



Scheduling astronomical observations

Maher Mallem¹, Frédéric Vivien¹, Anne Benoit²

¹Inria, CNRS, ENS de Lyon, Université Claude Bernard Lyon 1, LIP, UMR 5668,
69342, Lyon cedex 07, France,

²ENS de Lyon, CNRS, Inria, Université Claude Bernard Lyon 1, LIP, UMR 5668,
69342, Lyon cedex 07, France

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$(2-\epsilon)$ -inapproximability

$O(\log(n))$ -approximation

Fixed-parameter tractability

Bounded slack

Bounded (slack+width)

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Figure: Time lapse photography (Animalia Life)

Altitude over time

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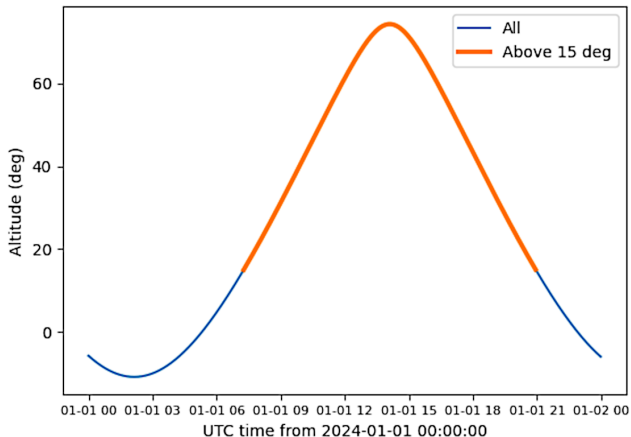
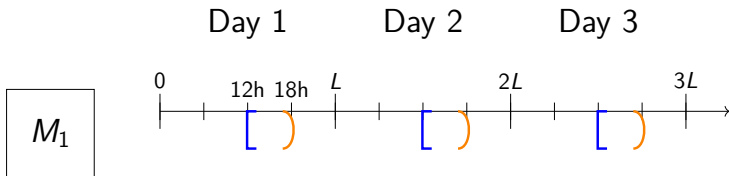


Figure: Altitude of star KELT 16 from the NenuFAR radio-telescope on 1 January 2024.

ROMA team, LIP, ENS de Lyon

Nov. 2024 - Apr. 2026

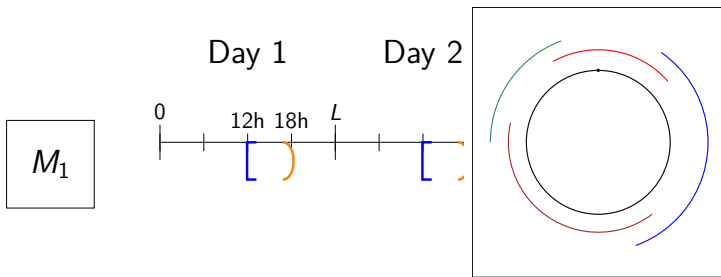
- *Topic:* Scheduling radio-astronomical observations.
 - Joint work with Frédéric Vivien and Anne Benoit.
 - Partnership with the ECLAT laboratory (HPC & AI for astronomy & astrophysics).
 - Access to NenuFAR radio-telescope usage data.



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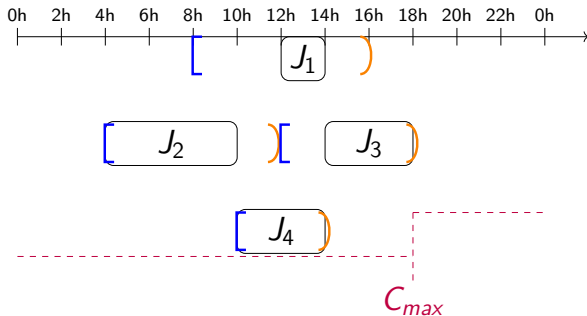
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Day m



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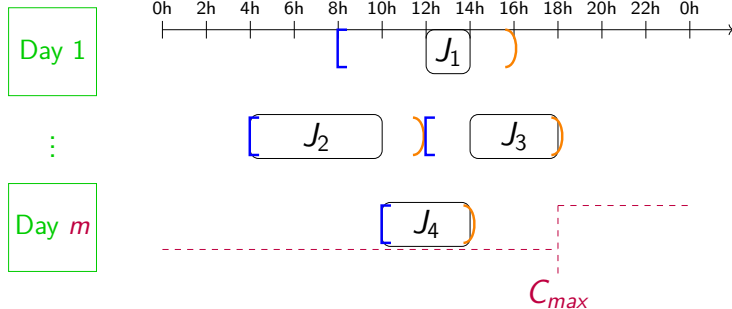
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One day: **strongly NP-complete** [Lenstra et al., 1977].

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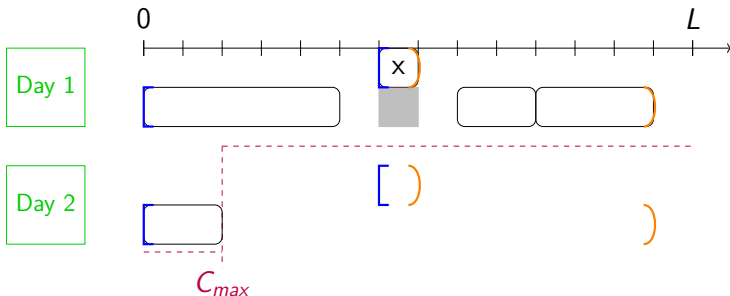
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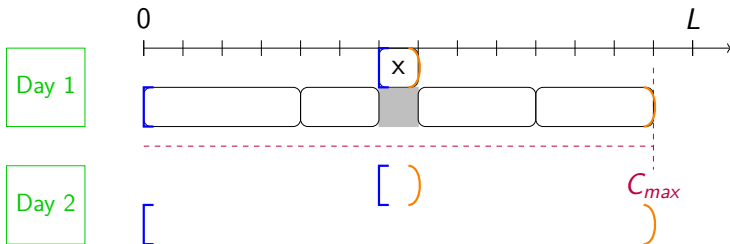
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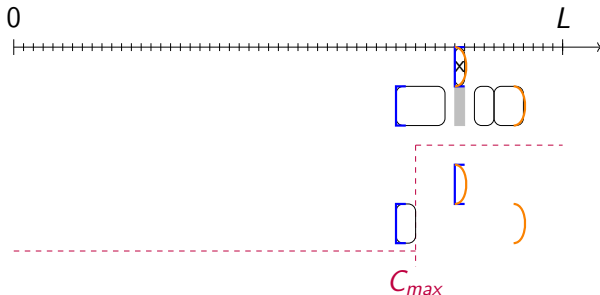
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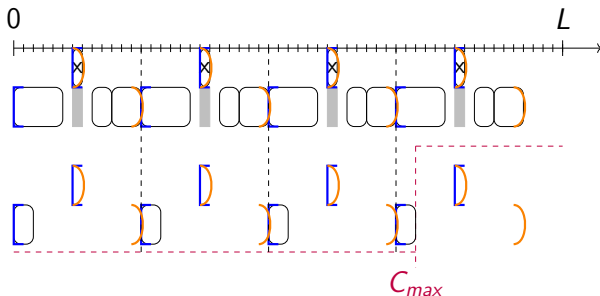
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Job Interval Selection problem.

- Goal: maximize the number of scheduled jobs.

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- **1/2-approximation**: “Earliest Completion Time”.
[Spieksma, 1999]

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Observation scheduling with isolated days.

- Goal: minimize the number of days.
 - $P|r_j, d_j| \min(m)$.

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- **Constant approximation algorithm?**

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Proposition

Any f -approximation algorithm with isolated days is a $[(2 + L/OPT) \cdot f]$ -approximation algorithm for observation scheduling.

$\mathcal{O}(\log(n))$ -approximation (cont.)

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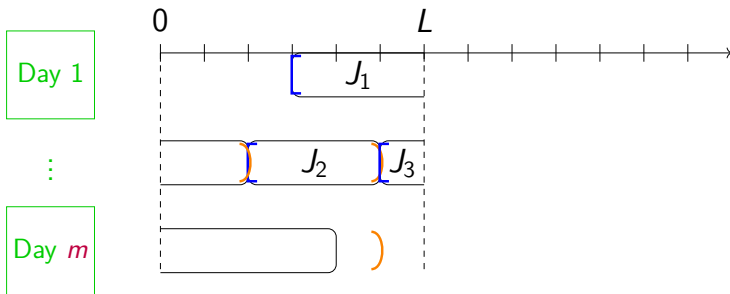
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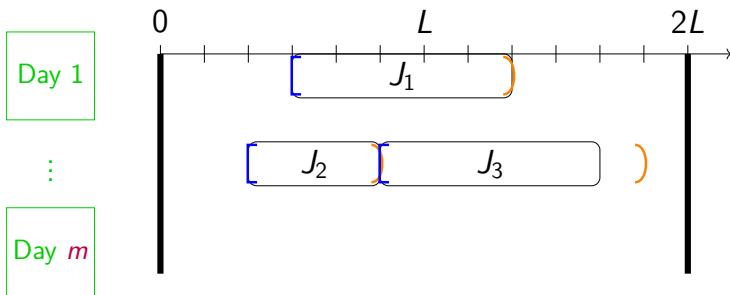
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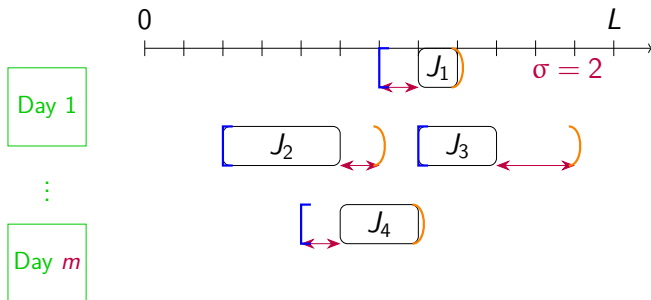
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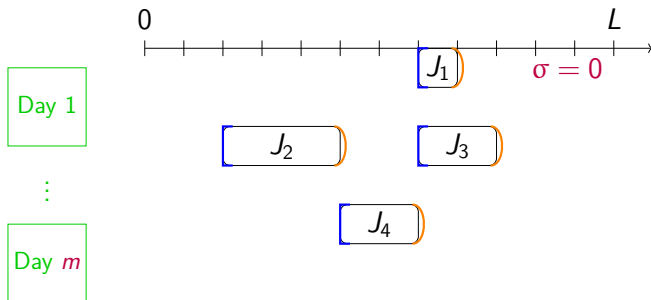
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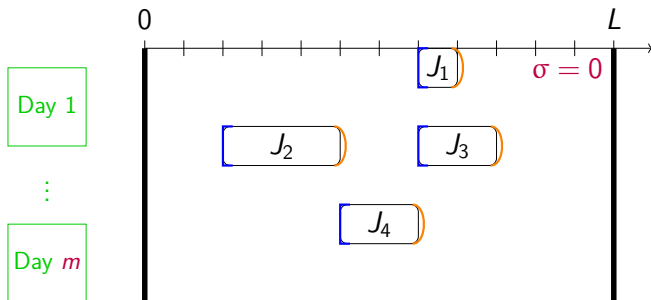
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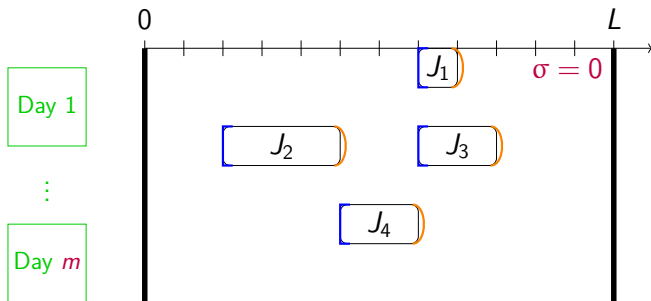
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Interval graph coloring: $\mathcal{O}(n \cdot \log(n))$ time.

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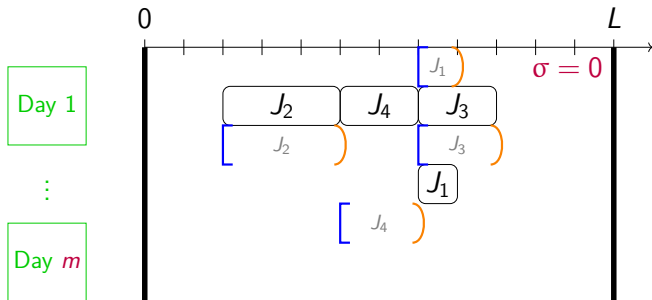
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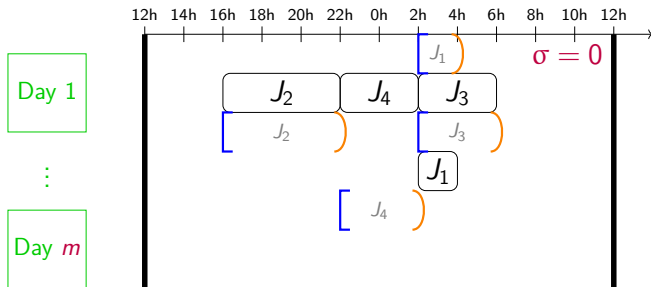
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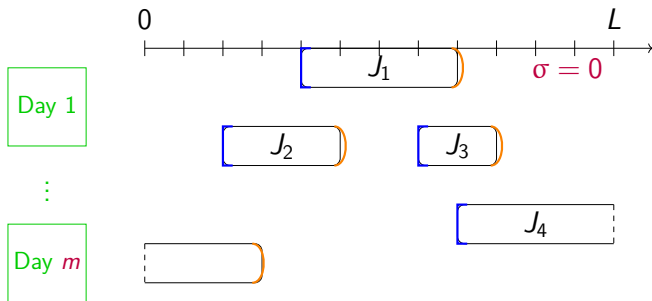
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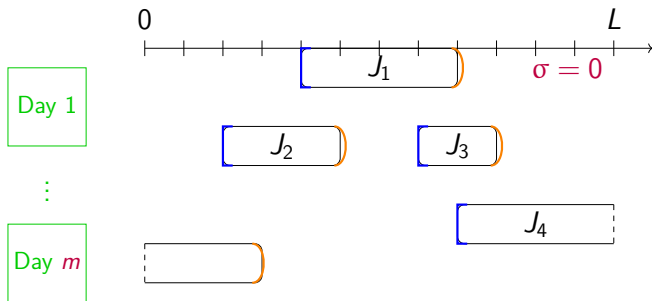
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Circular-arc graph coloring: **NP-complete** [Garey et al., 1980].

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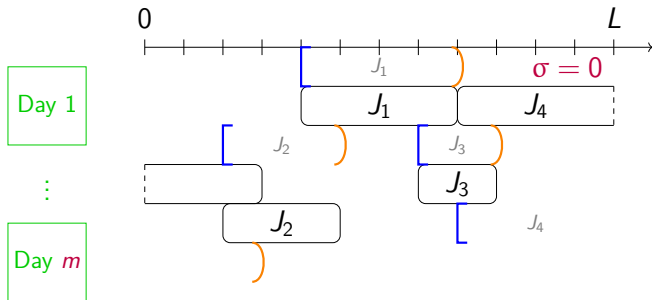
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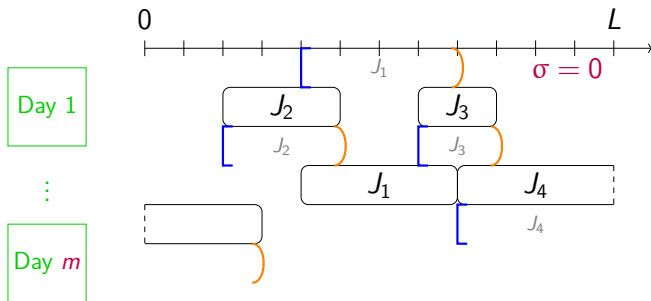
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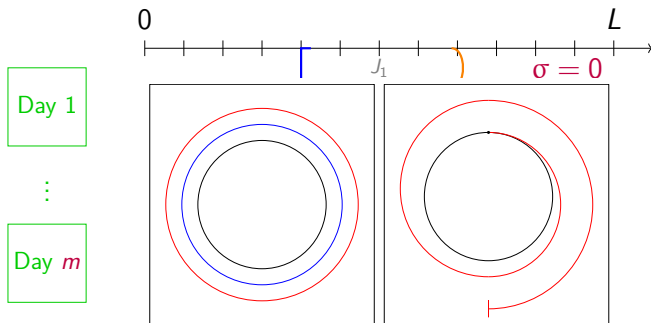
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Circular-arc graph coloring: **NP-complete** [Garey et al., 1980].

Multi-slot Just-in-time: $\mathcal{O}(n \log(n)^2)$ time [Dereniowski and Kubiak, 2010].

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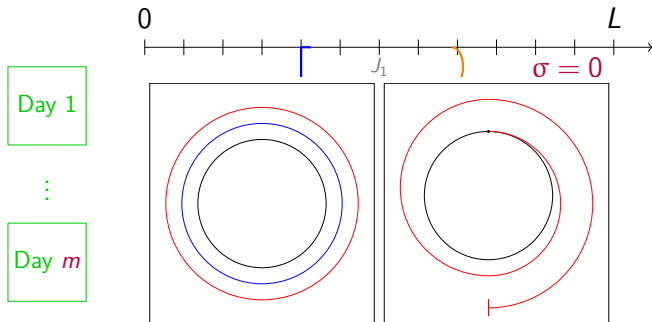
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→ TSP with a Gilmore-Gomory distance matrix.

[Gilmore and Gomory, 1964, Vairaktarakis, 2003]

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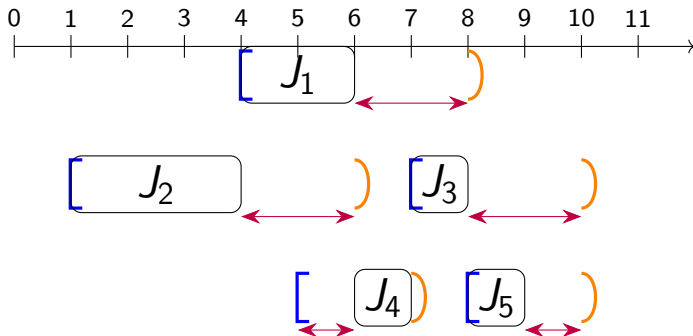
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$\sigma = 2$: **NP-complete** [Cieliebak et al., 2004].

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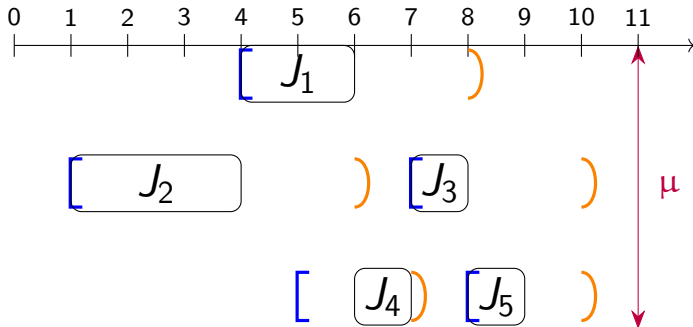
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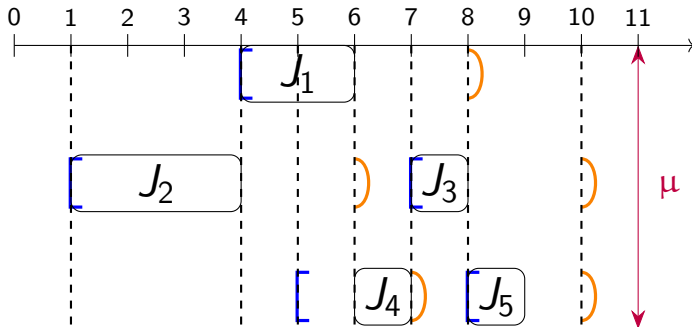
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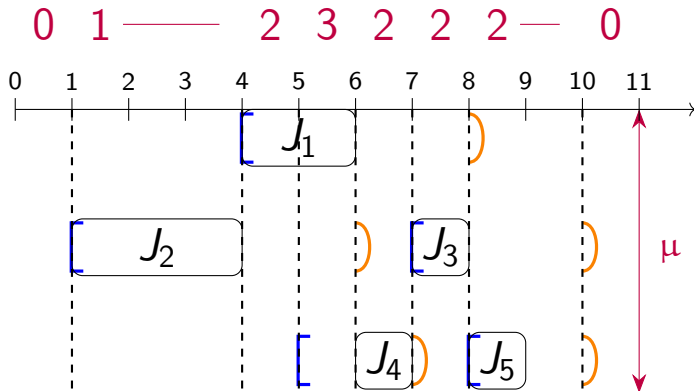
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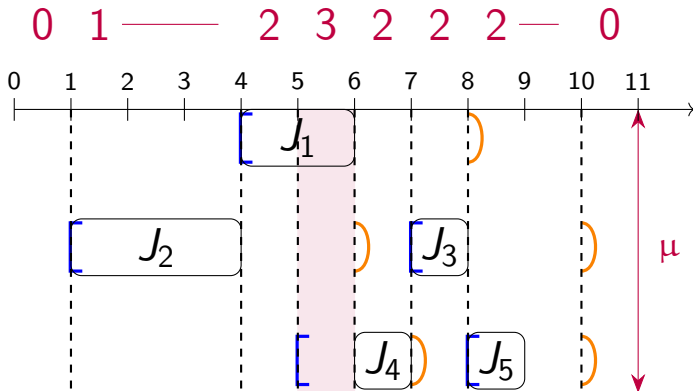
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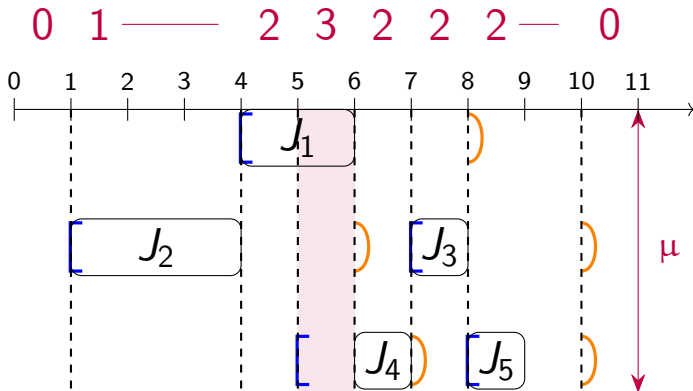
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$\mu = 4$: **NP-complete** [Hanan and Munier Kordon, 2023].

Border schedules

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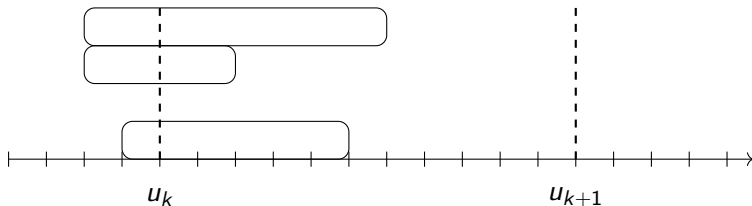
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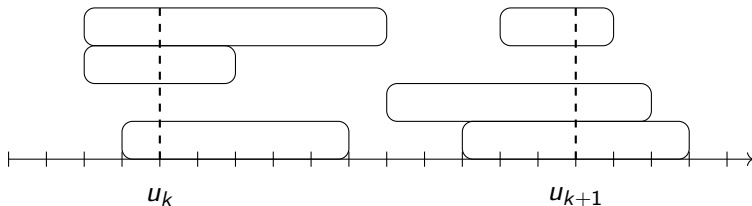
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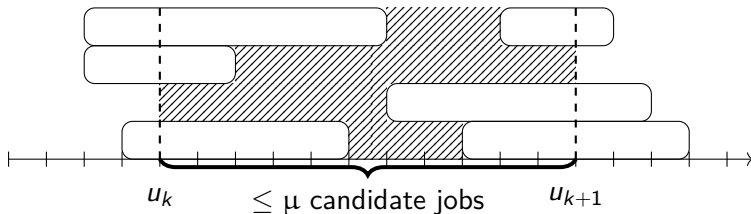
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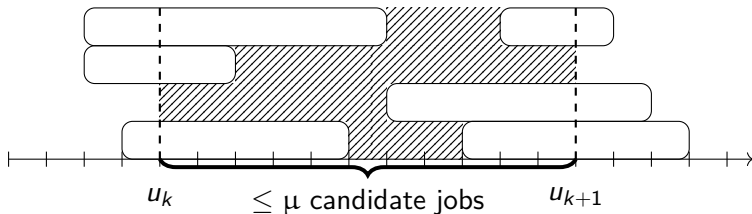
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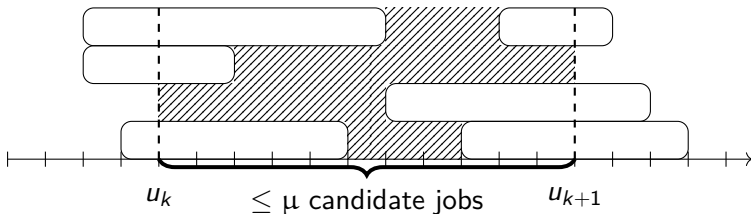
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Parameter definition

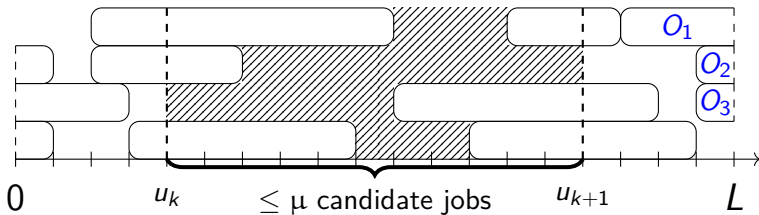
Border flexibility $\beta = \max_{J_j \in \mathcal{J}} [\min(p_j - 1, \sigma_j + 1)]$.



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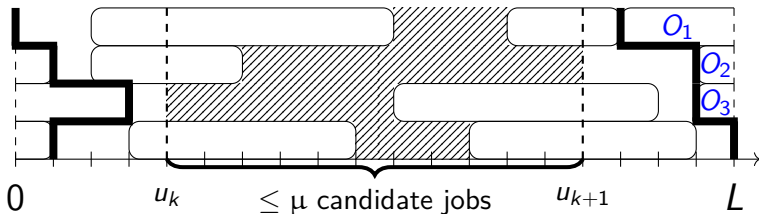
- $\mathcal{O}(2^\mu \cdot (\mu\beta + 1)^m)$ “border schedules” associated to u_k .
- Isolated days: in $\text{FPT}(\mu + \beta)$ [Hanan and Munier Kordon, 2023].



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Results

- $\mathcal{O}(\log(n))$ -approximation algorithm.
- No $(2 - \epsilon)$ -approximation algorithm (unless $P = NP$).
- Fixed-parameter tractability: $(\mu + \beta)$ and $(m + \sigma)$.

Future work

- Constant approximation algorithm?
- Improve the fixed-parameter algorithms.
 - $\mathcal{O}((\mu\beta + 1)^{3m-1} \cdot 2^{3\mu} \cdot m^\mu \cdot \mu \cdot n + n \cdot \log(n))$ time.
- “Earliest Start Time” performance guarantee?
- Refine the model: unary/fixed L ; limited preemption.



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