Kill-Safe Synchronization Abstractions

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Sibling Food-Sharing Protocol

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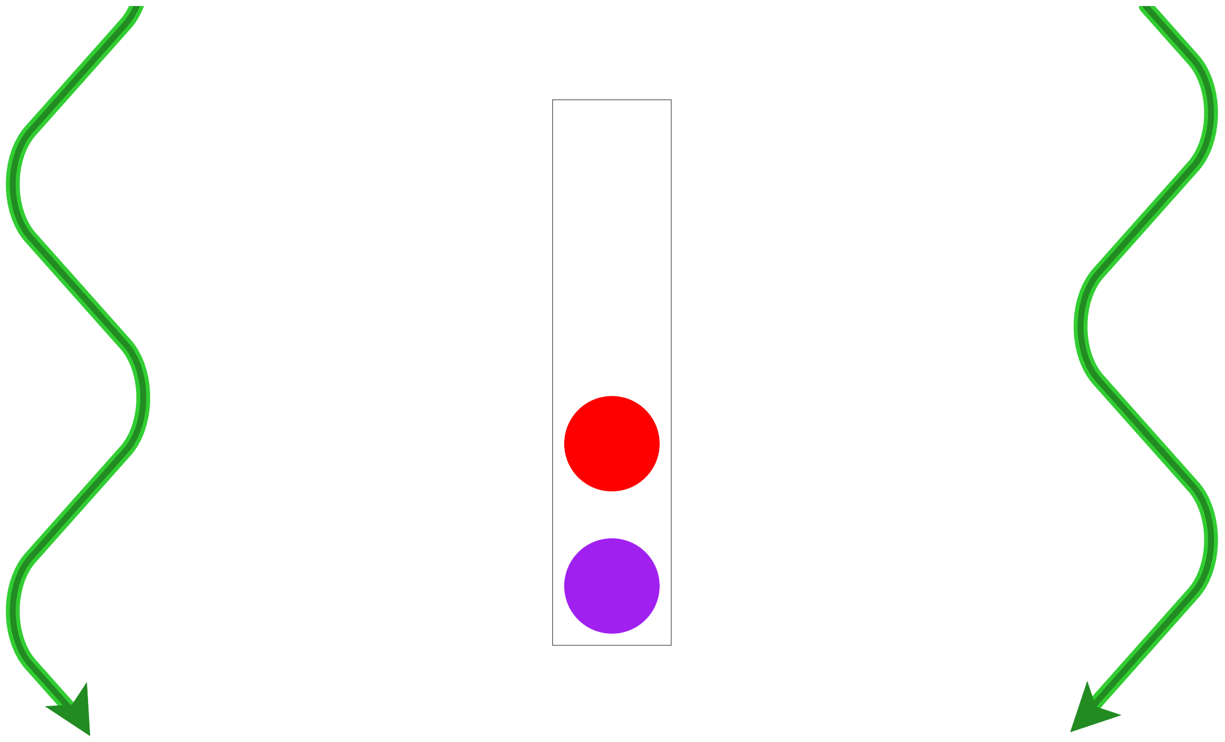
Sibling Food-Sharing Protocol

- By inspection, the protocol is fair
- No parental supervision required

Sharing among Processes



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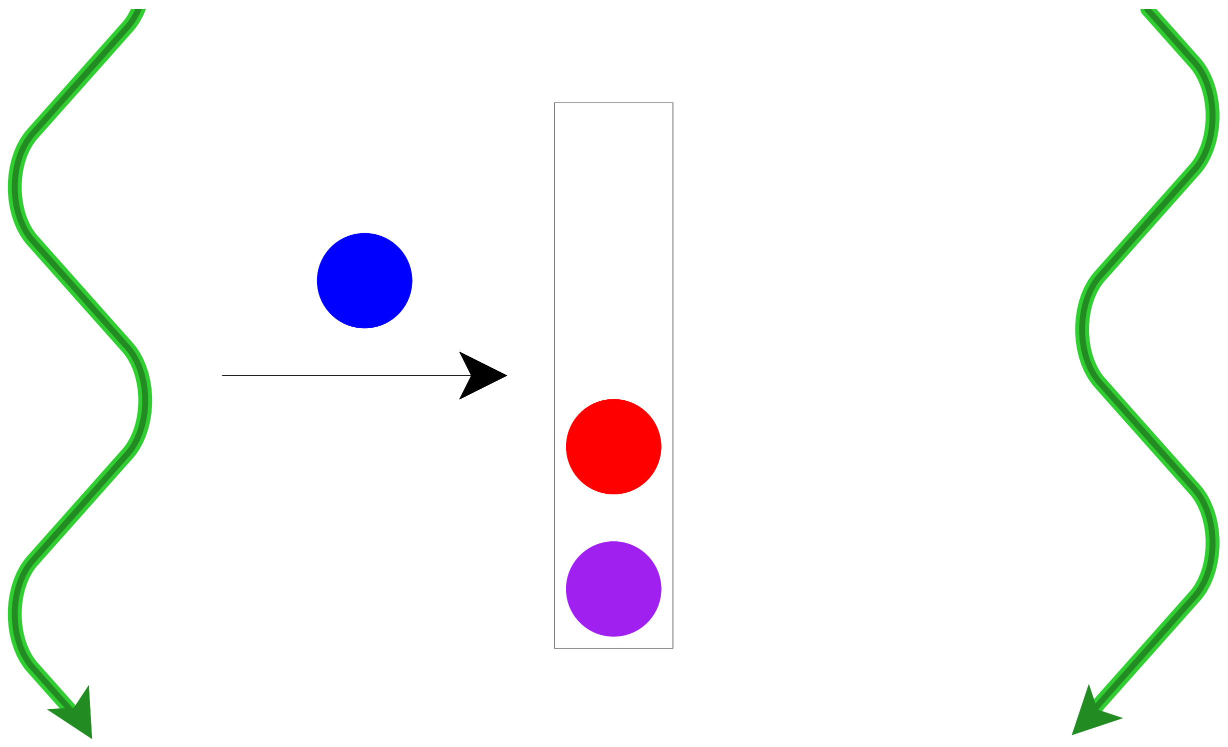

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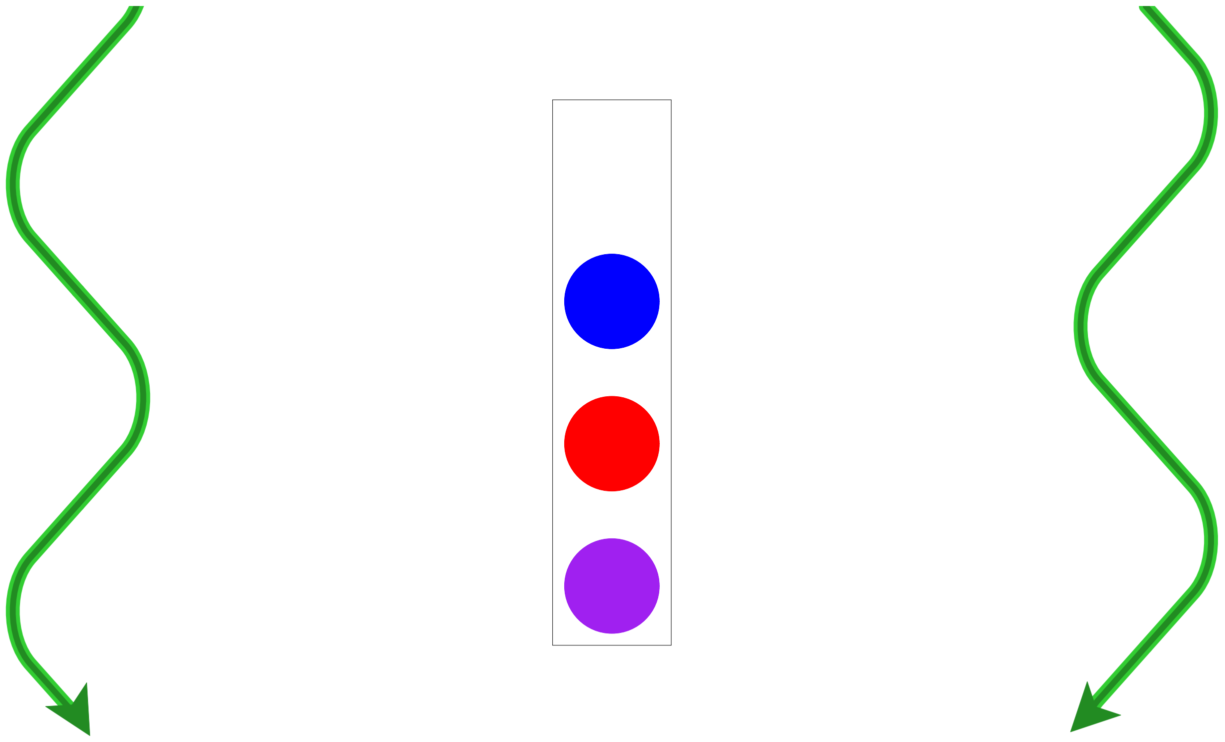

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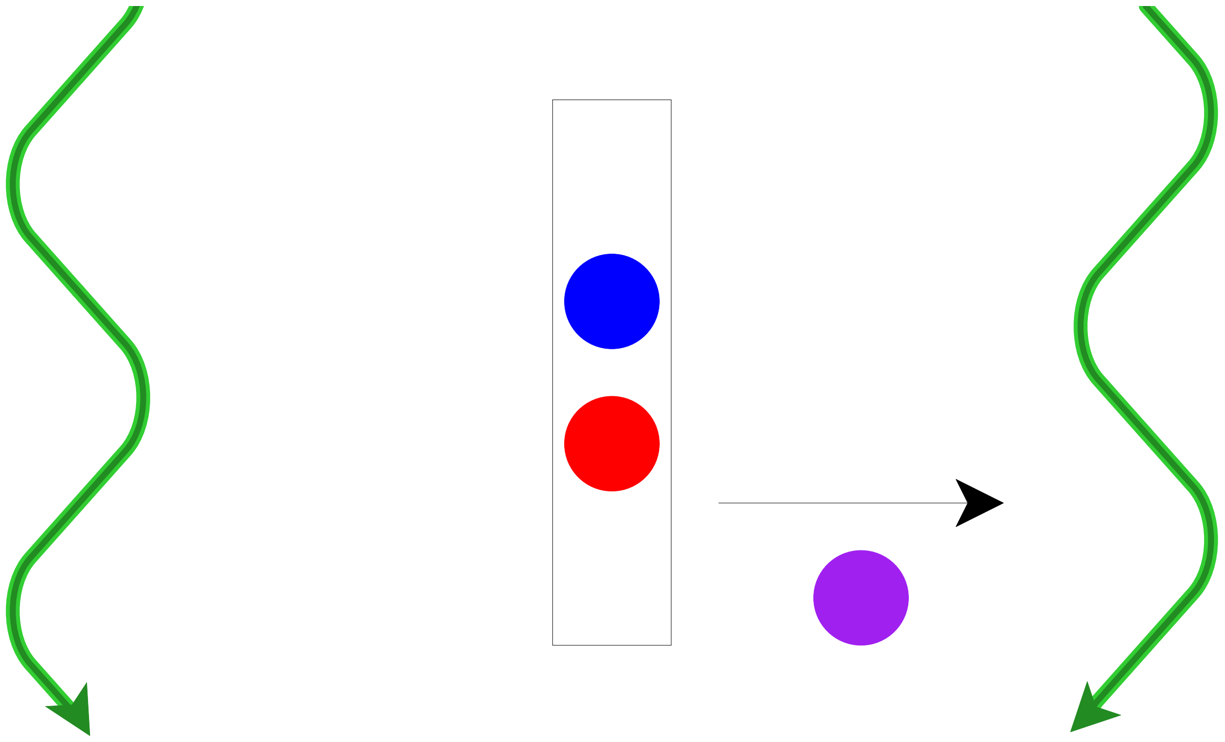

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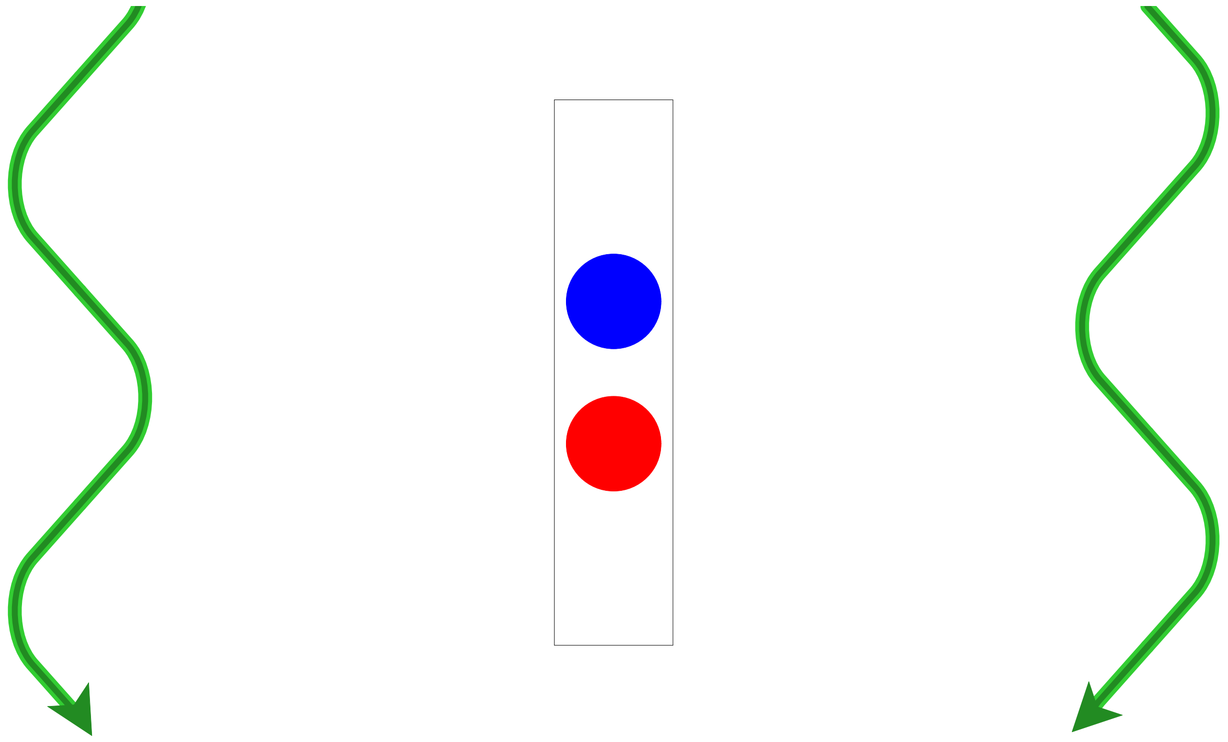
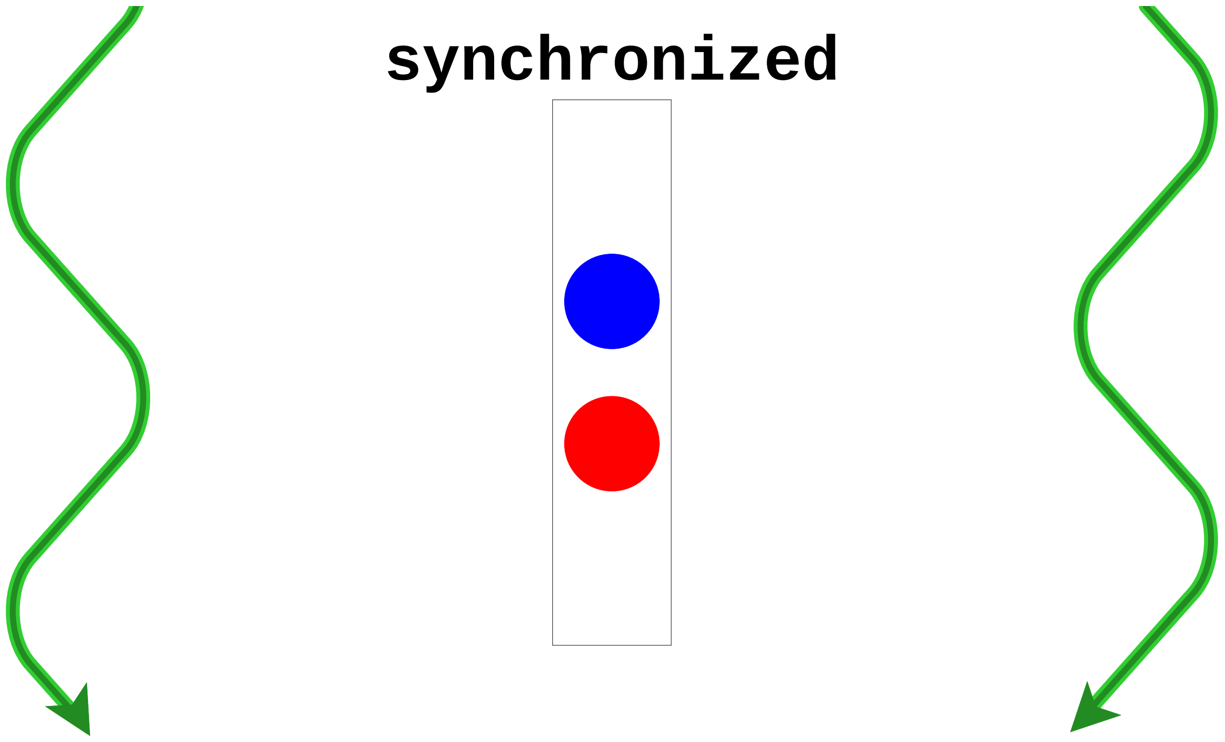
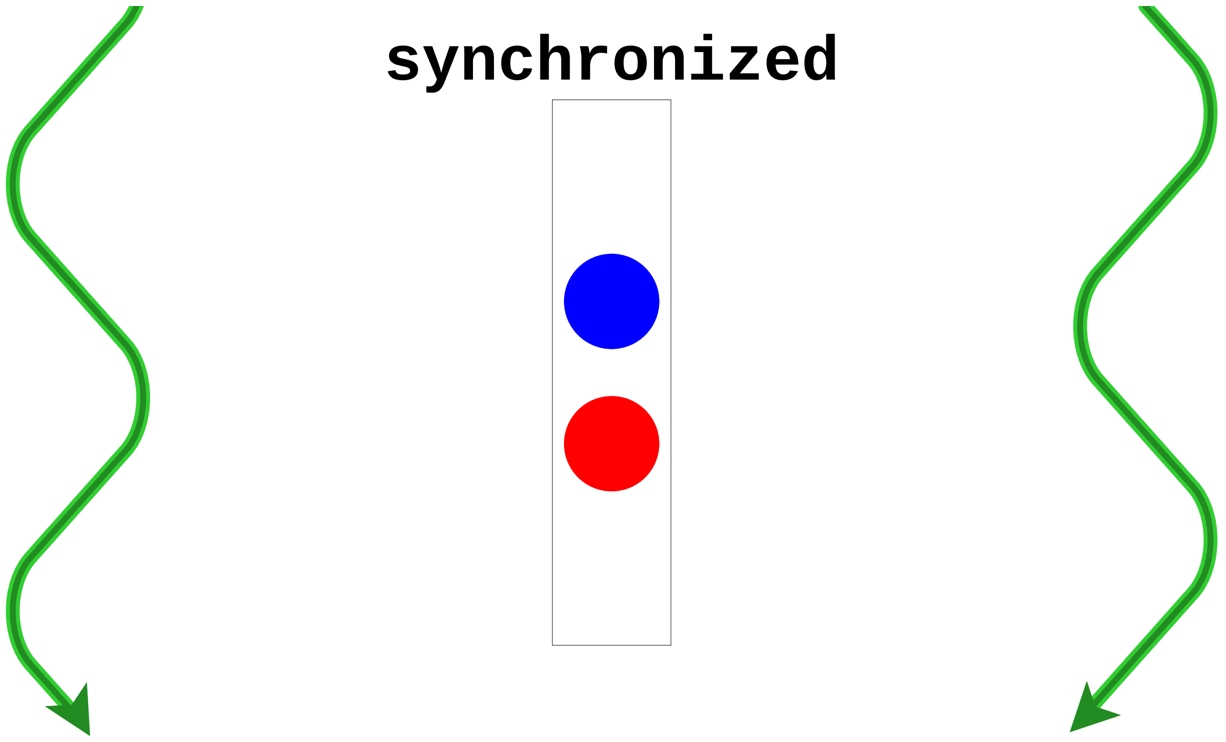


- Queue should be safe and fair
- Should require no kernel supervision

Sharing in Java

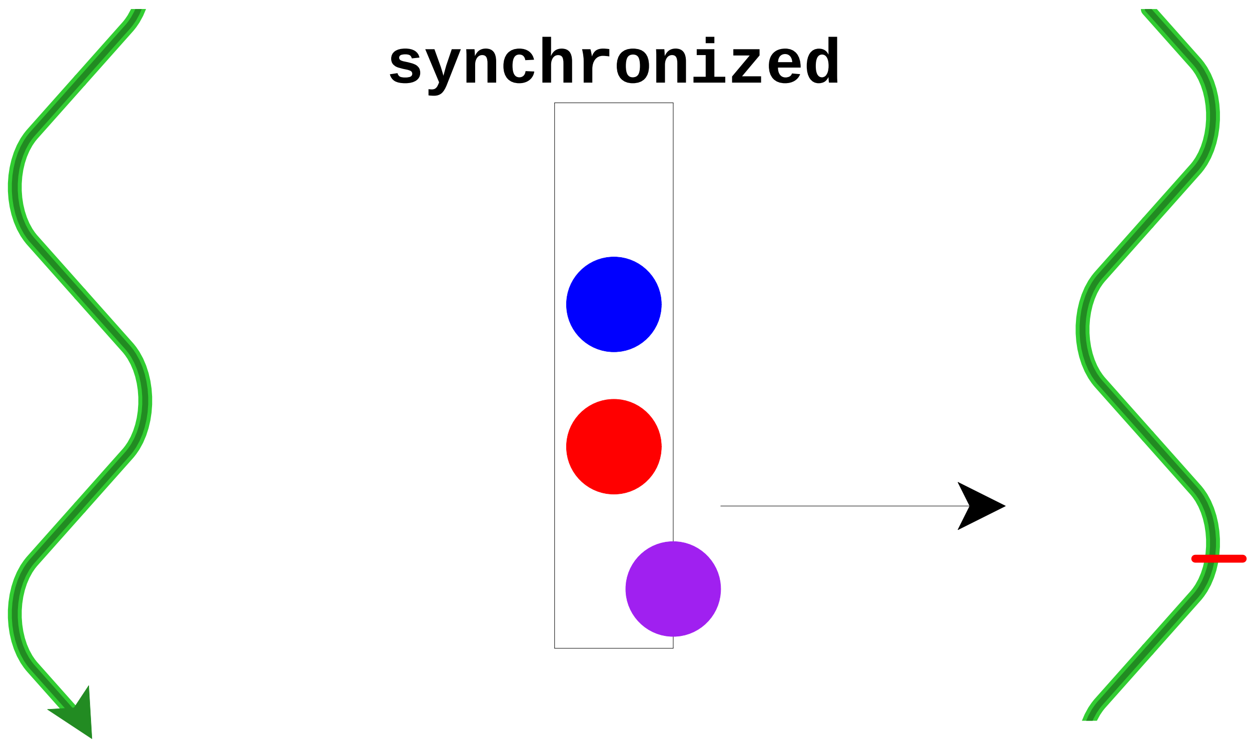


Sharing in Java



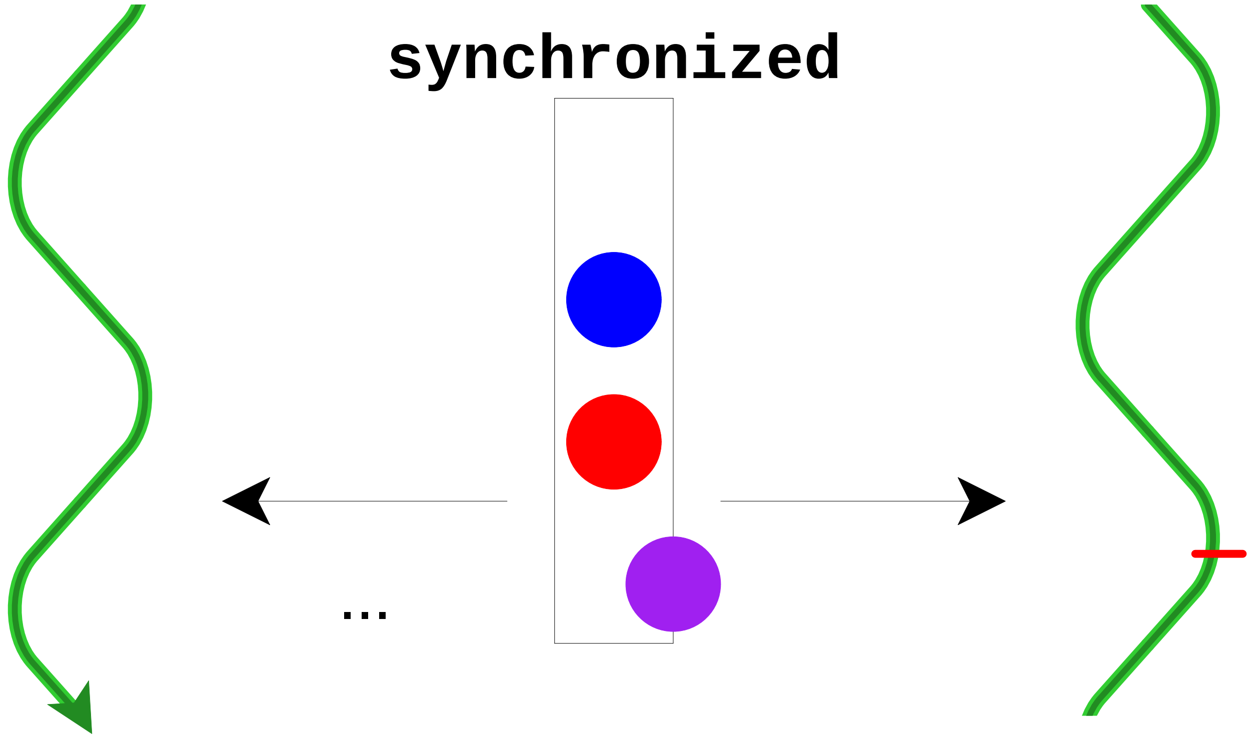
`Thread.stop` $\Rightarrow$ **`synchronized`** *isn't enough*

Sharing in Java



`Thread.stop` ⇒ **`synchronized`** *isn't enough*

Sharing in Java



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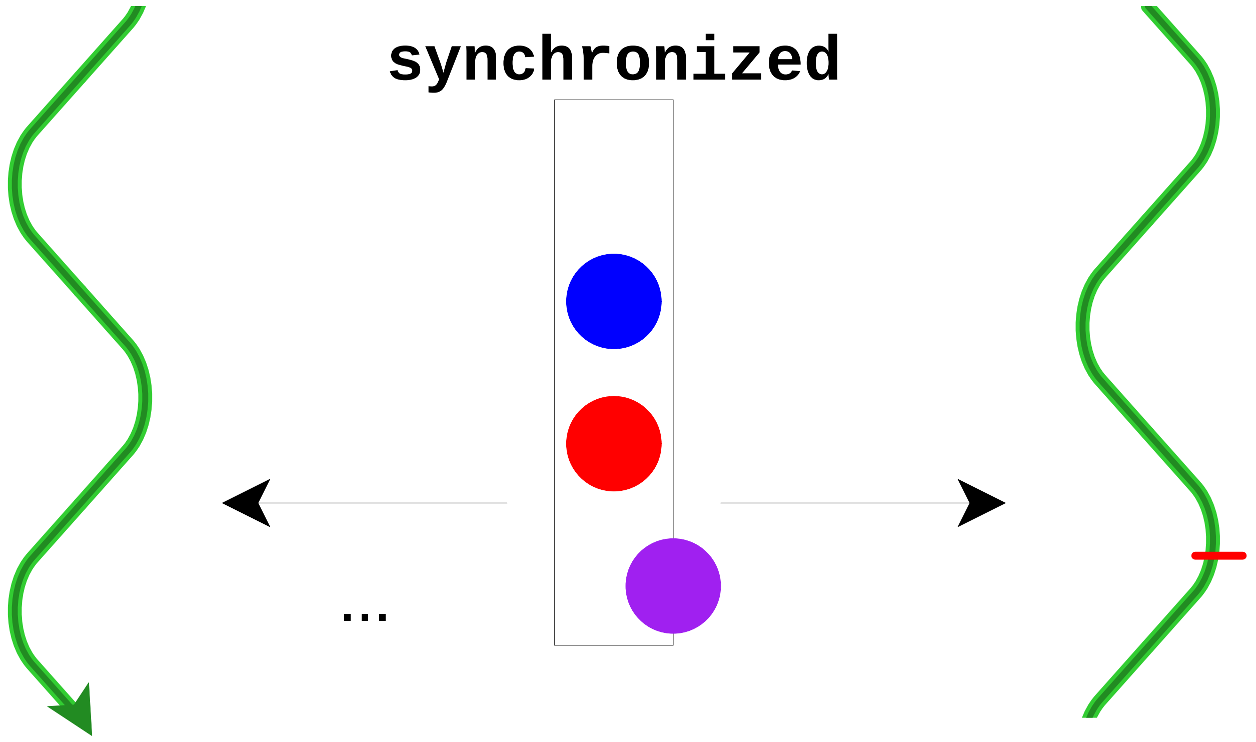
Sharing in Java

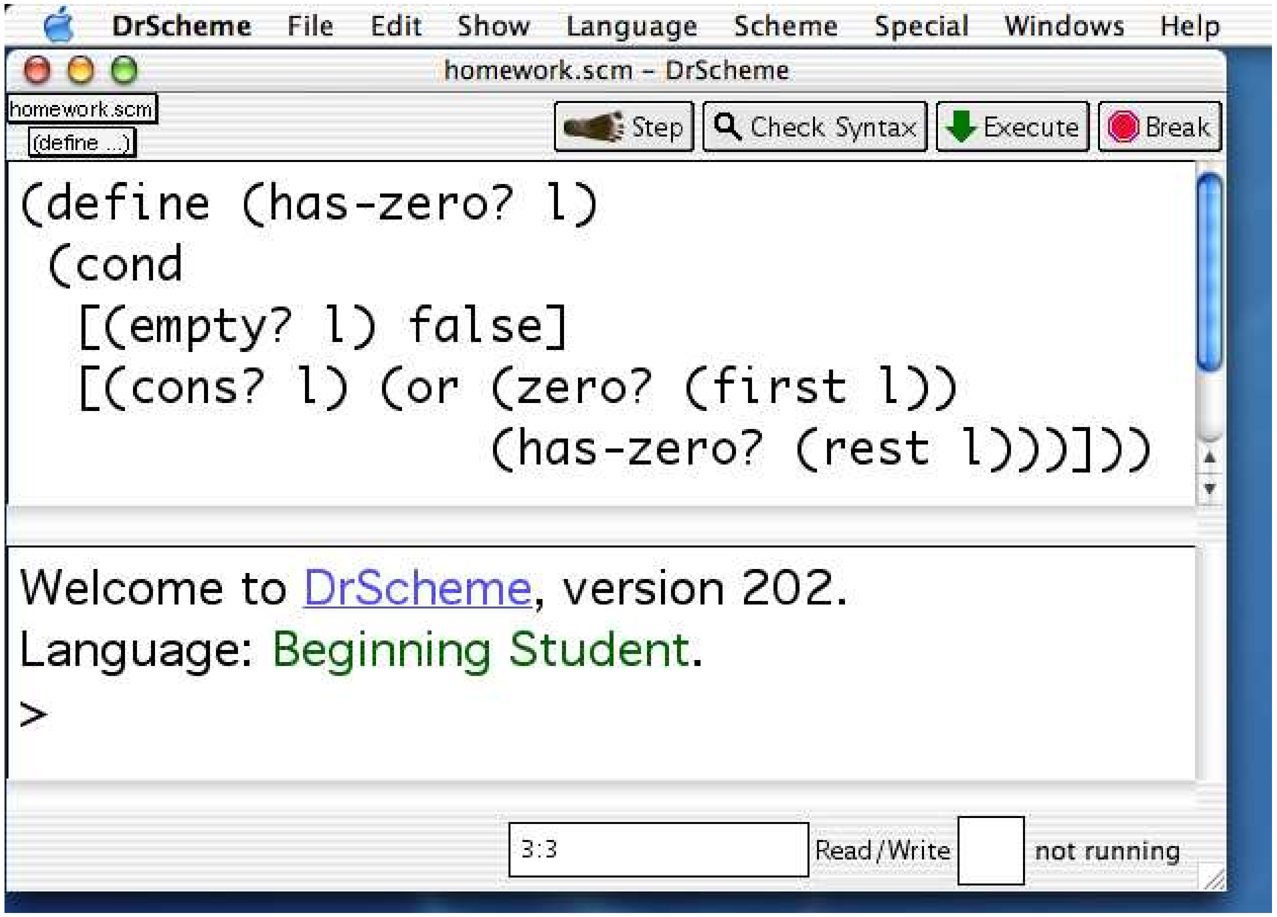


`Thread.stop` ⇒ **`synchronized`** *isn't enough*

∴ Java has no **`Thread.stop`**

Why Terminate?

- Execute code in a programming environment (DrScheme)

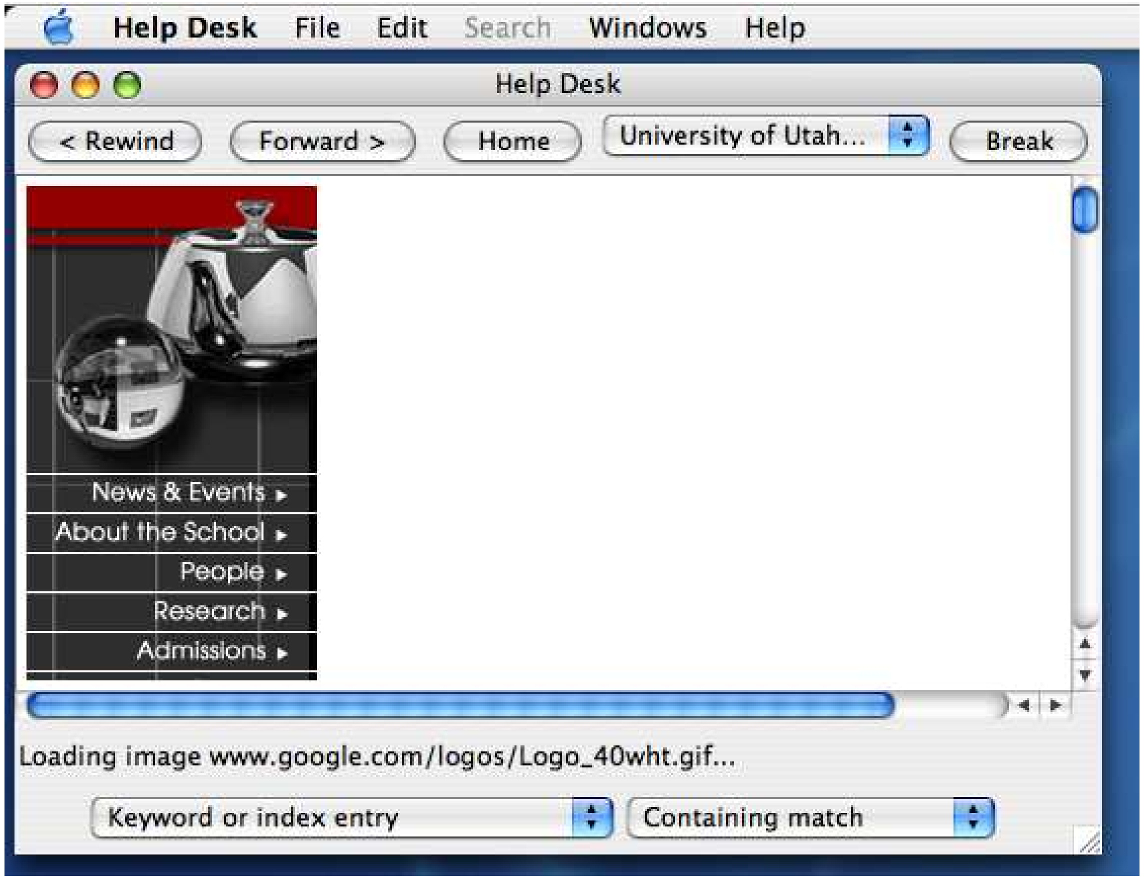


```
(define (has-zero? l)
 (cond
  [(empty? l) false]
  [(cons? l) (or (zero? (first l))
                 (has-zero? (rest l)))]))
```

```
Welcome to DrScheme, version 202.
Language: Beginning Student.
>
```

Why Terminate?

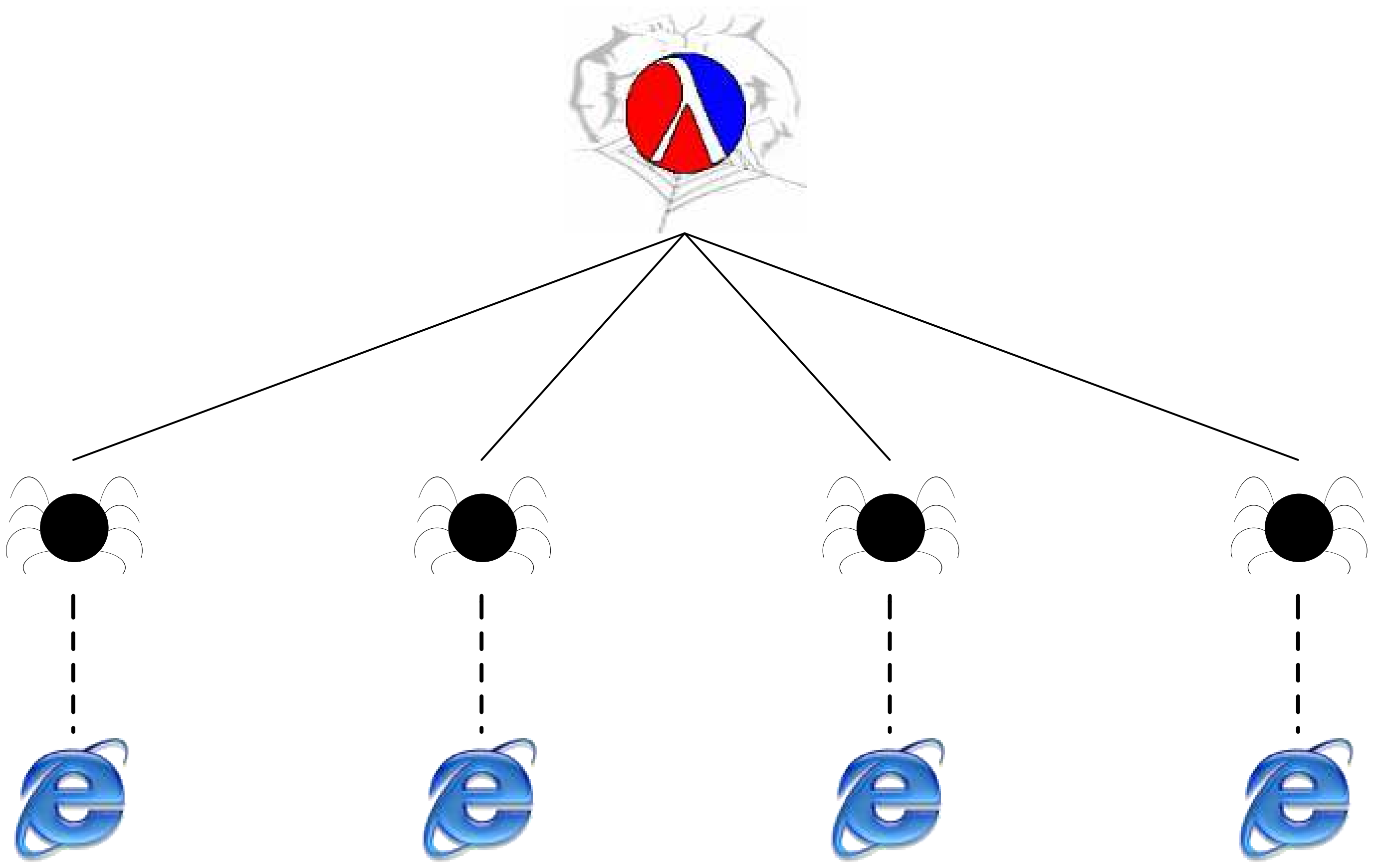
- Execute code in a programming environment (DrScheme)
- Cancel actions that allocate resources (HTML browser)



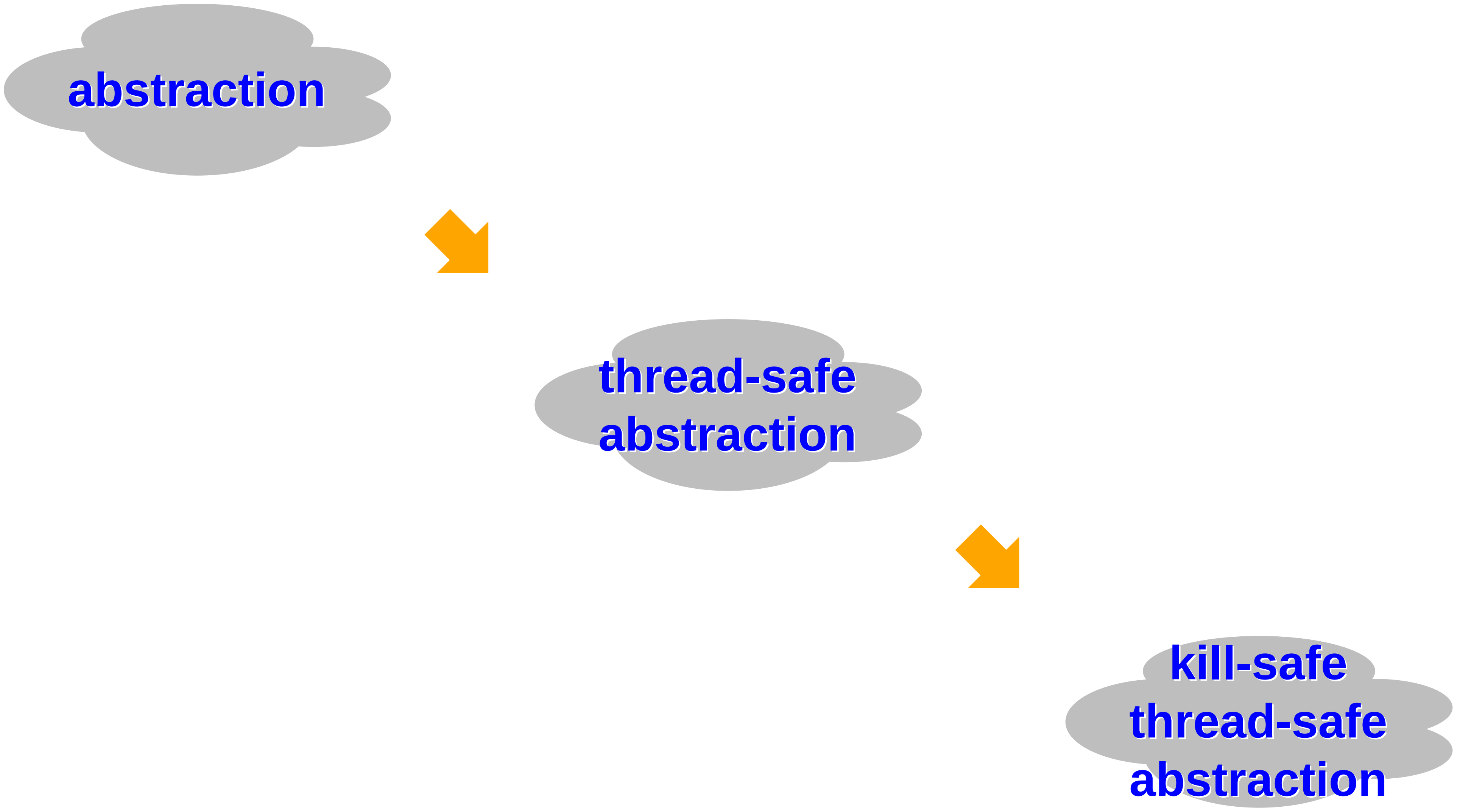
Loading image www.google.com/logos/Logo_40wht.gif...

Why Terminate?

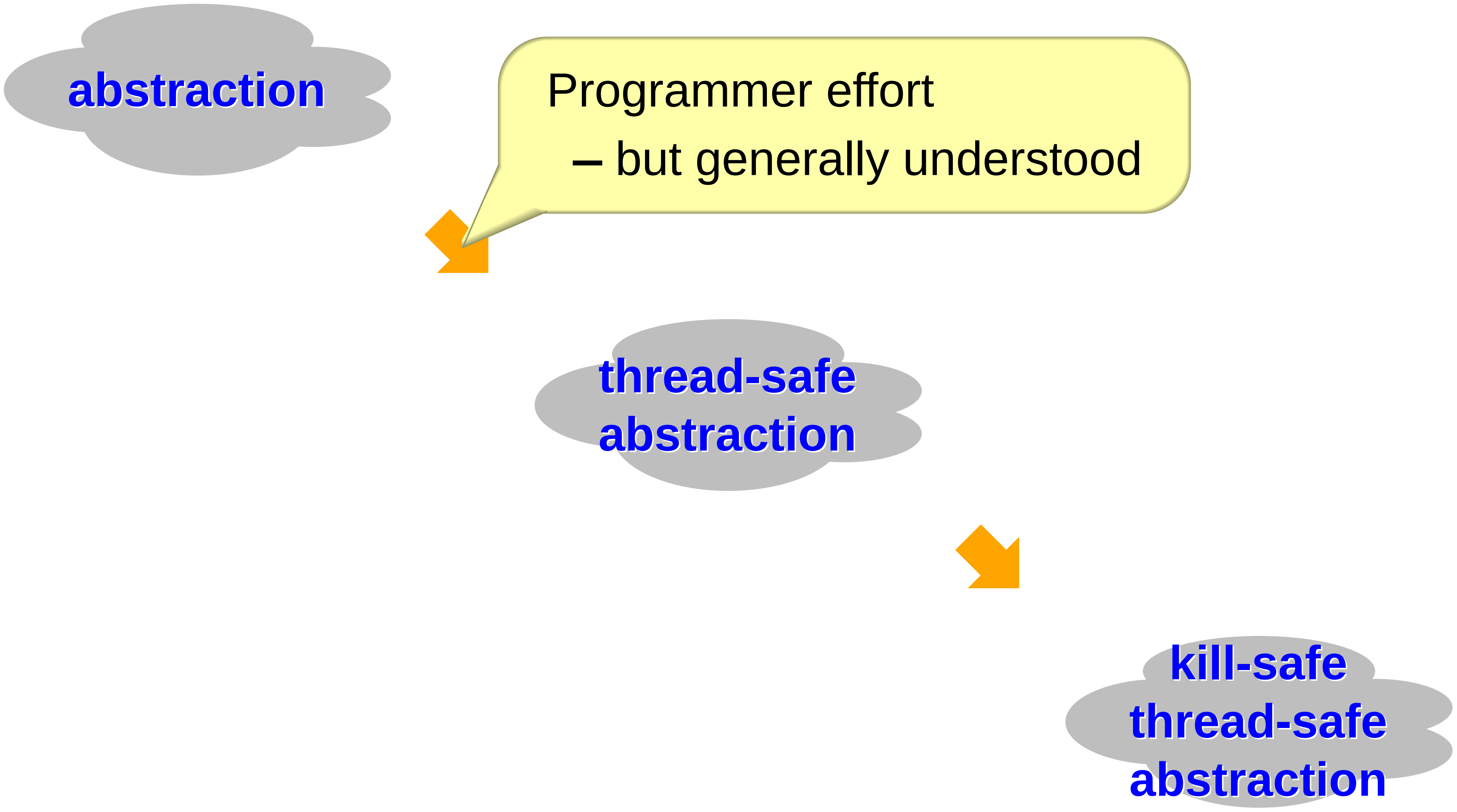
- Execute code in a programming environment (DrScheme)
- Cancel actions that allocate resources (HTML browser)
- Stop misbehaving servlets (web server)



Building Kill-Safe Abstractions



Building Kill-Safe Abstractions



Building Kill-Safe Abstractions

abstraction

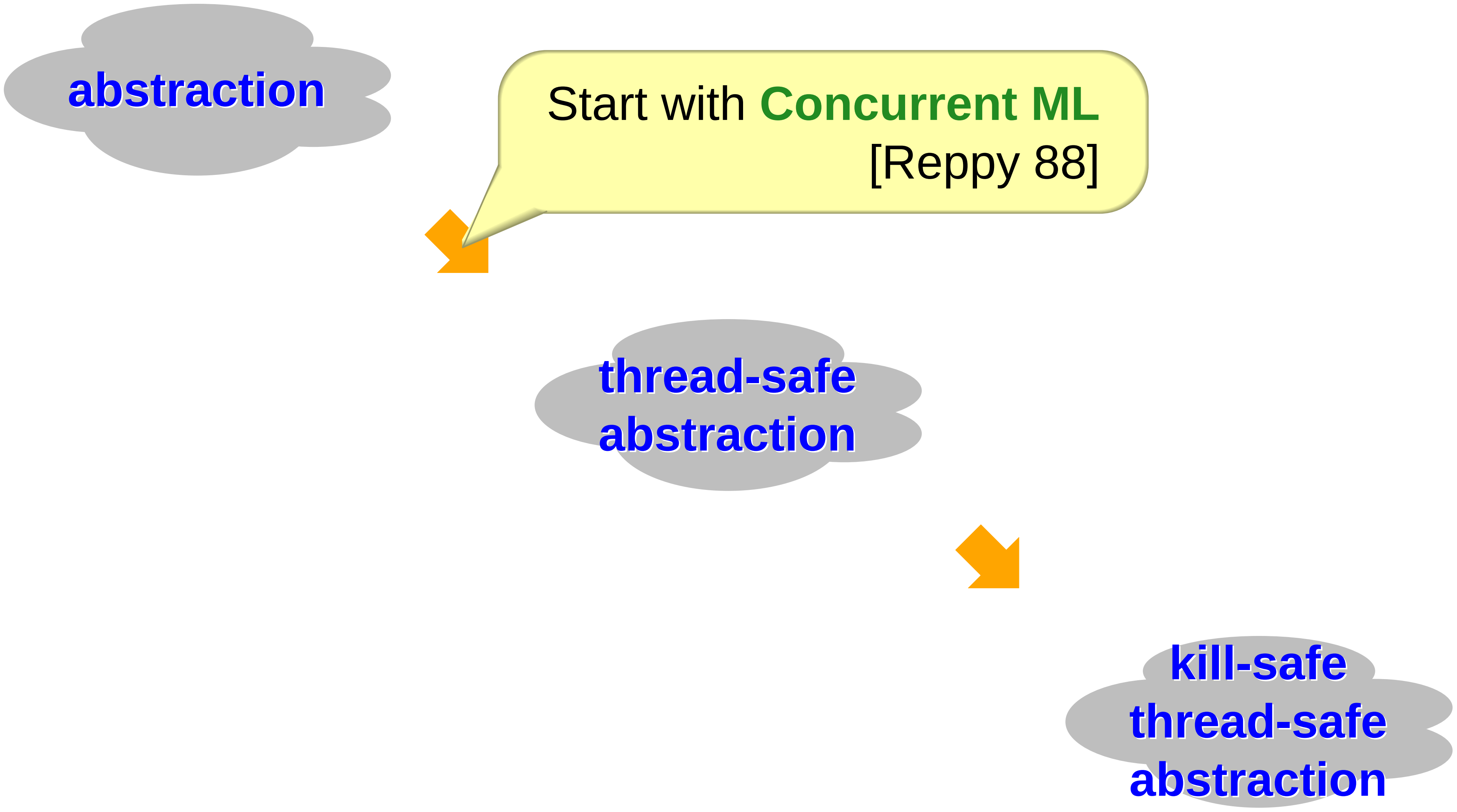
Programmer effort
– but generally understood

thread-safe abstraction

Programmer effort
– the subject of this talk

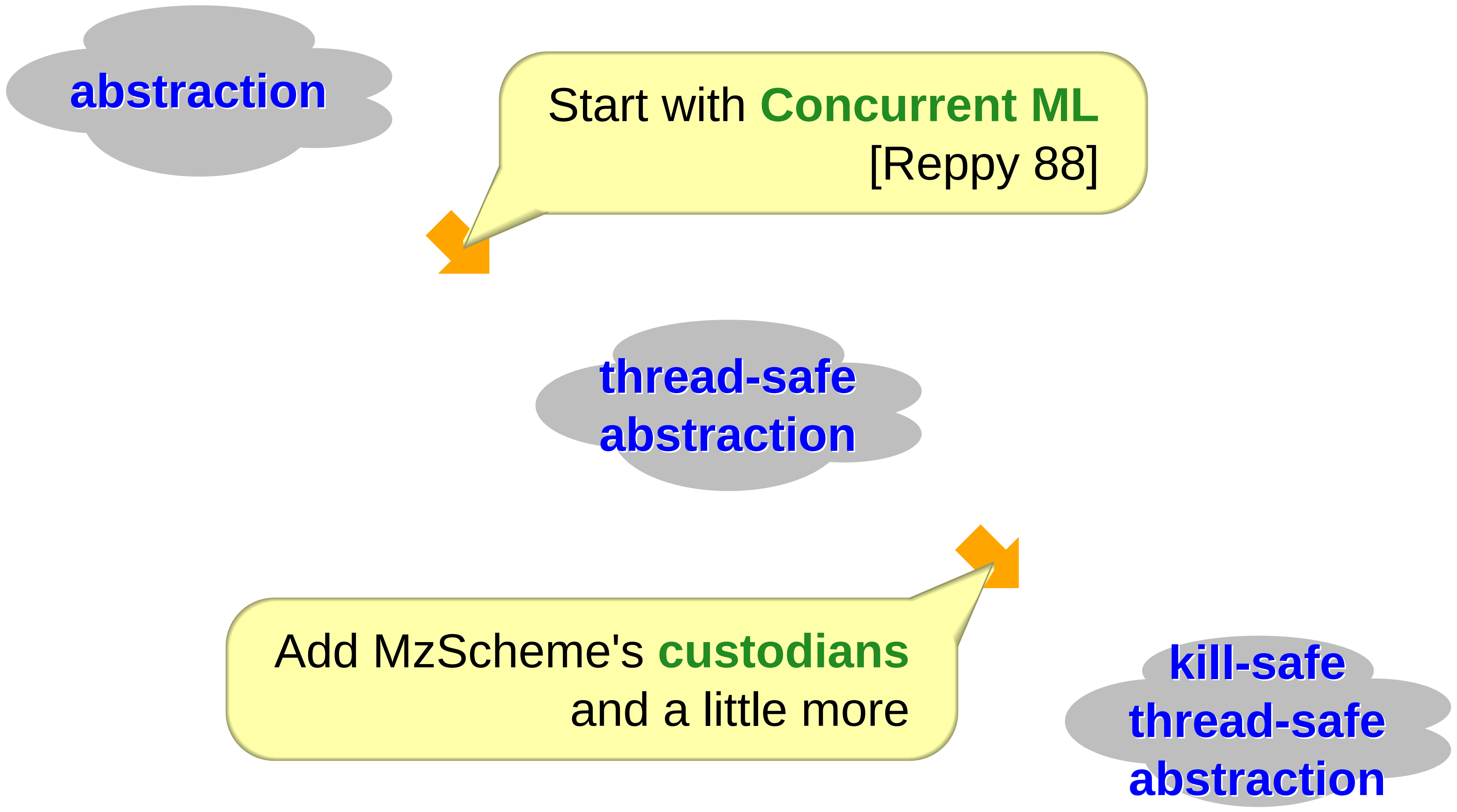
kill-safe thread-safe abstraction

Building Kill-Safe Abstractions

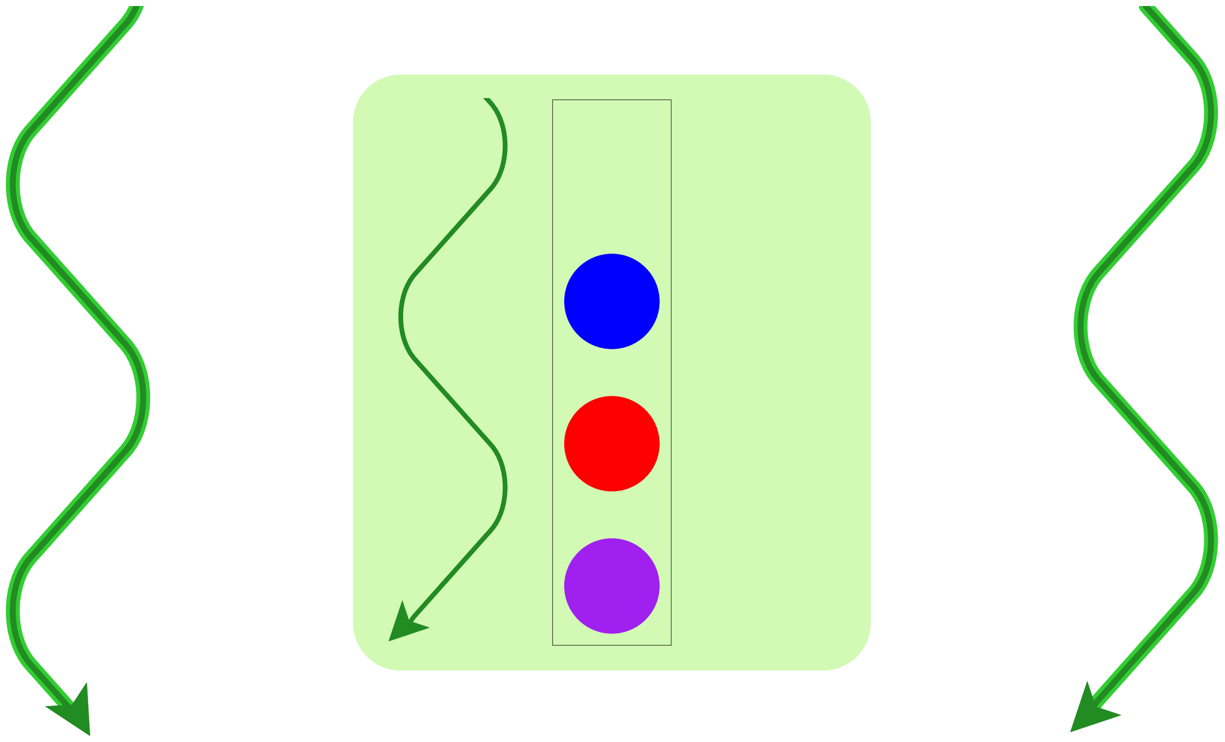


Start with **Concurrent ML** [Reppy 88]

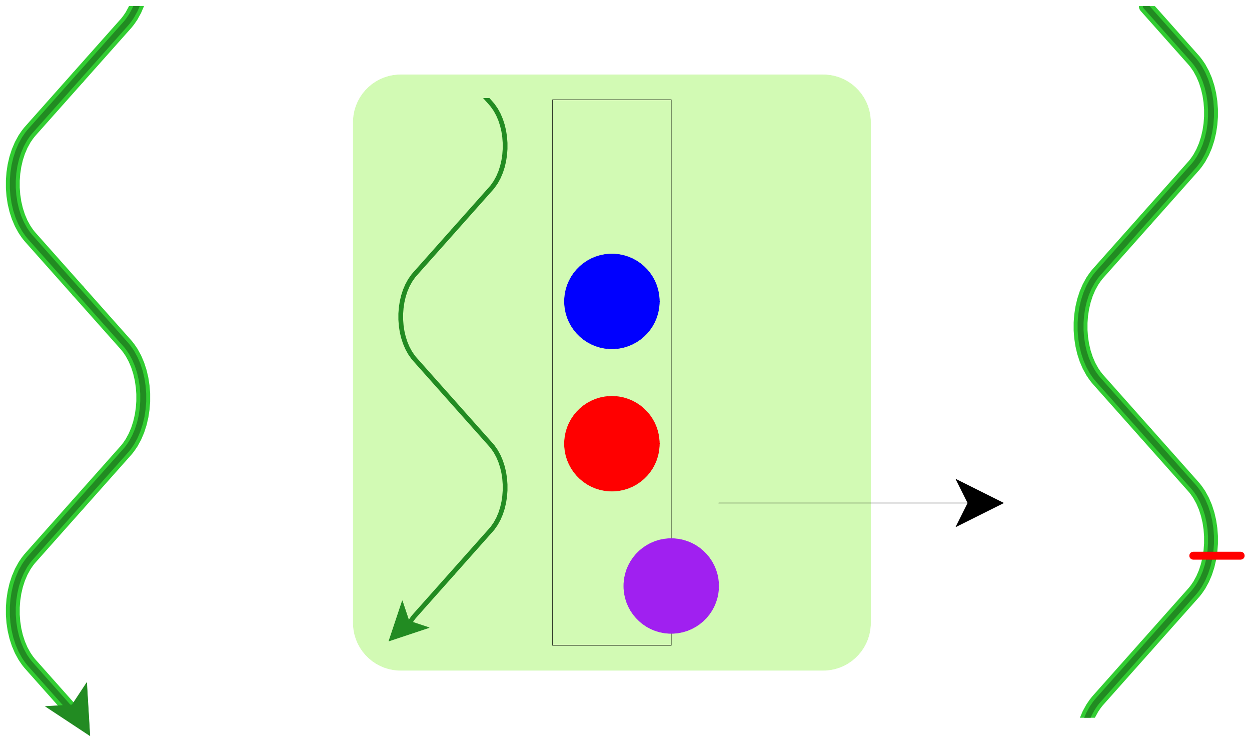
Building Kill-Safe Abstractions


abstraction
Start with Concurrent ML [Reppy 88]
thread-safe abstraction
Add MzScheme's custodians and a little more
kill-safe thread-safe abstraction

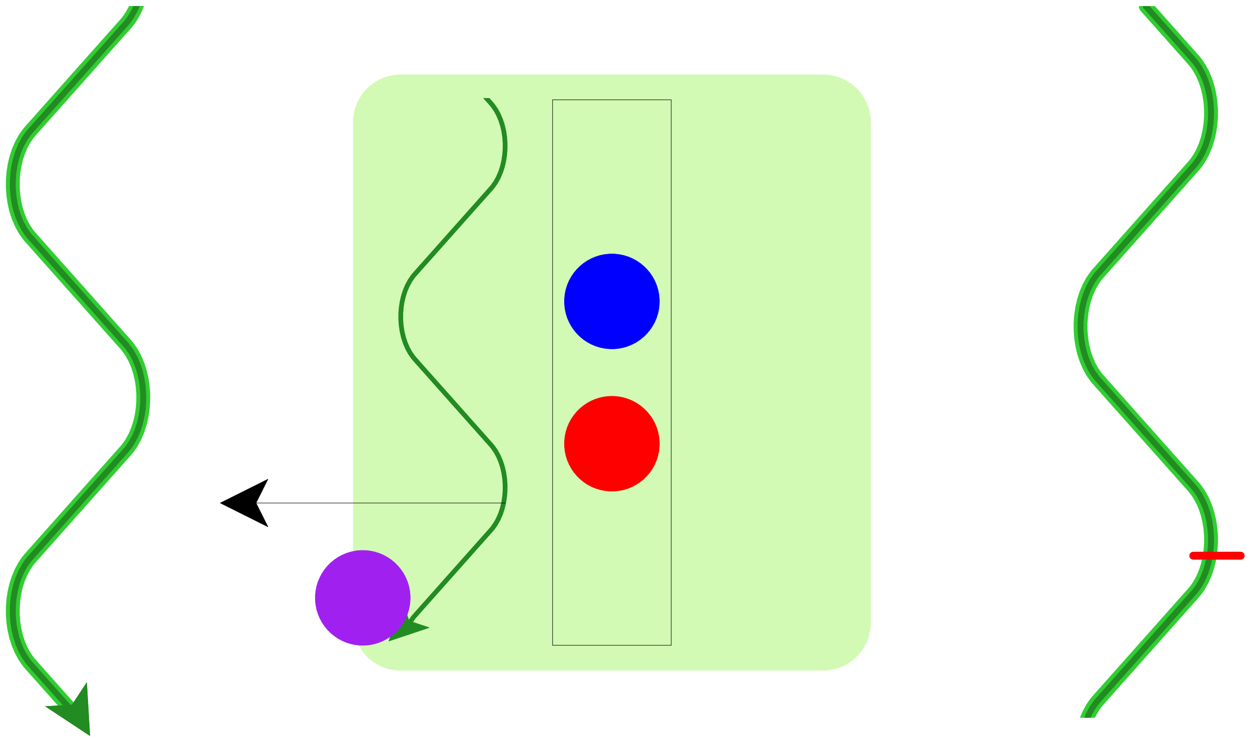
Sharing in Concurrent ML



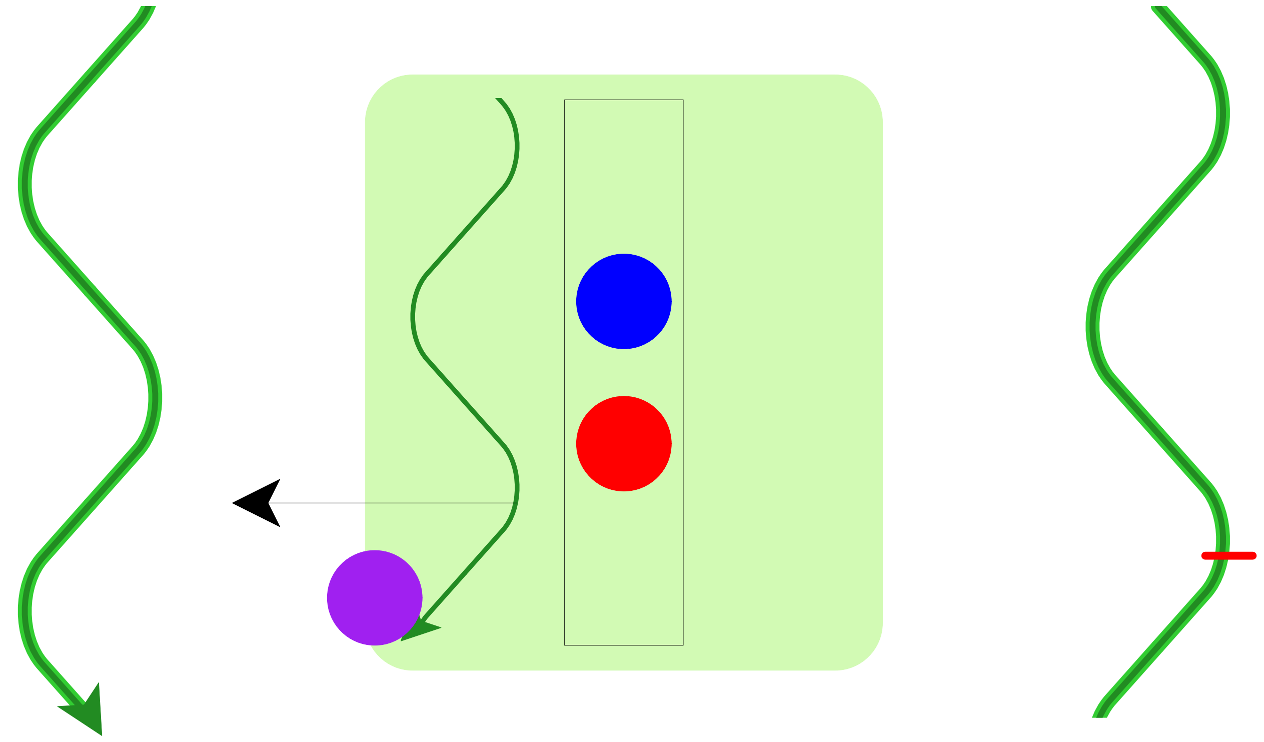
Sharing in Concurrent ML



Sharing in Concurrent ML

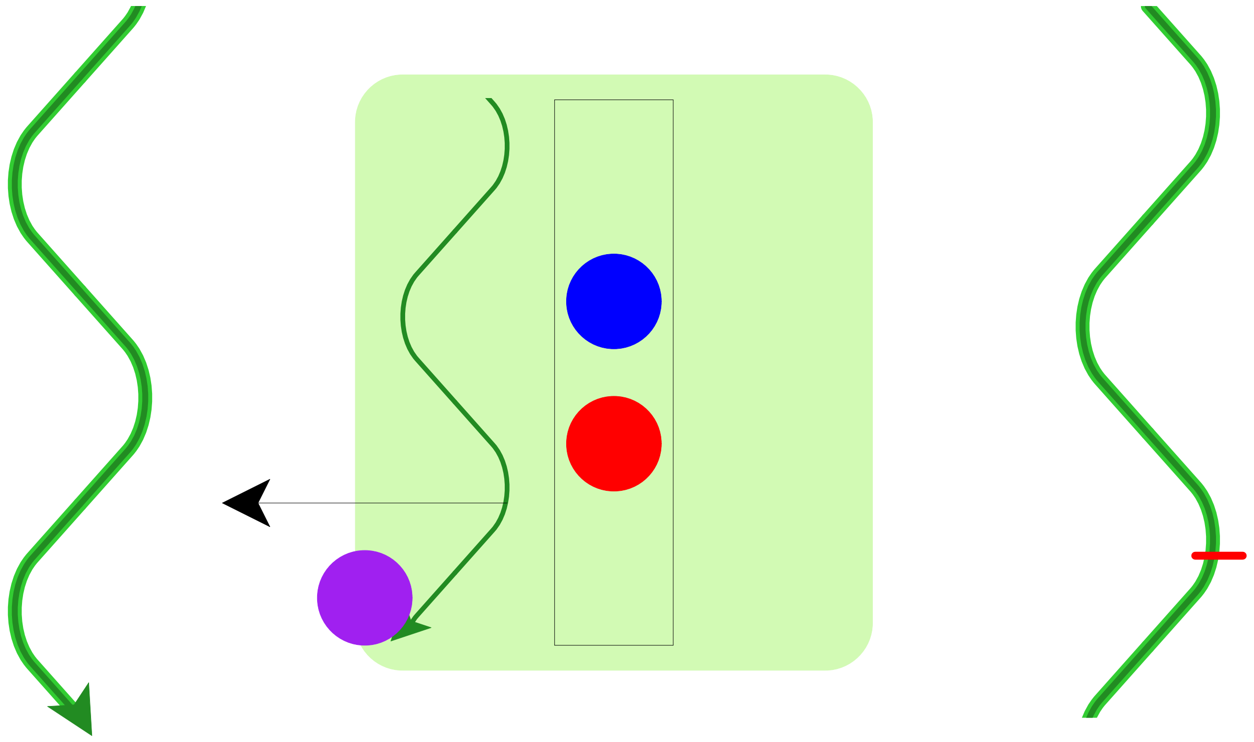


Sharing in Concurrent ML



Abstraction-as-process naturally supports termination

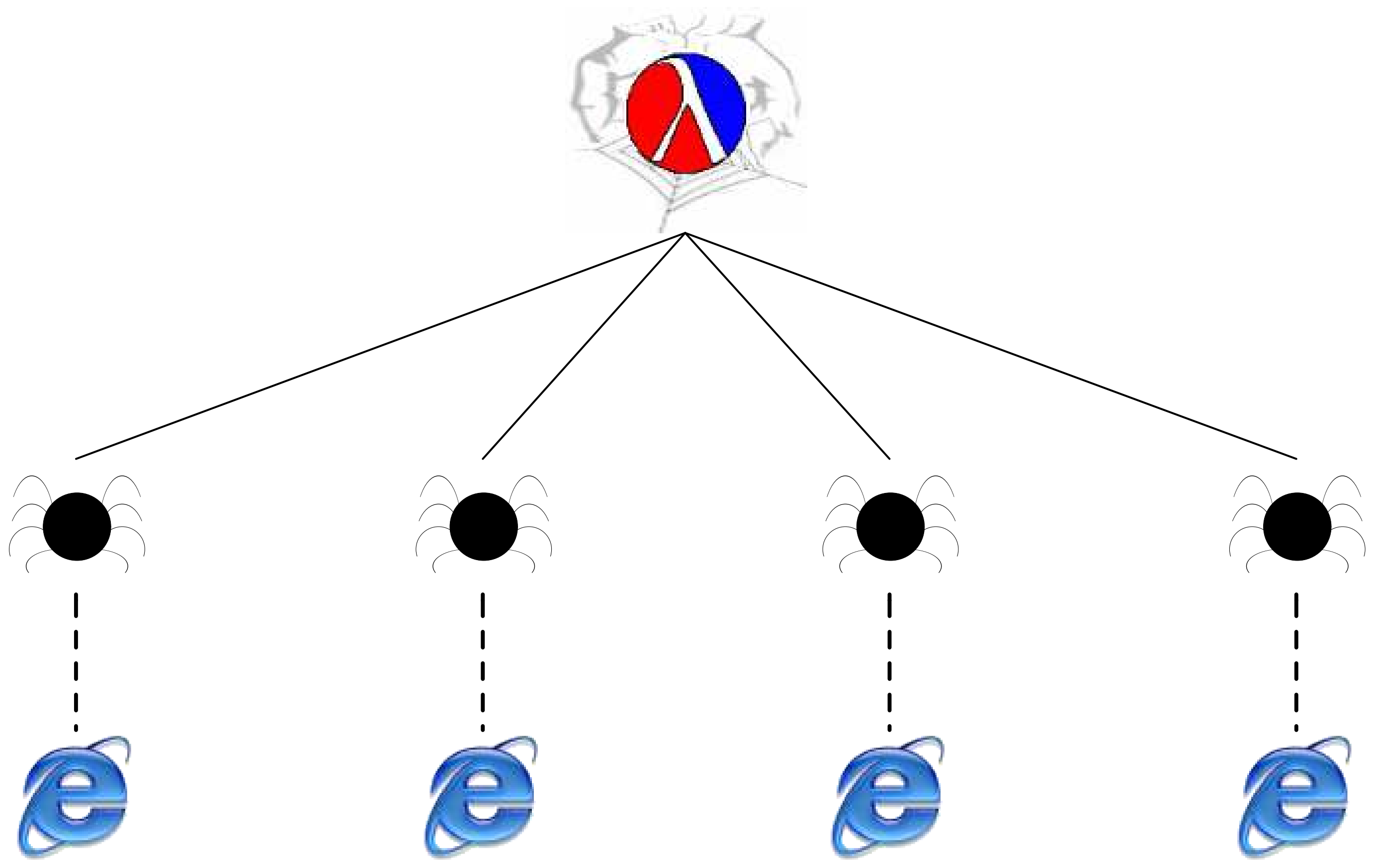
Sharing in Concurrent ML



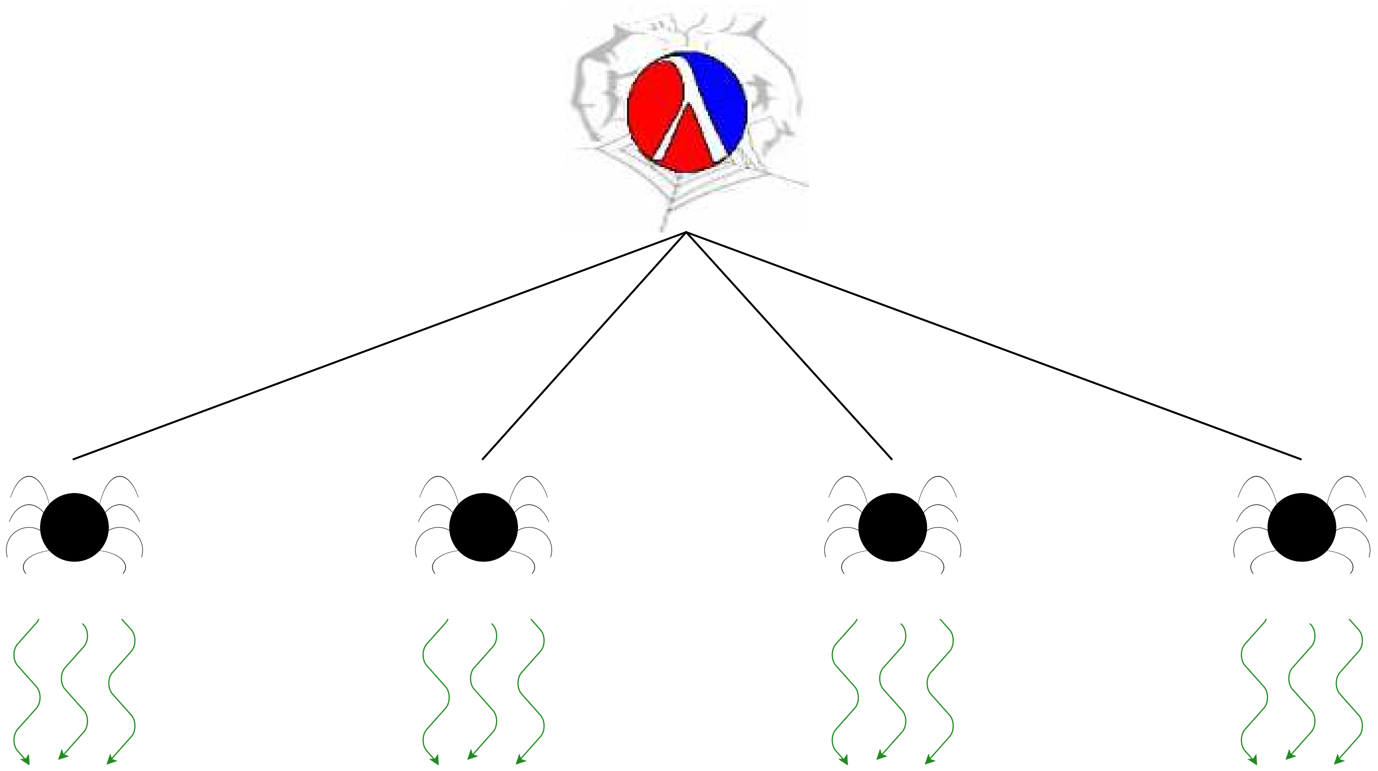
Abstraction-as-process naturally supports termination

Remaining problem: who controls the abstraction's process?

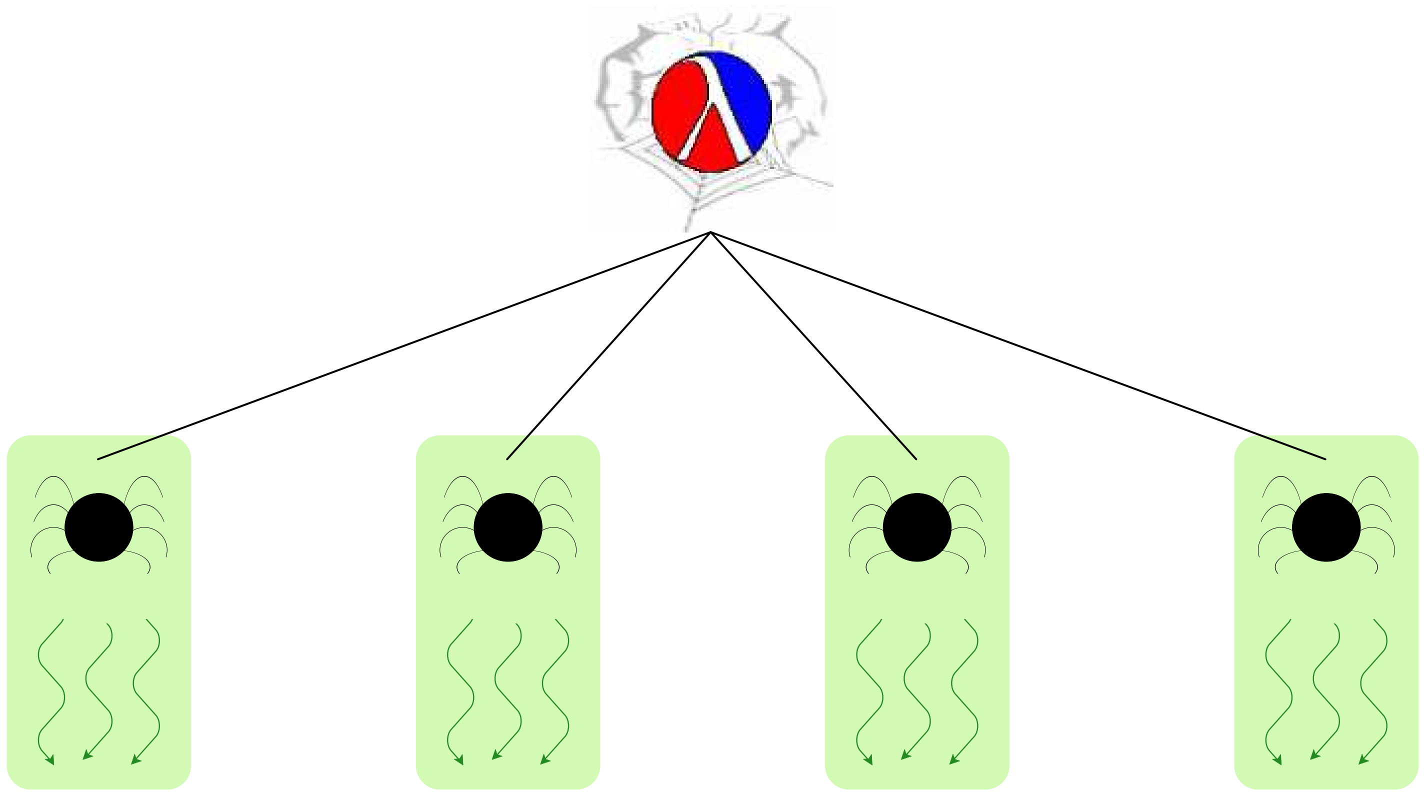
Managing Processes and Threads



Managing Processes and Threads

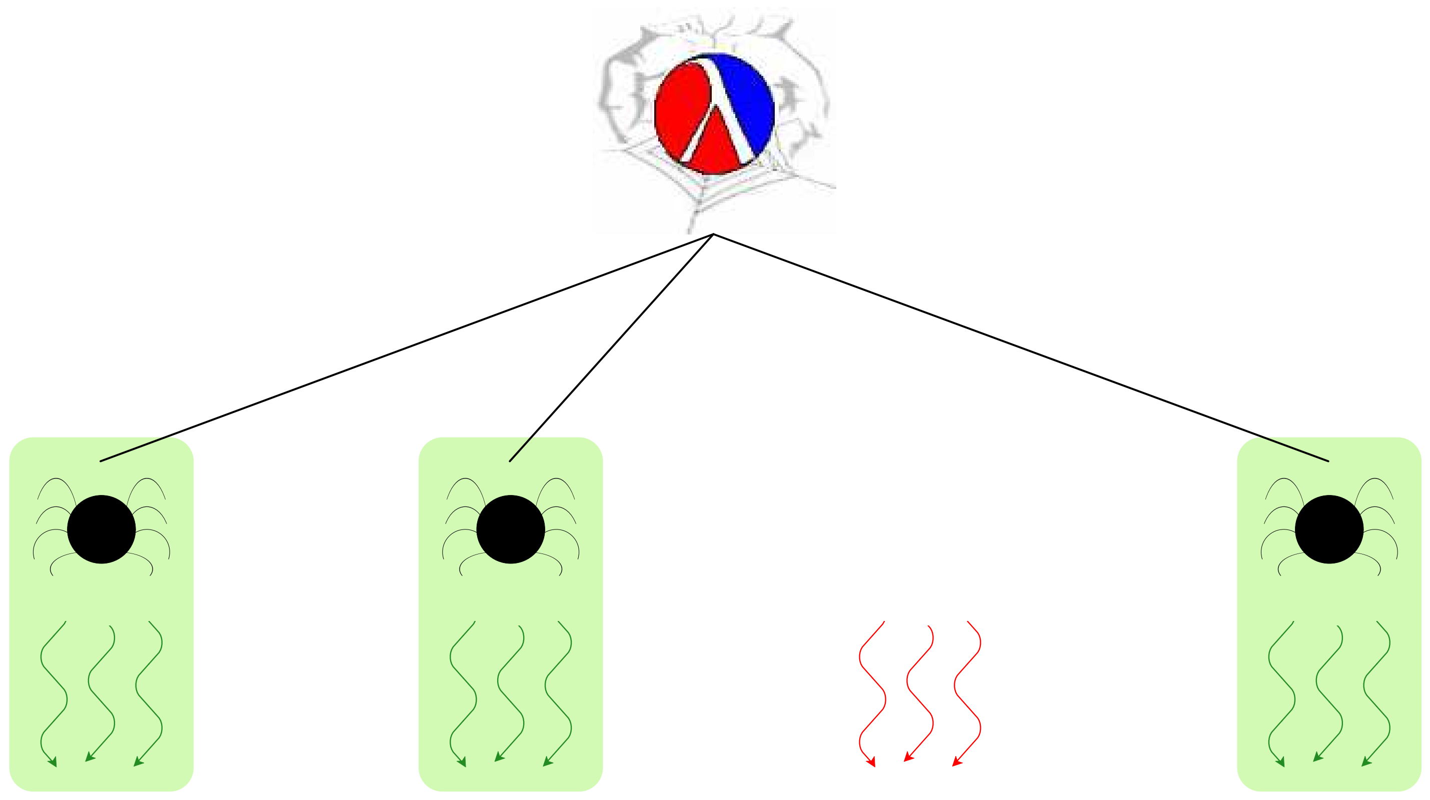


Managing Processes and Threads



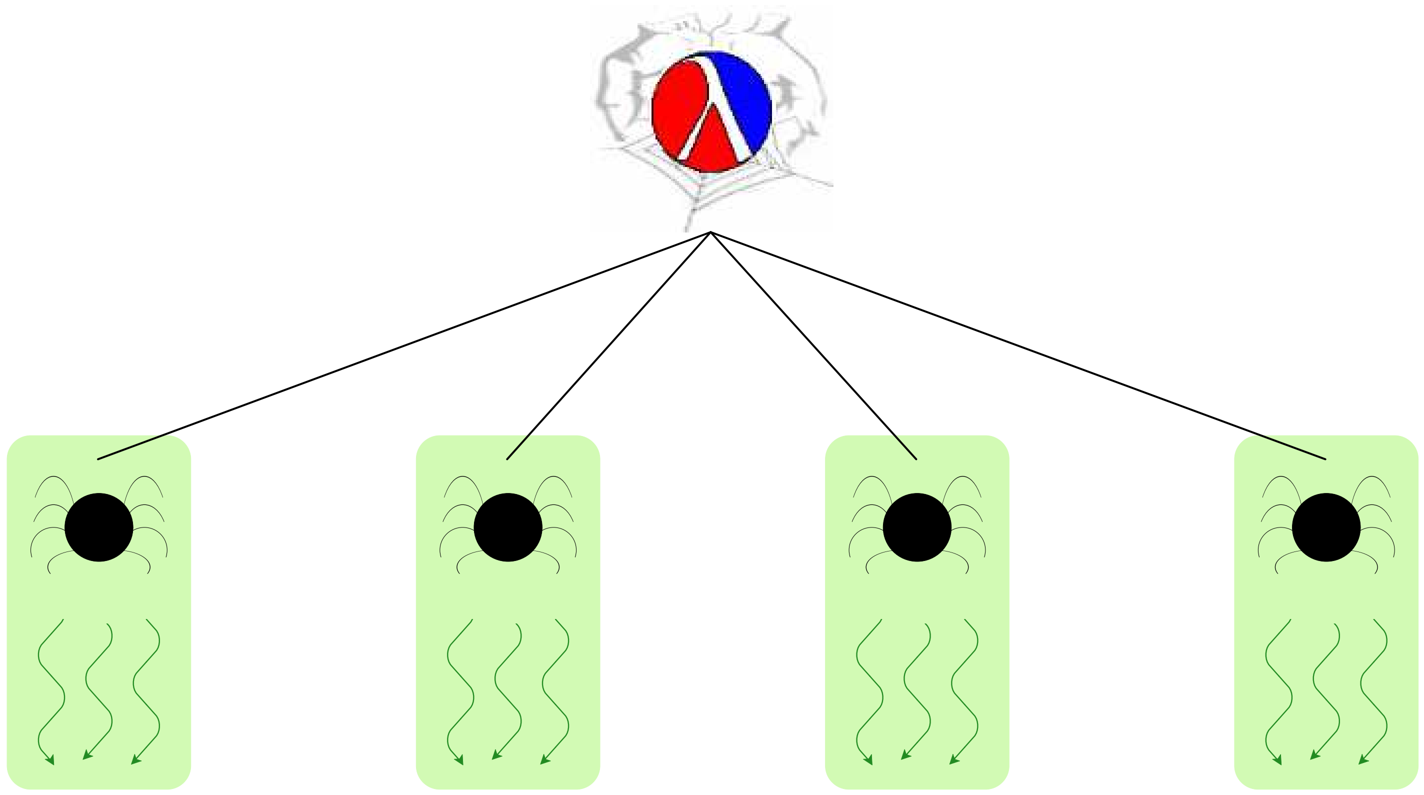
🟩 = **custodian** = capability to execute

Managing Processes and Threads



🟩 = **custodian** = capability to execute

Managing with Custodians



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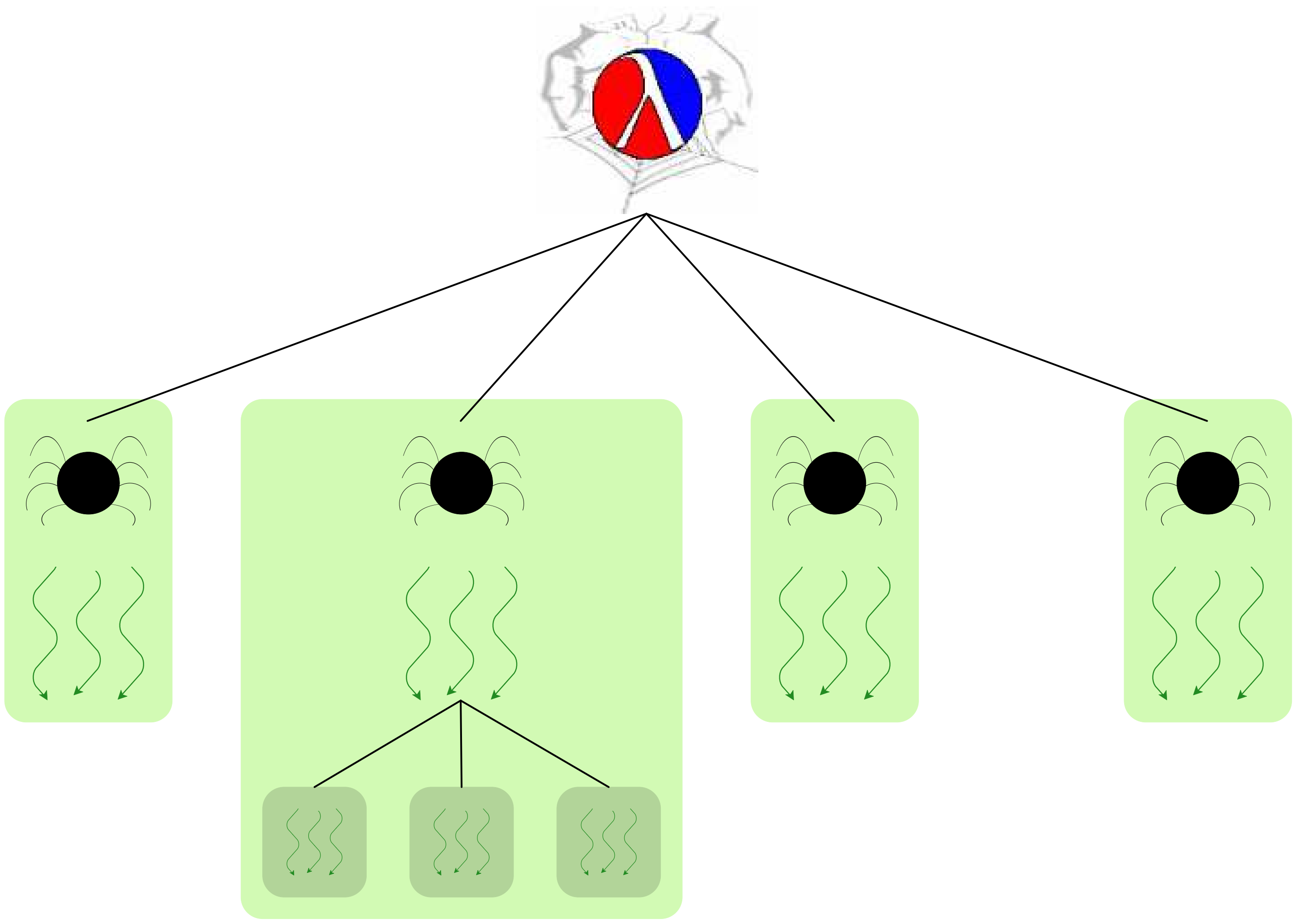

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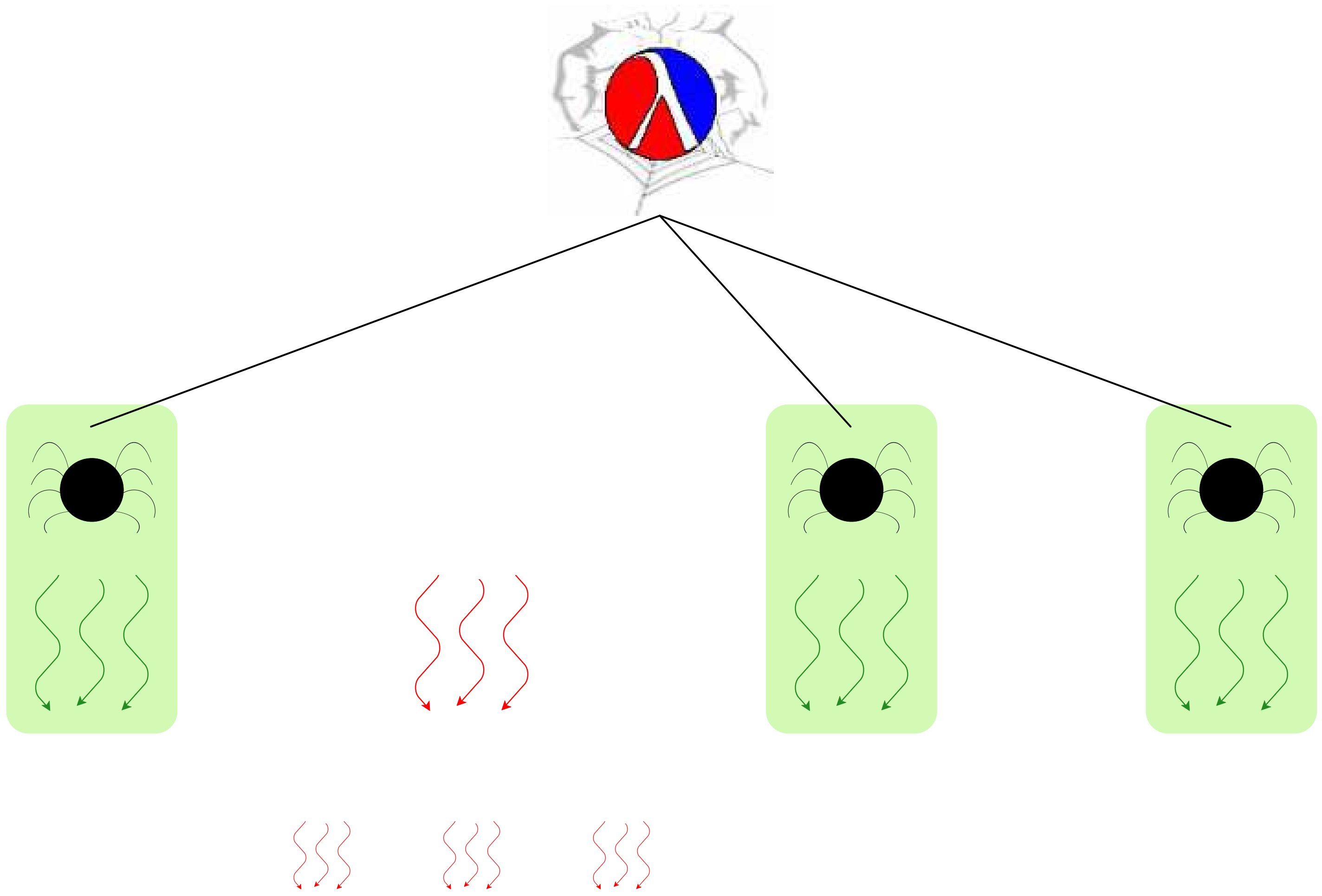

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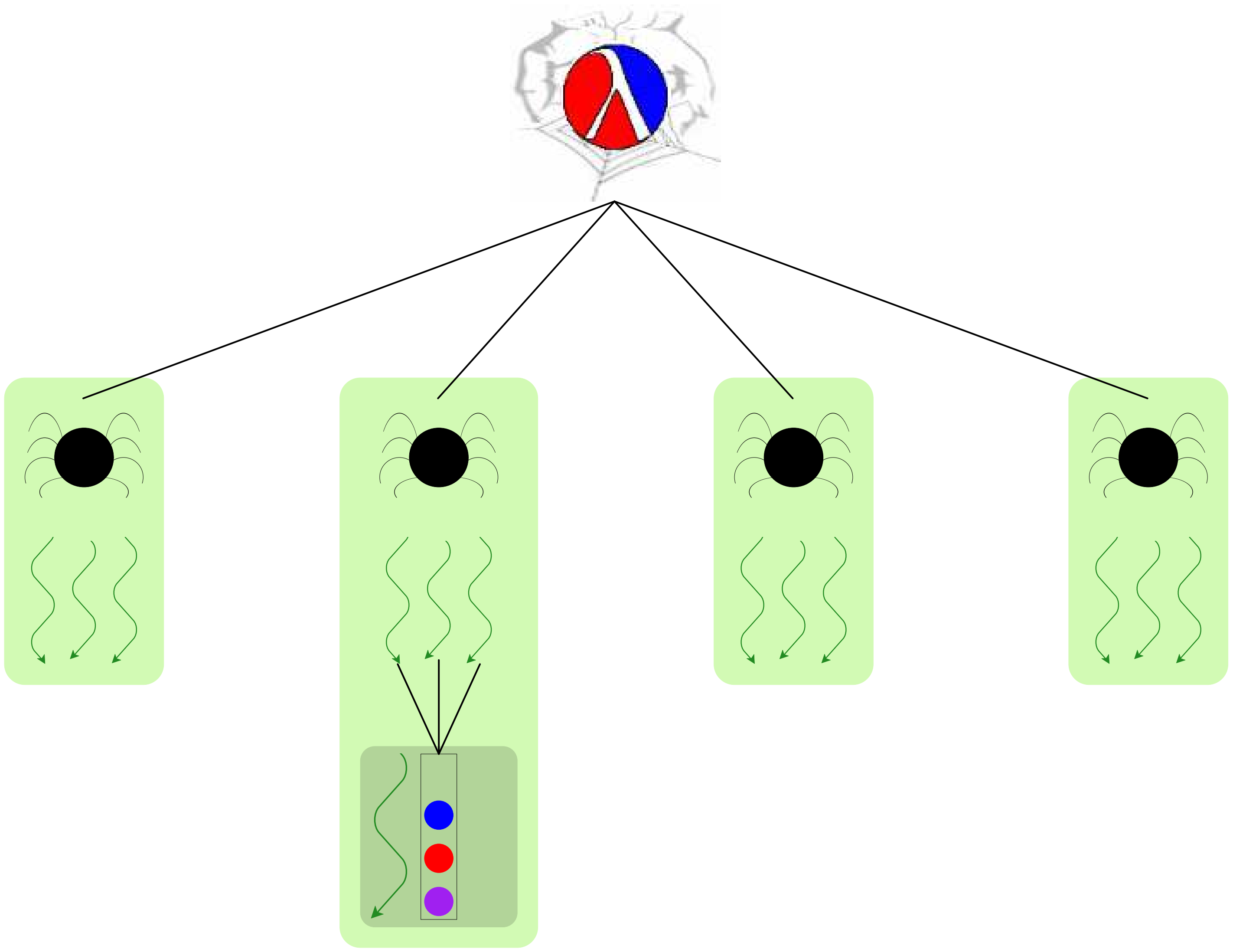
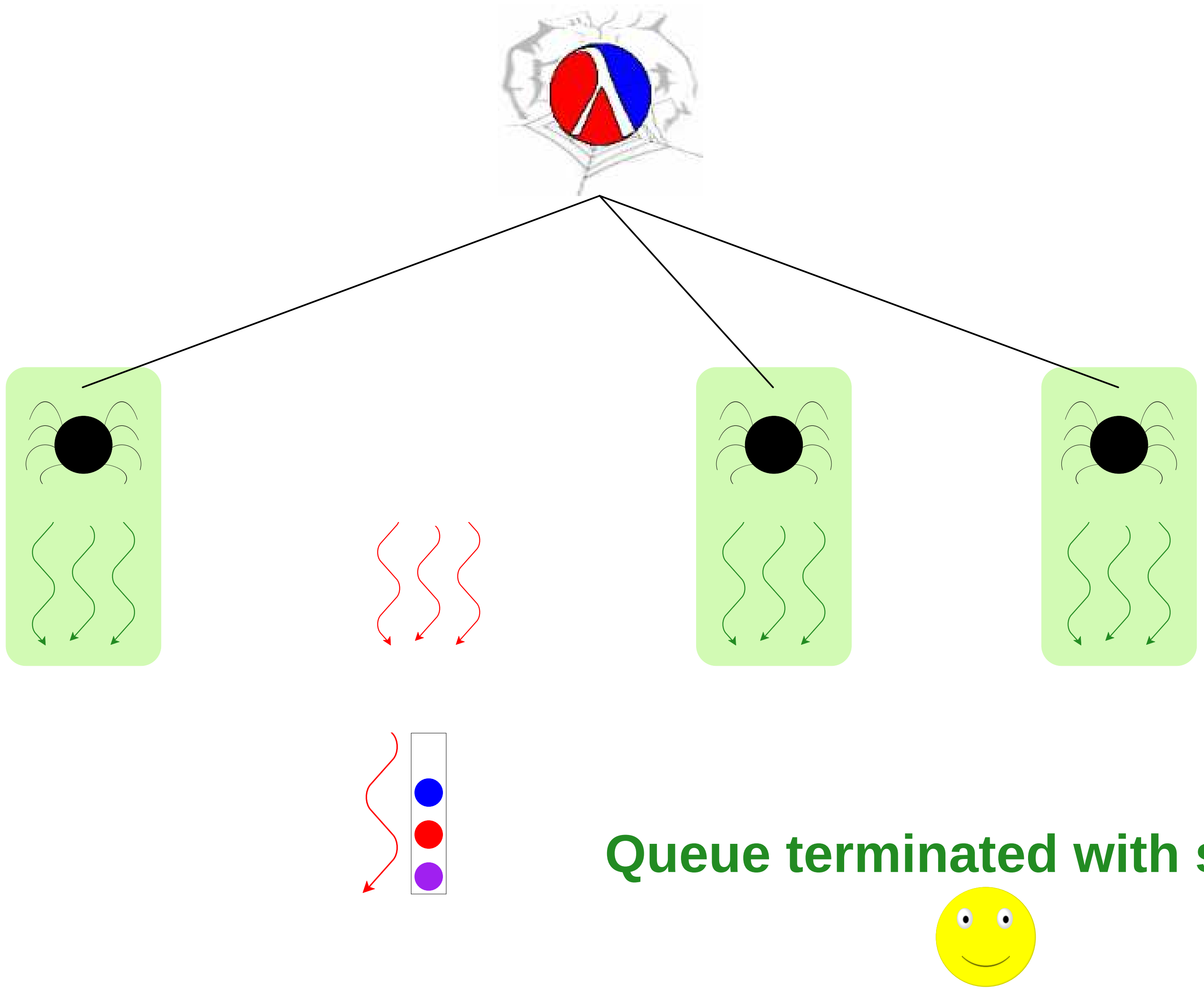


Managing with Custodians



Thread-Safe Abstractions

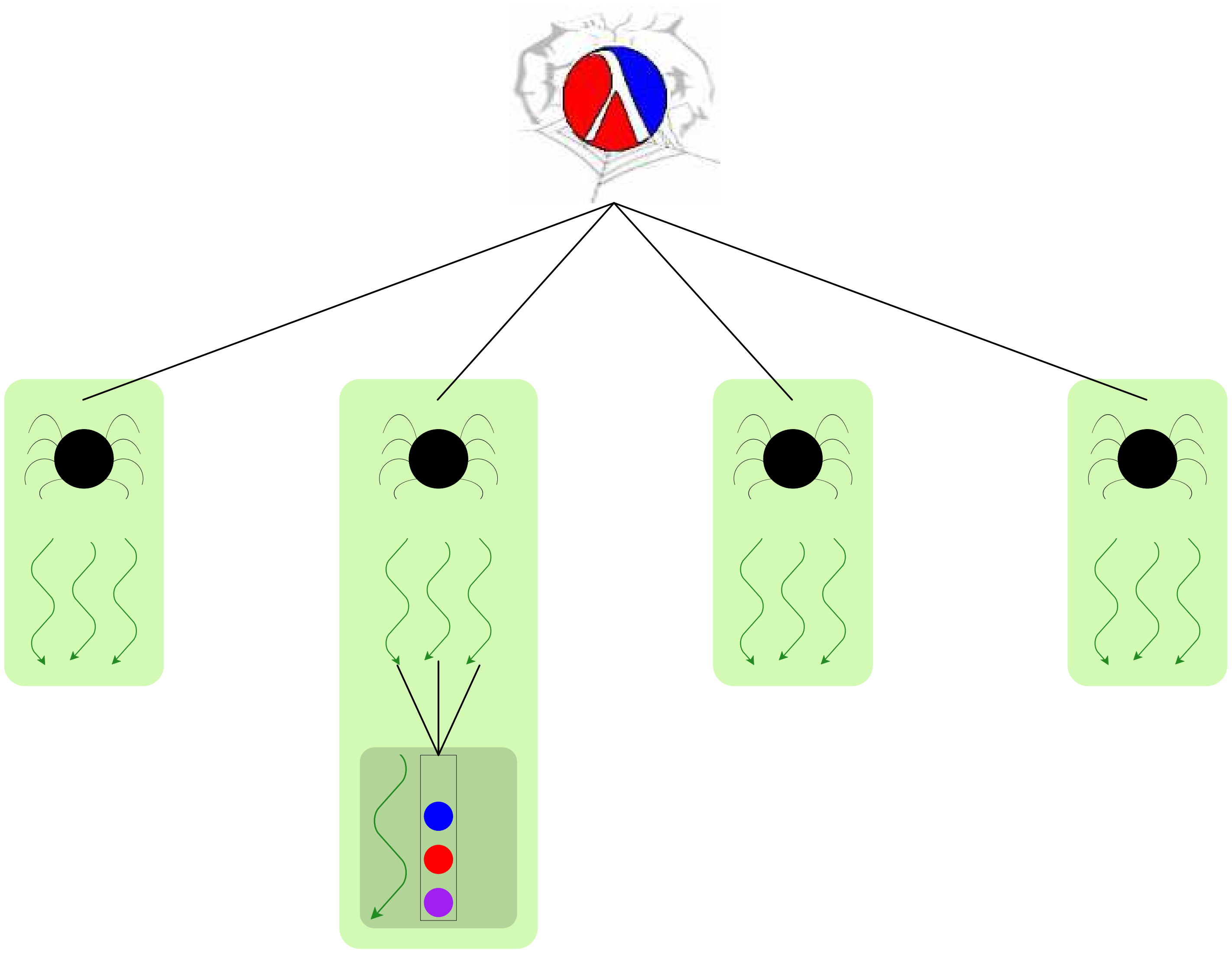
A language to support abstractions:

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

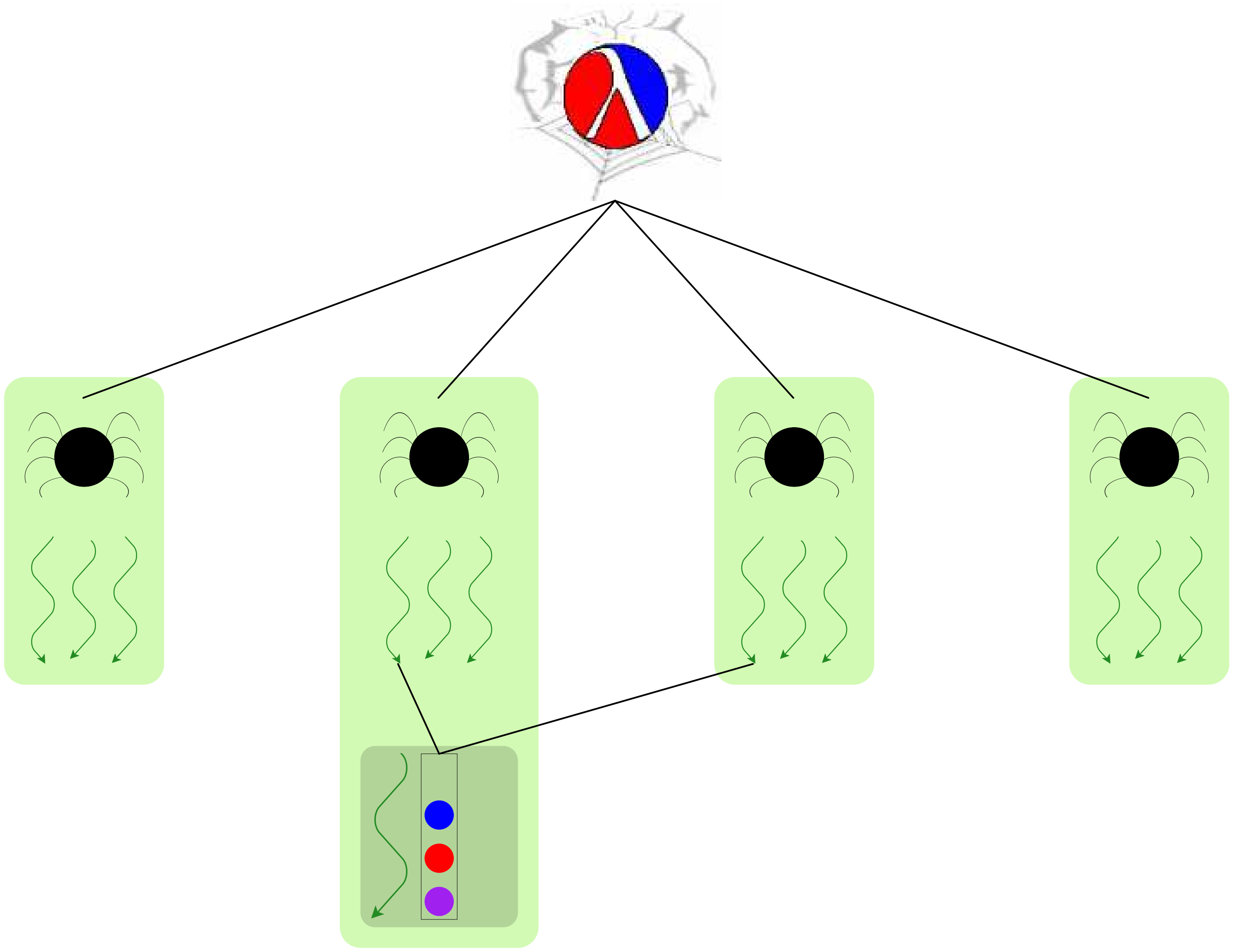
Each abstraction:

- Manager thread for state

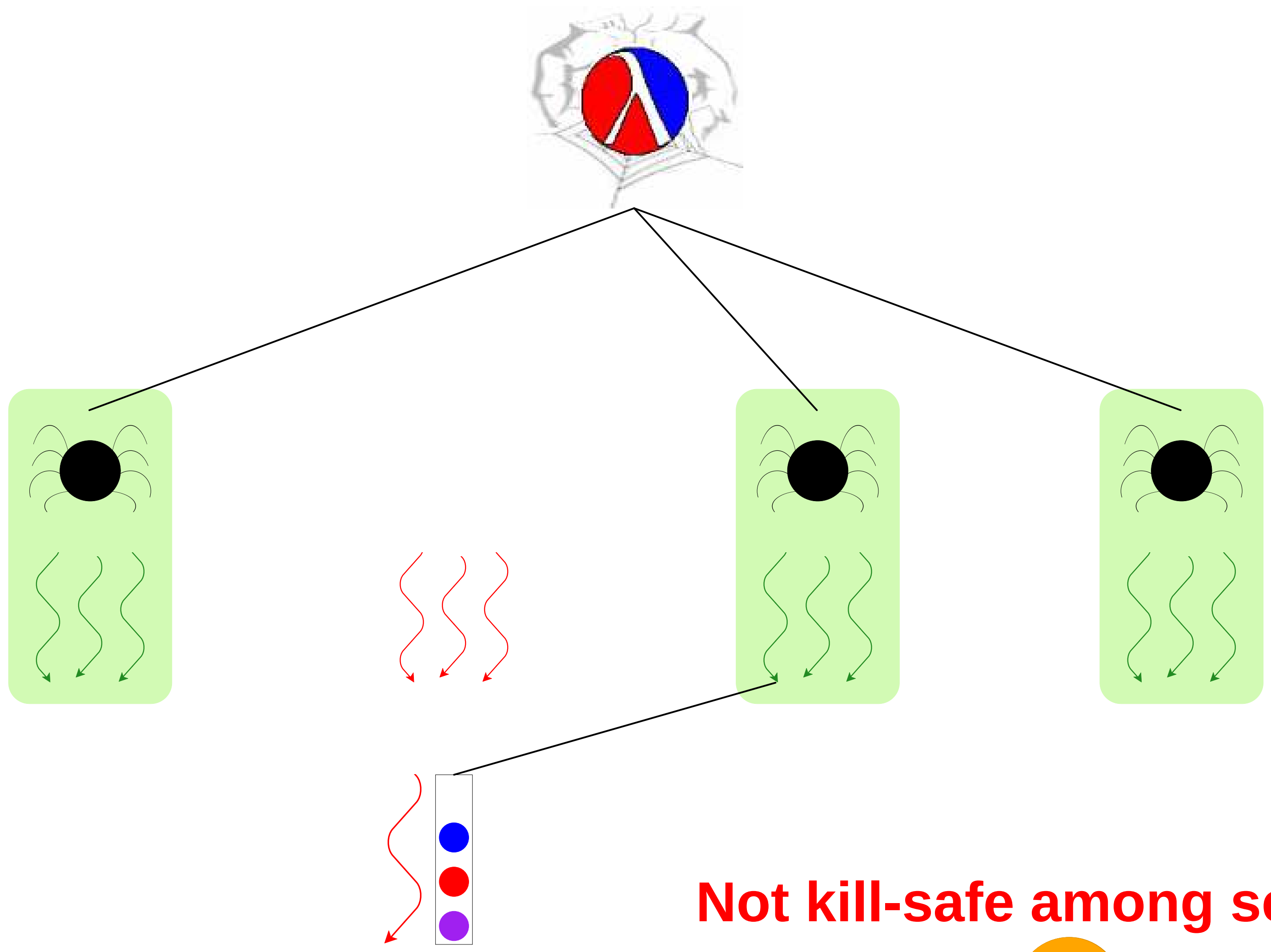
Towards Kill Safety with Custodians



Towards Kill Safety with Custodians

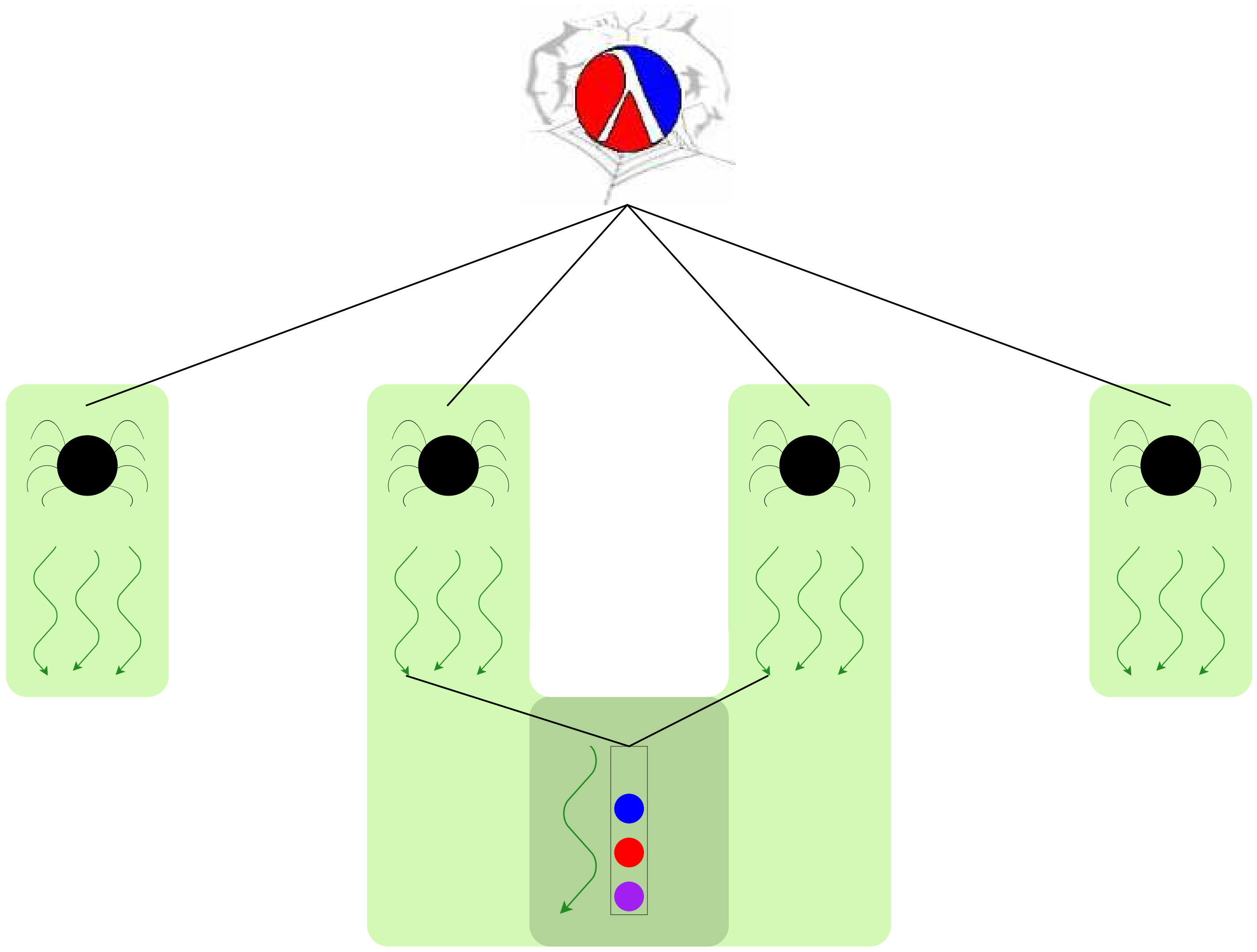


Towards Kill Safety with Custodians

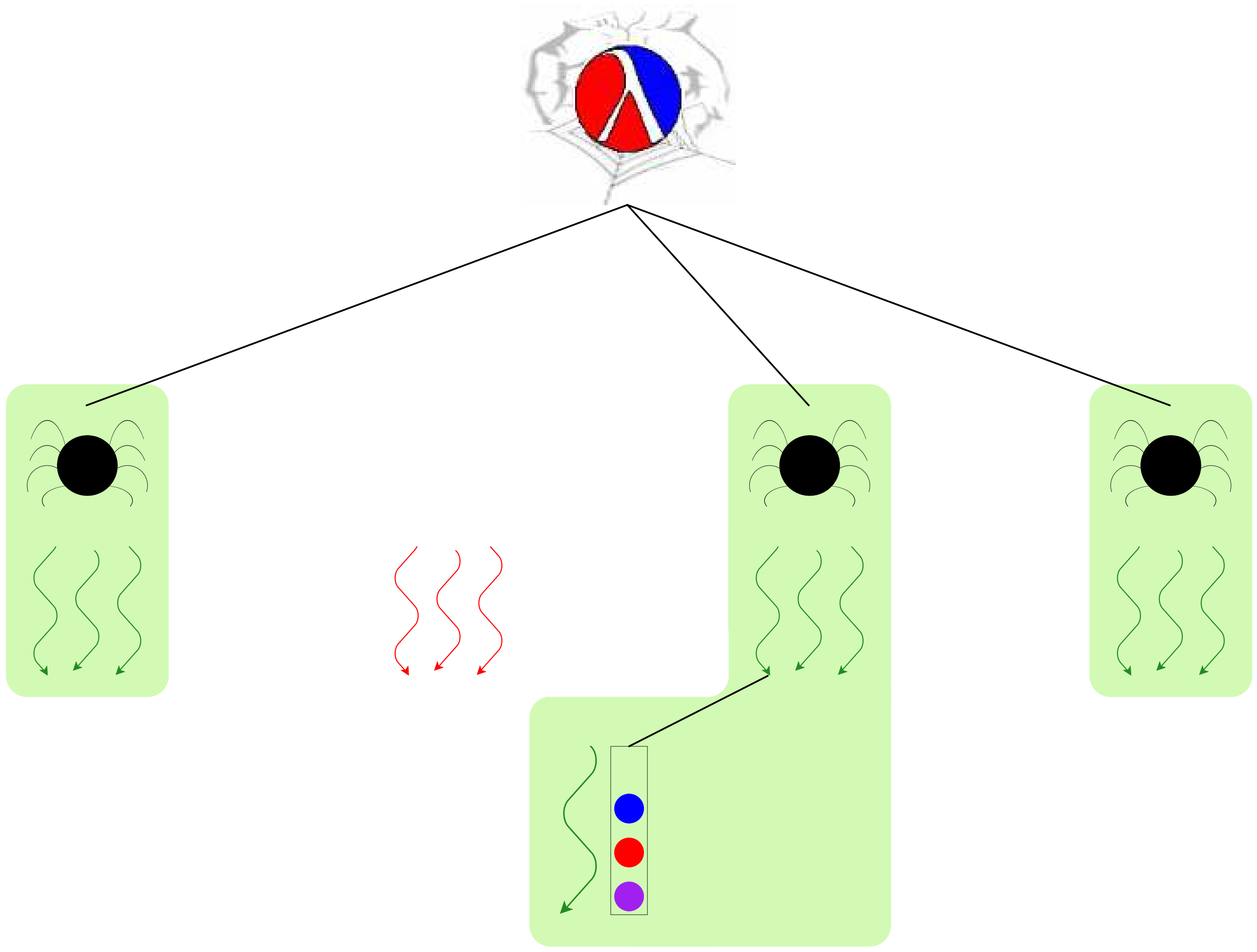


Not kill-safe among servlets

Kill Safety through Joint Custody



Kill Safety through Joint Custody



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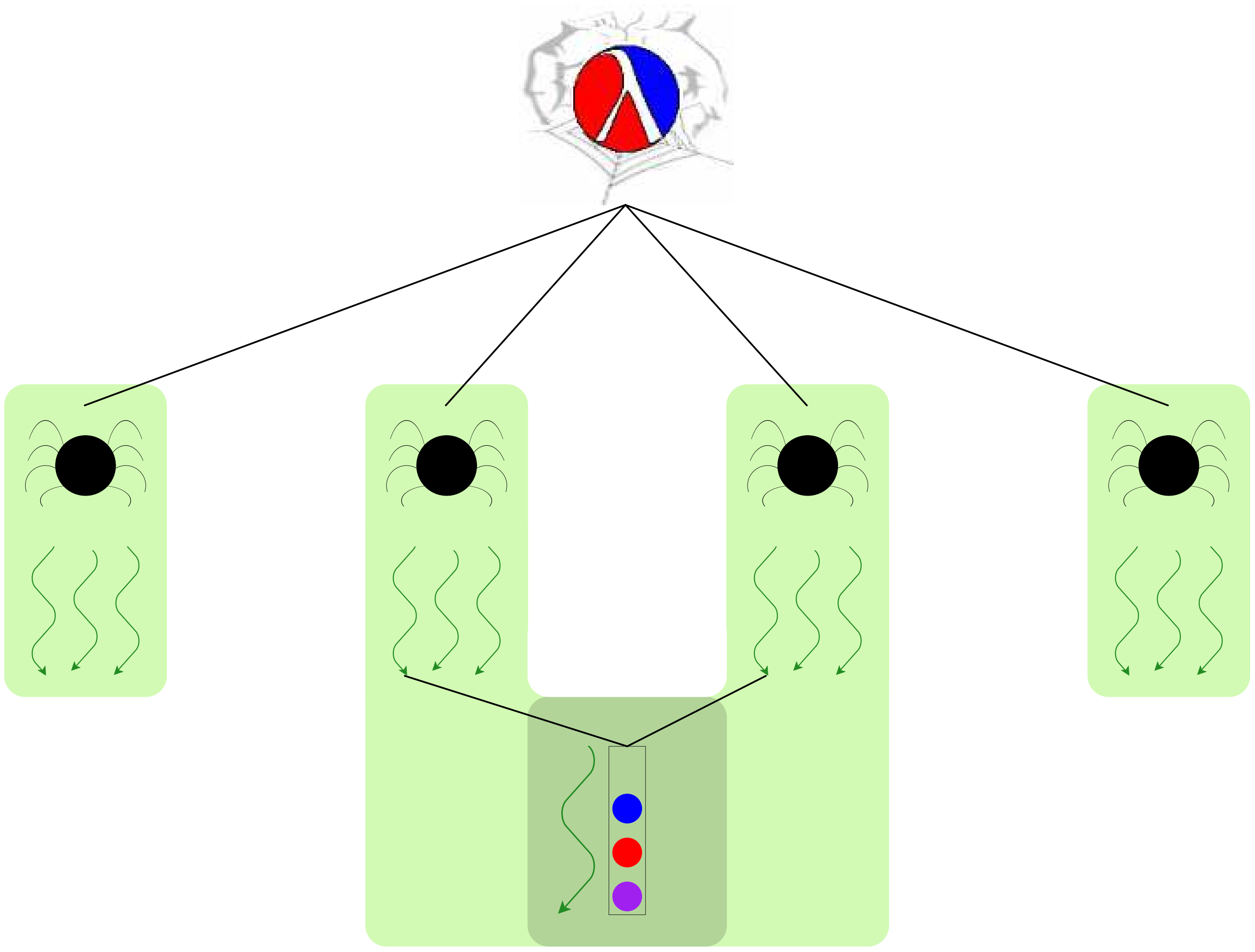

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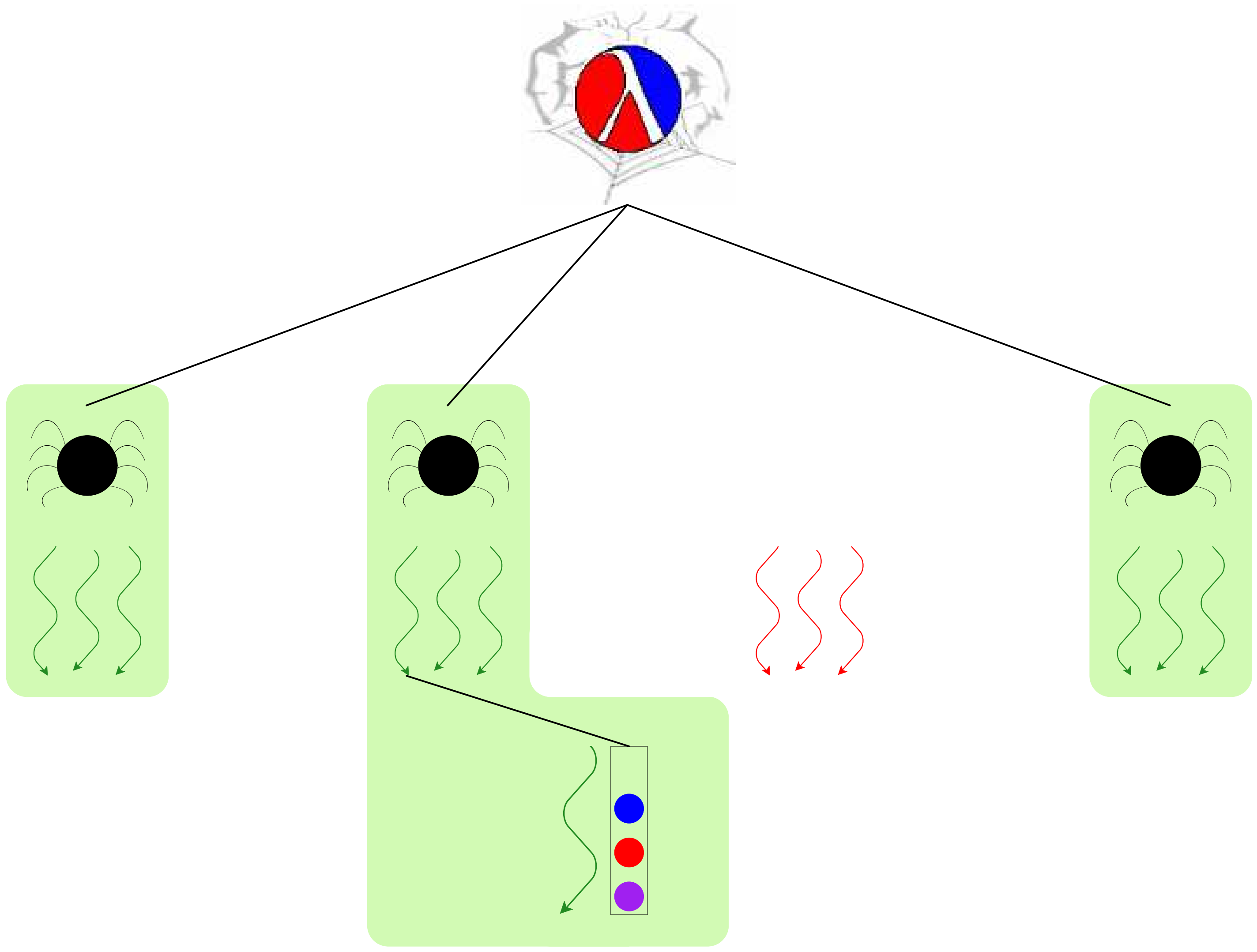
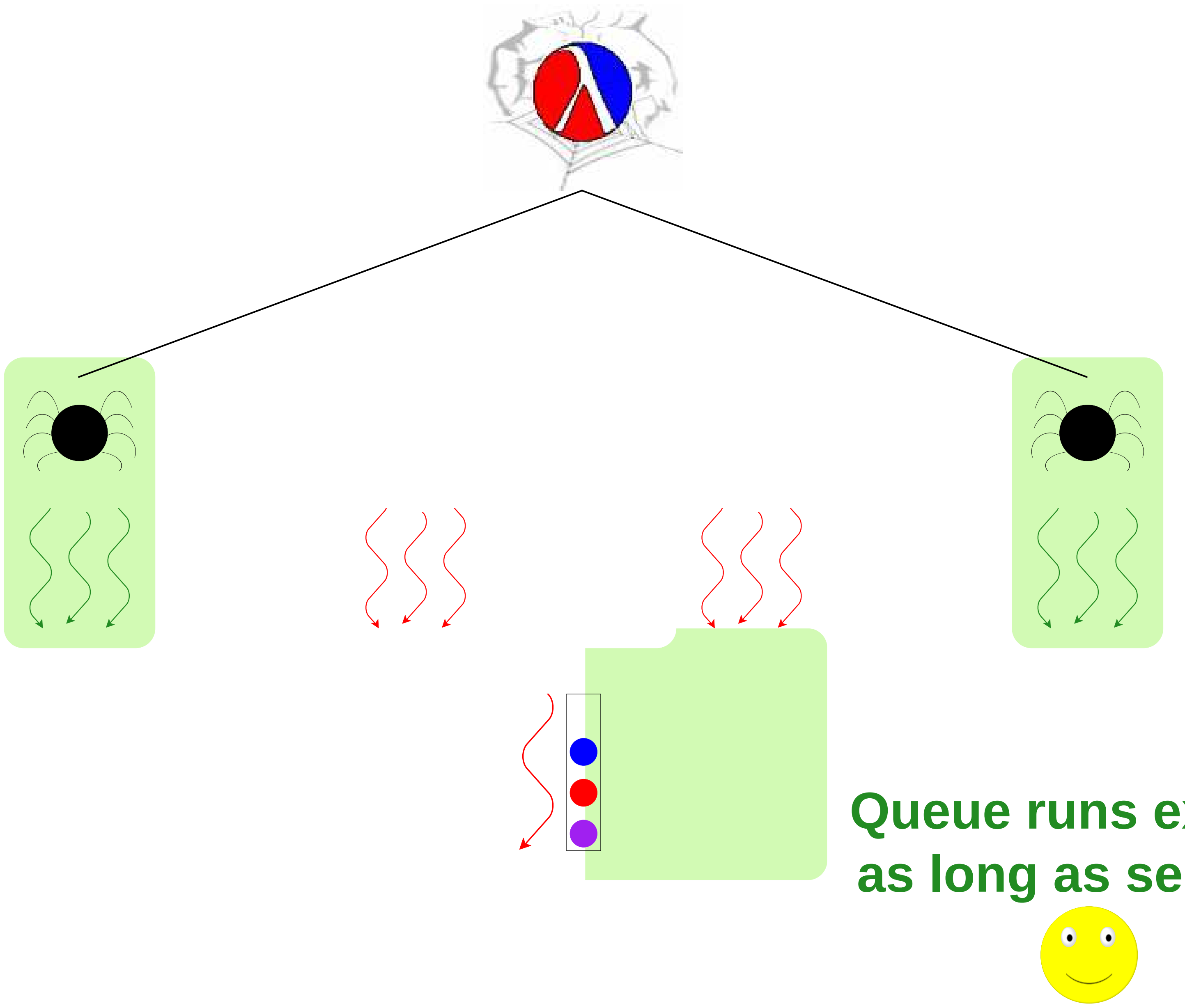
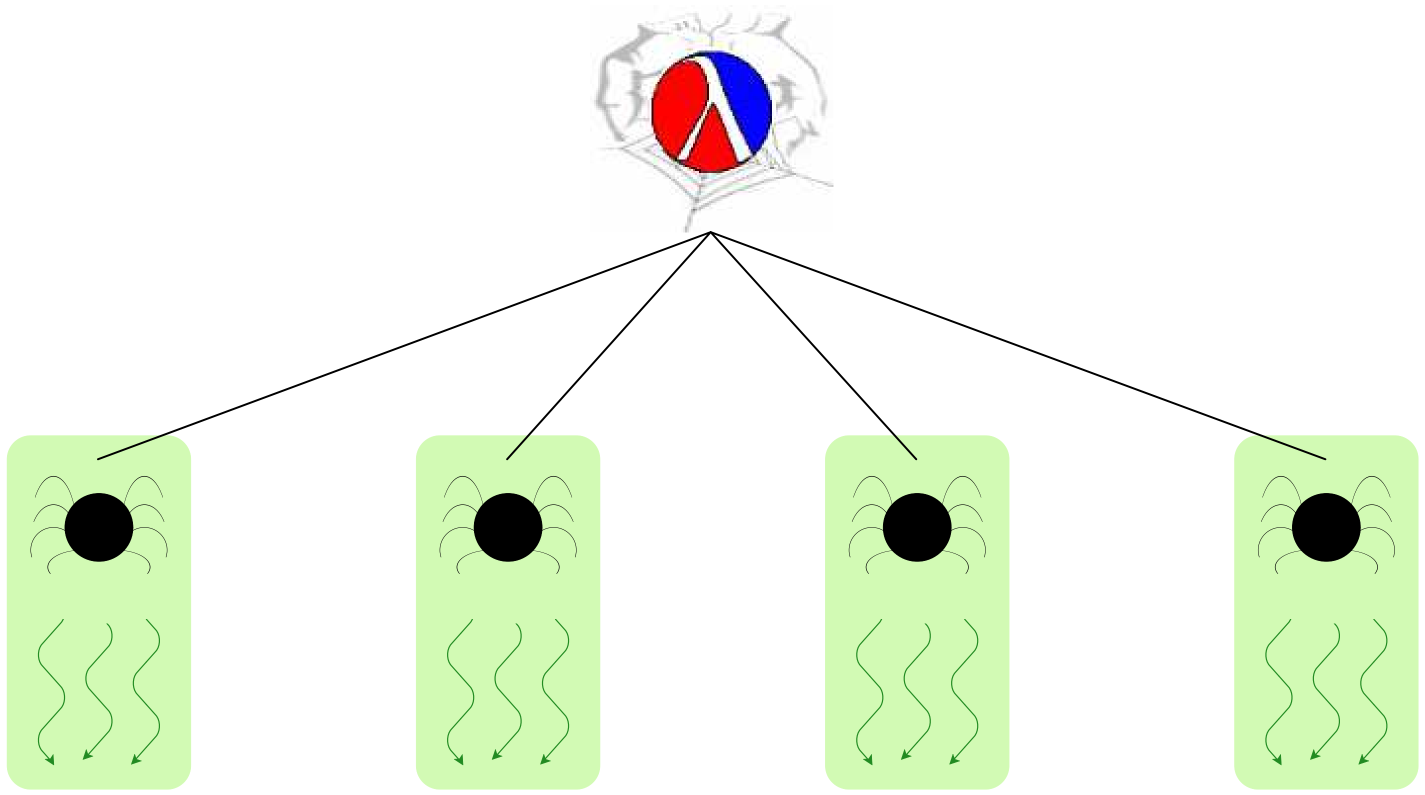


Kill Safety through Joint Custody



Why a Thread can have Multiple Custodians



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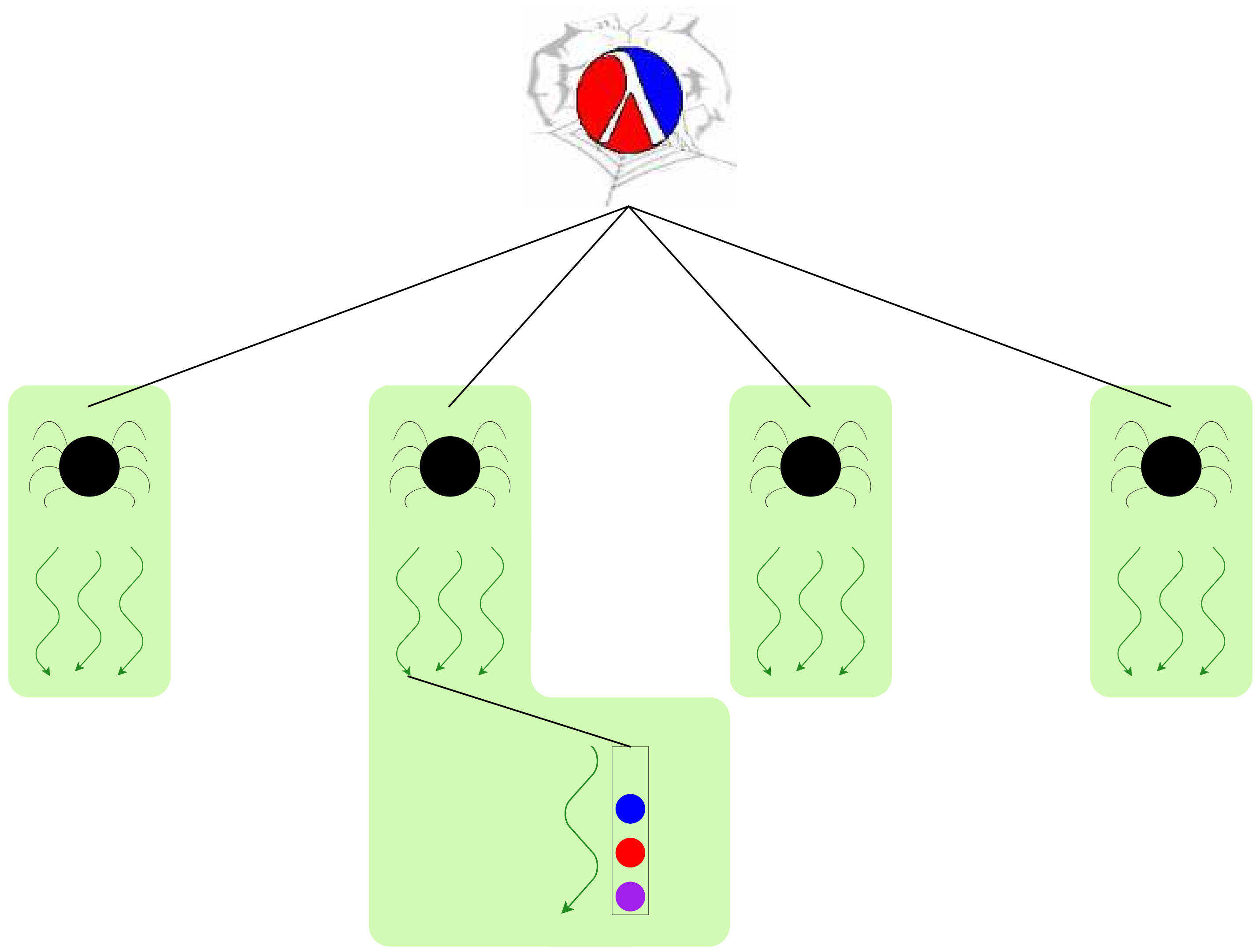

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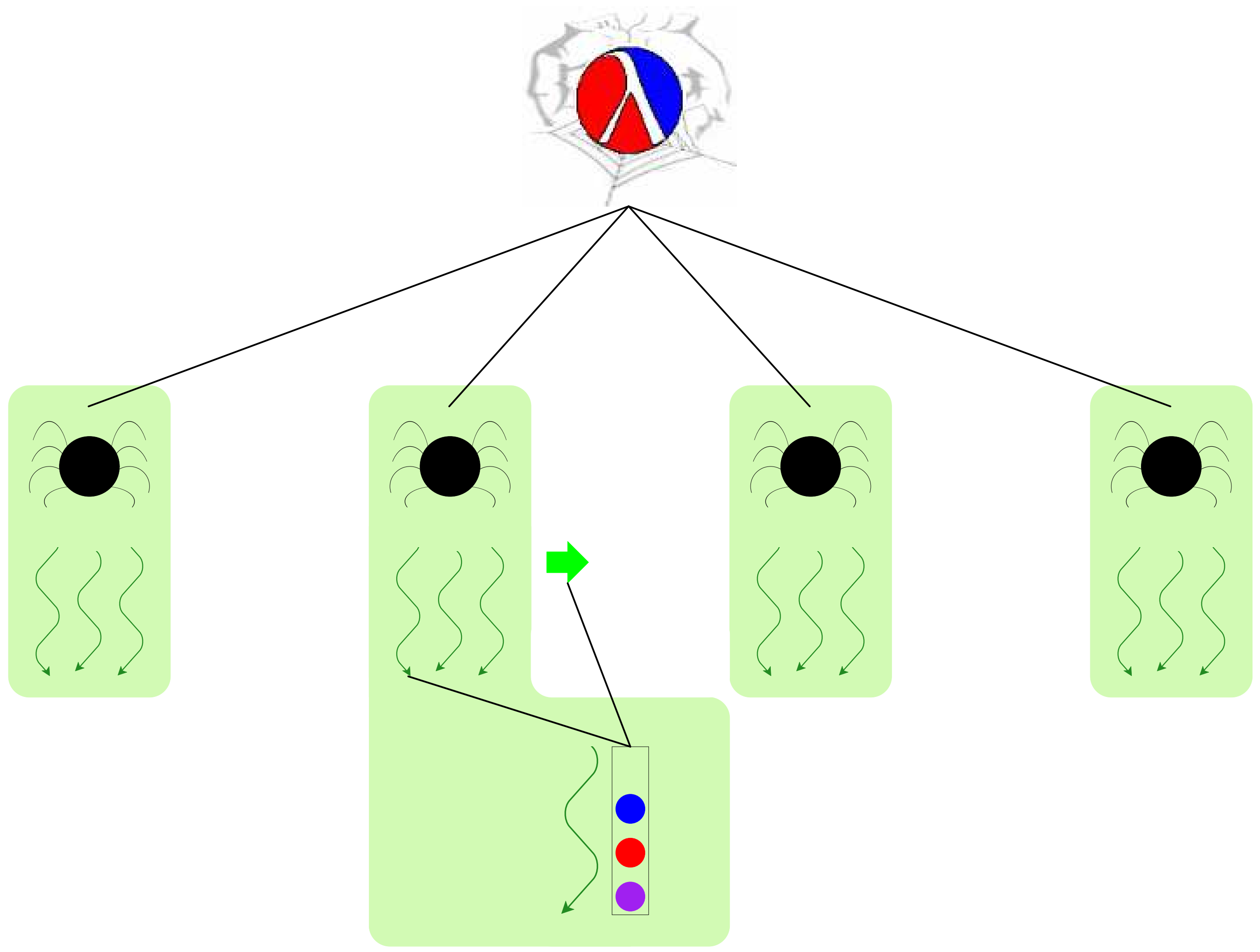

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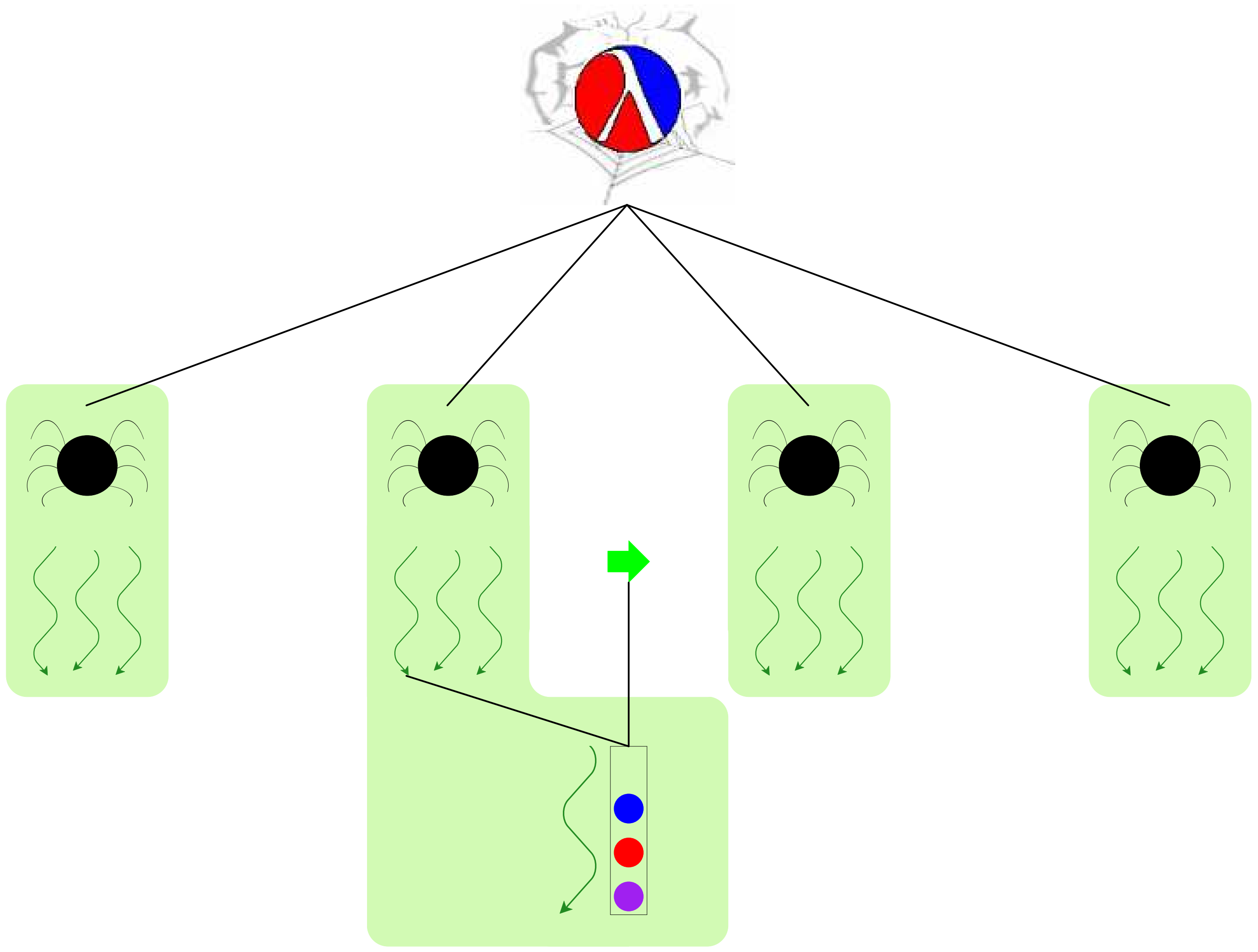

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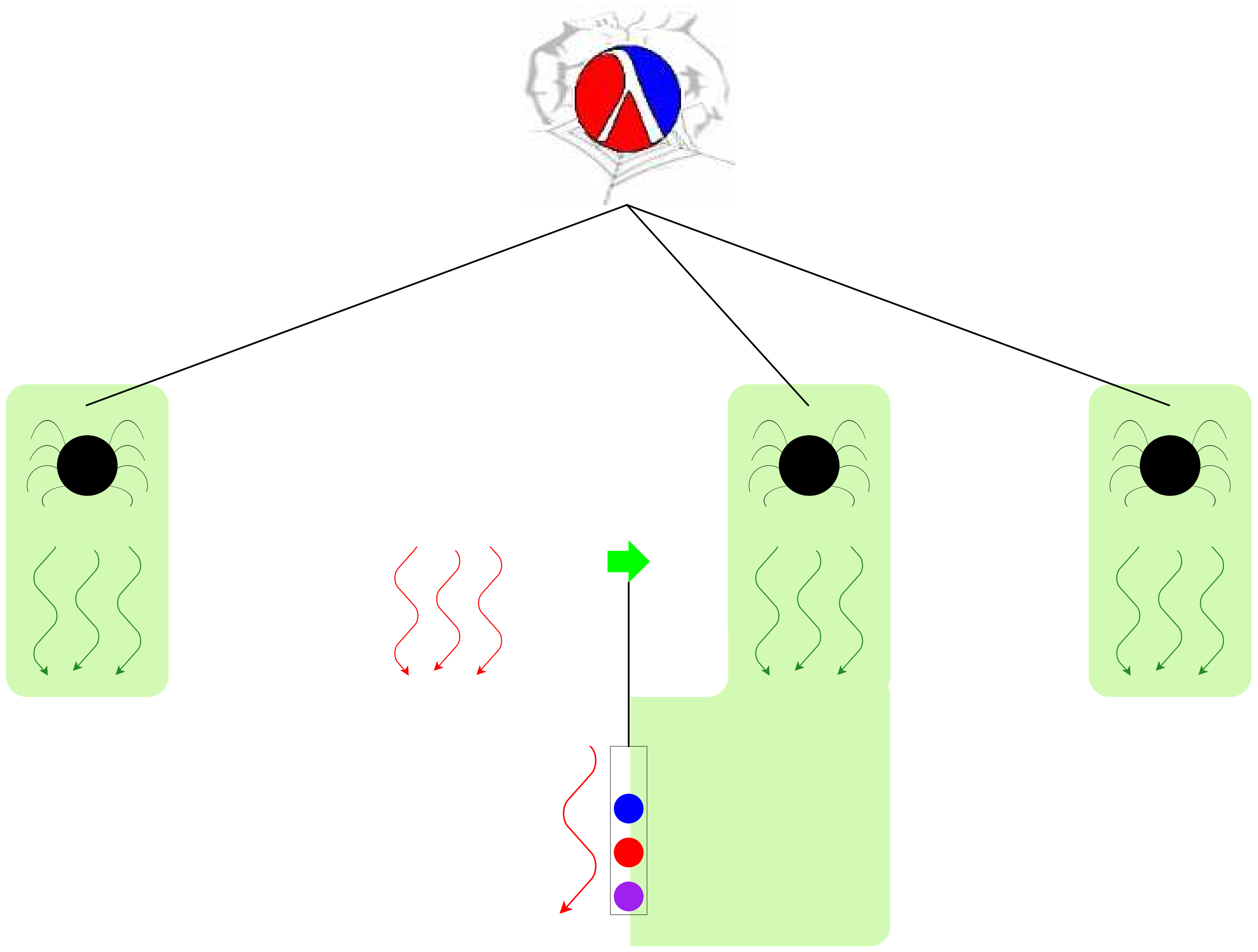
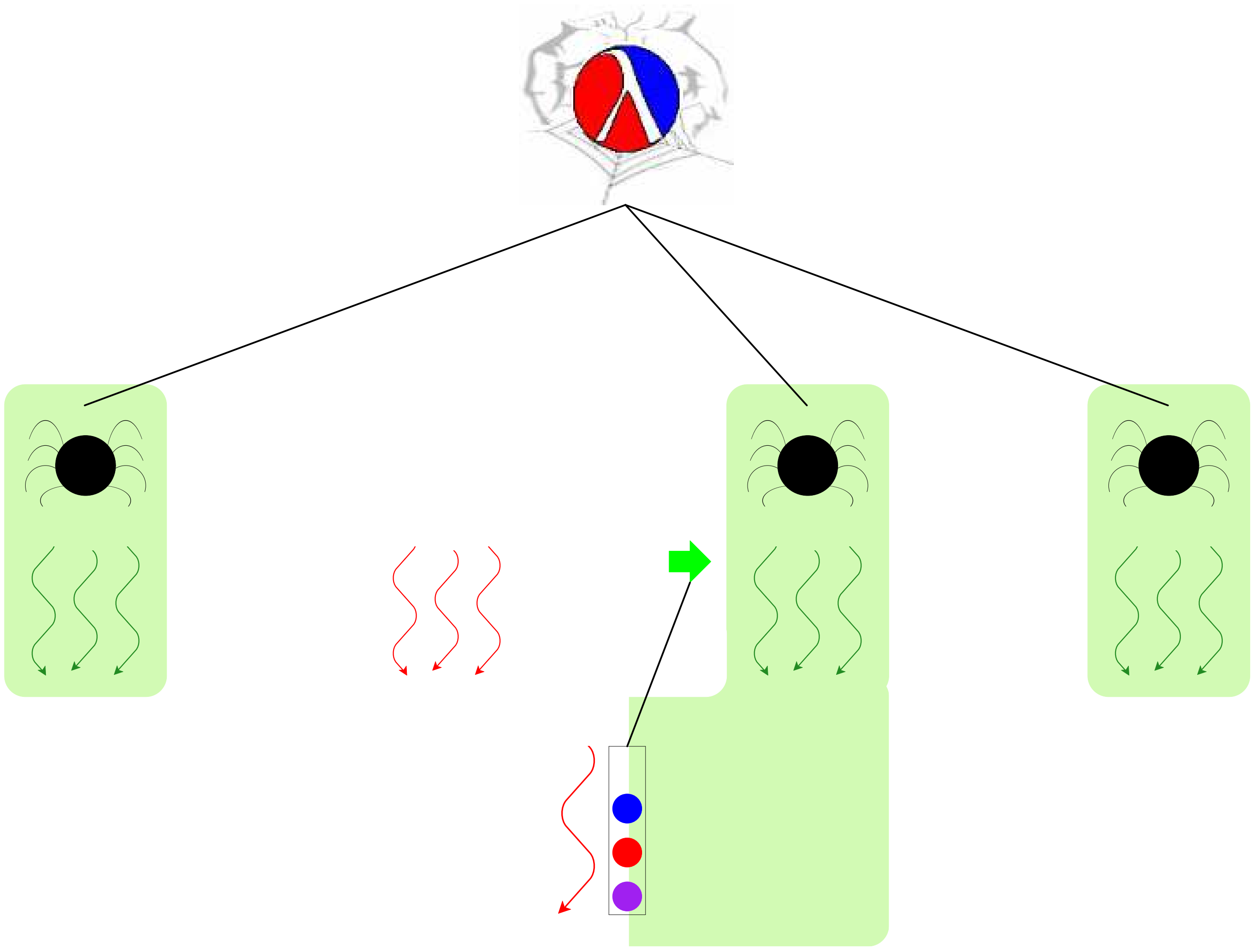


Queue is only *mostly dead*

Why a Thread can have Multiple Custodians



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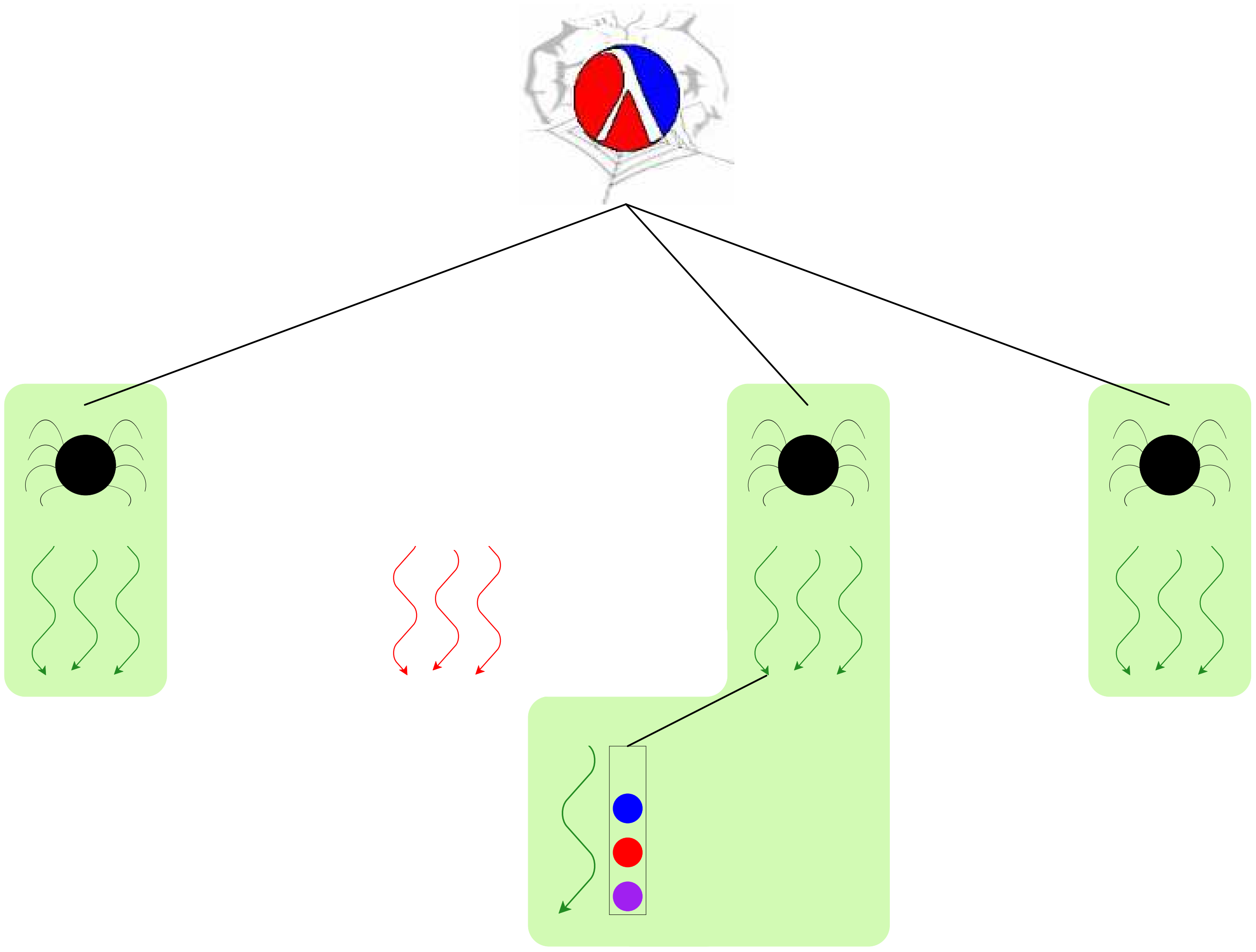


Use queue ⇒ grant custodian

Kill-Safe Abstractions

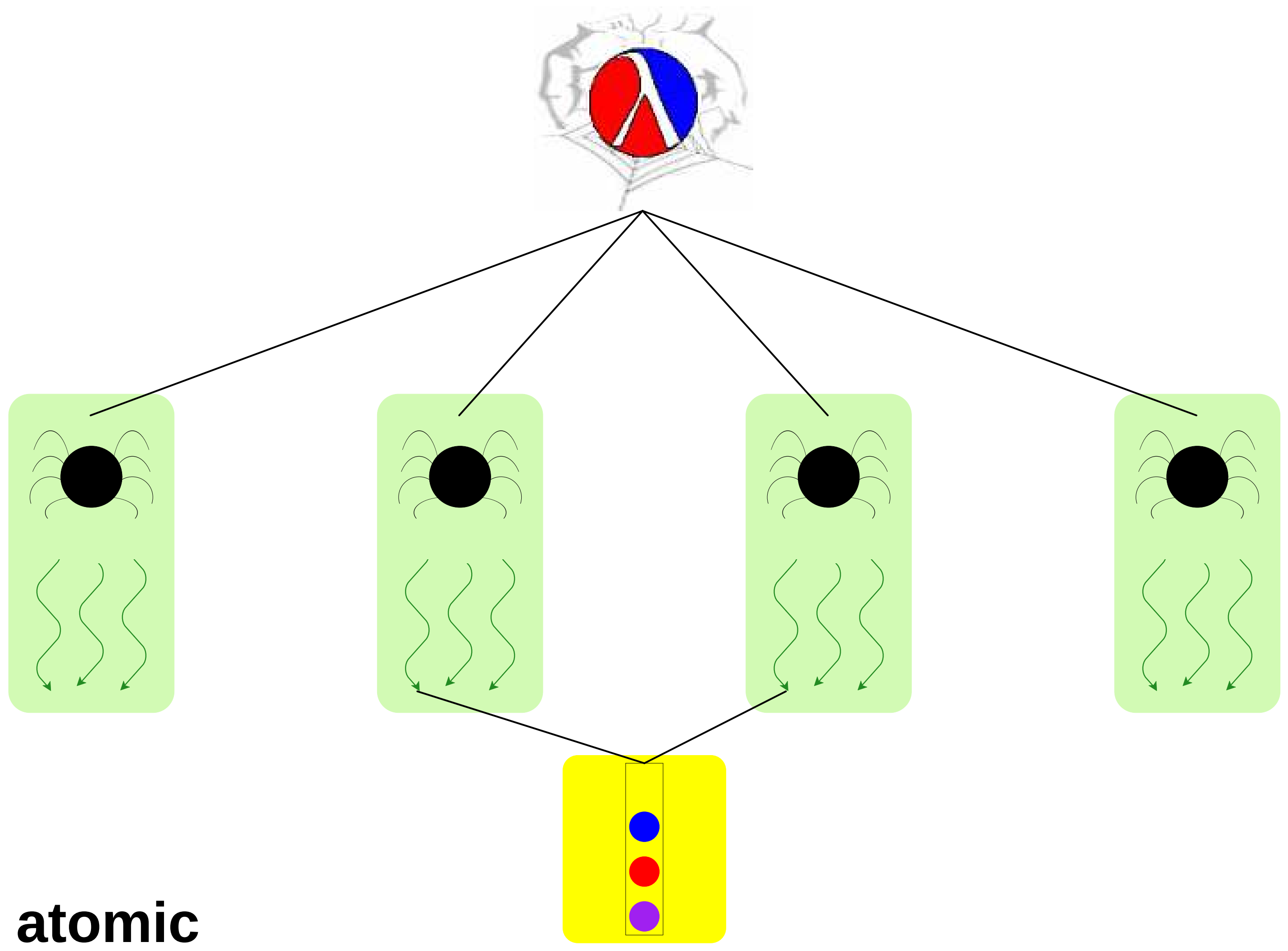
A language to support abstractions:

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

Each abstraction:

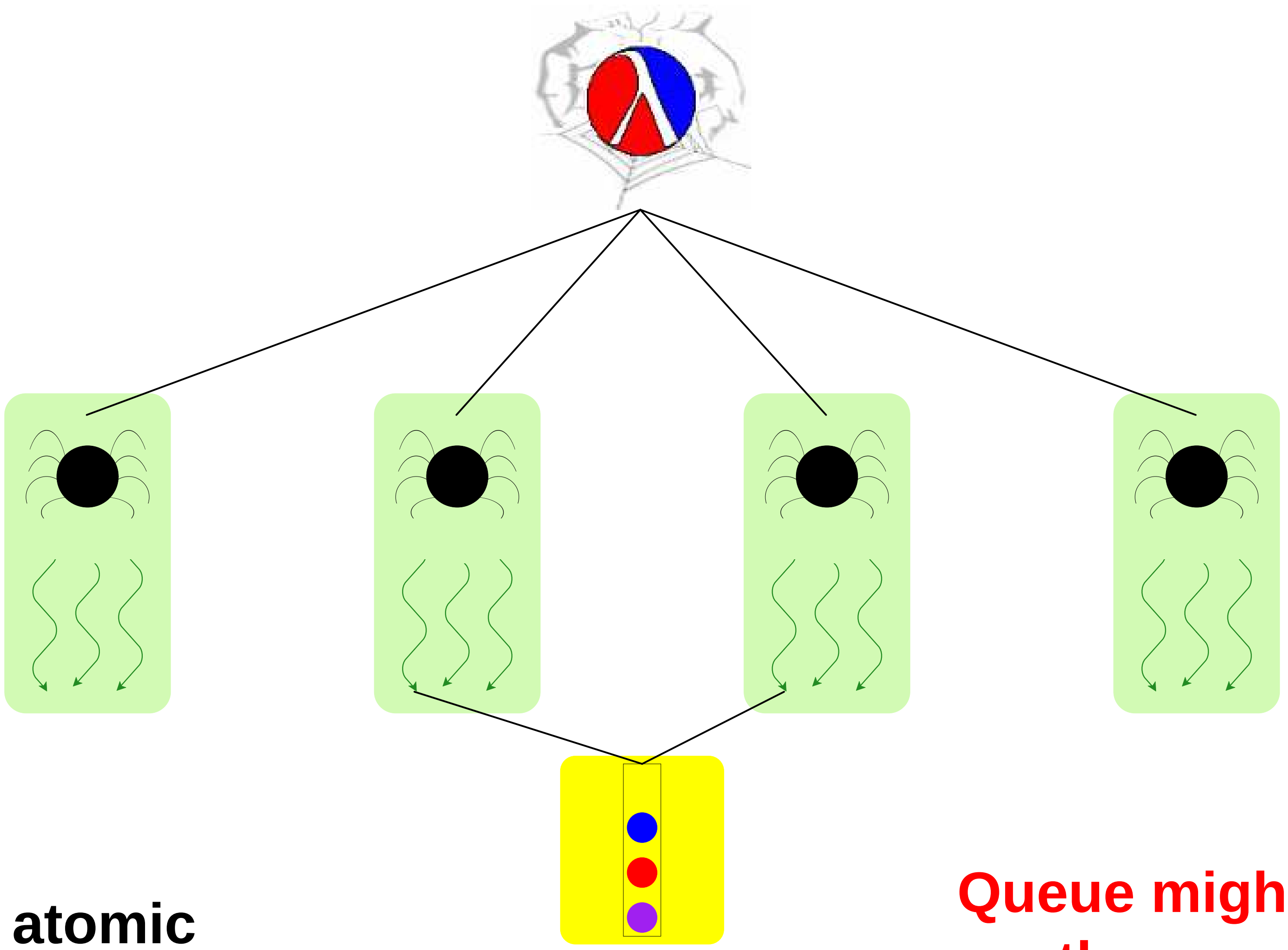
- Manager thread for state
- Each action grants custodian to manager thread

Non-Solution #1 — Atomic Region



🟨 = **atomic**

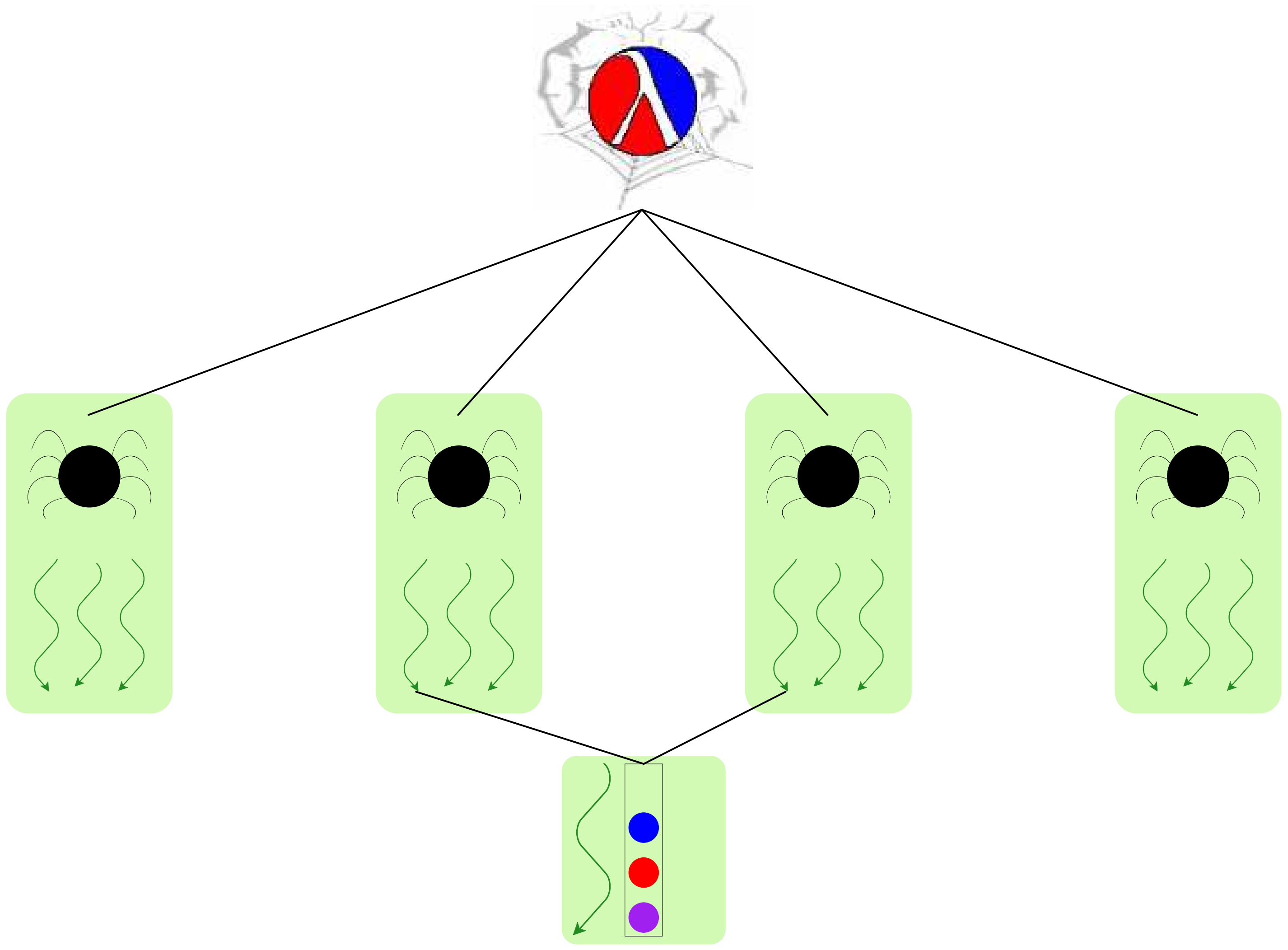
Non-Solution #1 — Atomic Region



🟨 = **atomic**

Queue might harm other servlets

Non-Solution #2 — Disjoint Process



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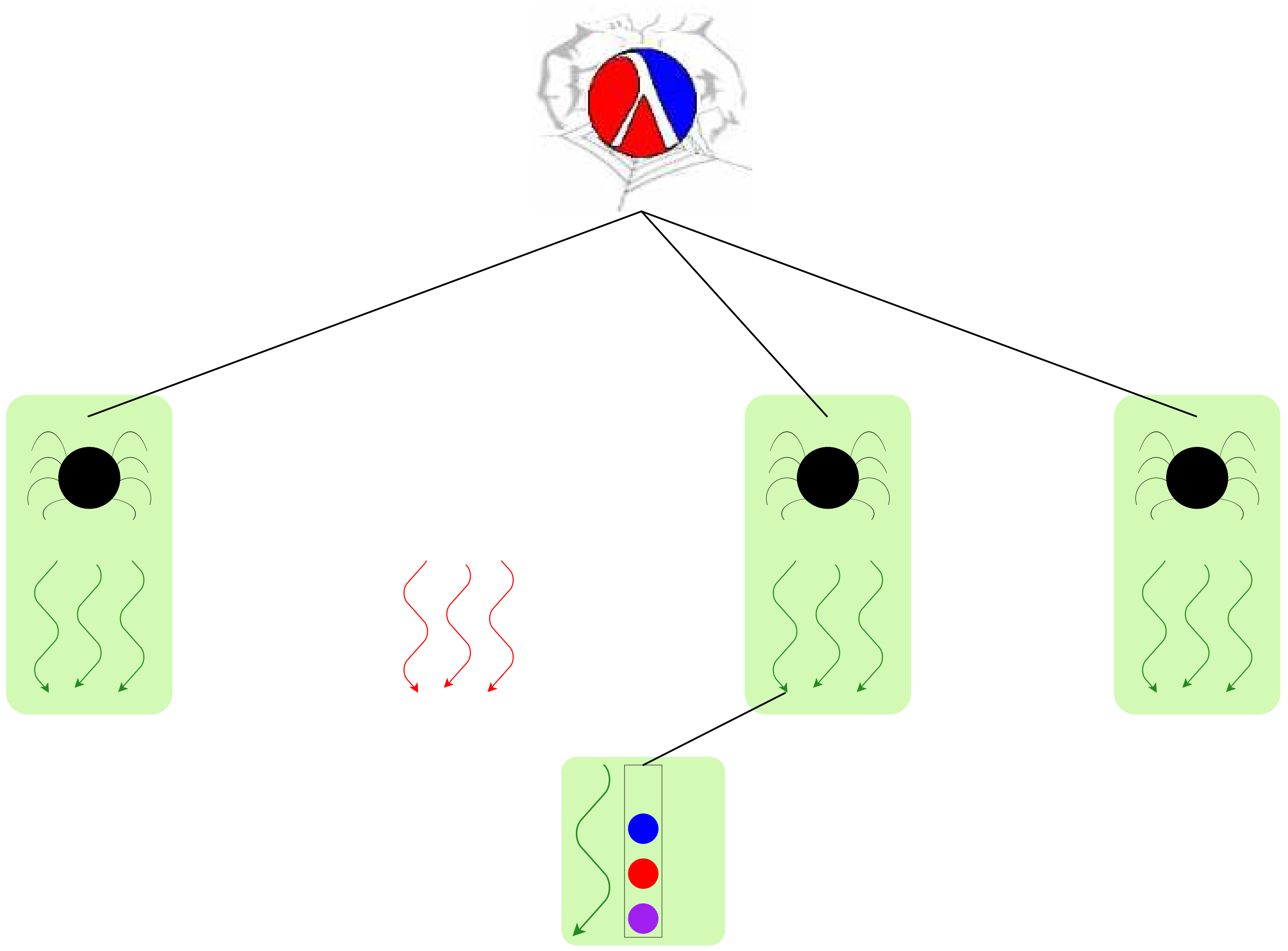

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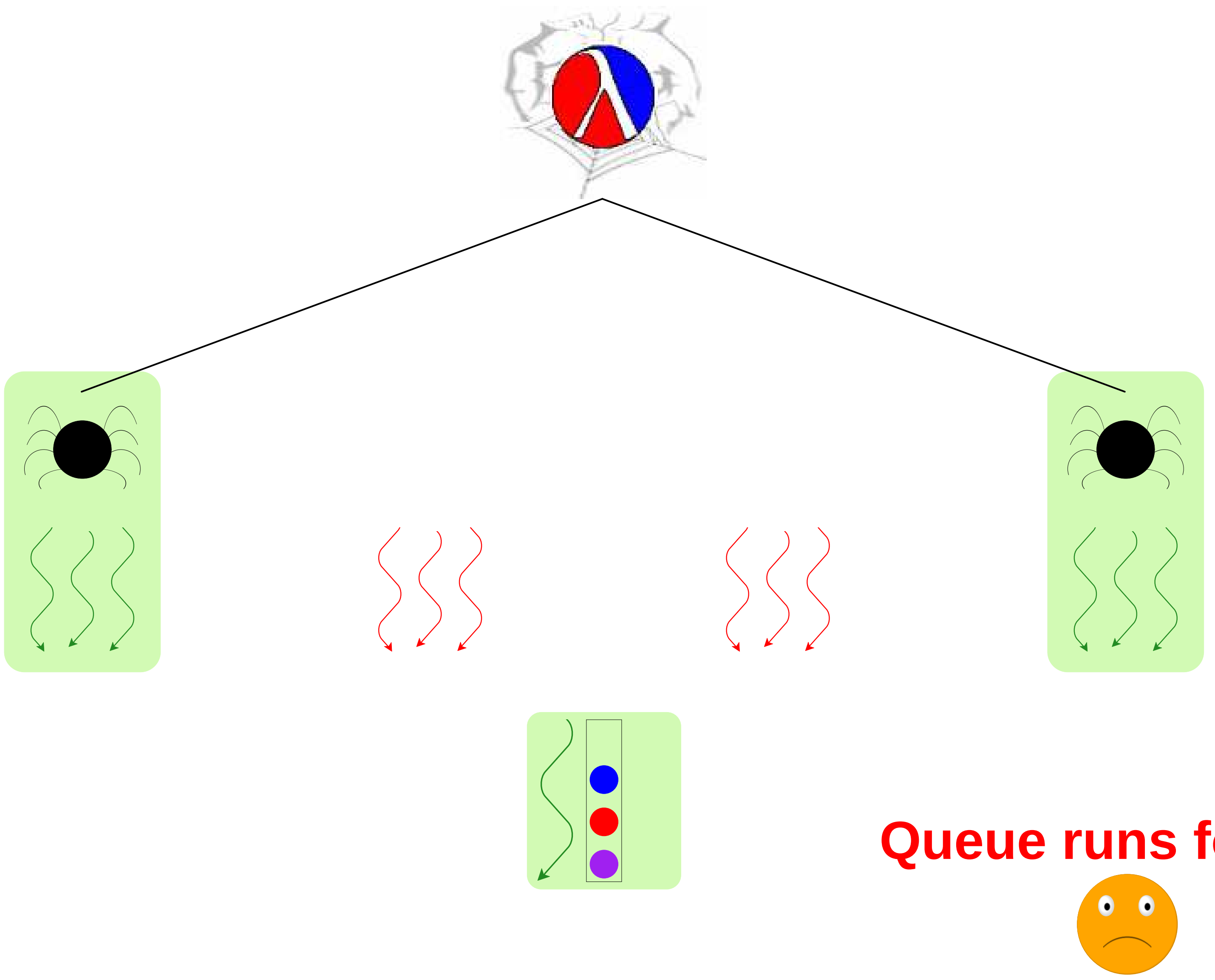
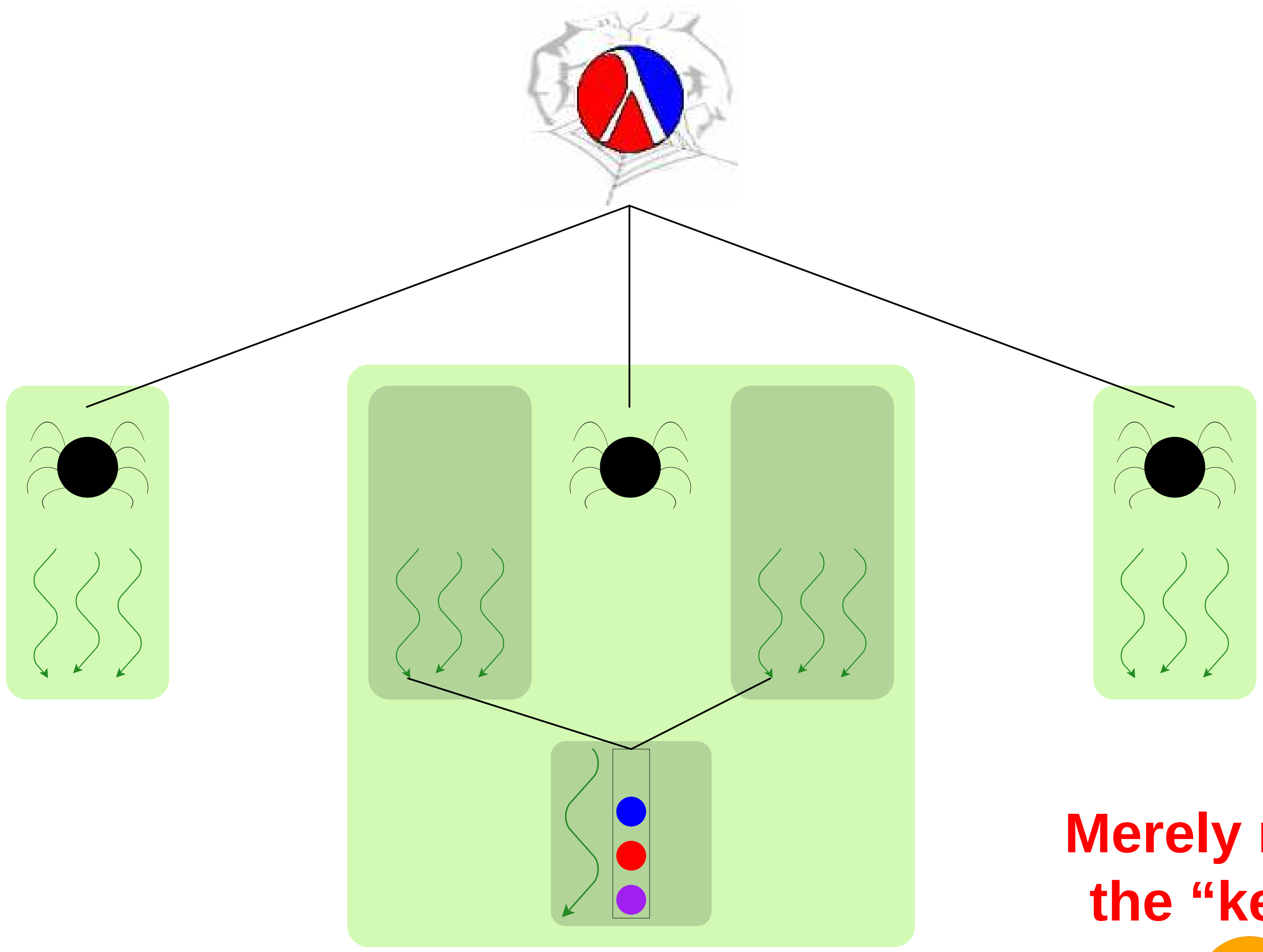
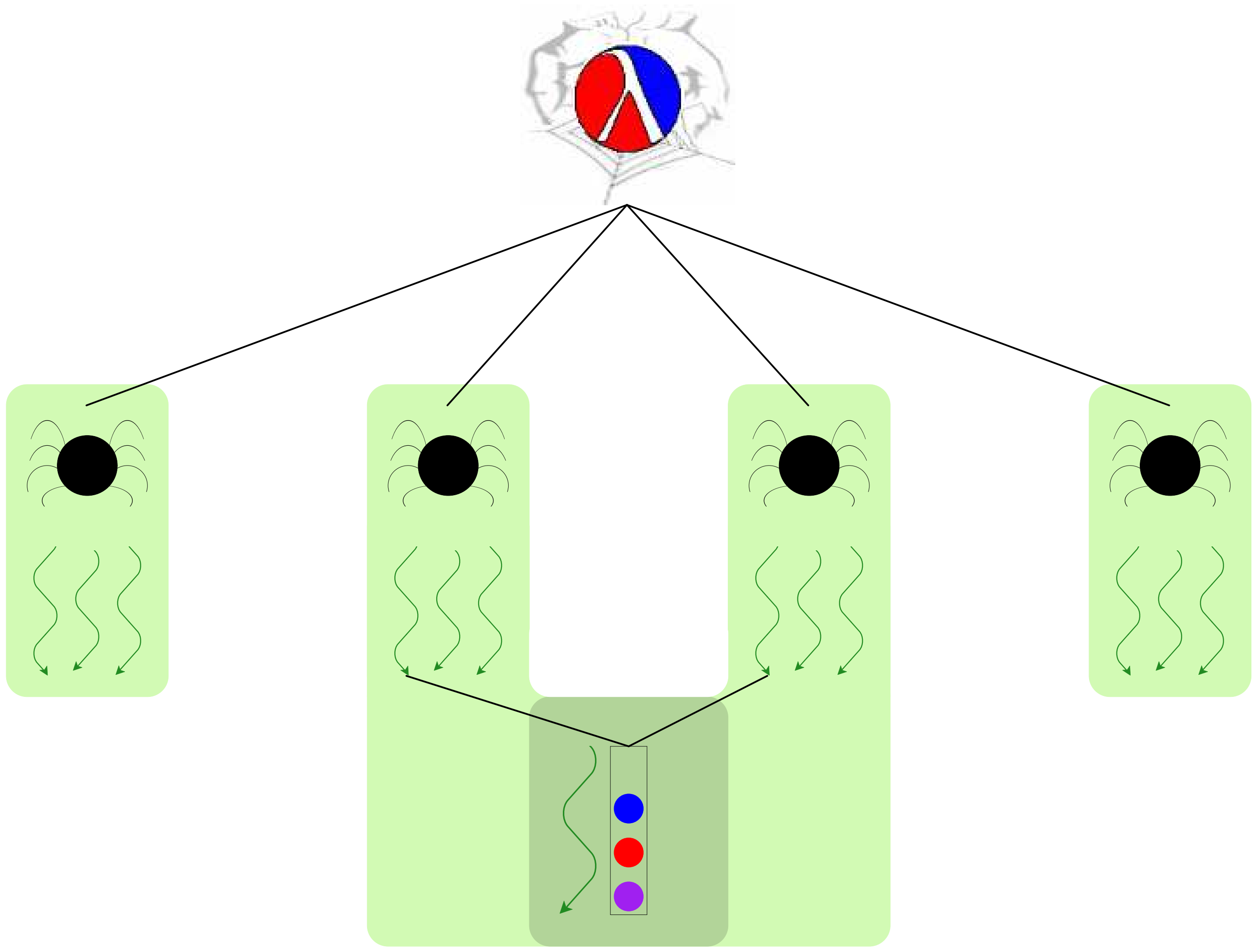


Non-Solution #3 — Meta-Servlet



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-recv put-ch)
       (lambda (v) (put q v)))))
    (q-loop))
  (spawn q-loop)
  (make-safe-q put-ch get-ch))
```

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

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

A Kill-Safe Queue

```
(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)))
```