

# Lab Worksheet 04 - Semaphores

## Objectives

1. Program basic data exchanges via shared memory.
2. Program synchronized exchanges with semaphores.

## Remarks

- **Always** clean up your shared memory objects -- segments and semaphores! It is critical because the kernel ignores them until it needs to reallocate the memory they occupy. By default, reopening a semaphore that already exists does not set its counter to the initialization value, so your code might not behave as expected if you run the same program multiple times **without cleaning up at the end of each run.**
- This is the point where you reach the limits of standard specifications: OS X and Linux/Unix/Cygwin handle shared memory objects in different ways.
  - OS X does not support unnamed semaphores. If you're using an Apple computer, **either limit your code to named semaphores or use the Linux VM.**
  - Linux/Unix/Cygwin provides a location in the file system namespace to manipulate shared memory objects from the terminal: they are kept in `/dev/shm/` and, given the right permissions, can be deleted with the `rm` command. The philosophy of OS X is to leave no such location directly exposed, and expects your code to perform all the proper `unlink` calls.
  - **OS X links the POSIX real-time (RT) library** *by default*, but Linux/Unix/Cygwin does not. In the latter case, since shared memory is part of the RT specification, you need to add option `-lrt` at the end of your compilation command.

*eg. `$gcc -o test -Wall my-code-with-shared-objects.c -lrt`*

## Exercise 1: First steps with shared memory

Write a program where the initial parent process creates a segment of shared memory that can hold N integer values, then creates N child processes and waits for their termination. Each child generates a random value `random_val`, stores it in shared memory and displays it before exiting. The random value is generated thus:

```
random_val = (int) (10 * (float) rand () / RAND_MAX);
```

Once all its children have terminated, the parent process reads all the values in shared memory, sums them up and then displays the result.

## Exercise 2: Synchronizing accesses to shared memory

Extend the program written for exercise 1 so that, instead of generating only one value, every child process generates  $N$  values. The parent process now sums up  $N * N$  values. Since the segment of shared memory can hold at most  $N$  integers, you now need to **synchronize accesses**.

### Exercise 3: Barrier

The program below creates  $N-1$  child processes. All  $N$  processes carry out `calc1()` and then `calc2()` concurrently.

```
void calc1 () {
    int i;
    for (i = 0; i < 1E8; i ++);
}

void calc2 () {
    int i;
    for (i = 0; i < 1E8; i ++);
}

int main (int argc, char * argv []) {
    int i = 0;
    pid_t pid_child [2];

    while ((i < N-1) && ((pid_child [i] = fork ()) != 0))
        i ++;

    calc1 ();
    calc2 ();
    printf ( "End Process %d \n", i);

    EXIT_SUCCESS return;
}
```

We want to change the program by using semaphores to make sure that no process begins `calc2` before all other processes have also finished `calc1`.

Write the program `barrier` that implements this new specification.