

# Custom Specializers in Object-Oriented Lisp

Jim Newton and Christophe Rhodes

Cadence Design Systems and Goldsmiths, University of London

23rd May 2008

## Common Lisp:

- Unification of various Lisp dialects;
- Not dead yet.

## Skill:

- Internal Lisp dialect from Cadence Design Systems;
- Extension language for Integrated Circuit software;
- Optional C-style syntax;
- Simple object system (Skill++, inspired by CLOS).

- CL structures and Skill++ objects:
  - single inheritance
  - single dispatch
- CL and VCLOS standard-objects and generic functions
  - multiple inheritance
  - multiple dispatch
  - method combination
  - [and lots more goodies]

Both CLOS and VCLOS are (almost) implementable as *extensions* to the base language

- In Common Lisp, CLOS is specified and fully-integrated;
- In Skill, VCLOS is an extension library.

- CL structures and Skill++ objects:
  - single inheritance
  - single dispatch
- CL and VCLOS standard-objects and generic functions
  - multiple inheritance
  - multiple dispatch
  - method combination
  - [and lots more goodies]

Both CLOS and VCLOS are (almost) implementable as *extensions* to the base language

- In Common Lisp, CLOS is specified and fully-integrated;
- In Skill, VCLOS is an extension library.

- CL structures and Skill++ objects:
  - single inheritance
  - single dispatch
- CL and VCLOS standard-objects and generic functions
  - multiple inheritance
  - multiple dispatch
  - method combination
  - [and lots more goodies]

Both CLOS and VCLOS are (almost) implementable as *extensions* to the base language

- In Common Lisp, CLOS is specified and fully-integrated;
- In Skill, VCLOS is an extension library.

VCLOS is implemented in itself; CLOS is 'encouraged' to be

- Metaobject Protocols
- Introspect and intercede...
- ...using the (V)CLOS mechanisms themselves.

Examples:

- customize slot access: integration with 'foreign' object systems;
- customize generic function call: integration with other languages;
- customize class precedence computation: run old codebases.

```
(defclass class (specializer)
  ((name :initarg :name :reader class-name)
   (direct-slots :initarg :direct-slots :reader class-direct-slots)
   ...))
```

```
(defclass eql-specializer (specializer)
  ((object :initarg :object :reader eql-specializer-object)))
```

What if we could do...

```
(defclass equal-specializer (specializer)
  ((object :initarg :object :reader equal-specializer-object)))
```

... and how hard is it to make this work?

```
(defclass class (specializer)
  ((name :initarg :name :reader class-name)
   (direct-slots :initarg :direct-slots :reader class-direct-slots)
   ...))
```

```
(defclass eql-specializer (specializer)
  ((object :initarg :object :reader eql-specializer-object)))
```

What if we could do...

```
(defclass equal-specializer (specializer)
  ((object :initarg :object :reader equal-specializer-object)))
```

... and how hard is it to make this work?



```
(defmethod walk ((expr list) env call-stack)
  (let ((call-stack (cons expr call-stack)))
    (walk (car expr) env call-stack)
    (walk (cdr expr) env call-stack)))
```

```
(defmethod walk ((form (cons (eql 'quote))) env call-stack)
  nil)
```

```
(defmethod walk ((form (cons (eql 'lambda))) env call-stack)
  (destructuring-bind (lambda lambda-list &rest body) form
    (let ((bs (derive-bindings-from-ll lambda-list)))
      (dolist (form body)
        (walk form (make-env bs env) (cons form call-stack)))
      (dolist (bind bs)
        (unless (used bind)
          (format t "unused: ~A: ~A~%" var call-stack))))))
```

```
(defmethod walk ((expr list) env call-stack)
  (let ((call-stack (cons expr call-stack)))
    (walk (car expr) env call-stack)
    (walk (cdr expr) env call-stack)))

(defmethod walk ((form (cons (eql 'quote))) env call-stack)
  nil)

(defmethod walk ((form (cons (eql 'lambda))) env call-stack)
  (destructuring-bind (lambda lambda-list &rest body) form
    (let ((bs (derive-bindings-from-ll lambda-list)))
      (dolist (form body)
        (walk form (make-env bs env) (cons form call-stack)))
      (dolist (bind bs)
        (unless (used bind)
          (format t "unused: ~A: ~A~%" var call-stack)))))))
```

```
(defgeneric simplify (x)
  (:method (x) x))

;;; in plus.lisp
(defmethod simplify ((x (+ _ 0)))
  (simplify (second x)))
(defmethod simplify ((x (+ 0 _)))
  (simplify (third x)))

;;; in times.lisp
(defmethod simplify ((x (* _ 0)))
  0)
(defmethod simplify ((x (* _ 1)))
  (simplify (second x)))
...

(simplify '(+ 0 (+ 1 0))) ; => 1
```

```
;;; default method: do nothing
(defmethod process-node ((node t) strip-space-p)
  (declare (ignore strip-space-p)))

;;; strip this text node if it contains whitespace only
(defmethod process-node ((node stp:text) (strip-space-p (eql t)))
  (when (whitespace-only-p (stp:data node))
    (stp:detach node)))

;;; process children recursively for document and element nodes
(defmethod process-node ((node stp:parent-node) strip-space-p)
  (mapc (lambda (child)
          (process-node child strip-space-p))
        (stp:list-children node)))

;;; override the stripping mode when declared explicitly on a element:
(defmethod process-node ((node (xpattern "[@xml:space = 'preserve']"))
                        strip-space-p)
  (declare (ignore strip-space-p))
  (call-next-method node nil))

(defmethod process-node ((node (xpattern "[@xml:space = 'strip']"))
                        strip-space-p)
  (declare (ignore strip-space-p))
  (call-next-method node t))
```

Run-time generic functions:

- `parse-specializer-using-class` *gf name*
- `unparse-specializer-using-class` *gf spec*

for *find-method*, debugger, tracer

`defmethod-time` generic function

- `make-method-specializers-form` *gf method names env*

(minimum necessary: more fine-grained protocol needed for convenience)

Run-time generic functions:

- `parse-specializer-using-class` *gf name*
- `unparse-specializer-using-class` *gf spec*

for *find-method*, debugger, tracer

defmethod-time generic function

- `make-method-specializers-form` *gf method names env*

(minimum necessary: more fine-grained protocol needed for convenience)

Discriminating functions *are* the 'function' part of a generic function.

```
(defmethod compute-discriminating-function ((gf generic-function))  
  (lambda (&rest args)  
    (let* ((ams (compute-applicable-methods gf args))  
          (mc (generic-function-method-combination gf))  
          (em (compute-effective-method gf mc ams))  
          (emf (generate-effective-method-function em)))  
      (apply emf args))))
```

We need to override *at least* `compute-applicable-methods`

Discriminating functions *are* the 'function' part of a generic function.

```
(defmethod compute-discriminating-function ((gf generic-function))
  (lambda (&rest args)
    (let* ((ams (compute-applicable-methods gf args))
           (mc (generic-function-method-combination gf))
           (em (compute-effective-method gf mc ams))
           (emf (generate-effective-method-function em)))
      (apply emf args))))
```

We need to override *at least* compute-applicable-methods



```
(defmethod compute-applicable-methods ((gf generic-function) args)
  (sort
   (remove-if-not (applicable-predicate args)
                  (generic-function-methods gf))
   (ordering-function gf args)))
```

Doing this on every generic function call would be slow.

Regular CLOS MOP has paired operators:

- 1 `compute-applicable-methods`
- 2 `compute-applicable-methods-using-classes`

and caching is done if `c-a-m-using-classes` can work out the answer.

```
(defmethod compute-applicable-methods ((gf generic-function) args)
  (sort
   (remove-if-not (applicable-predicate args)
                  (generic-function-methods gf))
   (ordering-function gf args)))
```

Doing this on every generic function call would be slow.

Regular CLOS MOP has paired operators:

- 1 `compute-applicable-methods`
- 2 `compute-applicable-methods-using-classes`

and caching is done if `c-a-m-using-classes` can work out the answer.

```
(defmethod compute-discriminating-function ((gf generic-function))
  (lambda (&rest args)
    (let* ((ams (compute-applicable-methods gf args))
           (mc (generic-function-method-combination gf))
           (em (compute-effective-method gf mc ams))
           (emf (generate-effective-method-function em)))
      (apply emf args))))
```

- CLOS MOP specifies `compute-effective-method`
- `compute-effective-method-function` would be more useful
- ... and also protocol for automatically
  - cacheing the effective method;
  - clearing the cache;
  - pre-filling the cache...

## Expressivity:

- clarity;
- modularity;
- dynamicity.

## Efficiency:

```
(defmethod compute-discriminating-function ((gf generic-function))  
  (let* ((methods (generic-function-methods gf))  
        (dfun (compile-dispatch-function methods)))  
    (lambda (&rest args)  
      (apply dfun args))))
```

## Expressivity:

- clarity;
- modularity;
- dynamicity.

## Efficiency:

```
(defmethod compute-discriminating-function ((gf generic-function))  
  (let* ((methods (generic-function-methods gf))  
        (dfun (compile-dispatch-function methods)))  
    (lambda (&rest args)  
      (apply dfun args))))
```

- Custom specializers are an additional tool in the CLOS toolbox;
- Skill/VCLOS experience shows that they can be useful;
- The basic machinery has been implemented in a Common Lisp;
- There are details in the protocol to be sorted out to make it easy to use.

- Usable protocol for compute-applicable-methods
  - `specializer-accepts-class-p`
  - `specializer<`
- Better cacheing protocol
  - `specializer-of`
  - `compute-applicable-methods-using-specializers`
  - invalidation on redefinition of dependents
- Compelling applications
  - efficient ML-style pattern matcher with run-time dynamicity
  - dispatch based on emacs-like 'active modes'
  - [your favourite here]

- Please download and try: available in current SBCLs!
- For the Skill version, contact your nearest Cadence Design Systems representative.

## Thanks:

- Cadence Design Systems
- Goldsmiths College
- David Lichteblau
- Paul Khuong
- Pascal Costanza