



MAX PLANCK INSTITUTE
FOR SOFTWARE SYSTEMS



CISTER
Research Centre in
Real-Time & Embedded
Computing Systems

Increasing Fixed-Priority Schedulability using Non-Periodic Load Shapers

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Load Shaping

- ▶ It is a technique that **shapes the workload** of each job of a task
- ▶ Can be implemented as **a reservation server** (for each task)

In this work: the budget is replenished with a **given pattern** that might **not** be **periodic**

Resemblance

Traffic shaping: a computer network traffic management technique which delays some or all datagrams to bring them into compliance with a desired *traffic profile* [wiki].

Traffic shaping acts like a simple periodic reservation server.

Load Shaping vs. Simple Reservation

- ▶ Period transformation is based on dividing a task into “equal” sub-tasks which have the same period and budget.

Normal workload

$$\tau_1: (C_1 = 10, T_1 = 30, D_1 = 30)$$



Simple periodic reservation

$$\tau_1^R: (2, 6, 6)$$



Load shaping

$$\tau_1^S: (\langle 3, 0, 10 \rangle, \langle 7, 10, 30 \rangle)$$



$S_{i,j}: \langle c_{i,j}, r_{i,j}, d_{i,j} \rangle$

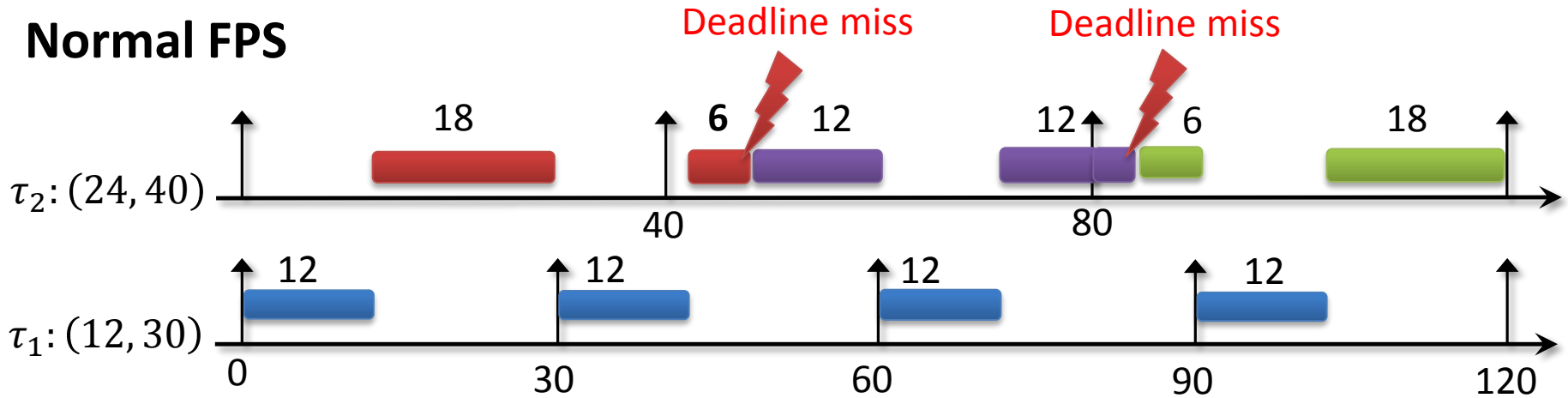
Each “sub-task” has a WCET, relative release time, and deadline.

What can We Do with Load Shaping?

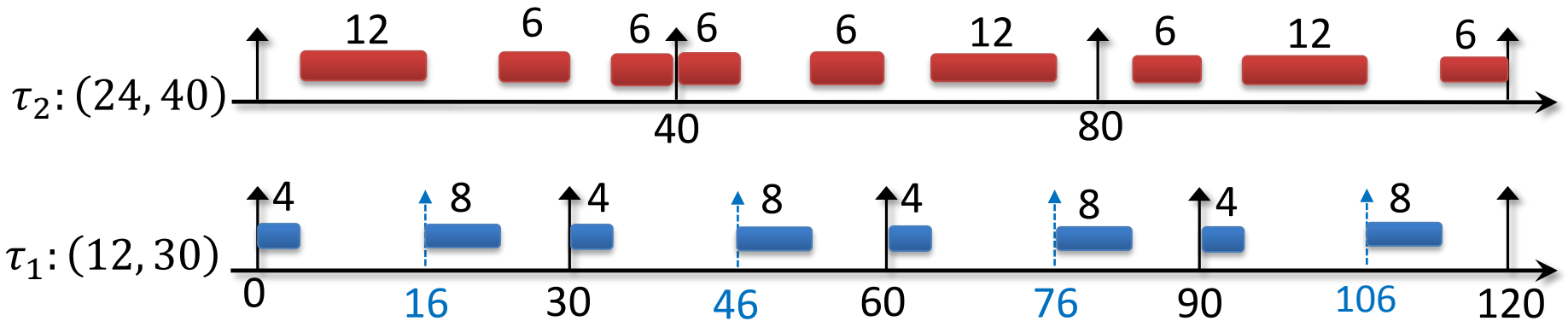
Improving schedulability of fixed-priority scheduling algorithms (FPS)

Example

Normal FPS



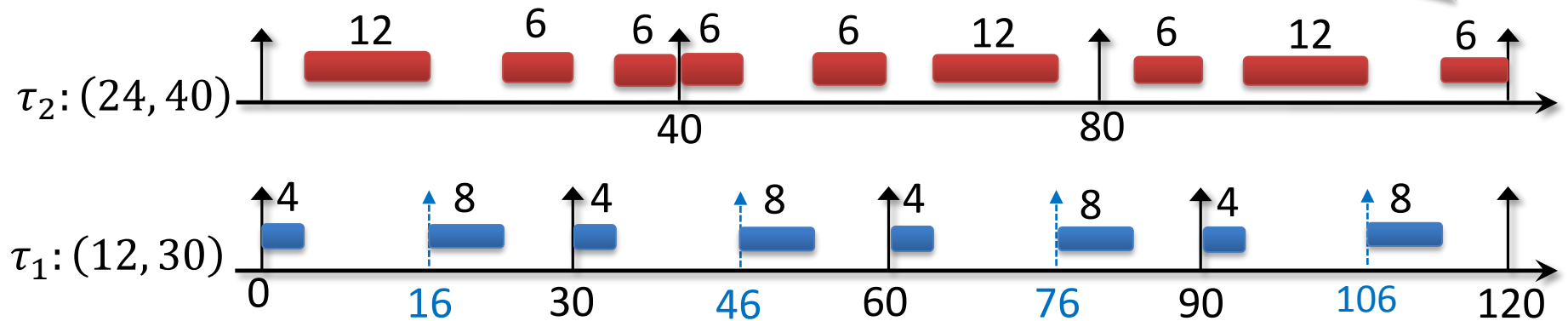
We use a shaper for τ_1 that has two sub-tasks



Example

If period transformation was used,
3 sub-tasks were needed per job

We use a shaper for τ_1 that has two sub-tasks



Open Problems

▶ Given:

- Uniprocessor
- Periodic tasks
- Release offsets
- Constrained (or arbitrary) deadline
- Dependent (or independent)

▶ Scheduled by FPS

- ▶ **Problem 1: Find shaper parameters such that the task set becomes schedulable and the number of sub-tasks is minimized.**

What can We Do with Load Shaping?

Improving schedulability of fixed-priority scheduling algorithms (FPS)

Optimizing/reducing the number of preemptions

Optimizing/Reducing the Number of Preemptions

- ▶ Use FPS to schedule the tasks
- ▶ Run each sub-task non-preemptively

If a task that too long is scheduled, other tasks with smaller period may miss their deadline.

We can break it such that it does not cause long blocking to other tasks

Normal workload

$$\tau_i: (C_i = 10, T_i = 30, D_i = 30)$$



Load Shaping

$$\tau_i^S: (\langle 3, 0, 10 \rangle, \langle 7, 10, 30 \rangle)$$



Load Shaping v.s. Fixed Preemption Point Placement

- Assume that each sub-task in load shaping is non-preemptive

FPS is work-conserving

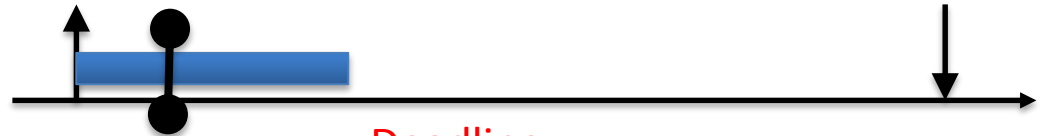
Normal workload

$$\tau_i: (C_i = 10, T_i = 30, D_i = 30)$$



Fixed Preemption Point

$$\tau_i: (C_i = \{3, 7\}, T_i = 30, D_i = 30)$$



$$\tau_1: (C_1 = 5, T_1 = 10, D_1 = 7)$$



Load Shaping

$$\tau_i^S: (\langle 3, 0, 10 \rangle, \langle 7, 10, 30 \rangle)$$



$$\tau_1: (C_1 = 5, T_1 = 10, D_1 = 7)$$



Load Shaping v.s. Fixed Preemption Point Placement

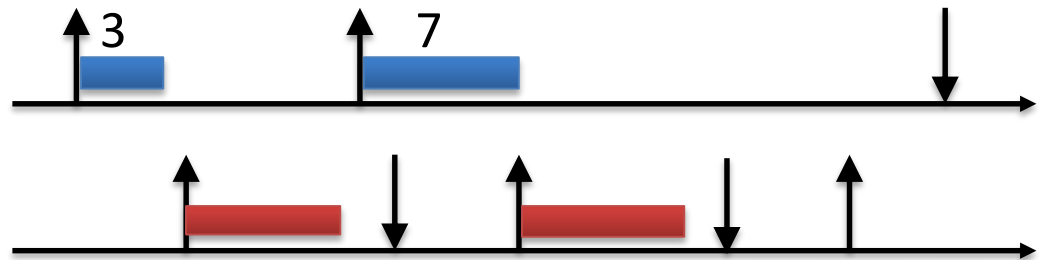
- ▶ Assume that each sub-task in load shaping is non-preemptive

With load shaping, we make FPS behave like a non-work-conserving algorithm

Load Shaping

$$\tau_i^S: (\langle 3, 0, 10 \rangle, \langle 7, 10, 30 \rangle)$$

$$\tau_1: (C_1 = 5, T_1 = 10, D_1 = 7)$$



Open Problems, cont.

▶ Given:

- Uniprocessor
- Periodic tasks
- Release offsets
- Constrained (or arbitrary) deadline
- Dependent (or independent)

▶ Scheduled by FPS

- ▶ **Problem 2: Find shaper parameters such that the task set remains/becomes schedulable and each sub-task is potentially executed non-preemptively.**

Summary

- ▶ Load shaping is a technique to shape the workload using a reservation server that is replenished with a given pattern.
- ▶ It is a generalization of periodic reservation servers

Improving FPS schedulability



A new approach for limited-preemptive scheduling



Open problems are finding shapers' parameters





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Questions

Thank you

