Programming Paradigms

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Programming Paradigm

- It is a style or “a way” of programming.
- *A paradigm is a way of doing something, and not a concrete thing (like a language).*
- If a programming language L happens to may a particular programming paradigm P, then we can say “L is a P language”

List of Common Paradigms

- **Imperative** — Control flow is an explicit sequence of commands.
- **Declarative** — Programs state the result you want, not how to get it.
- **Structured** — Programs have clean, goto-free, nested control structures.
- **Procedural** — Imperative programming with procedure calls.
- **Functional** — Computation proceeds by (nested) function calls that avoid any global state.
- **Object-Oriented** — Computation is effected by sending messages to objects; objects have state and behavior.

List of Common Paradigms

- **Event-Driven** — Control flow is determined by asynchronous actions (from humans or sensors).
- **Logic (Rule-based)** — Programmer specifies a set of facts and rules, and an engine infers the answers to questions.
- **Concurrent**

Imperative Programming

- Control flow is an explicit sequence of commands.

```
    result = []
    i = 0
start:
    numPeople = length(people)
    if i >= numPeople goto end
    p = people[i]
    nameLength = length(p.name)
    if nameLength <= 5 goto next
    upperName = toUpper(p.name)
    addToList(result, upperName)
next:
    i = i + 1
    goto start
end:
    return sort(result)
```

Declarative Programming

- Programs state the result you want, not how to get it.
- Control flow in declarative programming is *implicit*: the programmer states only *what* the result should look like, **r**

```
select upper(name)
from people
where length(name) > 5
order by name
```

Declarative Programming

- No loops, no assignments, etc.

- Whatever engine interprets this code is just supposed to go and get the desired information, and can use whatever approach it wants.

Object Oriented Programming

- OOP is based on the sending of messages to objects. Objects respond to messages by performing operations.

```
result = []
for p in people {
    if p.name.length > 5 {
        result.add(p.name.toUpper);
    }
}
return result.sort;
```

Functional Programming

- Control flow is expressed by combining function calls, rather than by assigning values to variables.

```
let(
  f, fun(
    people,
    if(equals(people, emptylist),
        emptylist,
        if(greater(length(name(head(people))), 5),
          append(to_upper(name(head(people))), f(tail(people))),
          f(tail(people))))),
    sort(f(people)))
```

Functional Programming

- There are no commands.
- Code is much shorter, less error-prone, and much easier to prove correct

Logic Programming

- We express computation in exclusively in terms of mathematical logic.
- While the functional paradigm emphasizes the idea of a mathematical function, the logic paradigm focuses on predicate logic, in which the basic concept is a relation.
- Logic languages are useful for expressing problems where it is not obvious what the functions should be.

Logic Programming

- Let us consider now how we can define the brother relation in terms of simpler relations and properties father, mother, and male.

Using the Prolog logic language one can say:

```
brother(X,Y)      /* X is the brother of Y                    */
                  /* if there are two people F and M for which*/
    father(F,X),        /*      F is the father of X          */
    father(F,Y),        /*  and F is the father of Y          */
    mother(M,X),        /*  and M is the mother of X          */
    mother(M,Y),        /*  and M is the mother of Y          */
    male(X).            /*  and X is male                     */
```

Concurrent programming

- Improve performance

- Multiprogramming systems attempt to utilize resources that would otherwise be wasted, by running two or more jobs concurrently.

- Multi-access systems extend this principle, allowing many jobs to be run, each on behalf of a user at an interactive terminal.

Concurrent programming

- Classified as:
- single processor (interleaved execution of concurrent tasks)
- multiprocessor environment

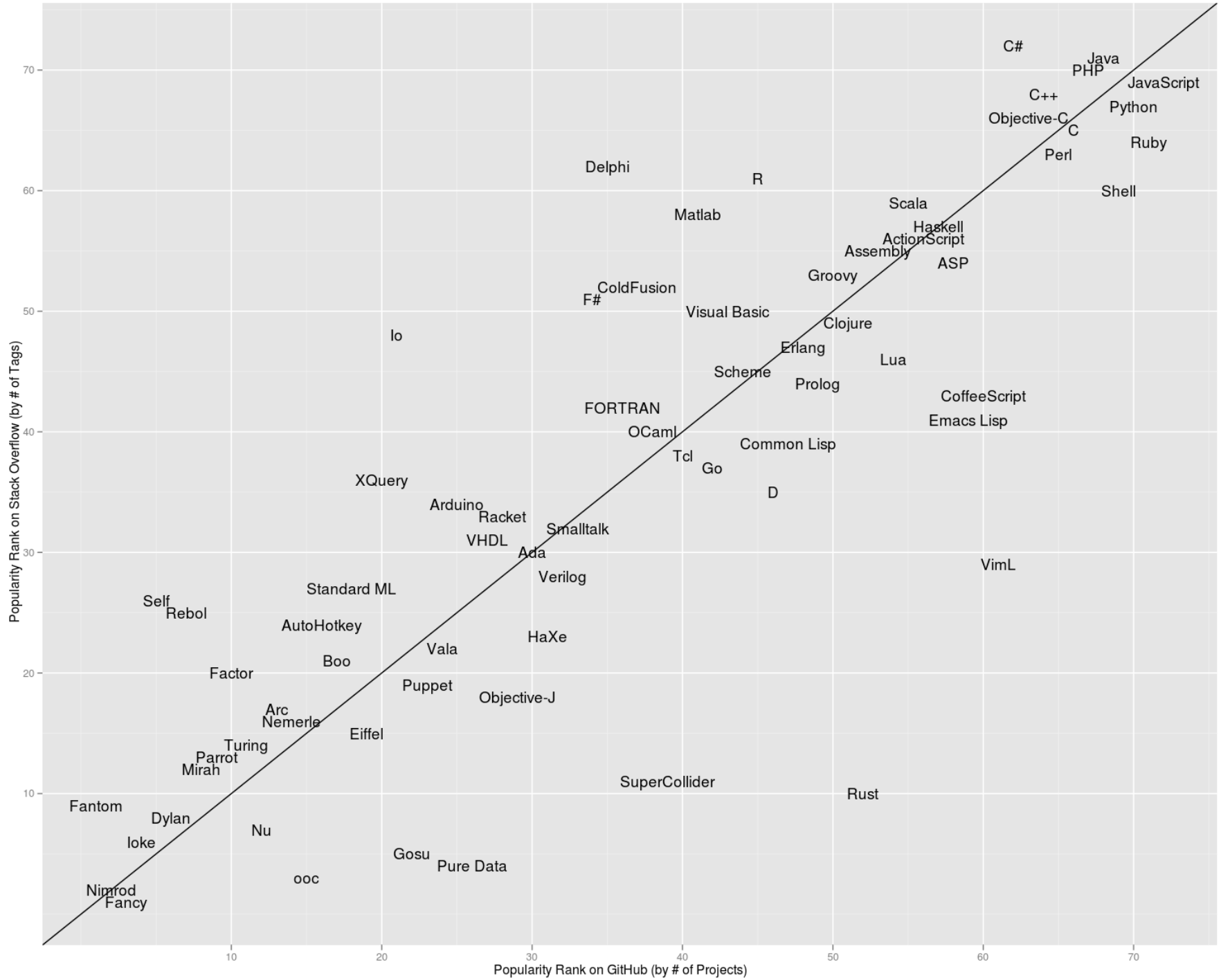
Paradigm	Aspect	
	Corresponding languages	Key features
Structured programming	Imperative programming languages Examples: FORTRAN, COBOL, Pascal, C	• Sequential execution of instructions • "Goto" less programs • Use of variables representing memory locations • Use of assignment to change values of variables • Conditional branch and iterative statements • Recursion is an alternative to iteration
Object-oriented programming	Object oriented programming languages Examples: Smalltalk, SNOBOL, C++, Java	• Object is the basic building block. An object is characterized by state and behavior. The state is specified by the attributes and the behavior is specified by the methods • Encapsulation, polymorphism, and inheritance as the foundational concepts that give an identity to this paradigm
Functional programming	Applicative programming languages Example: LISP	• The basic building block is a function • There is no notion of variable and assignment • Iteration is not supported • Recursion is the key facility
Logic programming	Declarative programming languages Example: PROLOG	• Logic programming is based on symbolic logic • A logic program is a collection of declarations which are true about the desired result. These are called facts • No notion of flow-of-control • A set of rules that operate on the facts are defined • A query reports the results drawn from the facts and governed by the rule base • The inference engine ensures the validity of the results

Event-driven programming	Visual programming languages Examples: Visual Basic, Visual C++	• Programming is based on the set of anticipated events • The base system recognizes the events as they occur and coordinates the necessary responses • This paradigm is very useful in developing a good user interface
Concurrent programming	Parallel programming languages Examples: Concurrent Pascal, ParC, PARLOG, Occam	This paradigm supports multi-threading (segments of the same program can be executed concurrently) and synchronization (facilitates cooperation amongst the several threads)
Distributed programming	Network and internet programming languages Example: Java	Synchronization and Semantics for message passing form the core support for implementing Remote Procedure Call (RPC) or Remote Method Invocation (RMI)
Database programming [4 GLs]	Structured query languages Example: SQL	• This paradigm provides a structured way of framing the query on a RDBMS • It also provides the framework for verifying and validating the query results

Classifications

This is just an example:

Imperative/ Algorithmic	Declarative		Object-Oriented
	Functional Programming	Logic Programming	
Algol Cobol PL/1 Ada C Modula-3	Lisp Haskell ML Miranda APL	Prolog	Smalltalk Simula C++ Java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