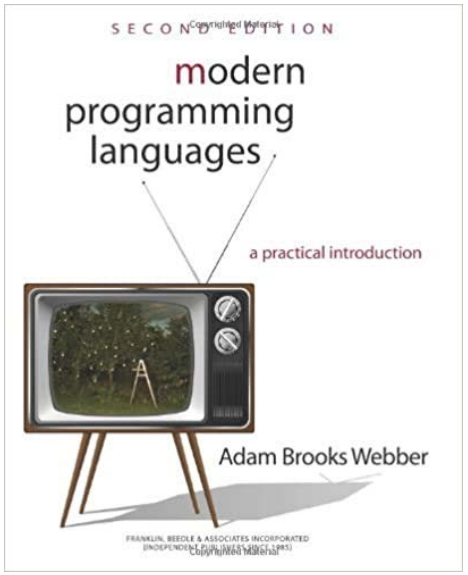
Welcome - CSC 301

CSC 301- Foundations of Programming Languages



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Why Study Programming Languages?

- Amazing variety
  - One of the moderated email lists counted ~2300 different programming languages (comp.lang.*)
- "Strange" controversies
  - Should a programming language have a 'goto' statement?
  - Should an OO language allow for global functions?
  - 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 four classes or paradigms stand out:

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

Example Computation

- Recursive definition of the factorial operator

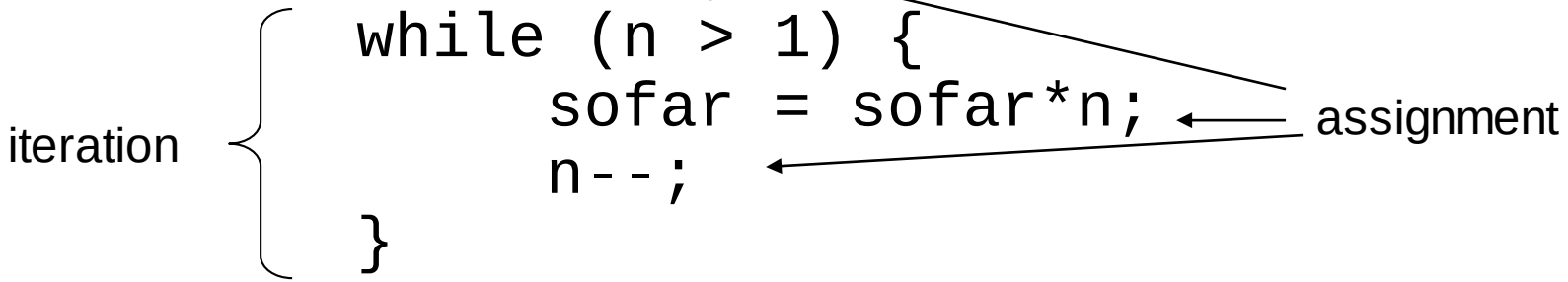
$$x! = \begin{cases} 1 \text{ if } x = 1, \\ x(x-1)! \text{ otherwise.} \end{cases}$$

for all $x > 0$.

Imperative Languages

- Hallmarks: assignment and iteration
- Examples: C, FORTRAN, COBOL
- Example Program: factorial program in C

```
int fact(int n) {
    int sofar;
    sofar = 1;
    while (n > 1) {
        sofar = sofar*n;
        n--;
    }
    return sofar;
}
```



Imperative Languages

Observations:

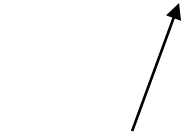
- The program text determines the order of execution of the statements.
- We have the notion of a '*current value*' of a variable – accessible state of variable.

This is not always true in other languages.

Functional Languages

- Hallmarks: recursion and *single valued variables*.
- Examples: ML, Lisp, Haskell
- Example Program: factorial program in ML

```
fun fact x = if x = 1 then 1
             else x*fact(x-1);
```



recursion

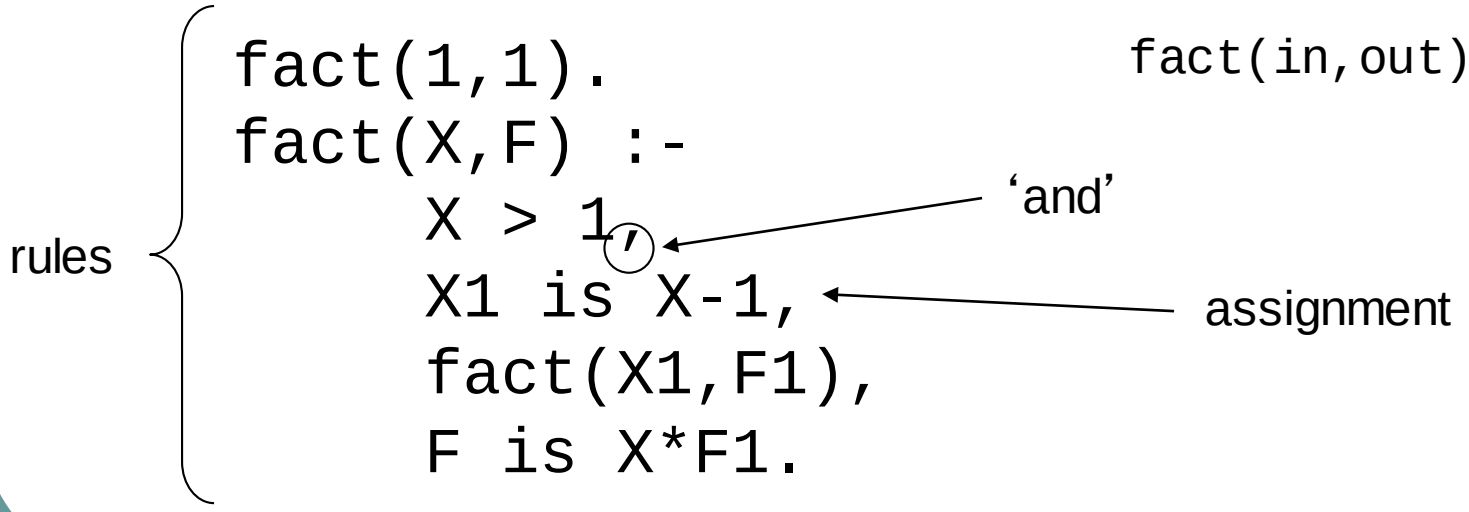
Functional Languages

Observations:

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

Logic Programming Languages

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



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.

Object-Oriented Languages

- Hallmarks: bundle data with the allowed operations ☞ Objects
- Examples: Java, C++, Smalltalk
- Example Program: factorial program in Java

```
class FactInt {
    private int val;
    public FactInt(int x) {
            val = fact(x);
    }
    public int getVal() {
            return val;
    }
    private int fact(int n) {
            int sofar = 1;
            while (n>1) {
                    sofar = sofar*n;
                    n--;
            }
            return sofar;
    }
}
```

data

allowed operations

Public operations

Operation only allowed by the object itself (or subobjects)

Programming Language Classes

General Observations:

- Programming languages guide programmers towards a particular programming style:
  - 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-oriented
    - bundle data with the allowed operations

Assignments

- Read Chapters 1&2