RT Assignment

Leonardo Carnevali - 0001175233, Jacopo Ferri - 0001159364, Lorenzo Tucci - 0001190439

1 Task and Resource Table

Table 1 shows the specification of tasks and their use of shared resources.

Tasks	T_i	ϕ_i	C_i	$t(R_1)$	δ_{i,R_1}	$t(R_2)$	δ_{i,R_2}	$t(R_3)$	δ_{i,R_3}
τ_1	10	2	3	1	1	–	–	–	–
τ_2	15	1	4	0	3	1	2	–	–
τ_3	30	0	8	3	3	5	3	1	7

Table 1: Task Set and Resource Usage

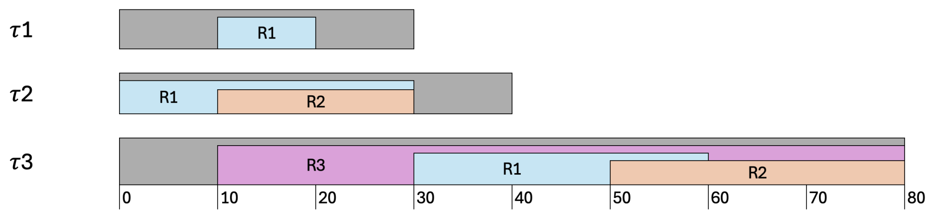

Figure 1: Task Set and Resource Usage

2 Feasibility Analysis

As first step we check the necessary condition for feasibility:

$$U_p = \sum_{i=1}^{n} U_i = \frac{3}{10} + \frac{4}{15} + \frac{8}{30} = \frac{25}{30} \approx 0.83334 \leq 1$$

It turns out that the condition is respected. We are going to use PIP and HLP protocols, thus it's necessary the use of extended analysis feasibility techniques that involves the blocking time, because a task τ_i can only be blocked by critical sections belonging to lower-priority tasks with a semaphore ceiling higher than or equal to P_i. The blocking time of the tasks results the same for both PIP and HLP protocols:

Tasks	δ_{i,R_1}	δ_{i,R_2}	δ_{i,R_3}	B_i^{PIP}	B_i^{HLP}
τ_1	1	–	–	3	3
τ_2	3	2	–	3	3
τ_3	3	3	7	0	0

Table 2: Task Set and Resource Usage

For PIP the blocking time is an estimate of the worst case for a task to be blocked, as a consequence it doesn't give an exact information about the feasibility.
Now, since we only have periodic tasks ($D_i = T_i$), we use LL Bound. Periods of tasks τ_1 and τ_3 are in harmonic relation, so we can group them:

$$\sum_{k=1}^{2} \frac{C_k}{T_k} + \frac{C_i + B_i}{T_i} \leq i(2^{\frac{1}{i}-1})$$

For τ_1 and τ_2 the condition is respected, while for τ_3 it is : $U_p \approx 0.833 > U_{LL}^{(2)} = 0.828$. Then using LL Bound we can't say that the task set is feasible, so we proceed using the Hyperbolic Bound (HB). We group τ_1 and τ_3 also in this case:

$$\prod_{k=1}^{2} (\frac{C_k}{T_k} + 1)(\frac{C_i + B_i}{T_i} + 1) = (\frac{3}{10} + \frac{8}{30} + 1) \approx 1.8577 \leq 2$$

The condition is respected, so we can say that the task set is feasible.

3 PIP - Priority Inheritance Protocol

Using PIP with phased job activation the simulation on VxWorks is almost identically equal to the theoretical schedule done by hand (ignoring the jitter of the simulation that cause different computation time related to each section of the tasks). It is shown in the following images:

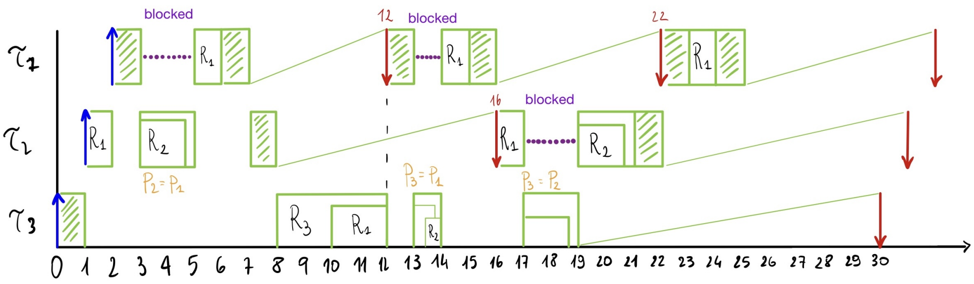

Figure 2: Task set scheduled by hand using Priority Inheritance Protocol

In the figure 2 are shown 3 different blocks done by lower priority tasks but no deadlock situation arise. The schedule guarantees that the task can execute before their period on the entire hyperperiod.

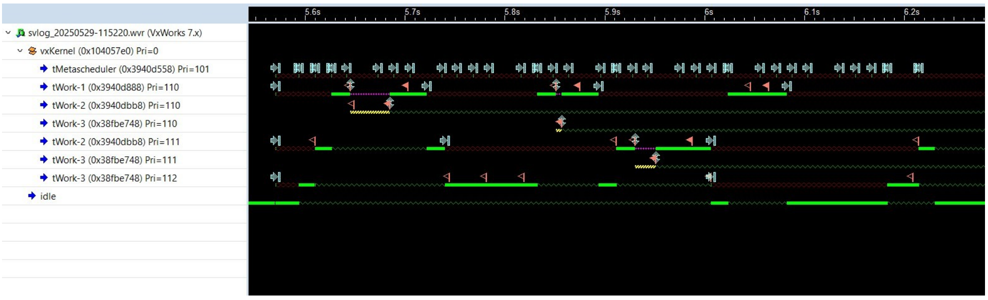

Figure 3: Task set scheduled by VxWorks simulator using Priority Inheritance Protocol

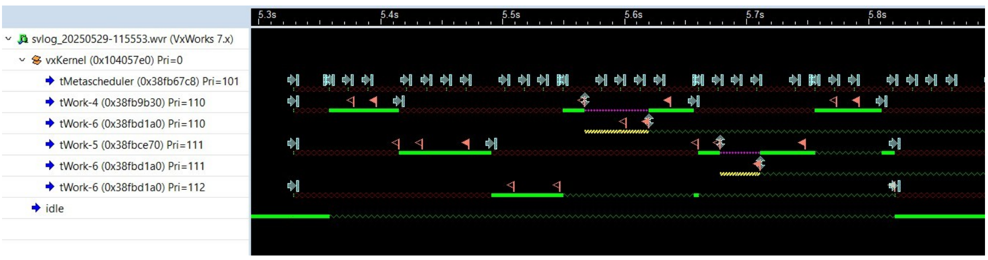

Figure 4: Simulation using Priority Inheritance Protocol with synchronous start

This simulation shows that even if the feasibility study is in some way "weak", due to the high utilization factor, the task are still schedulable, even with the synchronous start.

4 HLP - Highest Locker Protocol

As in the previous case, we started with the handwritten Gantt Chart in order to study the theoretical scheduling sequence and to compare it with the results of the simulation. The schedulability analysis of our task set using the Highest Locker Protocol (HLP) reveals a critical decision point at time unit 16, where τ_2 and τ_3 are both eligible for execution. In the first case, where τ_3 continues its execution, the scheduling proceeds without issues. However, in the second case, where a new instance of τ_2 resumes execution, a deadlock situation arises after one time unit: τ_2 requests access to resource R_2 currently held by τ_3, which has a lower priority. Indeed a deadlock occurs when we have simultaneously *Mutual Exclusion*, *Hold and wait*, *No preemption of resources*, *Circular wait* and this is the case. This scenario highlights that applying HLP, this specific task set may result incorrectly schedulable, due to the potential for unresolved blocking when multiple tasks contend for resources.

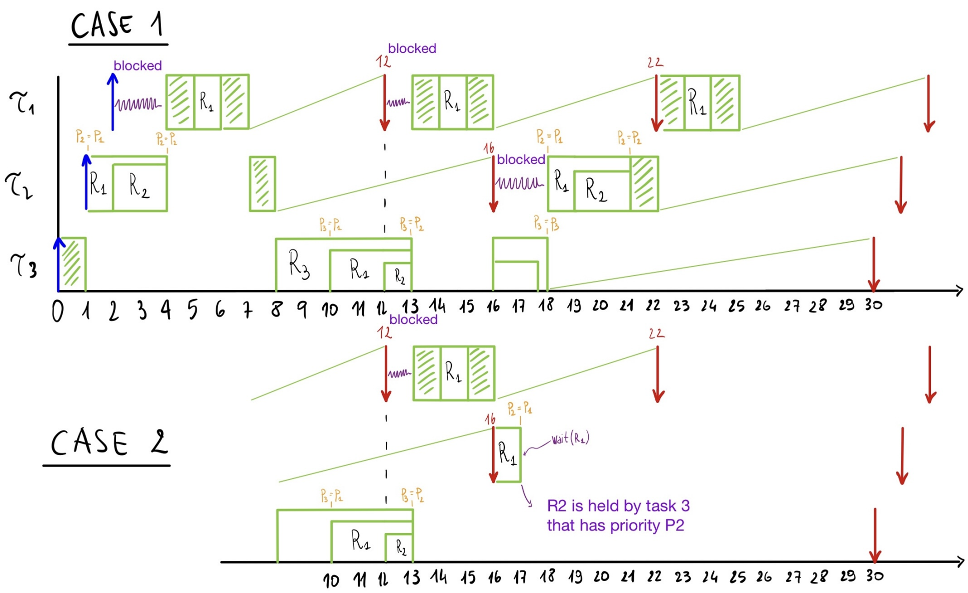

Figure 5: Task set scheduled by hand using Highest Locker Protocol

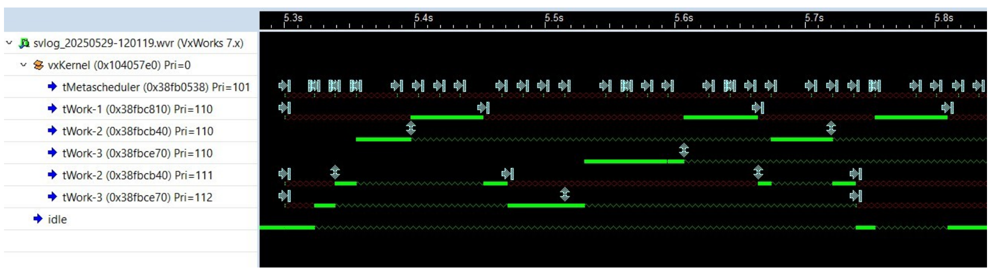

Figure 6: Simulation using Highest Locker Protocol with asynchronous start

Looking at the simulation the task set is feasible using HLP. It happens because the timings of the computer and the simulator are not properly the ideal ones and so the task τ_3 releases its resources before τ_2 requires one of them.