The Real-Time Multi-Resource Task Model

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Heterogeneous Systems for Real-Time Computing

- Integrate additional specialized resources such as FPGA, GPU
  - high performance
  - energy efficiency
  - highly reactive systems that interact with other environments

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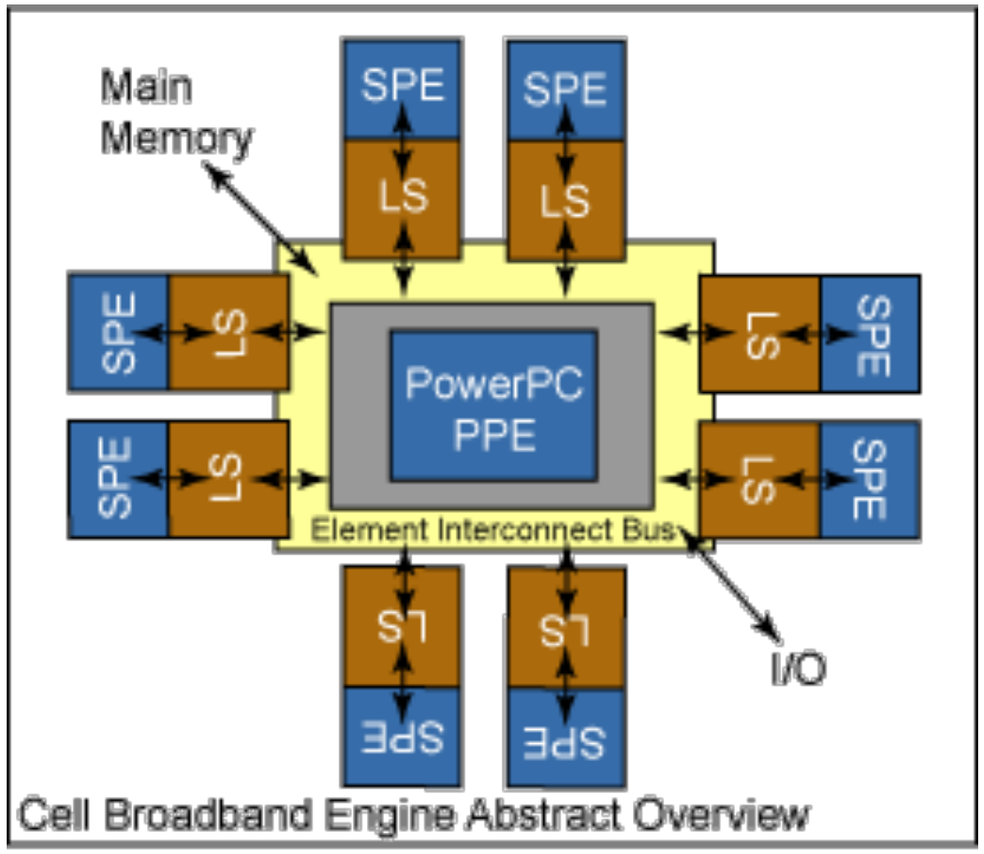
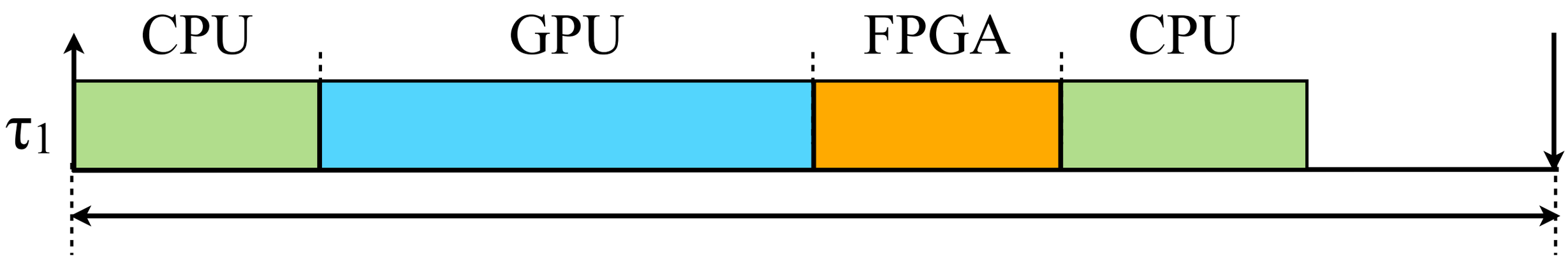


- IBM cell architecture
  - One "general" processor with eight "specialized" processors
  - Specialized processors designed for handling vectorized floating point code execution

Real-Time Sporadic Multi-Resource (SMR) Task Model

- Model real-time tasks that access multiple resources during execution
  - ➡ Extend the sporadic task model
  - ➡ Sporadically release jobs
  - ➡ Each job contains several phases, each executed on a specific resource

Real-Time Sporadic Multi-Resource (SMR) Task Model



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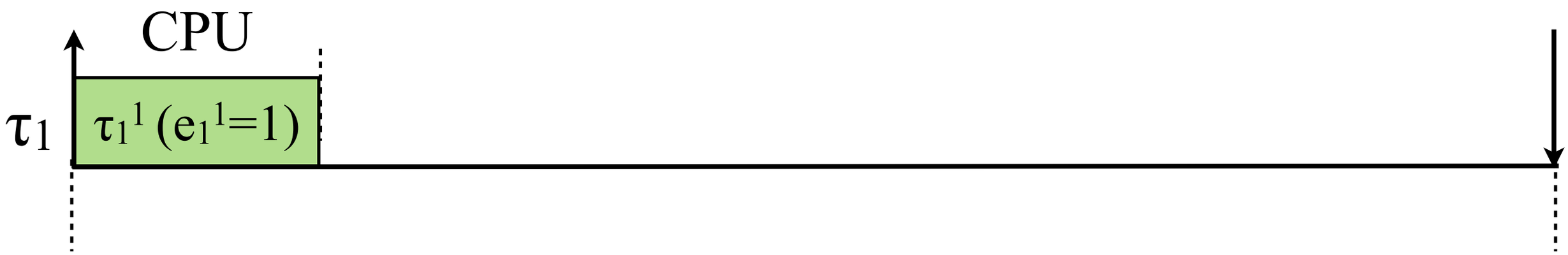

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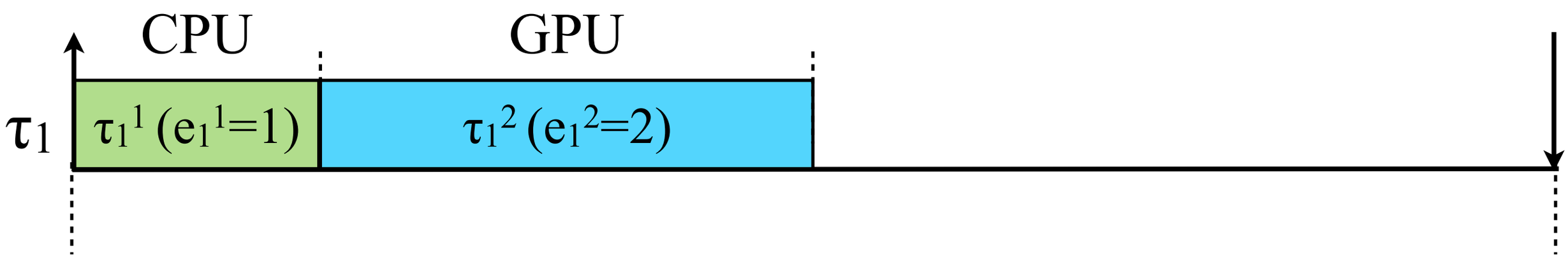

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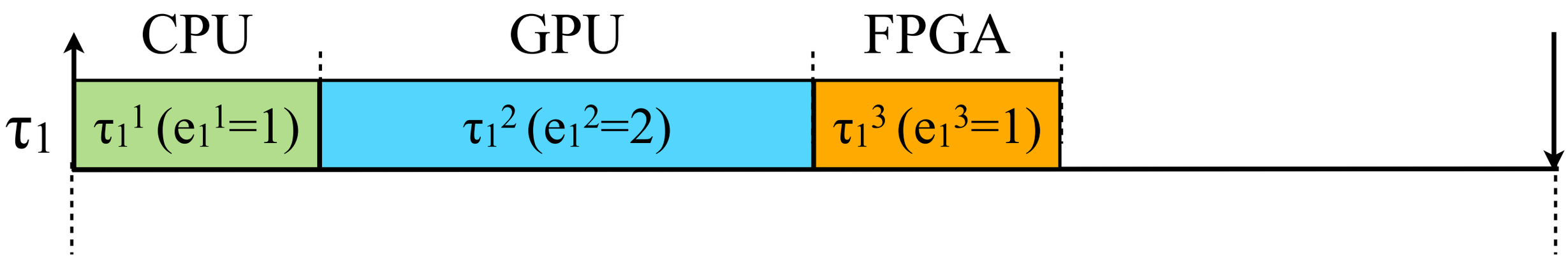

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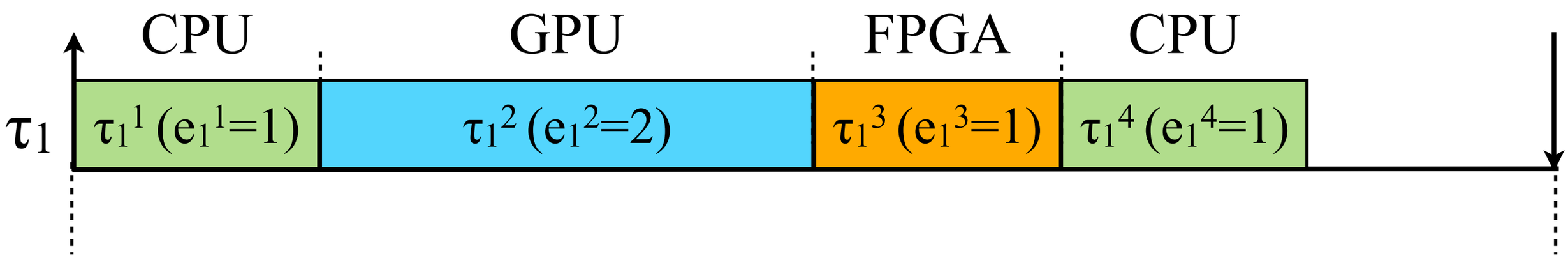

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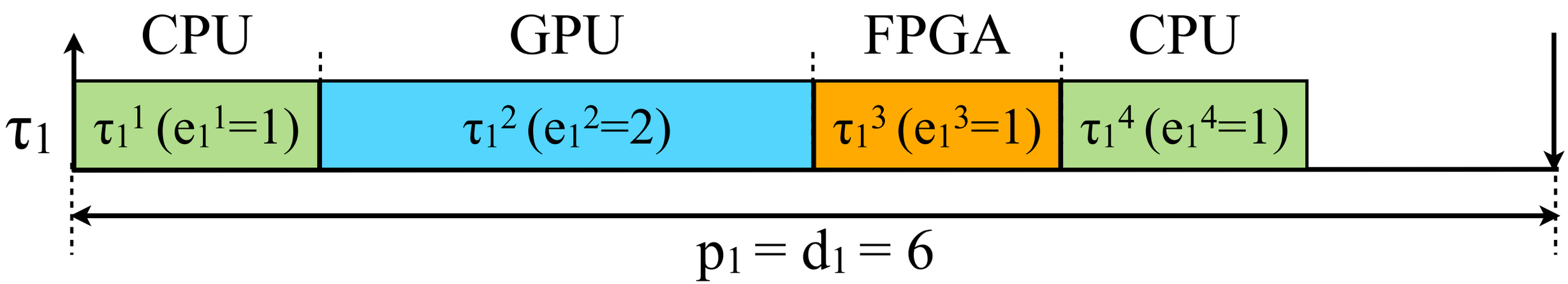

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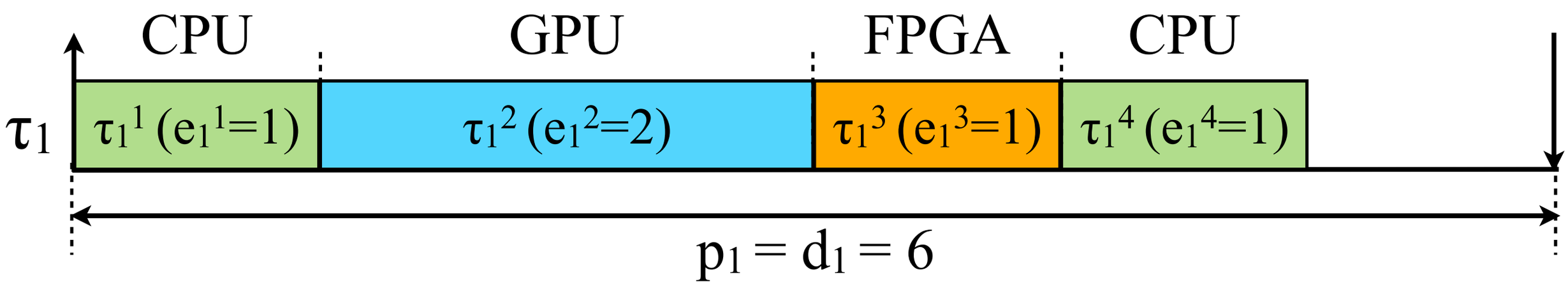


- Utilization on CPU = 2 / 6

Scheduling Restrictions on Certain Resources

- Non-preemptivity or non-job-migration restrictions
  - GPU: non-preemptive
  - Job migrations may cause significant overheads on resources such as GPU and FPGA

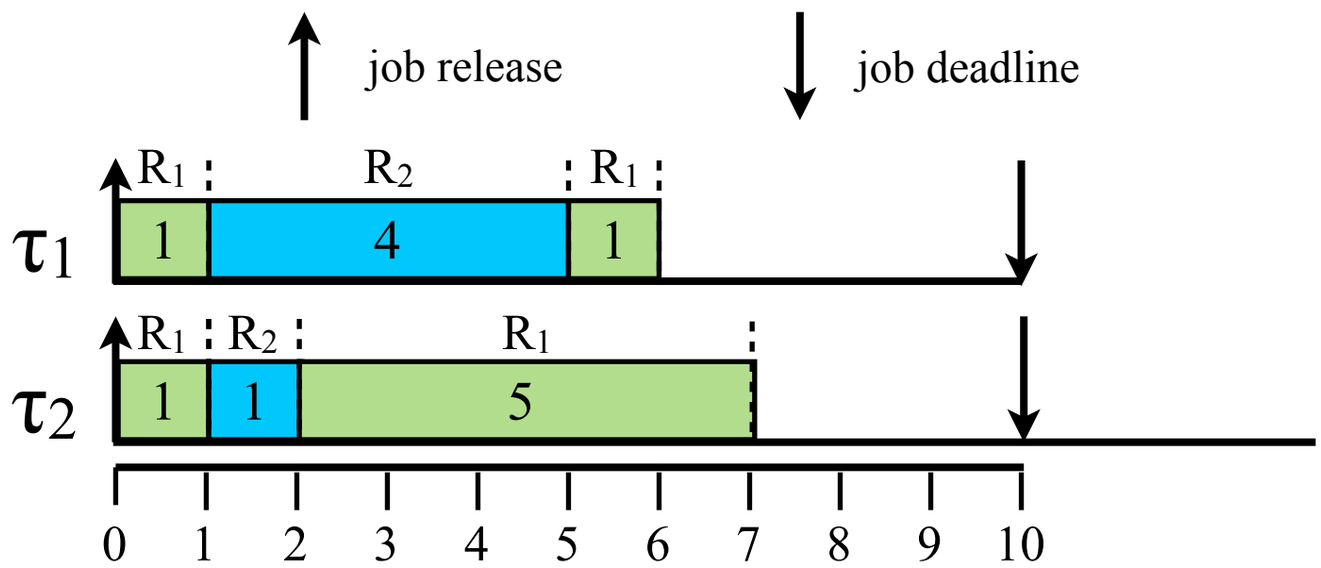
The Open Problem

How to schedule a set of hard real-time SMR tasks on a heterogeneous platform consisting of multiple types of resources, where each type of resource may have multiple processors and require certain scheduling restrictions?

The Challenge

- Difficult due to precedence constraints and interferences between executions of tasks on multiple resources

The Challenge



- Two SMR tasks executed on two resources, where R_1 has two processors and R_2 has one processor
- Lightly loaded system: 0.8 and 0.5 for the total utilization on R_1 and R_2, respectively

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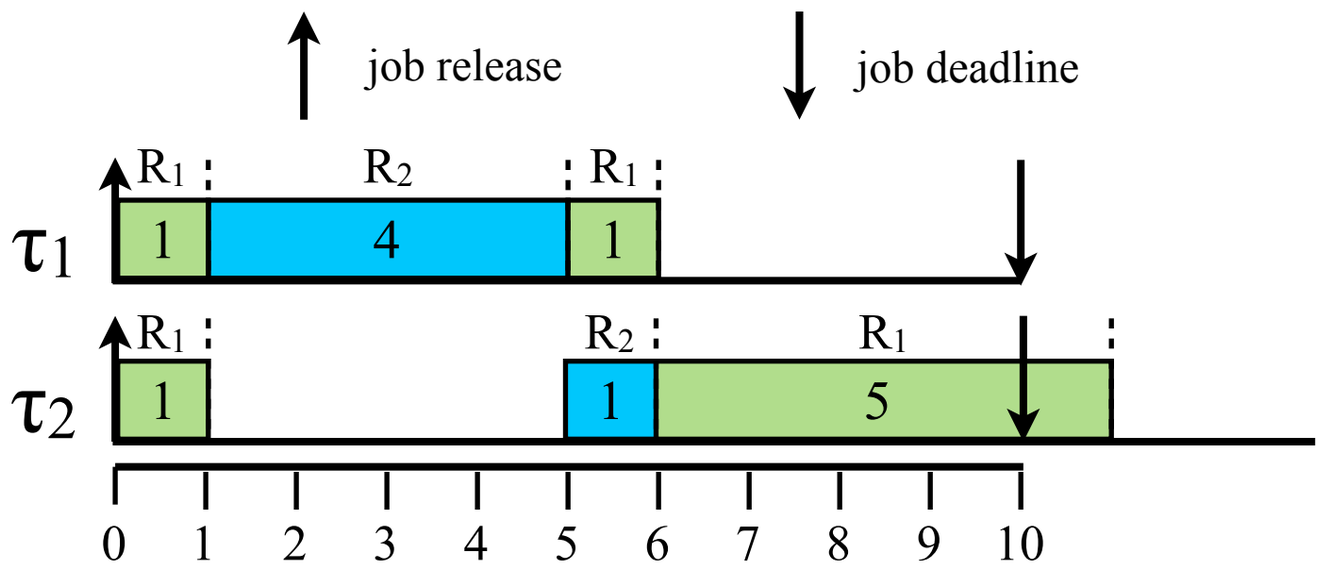

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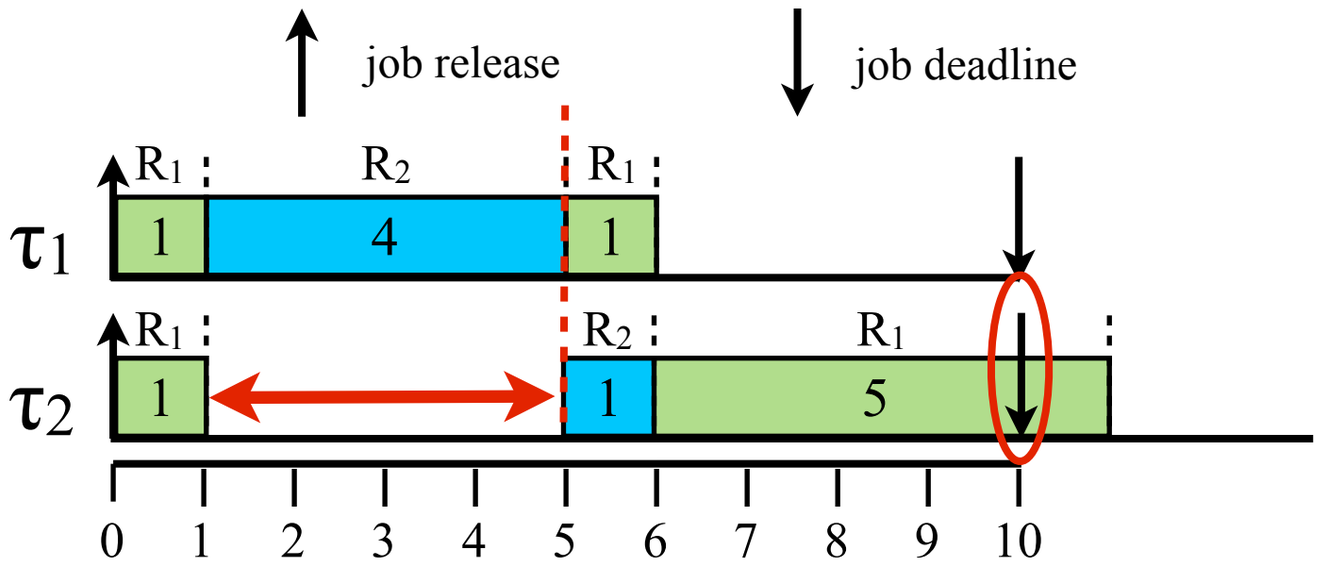

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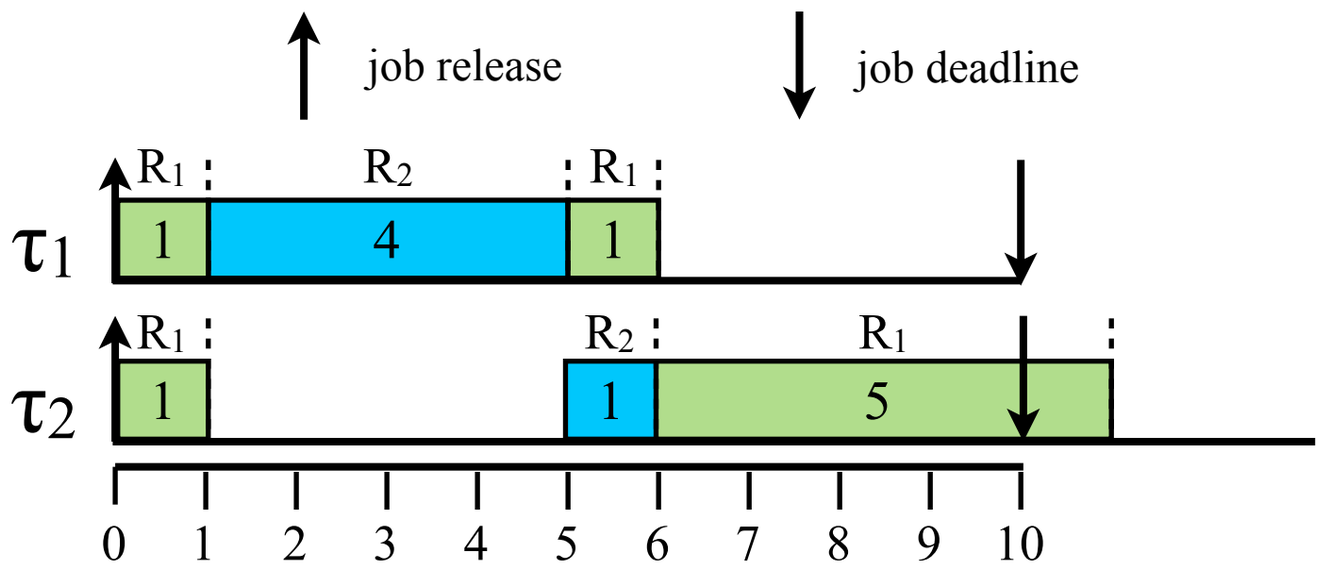
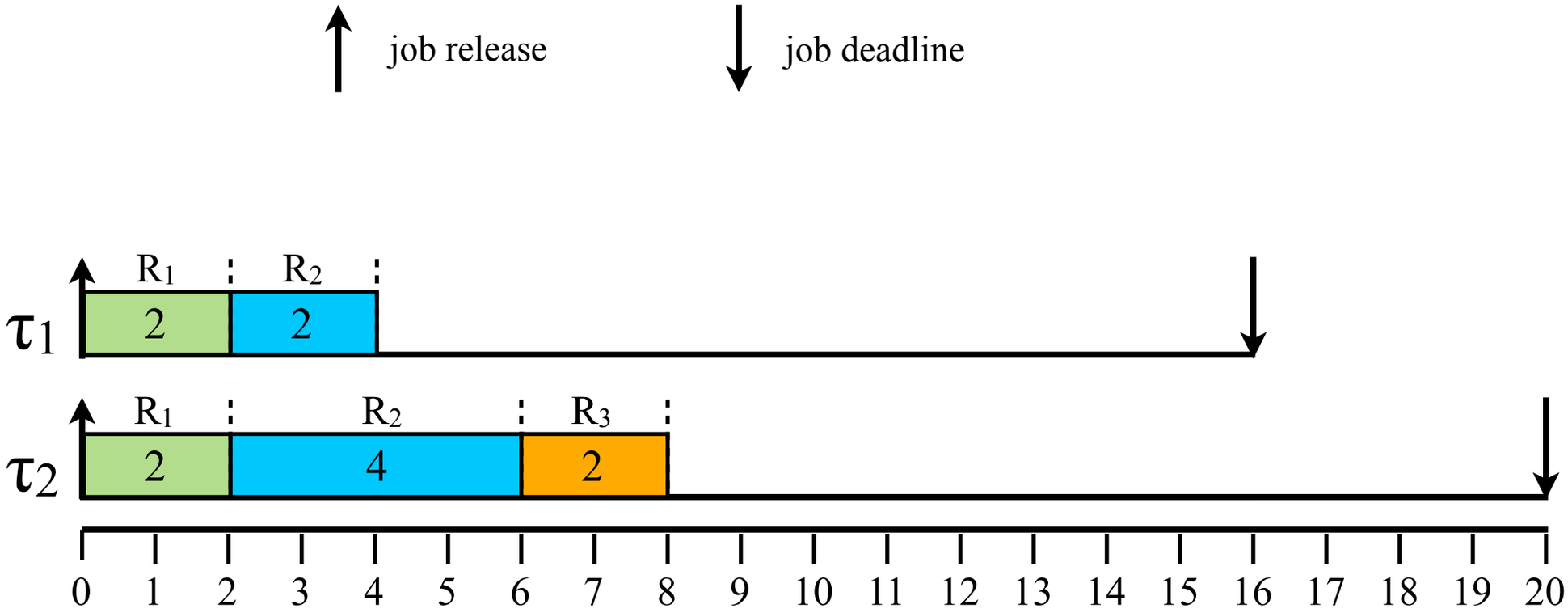


The precedence constraints among phases belonging to the same SMR task plus the interferences brought by other tasks quite negatively impact schedulability

An Intuitive Approach: Assigning Intermediate Releases and Deadlines

- Each phase of an SMR task is transformed into a constrained-deadline subtask
  - ➡ Each subtask requests a single resource
  - ➡ Apply corresponding existing schedulability tests on each resource
  - ➡ The original SMR task system is schedulable if the transformed subtasks on every resource are schedulable

An Example


job release
job deadline
τ_1
R_1
R_2
2
2
τ_2
R_1
R_2
R_3
2
4
2
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

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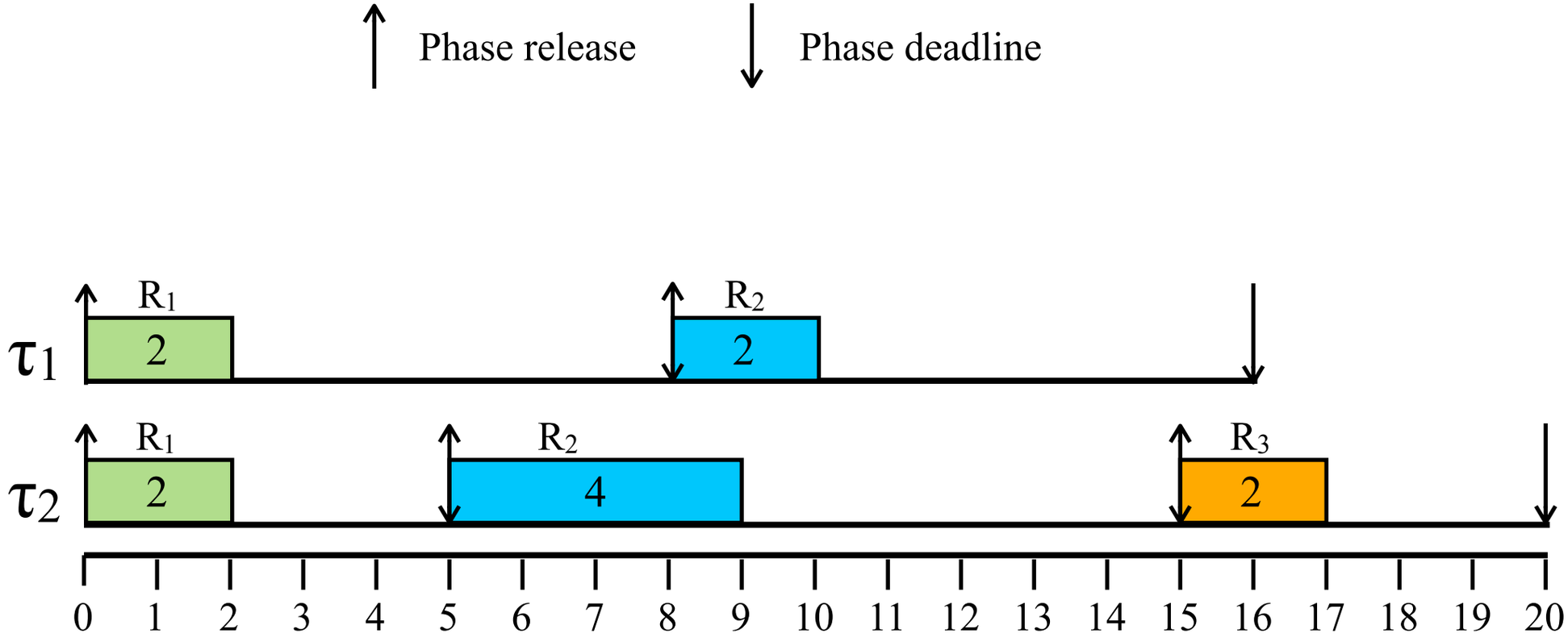

- If all phases of an SMR task can meet their assigned intermediate deadlines, they become independent from each other

Other Insights

- Study special cases
  - ➡ SMR task systems that only request two resources each of which contains a single processor
  - ➡ Execution times of all phases of all tasks are identical