Embedded OS Implementation, Fall 2020

Project #3 (due January 6, 2021 (Wednesday) 13:00)

[PART I] NPCS Implementation

Objective:

To implement the non-preemptible critical section (NPCS) based on RM scheduler in uC/OS-II.

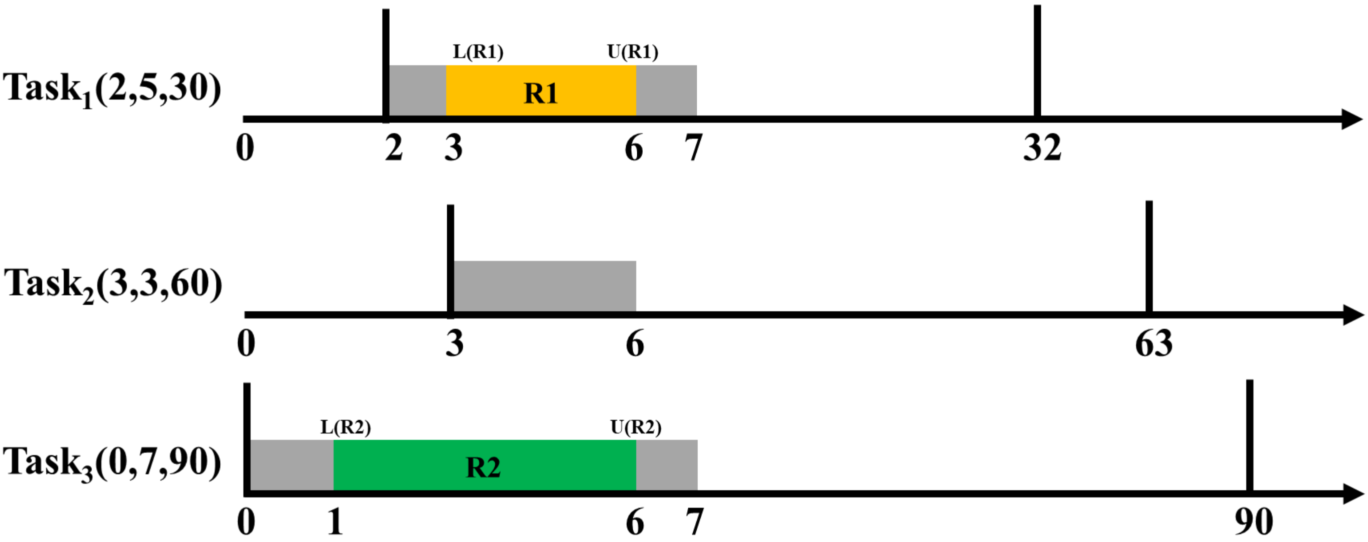
Problem Definition:

uC/OS-II uses a variation of the priority inheritance protocol to deal with priority inversions. In this assignment, you are going to implement the NPCS based on RM scheduler in uC/OS-II.

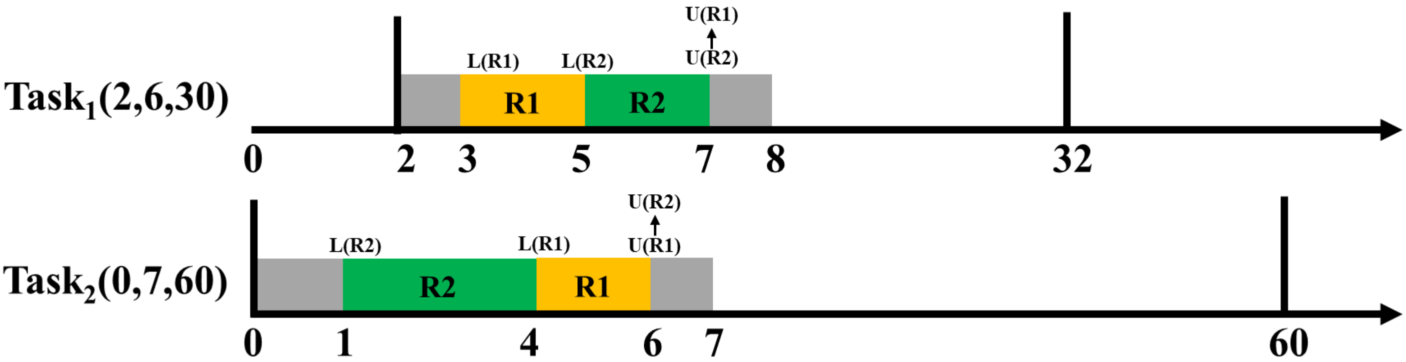
Consider the two periodic task sets and observe how the task suffers the schedule delay.

Periodic Task Set = {task$_{ID}$ (arrival time, execution time, period)}

Task Set 1 = {task$_1$ (2,5,30), task$_2$ (3,3,60), task$_3$ (0,7,90)}



Task Set 2 = {task$_1$ (2,6,30), task$_2$ (0,7,60)}



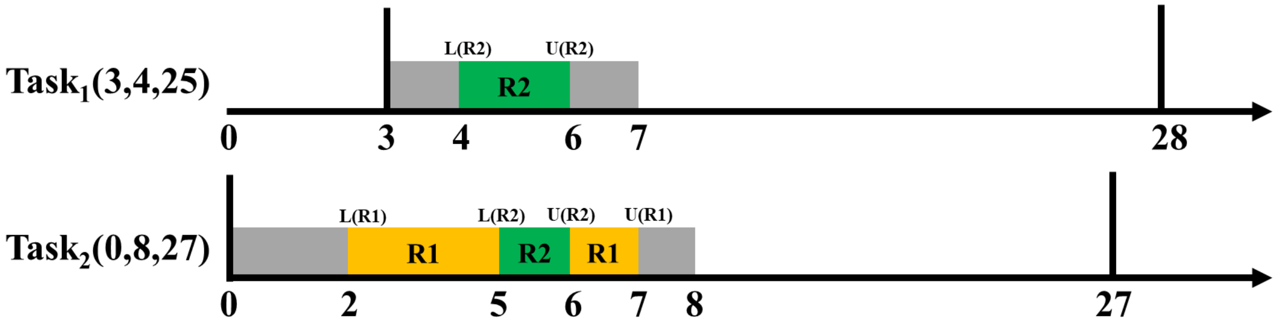
Evaluation:

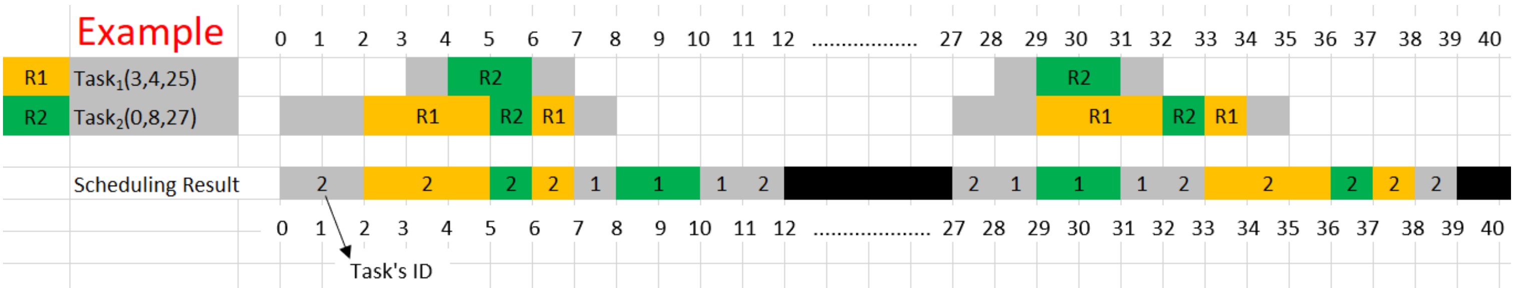
The output format:

Tick	Event
#	Task ID
#	Task ID get R
#	Task ID release R

The NPCS Example of Output Result:

Consider two tasks, $task_1(3,4,25)$, $task_2(0,8,27)$ and two resources R1, R2.






```
Tick    Event
0       Task 2
2       Task 2 get R1
5       Task 2 get R2
6       Task 2 release R2
7       Task 2 release R1
7       Task 1
8       Task 1 get R2
10      Task 1 release R2
11      Task 2
12      Task 63
27      Task 2
28      Task 1
29      Task 1 get R2
31      Task 1 release R2
32      Task 2
33      Task 2 get R1
36      Task 2 get R2
37      Task 2 release R2
38      Task 2 release R1
39      Task 63
```

[PART II] CPP Implementation

Objective:

To implement the ceiling-priority protocol (CPP) based on RM scheduler in uC/OS-II.

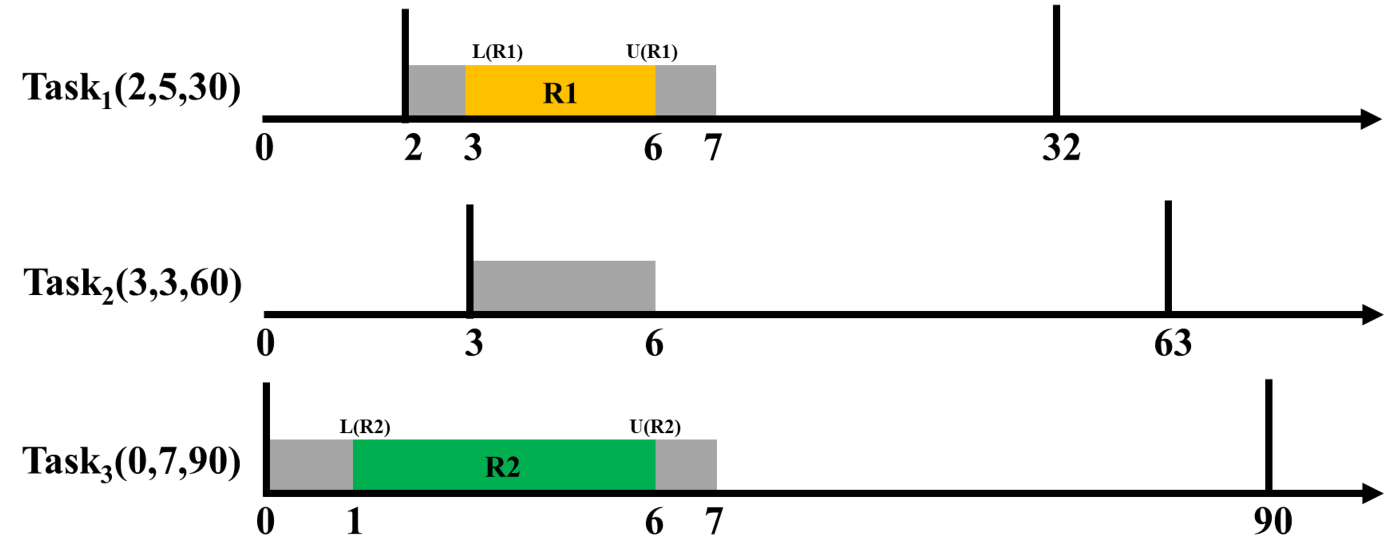
Problem Definition:

uC/OS-II uses a variation of the priority inheritance protocol to deal with priority inversions. In this assignment, you are going to implement the CPP based on RM scheduler in uC/OS-II.

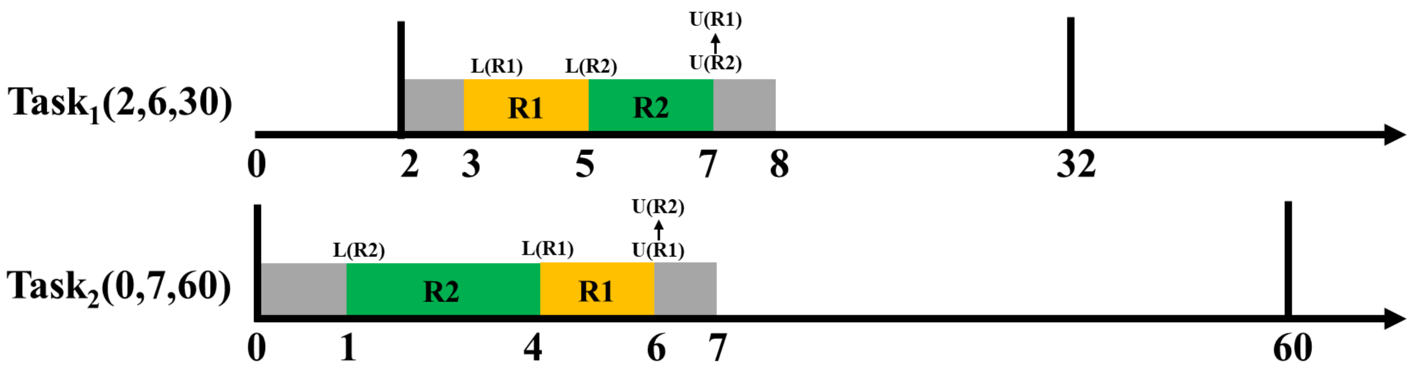
Consider the two periodic task sets and observe how the task suffers the schedule delay.

Periodic Task Set = {task$_{ID}$ (arrival time, execution time, period)}

Task Set 1 = {task$_1$ (2,5,30), task$_2$ (3,3,60), task$_3$ (0,7,90)}



Task Set 2 = {task$_1$ (2,6,30), task$_2$ (0,7,60)}



Evaluation:

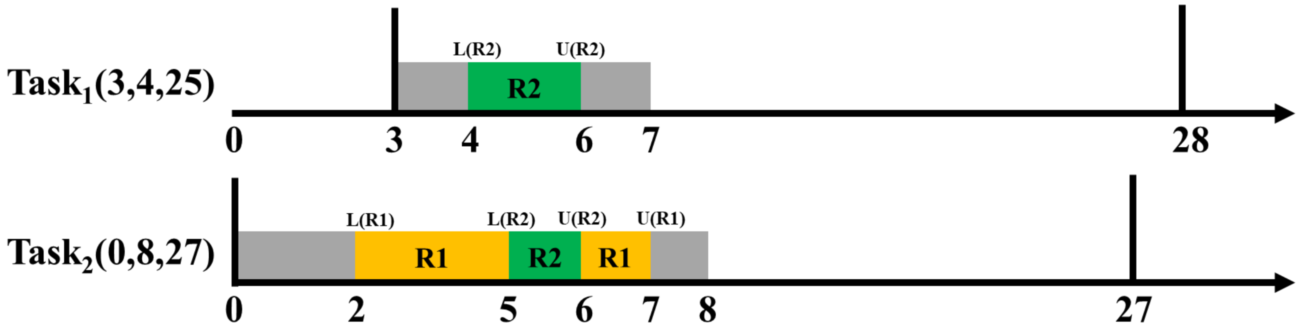
The output format:

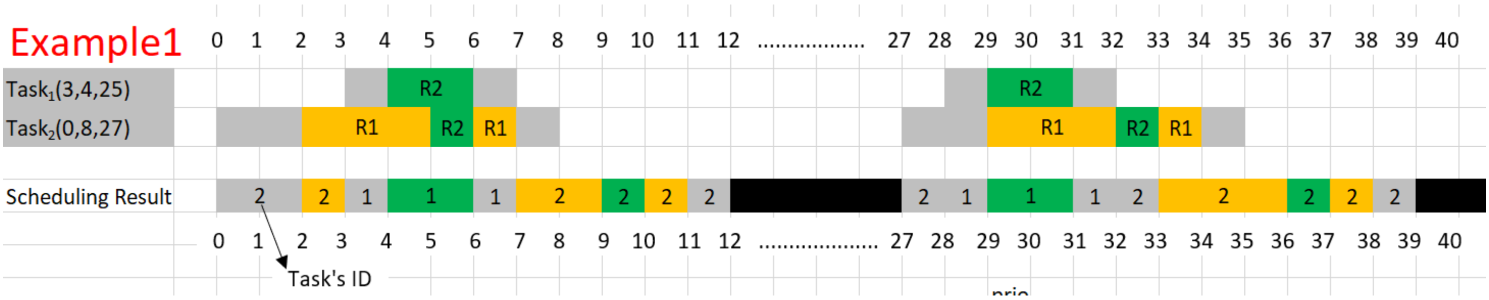
Tick	Event	Prio_Inheritance
#	Task ID	
#	Task ID get R	Prev_prio⟶New_prio
#	Task ID release R	Prev_prio⟶New_prio

※ Resource's ceiling is set by an odd number, and the task's priority is set by an even number.

The CPP Example1 of Output Result:

Consider two tasks, $task_1(3,4,25)$, $task_2(0,8,27)$, and two resources R1, R2.
We can set the priority of $task_1$ and $task_2$ as 2 and 4, respectively. Then, the ceiling of R1 and R2 is set as 3 and 1, respectively.

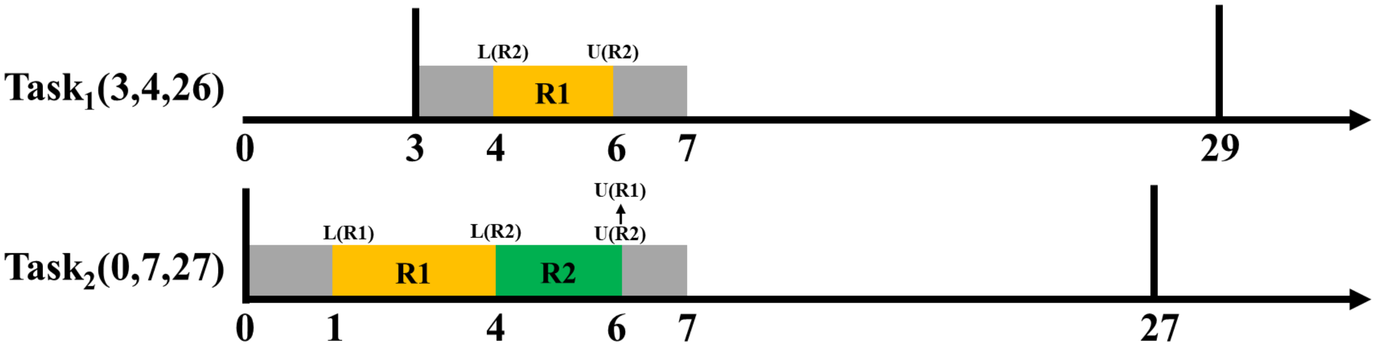


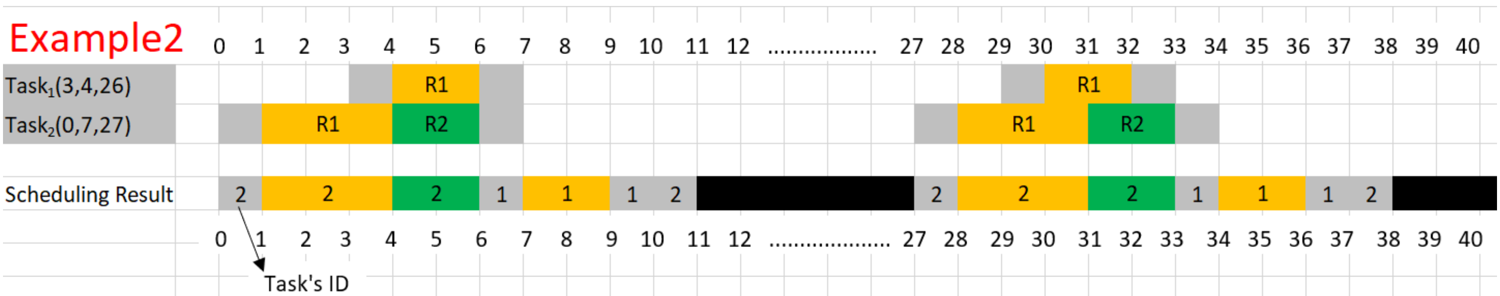



```
Tick    Event              Prio_Inheritance
0       Task 2
2       Task 2 get R1         4⟶3
3       Task 1
4       Task 1 get R2         2⟶1
6       Task 1 release R2     1⟶2
7       Task 2
9       Task 2 get R2         3⟶1
10      Task 2 release R2     1⟶3
11      Task 2 release R1     3⟶4
12      Task 63
27      Task 2
28      Task 1
29      Task 1 get R2         2⟶1
31      Task 1 release R2     1⟶2
32      Task 2
33      Task 2 get R1         4⟶3
36      Task 2 get R2         3⟶1
37      Task 2 release R2     1⟶3
38      Task 2 release R1     3⟶4
39      Task 63
```

The CPP Example2 of Output Result:

Consider two tasks, $task_1(3,4,26)$, $task_2(0,7,27)$, and two resources R1, R2.
We can set the priority of $task_1$ and $task_2$ as 2 and 4, respectively. Then, the ceiling of R1 and R2 is set as 1 and 3, respectively.






```
Tick    Event               Prio_Inheritance
0       Task 2
1       Task 2 get R1         4→1
4       Task 2 get R2         1→1
6       Task 2 release R2     1→1
6       Task 2 release R1     1→4
6       Task 1
7       Task 1 get R1         2→1
9       Task 1 release R1     1→2
10      Task 2
11      Task 63
27      Task 2
28      Task 2 get R1         4→1
31      Task 2 get R2         1→1
33      Task 2 release R2     1→1
33      Task 2 release R1     1→4
33      Task 1
34      Task 1 get R1         2→1
36      Task 1 release R1     1→2
37      Task 2
38      Task 63
```

Crediting :

[PART I] NPCS Implementation [50%]

- The screenshot result (with the given format) of the two task sets. (Time tick 0-100) (10%)
- A report that describes your implementation, including scheduling results of two task sets, modified functions, data structure, etc. (please **ATTACH** the screenshot of the code and **MARK** the modified part). (40%)

[PART II] CPP Implementation [40%]

- The screenshot result (with the given format) of the two task sets. (Time tick 0-100) (10%)
- A report that describes your implementation, including scheduling results of two task sets, modified functions, data structure, etc. (please **ATTACH** the screenshot of the code and **MARK** the modified part). (30%)

[PART III] Performance Analysis [10%]

- Compare the scheduling behaviors between NPCS and CPP with the results of PART I and PART II. (5%)
- Explain how NPCS and CPP avoid the deadlock problem. (5%)

※ You must modify the source code.

Project submit:

Submit to Moodle

Submit deadline: January 6, 2021 (Wednesday) 13:00

File name format: RTOS_your student ID_PA3.zip

RTOS_your student ID_PA3.zip includes :

- The report (RTOS_your student ID_PA3.pdf).
- The files you modify (main.c, os_core.c , etc.)

Hints:

1. In the application region, we define priorities of tasks and shared resources.

```
#define R1_PRIO 1
#define R2_PRIO 3
#define TASK1_PRIORITY      2
#define TASK2_PRIORITY      4
```

2. We also declare shared resource, as follows:

```
OS_EVENT* R1;
OS_EVENT* R2;
```

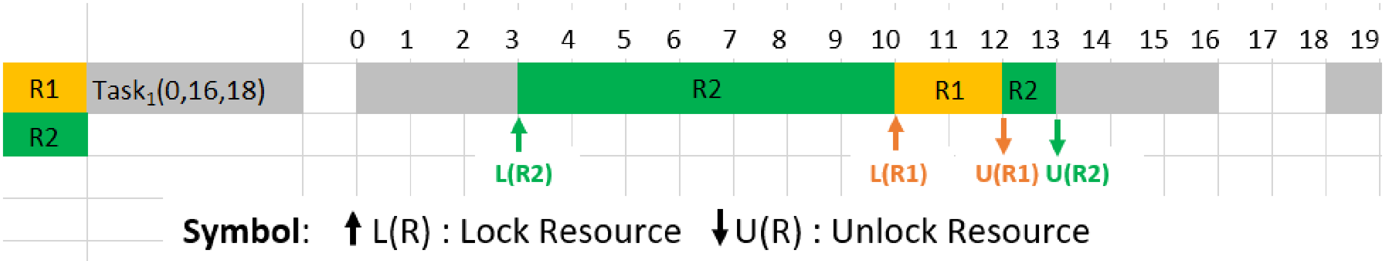
3. In main function, we not only create tasks but also create shared resources.

```
INT8U err;
R1 = OSMutexCreate(R1_PRIO, &err);
R2 = OSMutexCreate(R2_PRIO, &err);
```

4. To simulate the duration that a resource is held, we can program a function to implement it:

```
void mywait(int tick)
{
#if OS_CRITICAL_METHOD==3
    OS_CPU_SR cpu_sr = 0;
#endif
    int now, exit;
    OS_ENTER_CRITICAL();
    now = OSTimeGet();
    exit = now + tick;
    OS_EXIT_CRITICAL();
    while (1) {
        if (exit <= OSTimeGet())
            break;
    }
}
```

5. To modeling a task’s behavior, we can program the task function as following:




```c
void task1(void* pdata)
{
    INT8U err;
    while (1)
    {
        printf("%d\tTask 1\n", OSTimeGet());
        mywait(3);
        printf("%d\tTask 1 get R2\n", OSTimeGet());
        OSMutexPend(R2, 0, &err);
        mywait(7);

        printf("%d\tTask 1 get R1\n", OSTimeGet());
        OSMutexPend(R1, 0, &err);
        mywait(2);

        printf("%d\tTask 1 release R1\n", OSTimeGet());
        OSMutexPost(R1);
        mywait(1);

        printf("%d\tTask 1 release R2\n", OSTimeGet());
        OSMutexPost(R2);
        mywait(3);
        OSTimeDly( T1_Deadline - OSTimeGet());
    }
}
```