

# L10: Semaphores I

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Grado en Matemáticas e Informática  
Universidad Politécnica de Madrid

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# Mapa Conceptual

Concurrency = Simultaneous + Nondeterminism + Interaction

Interaction = Communication | Synchronization

Synchronization = Mutual Exclusion | Conditional Synchronization

## ■ Terminology:

atomic

interleaving

mutual exclusion

race condition

busy-wait

critical section

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# HW4: Garantizar exclusión mutua con semáforos

## Homework:

- HW1: Creación de threads en Java
- HW2: Provocar una condición de carrera
- HW3: Garantizar la exclusión mutua con espera activa
- **HW4: Garantizar la exclusión mutua con semáforos**

Fecha de Cierre:

**Miércoles 11-Marzo-2015 11am**

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# HW4: Garantizar exclusión mutua con semáforos

Hoja de ejercicios cortos (r1638)

Concurrencia

Segundo semestre 2013-2014

## 4. Garantizar exclusión mutua con semáforos

Este ejercicio, al igual que el anterior, consiste en evitar una condición de carrera. En esta ocasión tenemos el mismo número de procesos incrementadores que decrementadores que incrementan y decrementan, respectivamente, en un mismo número de pasos una variable compartida. El objetivo es asegurar la exclusión mutua en la ejecución de los incrementos y decrementos de la variable y el objetivo es hacerlo utilizando exclusivamente un semáforo de la clase `es.upm.babel.cclib.Semaphore` (está prohibido utilizar cualquier otro mecanismo de concurrencia). La librería de concurrencia `cclib.jar` puede descargarse de la página web de la asignatura.

### Material a entregar

El fichero fuente a entregar debe llamarse `CC_04_MutexSem.java`.

### Material de apoyo

Se ofrece el fichero `CC_04_MutexSem.todo.java` con un esqueleto que debe respetarse y que

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# Problems with Busy-Wait

Busy-wait algorithms (Peterson, Dekker, Bakery) are correct, but  
problems

- hard to prove correctness
- waste of CPU
- atomic actions are too fine grain and depend on the architecture



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solution



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solution

## semaphores



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- higher level, easier to reason about

# Semaphores

- **stop** threads (like join)  
no busy-wait
- based on atomic **test and set**  
supported by most hardware
- higher level, easier to reason about  
assertion based reasoning feasible

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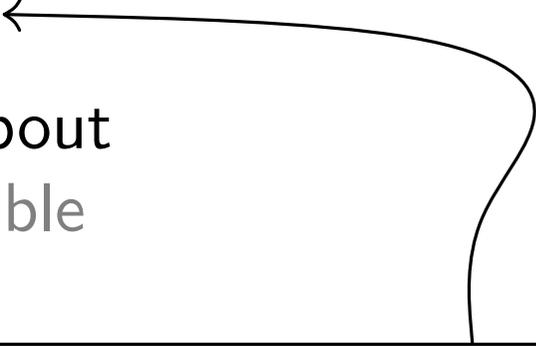
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Architecture independent  
Present in many OSs and languages

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# Semaphores

- **stop** threads (like join)  
no busy-wait
- based on atomic **test and set**  
supported by most hardware
- higher level, easier to reason about  
assertion based reasoning feasible

Architecture independent  
Present in many OSs and languages

- Allow to solve easily **mutual-exclusion** by  $n$  processes

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# What is a semaphore

Resembles (only remotely) traffic lights:

- if allowed, you pass
- if not allowed, you wait

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# What is a semaphore

Resembles (only remotely) traffic lights:

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A **semaphore** is a data-type with two operations:

- $P()$
- $V()$

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# What is a semaphore

Resembles (only remotely) traffic lights:

- if allowed, you pass
- if not allowed, you wait

A **semaphore** is a data-type with two operations:

- P()
- V()

Internally, a **semaphore** maintains a counter, which is initialize at creation.

```
semaphore s(3);
```

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# Semantics of semaphores

Semantics of  $s.P()$ :

$$\left\{ \begin{array}{l} \langle \text{if } s.\text{count} == 0 \quad \text{then } \textit{block} \rangle \\ \langle \text{if } s.\text{count} != 0 \quad \text{then } s.\text{count}-- \rangle \end{array} \right.$$
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Example 1:

$s.\text{count} == 0$   
 $s.P()$

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Example 1:

$s.\text{count} == 0$    
 $s.P_x()$

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Example 2:

$s.\text{count} == 1$    
 $s.P()$

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Example 2:

$$\begin{array}{l} s.\text{count} == 1 \\ \quad s.P() \\ s.\text{count} == 0 \end{array} \left. \vphantom{\begin{array}{l} s.\text{count} == 1 \\ \quad s.P() \\ s.\text{count} == 0 \end{array}} \right\}$$
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# Semantics of semaphores

Semantics of  $s.P()$ :

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Example 2:

Atomically!  $\downarrow$

$s.\text{count} == 1$   
 $s.P()$   
 $s.\text{count} == 0$

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# Semantics of semaphores

Semantics of  $s.V()$ :

$$\left\{ \begin{array}{l} \langle \text{if } \mathbf{no} \text{ blocked} \quad \text{then } s.count++ \rangle \\ \langle \text{if } \mathbf{some} \text{ blocked} \quad \text{then unblock } \mathit{one} \text{ thread} \rangle \end{array} \right.$$
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# Semantics of semaphores

Semantics of `s.V()`:

$$\left\{ \begin{array}{ll} \langle \text{if } \mathbf{no} \text{ blocked} & \text{then } s.\text{count}++ \rangle \\ \langle \text{if } \mathbf{some} \text{ blocked} & \text{then unblock } \mathit{one} \text{ thread} \rangle \end{array} \right.$$

Example 3:

`s.count==0`       $\left. \begin{array}{l} \text{~~~~~} \\ \text{~~~~~} \\ \text{~~~~~} \end{array} \right\} s.P_x()$

$\left. \begin{array}{l} \text{~~~~~} \\ \text{~~~~~} \\ \text{~~~~~} \\ \text{~~~~~} \\ \text{~~~~~} \end{array} \right\} s.V()$

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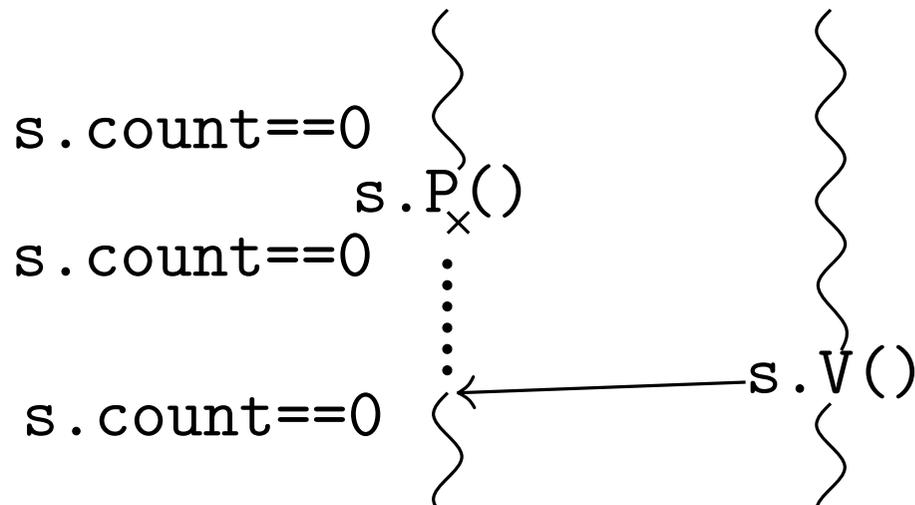
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# Semantics of semaphores

Semantics of `s.V()`:

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Example 3:



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# Questions

1. Could a semaphore become negative?

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# Questions

1. Could a semaphore become negative?
2. Could a semaphore (initialized to  $\geq 0$ ) become negative?

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# Questions

1. Could a semaphore become negative?
2. Could a semaphore (initialized to  $\geq 0$ ) become negative?
3. Let  $s$  be a semaphore be initialized to  $\geq 0$ . Is the following true?:  
*If a thread is blocked then  $s.count == 0$*

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# Questions

1. Could a semaphore become negative?
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3. Let  $s$  be a semaphore be initialized to  $\geq 0$ . Is the following true?:  
*If a thread is blocked then  $s.count == 0$*
4. Let  $s$  be a semaphore be initialized to  $\geq 0$ . Is the following true?:  
*If  $s.count == 0$  then a thread is blocked*

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# Semaphores in Java

In HW4 you must use

```
es.upm.babel.cclib.Semaphore
```

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Create a semaphore:

```
Semaphore s(1);
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Create a semaphore:

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**Acquire** a semaphore:

```
s.await();
```



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# Operations Names

Original	cclib	java
P()	await()	acquire()
V()	signal()	release()

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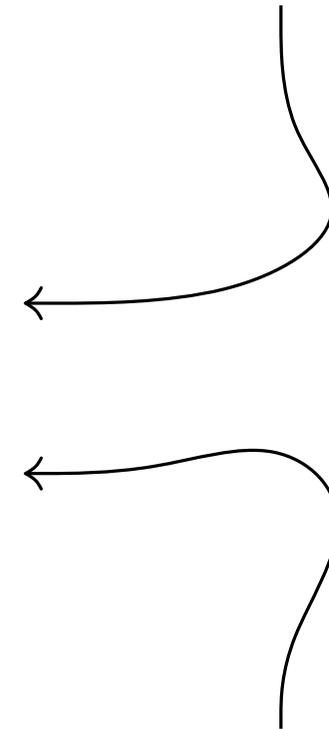
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# Operations Names

`decrement_or_block_if_the_result_is_negative()`

Original	cclib	java
<code>P()</code>	<code>await()</code>	<code>acquire()</code>
<code>V()</code>	<code>signal()</code>	<code>release()</code>



`wake_a_waiting_process_if_any_or_increment()`

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# Fairness

Q: Which **blocked** thread is awoken?

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# Fairness

Q: Which **blocked** thread is awoken?

A: *non-deterministic*

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# Fairness

Q: Which **blocked** thread is awoken?

A: *non-deterministic*

Q: Can a **blocked** thread always loose against others?

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# Fairness

Q: Which **blocked** thread is awoken?

*A: non-deterministic*

Q: Can a **blocked** thread always loose against others?

*A: It depends*

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Q: Which **blocked** thread is awoken?

A: *non-deterministic*

Q: Can a **blocked** thread always loose against others?

A: *It depends*

**Fairness:** a thread cannot be blocked forever  
(if its semaphore is ready repeatedly)



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# Fairness

Q: Which **blocked** thread is awoken?

A: *non-deterministic*

Q: Can a **blocked** thread always loose against others?

A: *It depends*

**Fairness:** a thread cannot be blocked forever  
(if its semaphore is ready repeatedly)

Typically, threads are awoken in the order they were blocked.



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