

Parallelism

Synchronous mechanism

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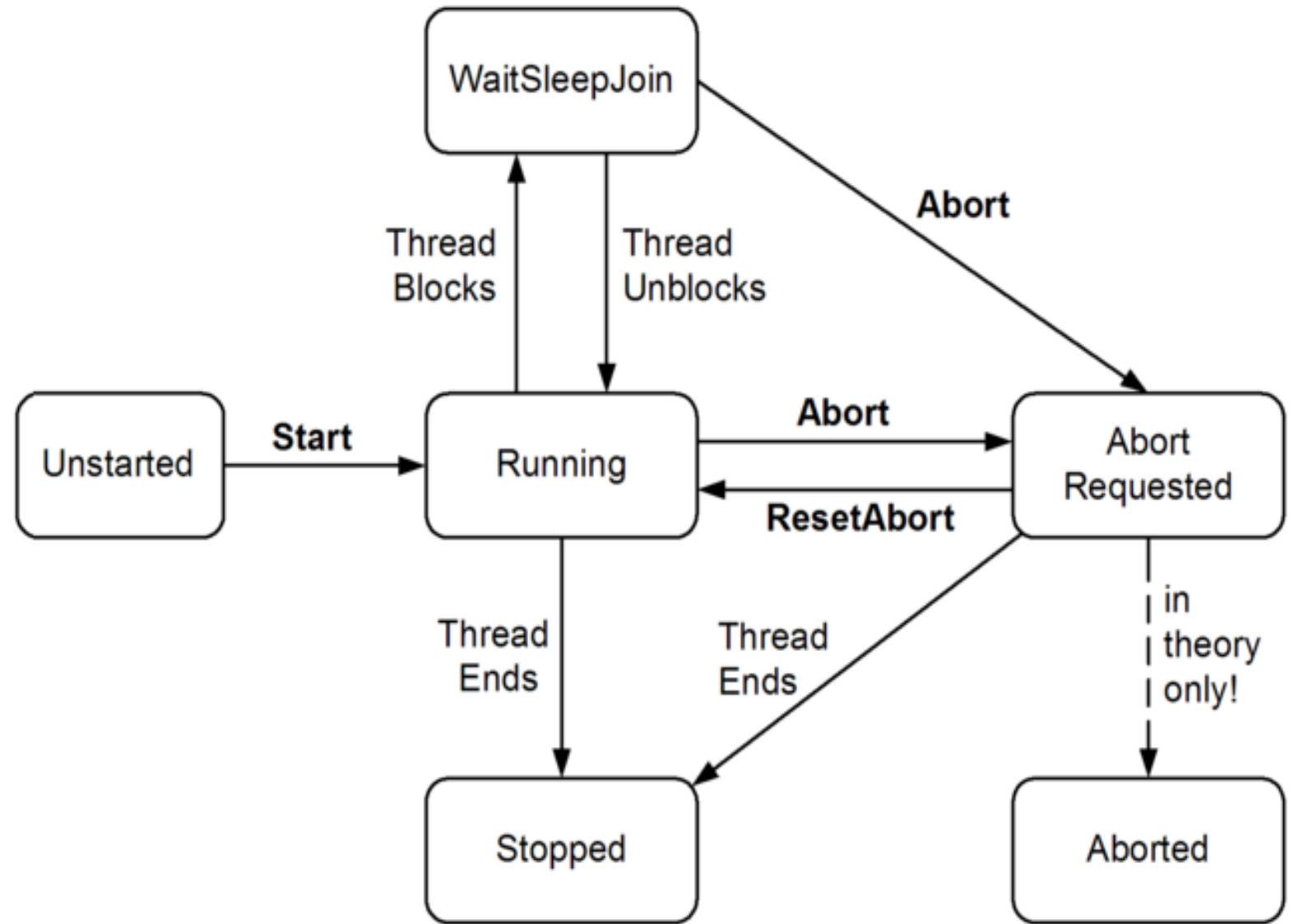
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Time consuming operations

Two categories

- CPU-bound operations
- I/O-bound operations

Thread Life cycle



Thread in C#

```
Thread t = new Thread (-- delegate Method --);  
t.Start();
```

...

```
t.Join(); // wait here until t is completed
```

? Delegate Method

Delegate in C#

- Like you have references to objects
- **A delegate is a reference to a method**

How to define:

```
public delegate <<returnType>> MethodName(<<parameter list>>); // MethodName often xxxMethodType
```

How to declare:

```
xxxMethodType methodReferenceName;
```

How to instantiate:

```
methodReferenceName = 1) NameOfMethod  
                     2) Lambda expression
```

How to use:

```
ReturnType var-name = methodReferenceName(parameter values);
```

Delegate build-in method types in C#

C# has a lot of build-in method types

- **Action:** a set of methods with no return types (i.e. void)

ex. Action<int, string> is equal to `public delegate void XX(int i, String str)`

- **Func:** a set of methods with return types (the LAST type is the return type)

ex. Func<int> is equal to `public delegate int XX()`

ex. Func<int,string,int> is equal to `public delegate int XX(int i, String str)`

- **Predicate:** a set of methods with bool return type and only one parameter

ex. Predicate<string> is equal to `public delegate bool XX(String str)`

Thread in C# - exceuting

```
class ThreadTest
{
    static bool done=false; // Static fields are shared between all threads

    static void Main()
    {
        new Thread (Go).Start();
        Go();
    }

    static void Go()
    {
        if (!done) { done = true; Console.WriteLine ("Done"); }
    }
}
```

Parallelism in C#

Levels of parallelism:

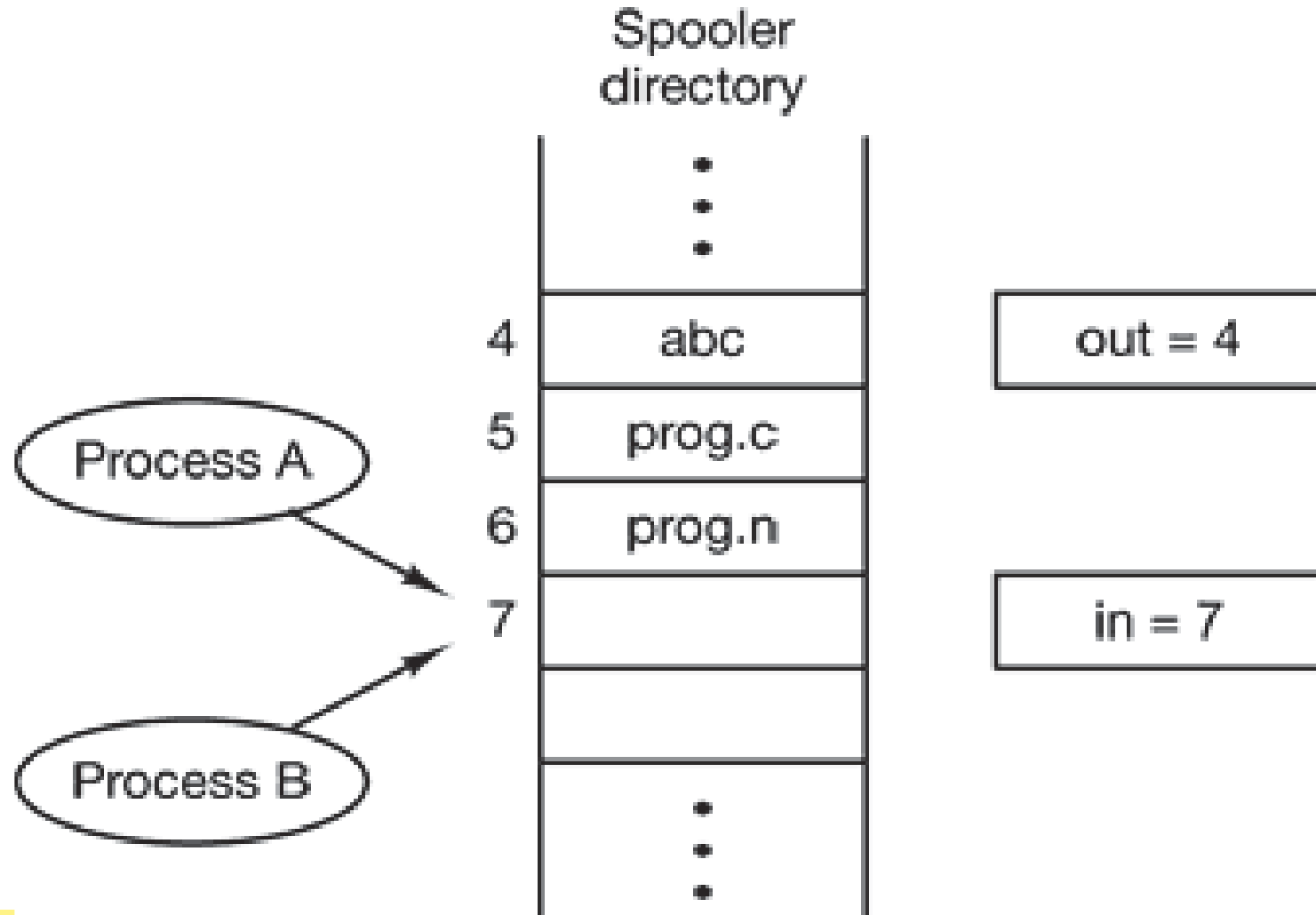
- Thread -- basic structure for parallelism
(in most programming languages)
- Task -- C# smooth variant i.e. Task.Run(---)
- Parallel.Invoke -- Can start several threads
(blocked until after all thread is completed)
- Parallel.For / Foreach -- Can start several threads in a loop
(blocked until after all thread is completed)
- Plinq -- can execute a Linq expression in parallel

Demo

Exercises C#Exercises Prog.4.1, 4.2

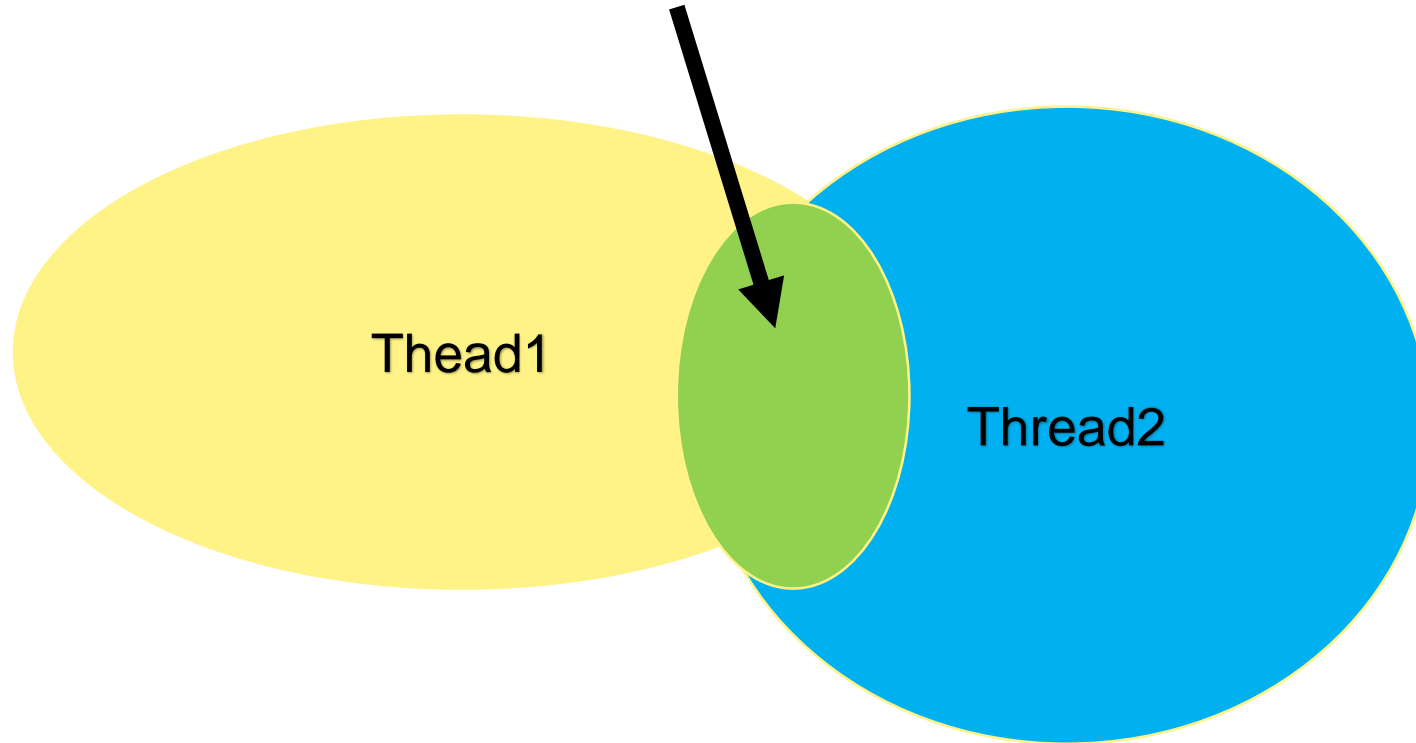
Synchronous Mechanism

Race Conditions:



Critical Regions

Common area (shared data) between several threads



Like 'done' in ThreadTest

Control of Critical Sections

A. Mutual Exclusion with busy waiting

`while (x != 0); // do nothing though loop again`

Petersons solution / TSL in machine language

B. Sleep and wakeup

- i. Lock
- ii. Semaphores
- iii. Mutex (binary semaphores)
- iv. Monitors (e.g. bounded buffer)

Overview Sleep and Wait

Lock

Ensure only one thread in block

Semaphore

Down for enter – count down by one if possible otherwise wait

Up for leave – increment by one if not reach roof (counting e.g. max 10)

C# waitOne, Release

Mutex

General like semaphore where roof is one

C# waitOne, ReleaseMutex

Monitor

The monitor are the critical section

Variable => conditions || Wait / signal

C# Enter / Exit

Classic Problems

- The Dining Philosophers Problem

Need two resources

- Producer / Consumer

Send data from producer to consumer – like a production line

- The Readers and Writers Problem

Many reader (shared) one writer (exclusive) – like a Database

- The Sleeping Barber Problem

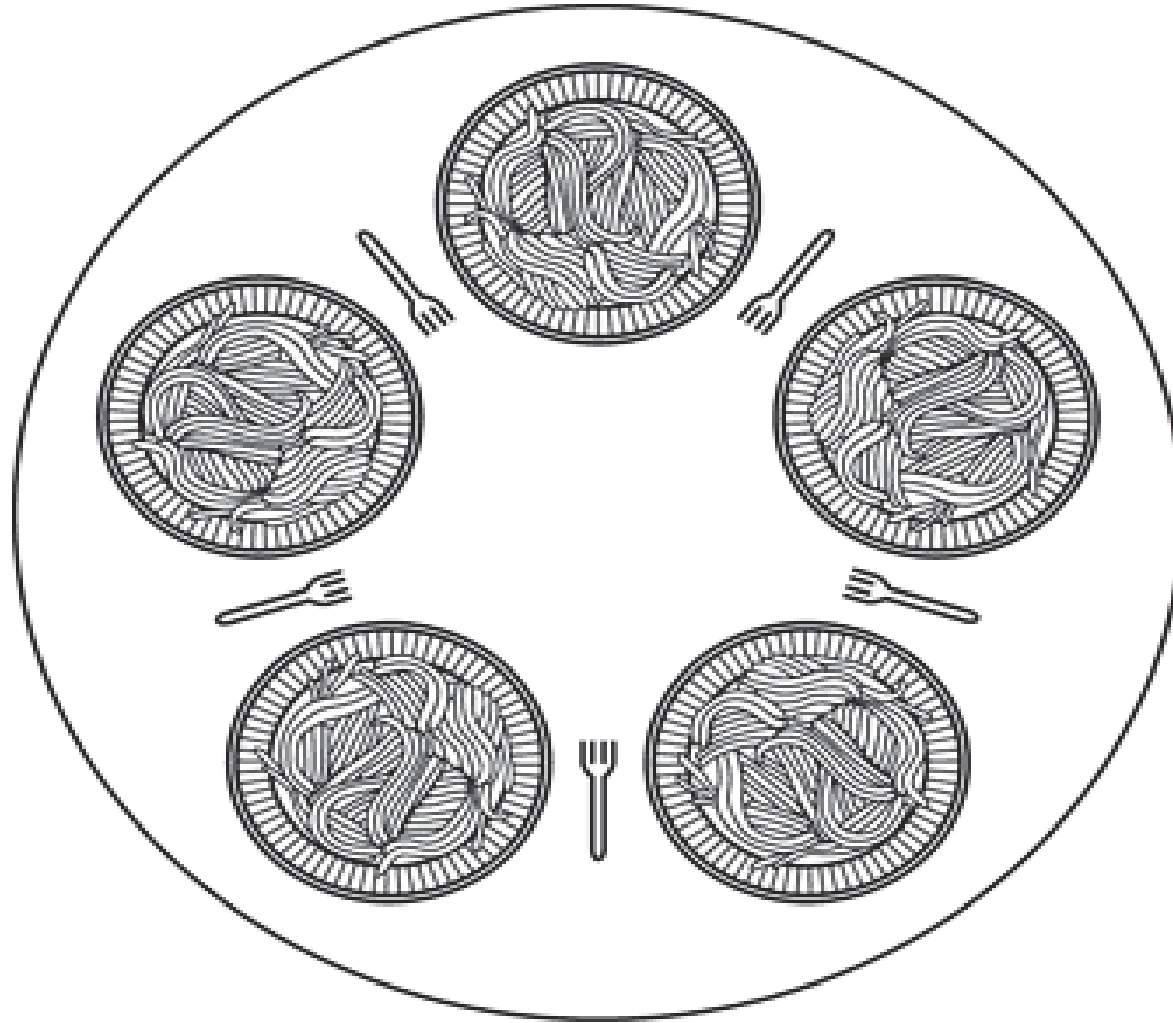
A limited queue to one resource

The Dining Philosophers Problem

Philosophers do

Think

Eat



Example code for Dining philosophers

```
#define N 5/* number of philosophers */
void philosopher(int i)/* i: philosopher number, from 0 to 4 */
{
    while (TRUE) {
        think( ); /* philosopher is thinking */
        take_fork(i); /* take left fork */
        take_fork((i+1) % N); /* take right fork; % is modulo operator */
        eat(); /* yum-yum, spaghetti */
        put_fork(i); /* Put left fork back on the table */
        put_fork((i+1) % N); /* put right fork back on the table */
    }
}
```


Solution using semaphores

```
void philosopher (int i)/* i: philosopher number, from 0 to N-1 */  
{  
  while (TRUE) {/* repeat forever */  
    think();/* philosopher is thinking */  
    take_forks(i);/* acquire two forks or block */  
    eat();/* yum-yum, spaghetti */  
    put_forks(i);/* put both forks back on table */  
  }  
}
```

```
void test(i)/* i: philosopher number, from 0 to N-1 */  
{  
  if (state[i] == HUNGRY && state[LEFT] != EATING && state[RIGHT]  
      != EATING) {  
    state[i] = EATING;  
    up(&s[i]);  
  }  
}
```

```
void take_forks(int i)  
{  
  down(&mutex); /* enter critical region */  
  state[i] = HUNGRY; /* record fact that philosopher i is hungry */  
  test(i); /* try to acquire 2 forks */  
  up(&mutex); /* exit critical region */  
  down(&s[i]); /* block if forks were not acquired */  
}  
void put_forks(i)/* i: philosopher number, from 0 to N-1 */  
{  
  down(&mutex); /* enter critical region */  
  state[i] = THINKING; /* philosopher has finished eating */  
  test(LEFT); /* see if left neighbor can now eat */  
  test(RIGHT); /* see if right neighbor can now eat */  
  up(&mutex); /* exit critical region */  
}
```

Demo

Exercises C#Exercises Prog.4.4 + Brewery .