COMP 322: Fundamentals of Parallel Programming

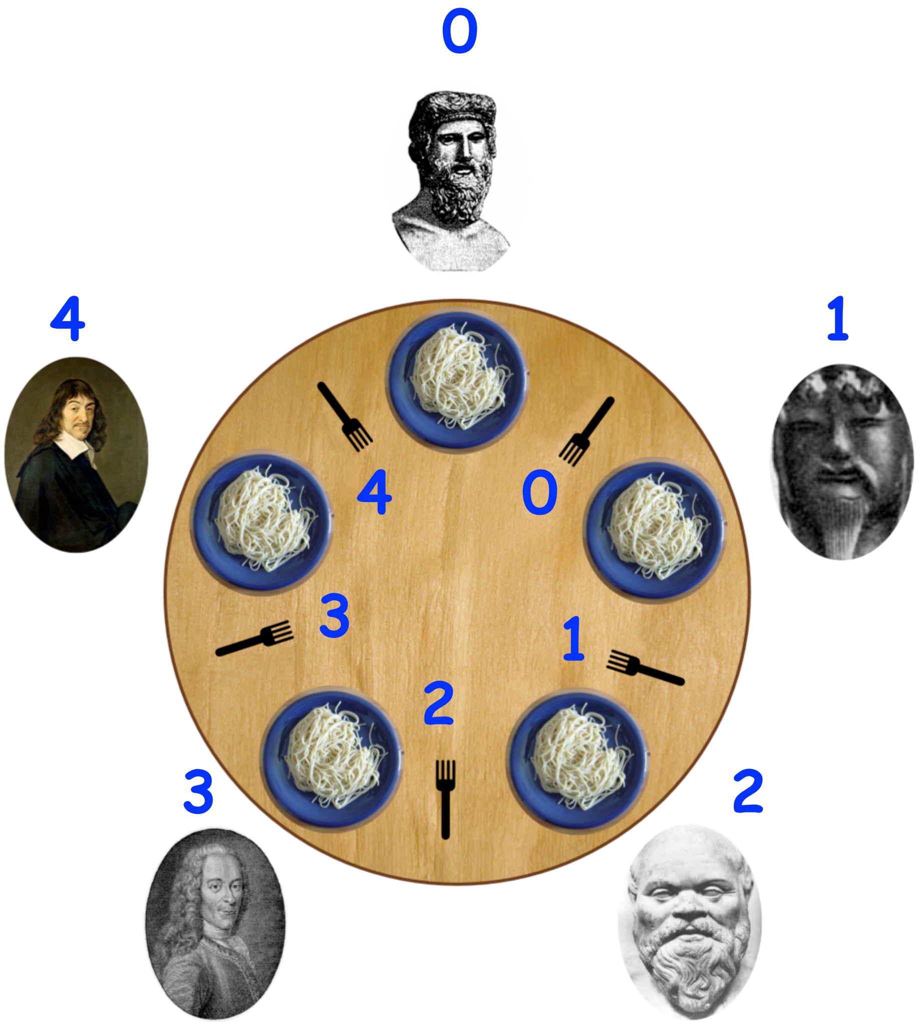
Lecture 30: Dining Philosophers Problem (DRAFT SLIDES)

Vivek Sarkar, Shams Imam
Department of Computer Science, Rice University

Contact email: vsarkar@rice.edu, shams.imam@twosigma.com

http://comp322.rice.edu/

The Dining Philosophers Problem



Constraints

- Five philosophers either eat or think
- They must have two forks to eat (chopsticks are a better motivation!)
- Can only use forks on either side of their plate
- No talking permitted

Goals

- Progress guarantees
  - Deadlock freedom
  - Livelock freedom
  - Starvation freedom
  - Maximum concurrency (no one should starve if there are available forks for them)

General Structure of Dining Philosophers Problem: PseudoCode

```
int numPhilosophers = 5;
int numForks = numPhilosophers;
Fork[] fork = ... ; // Initialize array of forks
forall(point [p] : [0:numPhilosophers-1]) {
  while(true) {
    Think ;
    Acquire forks;
      // Left fork = fork[p]
      // Right fork = fork[(p-1)%numForks]
    Eat ;
  } // while
} // forall
```

Solution 1: using Java’s synchronized

```
int numPhilosophers = 5;
int numForks = numPhilosophers;
Fork[] fork = ... ; // Initialize array of forks
forall(point [p] : [0:numPhilosophers-1]) {
  while(true) {
    Think ;
    synchronized(fork[p])
      synchronized(fork[(p-1)%numForks]) {
        Eat ;
      }
    }
  } // while
} // forall
```

Solution 2: using Java’s Lock library

```
int numPhilosophers = 5;
int numForks = numPhilosophers;
Fork[] fork = ... ; // Initialize array of forks
forall(point [p] : [0:numPhilosophers-1]) {
  while(true) {
    Think ;
    if (!fork[p].lock.tryLock()) continue;
    if (!fork[(p-1)%numForks].lock.tryLock()) {
      fork[p].lock.unLock(); continue;
    }
    Eat ;
    fork[p].lock.unlock();fork[(p-1)%numForks].lock.unlock();
  } // while
} // forall
```

Solution 3: using HJ’s isolated

```
int numPhilosophers = 5;
int numForks = numPhilosophers;
Fork[] fork = ... ; // Initialize array of forks
forall(point [p] : [0:numPhilosophers-1]) {
  while(true) {
    Think ;
    isolated {
      Pick up left and right forks;
      Eat ;
    }
  } // while
} // forall
```

Solution 4: using HJ’s object-based isolation

```
int numPhilosophers = 5;
int numForks = numPhilosophers;
Fork[] fork = ... ; // Initialize array of forks
forall(point [p] : [0:numPhilosophers-1]) {
  while(true) {
    Think ;
    isolated(fork[p], fork[(p-1)%numForks]) {
      Eat ;
    }
  } // while
} // forall
```

Solution 5: using Java’s Semaphores

```
int numPhilosophers = 5;
int numForks = numPhilosophers;
Fork[] fork = ... ; // Initialize array of forks
Semaphore table = new Semaphore(4); // assume semaphores are fair
for (i=0;i<numForks;i++) fork[i].sem = new Semaphore(1);
forall(point [p] : [0:numPhilosophers-1]) {
  while(true) {
    Think ;
    table.acquire(); // At most 4 philosophers at table
    fork[p].sem.acquire(); // Acquire left fork
    fork[(p-1)%numForks].sem.acquire(); // Acquire right fork
    Eat ;
    fork[p].sem.release(); fork[(p-1)%numForks].sem.release();
    table.release();
  } // while
} // forall
```

Worksheet #30: Characterizing Solutions to the Dining Philosophers Problem

Name: ______________________ Netid: ______________________

For the five solutions studied in today's lecture, indicate in the table below which of the following conditions are possible and why:

1. Deadlock: when all philosopher tasks are blocked (neither thinking nor eating)
2. Livelock: when all philosopher tasks are executing but ALL philosophers are starved (never get to eat)
3. Starvation: when one or more philosophers are starved (never get to eat)
4. Non-Concurrency: when more than one philosopher cannot eat at the same time, even when resources are available

	Deadlock	Livelock	Starvation	Non-concurrency
Solution 1: synchronized				
Solution 2: tryLock/unLock				
Solution 3: isolated				
Solution 4: object-based isolation				
Solution 5: semaphores				