Dining philosophers:
An exercise in message passing and state

TRUTH EVEN UNTO ITS INNERMOST PARTS
Brandeis
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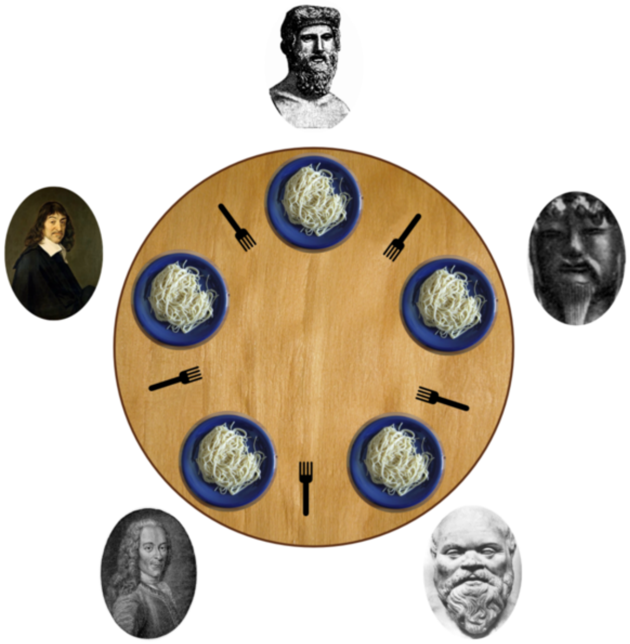
CS21b: Structure and Interpretation of Computer Programs

Spring Term, 2015

Raphael, *The School of Athens*



Dining philosophers:

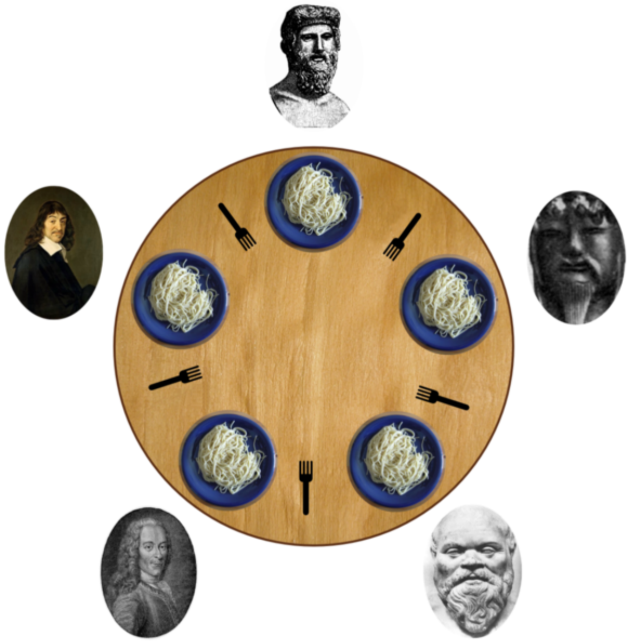
Seat *n* philosophers around a table.
One fork between each philosopher.
Philosophers either think (away from table)...

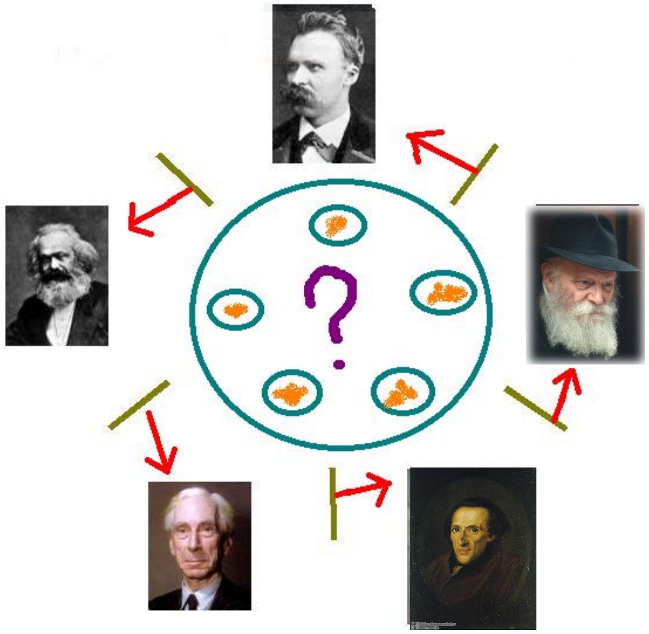
...or eat (arrive at preassigned seat, pick up fork to left and right, start eating).

Shared resource: the forks.

Parable: how do independent, asynchronous parallel processes share resources?

Deadlock!





How to make a philosopher

```
(define (make-philosopher name)
  (let ((left-fork '())
        (right-fork '())
        (what-i-am-doing 'thinking))
    (define (eating?) (eq? what-i-am-doing 'eating))
    (define (thinking?) (eq? what-i-am-doing 'thinking))
    (define (thinker m)
      (cond
        ((eq? m 'name) (list 'philosopher name))
        ((eq? m 'thinking?) (thinking?))
        ((eq? m 'eating?) (eating?))
        ((eq? m 'status)
         (list 'philosopher name
               (list '(left fork) (left-fork 'name))
               (list '(right fork) (right-fork 'name))
               (list 'what-i-am-doing? what-i-am-doing)))
        ((eq? m 'load-left-fork)
         (lambda (fork)
           (set! left-fork fork)
           'left-fork-loaded))
        ((eq? m 'load-right-fork)
         (lambda (fork)
           (set! right-fork fork)
           'right-fork-loaded))    ;; to be continued
```

```
((eq? m 'think!)
      ; You can only start thinking if you are currently eating
      (if (eating?)
          (begin
            ((left-fork 'put-down!) thinker)
            ((right-fork 'put-down!) thinker)
            (set! what-i-am-doing 'thinking)
            (list 'philosopher name 'thinking))
          ; If you are not eating, you are already thinking
          (cons (list 'philosopher name)
                '(already thinking!))))
                                      ;; to be continued
```

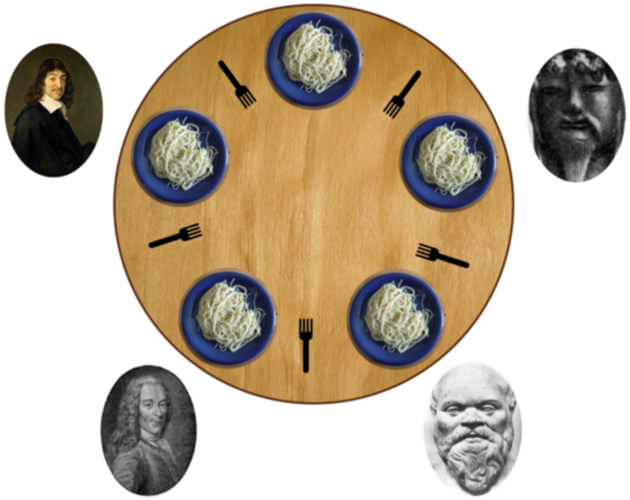
```
    ((eq? m 'eat!)
     ; You can only start eating if you are currently thinking
     (if (thinking?)
         (if ((left-fork 'grab!) thinker)
             (if ((right-fork 'grab!) thinker)
                 ; Both forks successfully grabbed
                 (begin
                   (set! what-i-am-doing 'eating)
                   (list 'philosopher name 'eating))
                     ; Grabbed left OK, but right fork already
                     ; taken...
                 ; So you failed:
                 ;   put left fork down, keep thinking...
                 (begin
                   ((left-fork 'put-down!) thinker)
                   'i-am-hungry-but-still-thinking))
             ; Failed to grab left fork...
             'i-am-hungry-but-still-thinking)
         ; If you are not thinking, you are already eating
         (cons (list 'philosopher name) '(already eating!))))
    (else (error "What ?"))))
thinker))
```

How to make a fork

```
(define (make-fork name)
  (let ((left-philosopher '())
        (right-philosopher '())
        (fork-held-by '()))
    (define (fork-raised?) (not (null? fork-held-by)))
    (define (fork m)
      (cond
        ((eq? m 'name)  (list 'fork name) )
        ((eq? m 'status)  (list
                            (fork 'name)
                            (list '(left-philosopher)
                                  (left-philosopher 'name))
                            (list '(right-philosopher)
                                  (right-philosopher 'name))
             (list '(fork raised?) (fork-raised?))))
        ((eq? m 'load-left-philosopher)
         (lambda (thinker)
           (set! left-philosopher thinker)
           'left-philosopher-loaded))
        ((eq? m 'load-right-philosopher)
         (lambda (thinker)
           (set! right-philosopher thinker)
           'right-philosopher-loaded))
                                  ;; to be continued
    ((eq? m 'grab!)
     (lambda (thinker)
       (if (or (fork-raised?)
               (and (not (equal? thinker left-philosopher))
                    (not (equal? thinker right-philosopher))))
           #f
           (begin (set! fork-held-by thinker)
                  #t))))
    ((eq? m 'put-down!)
     (lambda (thinker)
       (if (or (not fork-raised?)
               (not (equal? thinker fork-held-by)))
           'fork-cannot-be-put-down
           (begin (set! fork-held-by '())
                  'fork-put-down))))
    (else (error "What ?"))))
fork))
```

```
(define (make-table n)
  (let ((count (integers-from 1 n)))
    (let ((thinkers
           (map (lambda (x) (make-philosopher x)) count))
          (forks
           (map (lambda (x) (make-fork x)) count)) )
      (linkup thinkers forks)
      (cons thinkers forks))))

(define (linkup thinkers forks)
  (define (link t-list f-list)
    (let ((first-thinker (car t-list))
          (left-fork (car f-list))
          (right-fork (cadr f-list)))
      ((first-thinker 'load-left-fork) left-fork)
      ((first-thinker 'load-right-fork) right-fork)
      ((left-fork 'load-right-philosopher) first-thinker)
      ((right-fork 'load-left-philosopher) first-thinker)
      (if (not (null? (cdr t-list)))
          (link (cdr t-list) (cdr f-list)))))
  (link thinkers (cons (last forks) forks)))
```

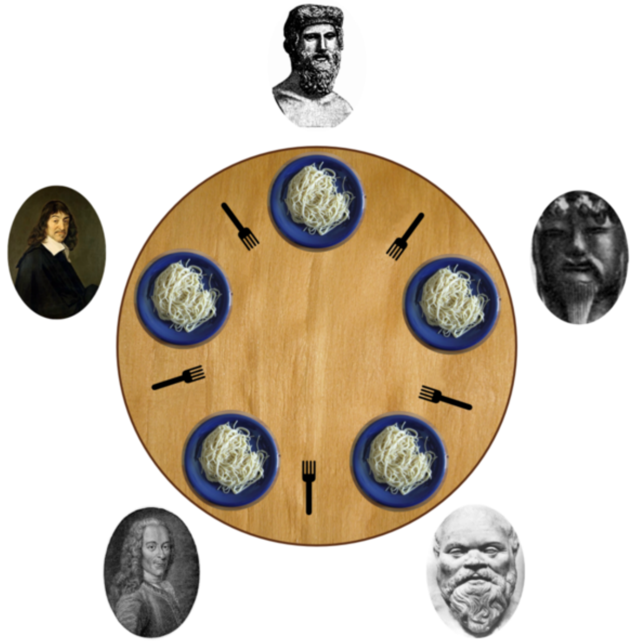


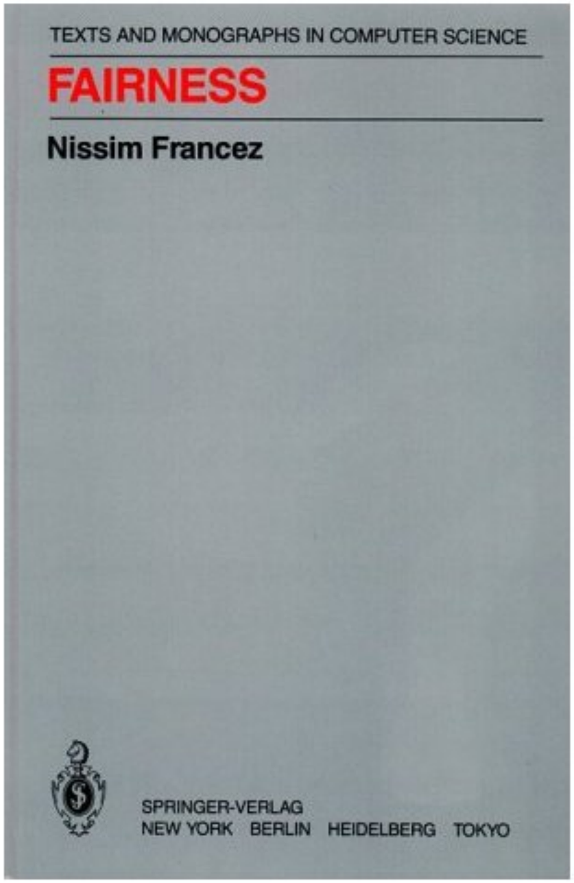
Claim: Four philosophers will not deadlock.

Fairness of scheduling

Q: What if one philosopher keeps eating and thinking and eating and thinking, real fast?

A: The neighboring philosophers get locked out of eating...





TEXTS AND MONOGRAPHS IN COMPUTER SCIENCE

FAIRNESS

Nissim Francez

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