Kill-Safe Synchronization Abstractions

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Sibling Food-Sharing Protocol
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- By inspection, the protocol is fair
- No parental supervision required
Sharing among Processes
Sharing among Processes
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Sharing among Processes

- Queue should be safe and fair
- Should require no kernel supervision
Sharing in Java

synchronized
Sharing in Java

Thread.stop ⇒ synchronized isn't enough
Sharing in Java

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Sharing in Java

synchronized

Thread.stop ⇒ synchronized isn't enough

.: Java has no Thread.stop
Why Terminate?

- Execute code in a programming environment (DrScheme)

```
(define (has-zero? l)
  (cond
    [(empty? l) false]
    [(cons? l) (or (zero? (first l))
                   (has-zero? (rest l)))]))
```

Welcome to DrScheme, version 202.
Language: Beginning Student.
Why Terminate?

- Execute code in a programming environment (DrScheme)
- Cancel actions that allocate resources (HTML browser)
Why Terminate?

- Execute code in a programming environment (DrScheme)
- Cancel actions that allocate resources (HTML browser)
- Stop misbehaving servlets (web server)
Building Kill-Safe Abstractions

abstraction

thread-safe abstraction

kill-safe thread-safe abstraction
Building Kill-Safe Abstractions

- abstraction
- thread-safe abstraction
- kill-safe thread-safe abstraction

Programmer effort — but generally understood
Building Kill-Safe Abstractions

- abstraction
- thread-safe abstraction
- kill-safe thread-safe abstraction

Programmer effort — but generally understood

Programmer effort — the subject of this talk
Building Kill-Safe Abstractions

Start with **Concurrent ML**
[Reppy 88]
Building Kill-Safe Abstractions

Start with **Concurrent ML** [Reppy 88]

Add MzScheme's **custodians** and a little more

**abstraction**

**thread-safe abstraction**

**kill-safe thread-safe abstraction**
Sharing in Concurrent ML
Sharing in Concurrent ML
Sharing in Concurrent ML
Sharing in Concurrent ML

Abstraction-as-process naturally supports termination
Sharing in Concurrent ML

Abstraction-as-process naturally supports termination

Remaining problem: who controls the abstraction's process?
Managing Processes and Threads
Managing Processes and Threads
Managing Processes and Threads

= custodian = capability to execute
Managing Processes and Threads

= custodian = capability to execute
Managing with Custodians
Managing with Custodians
Managing with Custodians
Managing with Custodians
Managing with Custodians

Queue terminated with servlet

Queue terminated with servlet
Thread-Safe Abstractions

A language to support abstractions:

- Concurrent ML primitives for thread communication
- Custodians for process hierarchy

Each abstraction:

- Manager thread for state
Towards Kill Safety with Custodians
Towards Kill Safety with Custodians
Towards Kill Safety with Custodians

Not kill-safe among servlets 😞
Kill Safety through Joint Custody
Kill Safety through Joint Custody
Kill Safety through Joint Custody
Kill Safety through Joint Custody
Kill Safety through Joint Custody

Queue runs exactly as long as servlets
Why a Thread can have Multiple Custodians
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Why a Thread can have Multiple Custodians
Why a Thread can have Multiple Custodians

Queue is only *mostly dead*
Why a Thread can have Multiple Custodians

Queue is only *mostly dead*
Why a Thread can have Multiple Custodians

Use queue ⇒ grant custodian
Kill-Safe Abstractions

A language to support abstractions:

- Concurrent ML primitives for thread communication
- Custodians for process hierarchy
- **Operation to grant a thread another custodian**

Each abstraction:

- Manager thread for state
- **Each action grants custodian to manager thread**
Non-Solution #1 — Atomic Region

= atomic
Non-Solution #1 — Atomic Region

Queue might harm other servlets

= atomic
Non-Solution #2 — Disjoint Process
Non-Solution #2 — Disjoint Process
Non-Solution #2 — Disjoint Process
Non-Solution #2 — Disjoint Process

Queue runs forever

Queue runs forever
Non-Solution #3 — Meta-Servlet
Non-Solution #3 — Meta-Servlet

Merely moves the “kernel” 😞
Solution — Joint Custody
Details (See Paper)

- Custodians granted through `thread-resume`
- CML's `guard-evt` a natural place for `thread-resume`
- Improved `nack-guard-evt` for two-step protocols
- Kill-safe does not always imply break-safe, nor vice-versa
A Thread-Safe Queue

(define-struct safe-q
  (put-ch get-ch))

(define (safe-queue)
  (define q (queue))
  (define get-ch (channel))
  (define put-ch (channel))
  (define (q-loop)
    (sync
     (choice-evt
      (wrap-evt
       (channel-send get-ch (peek q))
       (lambda () (get q)))
      (wrap-evt
       (channel-recev put-ch)
       (lambda (v) (put q v))))))
  (spawn q-loop)
  (make-safe-q put-ch get-ch))

(define (safe-get sq)
  (channel-recev
   (safe-q-get-ch sq)))

(define (safe-put sq v)
  (channel-send
   (safe-q-put-ch sq) v))
(define-struct safe-q
  (manager-t put-ch get-ch))

(define (safe-queue)
  (define q (queue))
  (define get-ch (channel))
  (define put-ch (channel))
  (define (q-loop)
    (sync
      (choice-evt
        (wrap-evt
          (channel-send get-ch (peek q))
          (lambda () (get q)))
        (wrap-evt
          (channel-recv put-ch)
          (lambda (v) (put q v)))))
    (q-loop))
  (define manager-t (spawn q-loop))
  (make-safe-q manager-t put-ch get-ch))

(define (safe-get sq)
  (resume sq)
  (channel-recv
    (safe-q-get-ch sq)))

(define (safe-put sq v)
  (resume sq)
  (channel-send
    (safe-q-put-ch sq) v))

(define (resume sq)
  (thread-resume
    (safe-q-manager-t sq)
    (current-thread)))