Prototypes with Multiple Dispatch: An Expressive and Dynamic Object Model

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1. Benefits of prototypes and multiple dispatch
2. Challenges in combining prototypes and multiple dispatch
3. PMD: a new model of multiple dispatch
4. Slate: practical experience with PMD
Why Prototypes?

Objects represent themselves (without classes) by describing their own methods and inheritance relationships.

Benefits

- Simpler language kernel
- Metaprogramming
- Interactive and incremental development
Why Multiple Dispatch?

All arguments to a method invocation participate in dispatch, not just the first.

Benefits

- fewer restrictions on code factoring and reuse
- don’t need to use simulations such as double dispatch or visitor pattern

Example

Integer + Integer
Float + Fraction
Complex + Float
## CombiningPrototypes and Multiple Dispatch

<table>
<thead>
<tr>
<th></th>
<th>Self [Ung 87] prototypes</th>
<th>Cecil [Cha 92] prototypes + multiple dispatch</th>
</tr>
</thead>
<tbody>
<tr>
<td>dispatch</td>
<td>dictionaries containing methods</td>
<td>methods constrained to specific objects or objects inheriting them</td>
</tr>
<tr>
<td>cloning</td>
<td>copies all methods</td>
<td>may only copy fields and must inherit methods</td>
</tr>
<tr>
<td>method update</td>
<td>anywhere</td>
<td>may only define methods at top–level</td>
</tr>
<tr>
<td>inheritance</td>
<td>delegation</td>
<td>inclusion (fixed) and predicate dispatch (dynamic) [Cha 93]</td>
</tr>
</tbody>
</table>
Combining Prototypes and Multiple Dispatch: Generic Functions

- prior multiple dispatch approaches rely on generic functions [Bob 88] or similar mechanisms
- generic function groups together all methods with similar name and arity
- apply generic function to invoke a method
- generic function selects applicable methods by checking method constraints against arguments
- orders applicable methods by constraints to find the most specific one
Combining Prototypes and Multiple Dispatch: Generic Functions Won’t Work

- dispatch information stored in external constraints – not encapsulated
- expensive to test and order all the constraints at the time of dispatch
- implementations generate dispatch tables or decision trees based on static inheritance relationships
- ideal for use with classes where inheritance relationships are fixed
- problematic for prototypes where inheritance may be unpredictable
PMD: A Paradigm Shift

Requirements
- must internalize dispatch information into objects
- all method arguments must decide the result of dispatch
- must be practical to evaluate inheritance at time of dispatch

Solution: roles
- Objects may play roles in a method corresponding to the method’s parameters.
- A method represents an interaction in which all necessary roles have been fulfilled.
- Only objects know which roles they may fulfill.
A role identifies, for a method definition, a method name and parameter for which an object agrees to be used, as well as a method to be run should the role be satisfied.

An object is a set of roles and delegation relationships, and roles may be inherited by delegation.

A role is satisfied if the name of the method to be invoked and the argument position where the role was found invocation match those described by the role.

A method is applicable if there is a set of satisfied roles referring to it that cover all arguments to an invocation.

Applicable methods are ranked according to the positions of their corresponding roles in the delegation hierarchy.

```c
int inc(int n)
{
    return n + 1;
}
```
encounter(Shark1, Shark2)

Shark 1
aggressor
eater

(0, 0)

(0, 1)

Shark 2
victim

delegation

Fish
food
role

method

rank

encounter

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Concepts

- roles
- object identity modeled through object store
- method update based on roles
- dynamic inheritance of roles through delegation
- multiple dispatch based on roles

Abstracts over:

- inheritance order
- precedence of method parameters
• programming language based on PMD and strongly inspired by Self
• object model largely the same as Self, with provisions for roles
• incorporates many organizational concepts from Self without loss (namespaces and traits)
- multiple dispatch extensively used in libraries such as numerics, collections, streams and the compiler
- libraries designed to take advantage of multiple dispatch and benefited from it
- allowed for practical integration of large amounts of objects
Us [Ung 96]

- perspective-receiver symmetry for subjectiveness
- dispatch on perspective and receiver
- perspectives dynamically composed with layers
- noted multiple dispatch allows for similar benefits

Potential uses

- security
- multi-user

PMD

- prototypes useful for creating and composing unique or shared perspectives
- multiple dispatch embeds subjectiveness with only a few changes
PMD consistently combines prototypes and multiple dispatch.
PMD provides a conceptual understanding of why they combine.
PMD’s roles internalize dispatch information.
PMD allows for flexible objects with fewer restrictions.