


Programming Language Classes

General Observations:

- Programming languages guide programmers towards a particular programming style:
 - Imperative → iteration/assignment
 - Functional → mathematical functions
 - OO → objects
 - Logic → rules
- Programming itself guides the developer towards new language ideas:
 - Recursion was introduced by John McCarthy in the 1950' s with the programming language Lisp to solve problems in AI.
 - Classes and objects were developed by Nygaard and Dahl in the 1960' s and 70' s for the language Simula in order to solve problem in simulations.

Take Away

- There exist many programming languages today (> 2000)
- In order to understand the similarities and differences \Rightarrow sort into *classes*
 - Imperative
 - assignment and iteration
 - Functional
 - Recursion, single valued variables
 - Logic/rule based
 - programs consist of rules
- Object-based
 - bundle data with the allowed operations

Reading & Assignments

- Reading: Asteroid User Guide
 - github.com/lutzhamel/asteroid/blob/master/Asteroid%20User%20Guide.md
- Assignment #0: Download & Read Syllabus – upload a copy of it into BS