

A New Foraging-Based Algorithm for Online Scheduling

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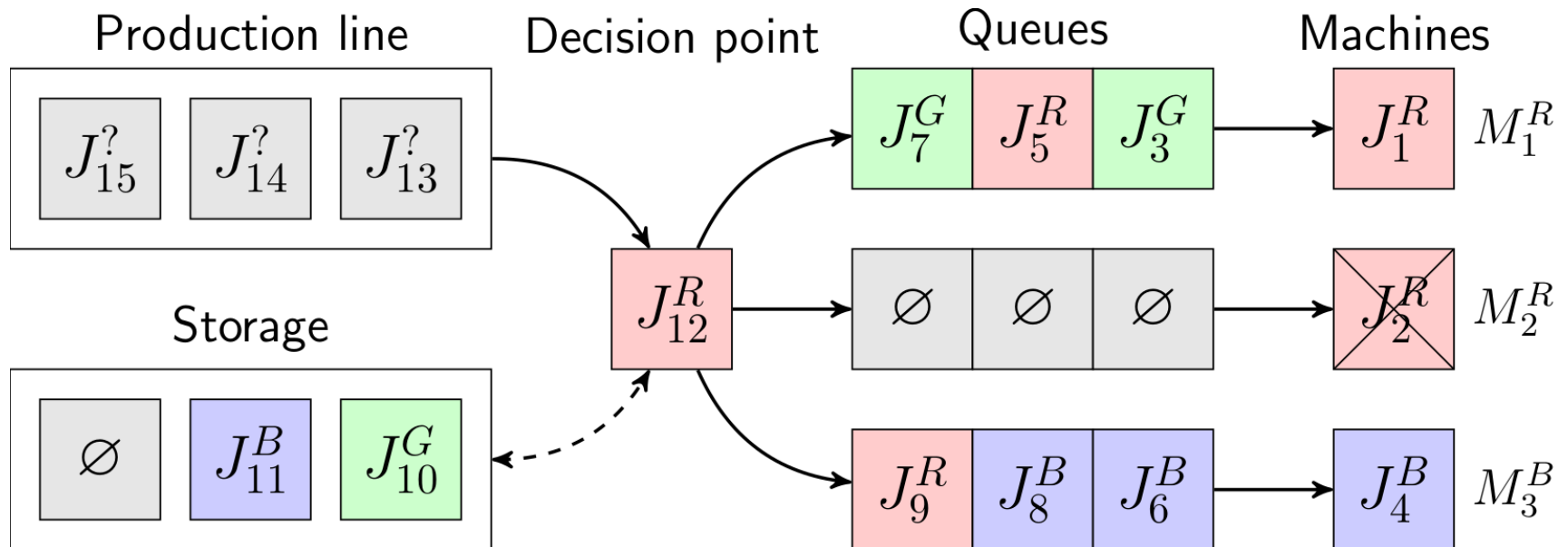
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Online scheduling

- Much work in scheduling
- Little in online scheduling
- Division of labour algorithms look promising
[Smith 2005, Ouelhadj+Petrovic 2009]

Truck painting problem

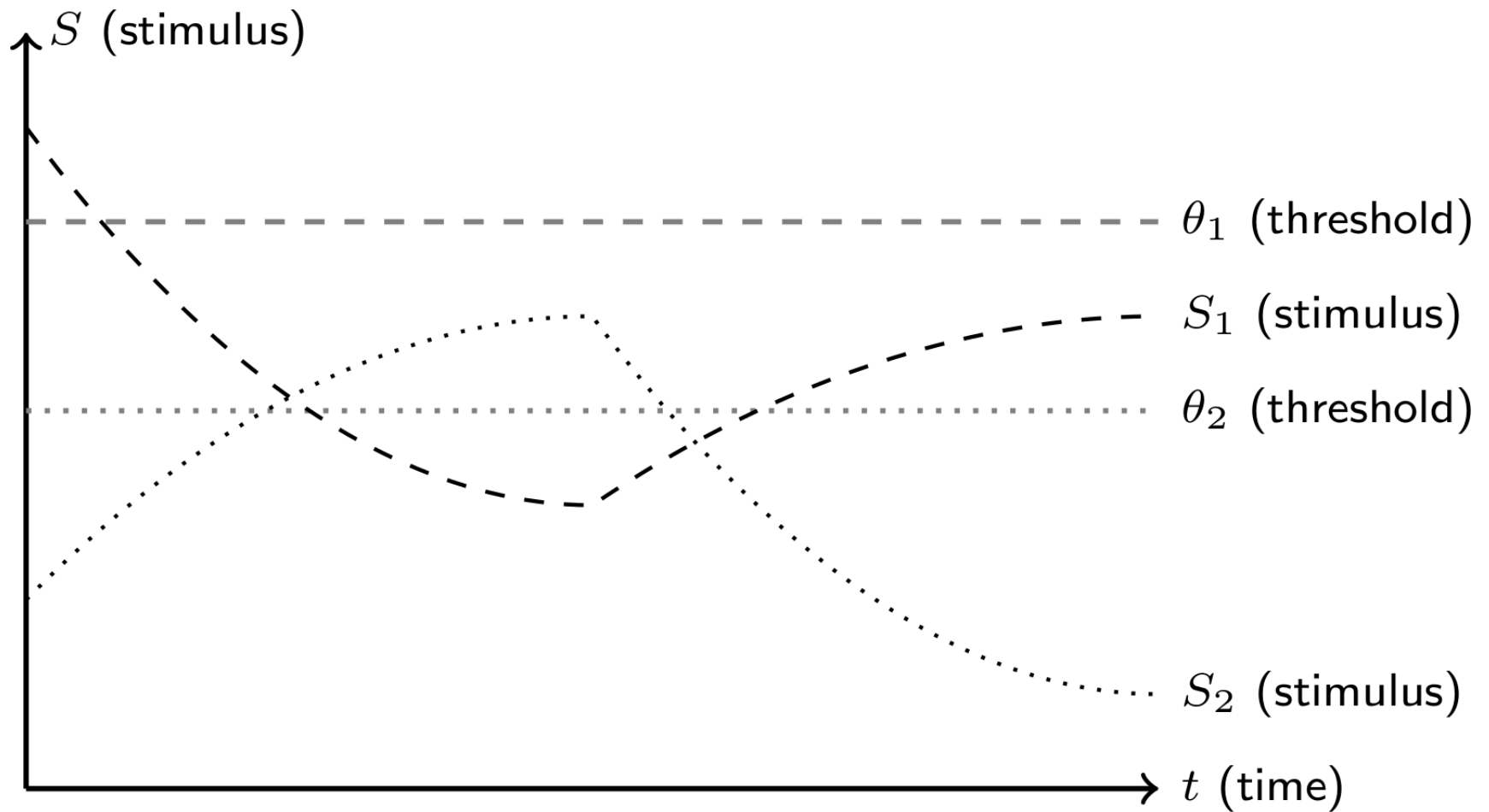
[Morley et al 1993,1996,1998]



Models of division of labour

- Multiple biological models
 - Threshold [Theraulaz et al 1998]
 - Foraging for work [Tofts 1993]
 - Self-reinforcement [Plowright+Plowright 1988]
 - Social inhibition [Gordon et al 1992]
 - Network [Beshers+Fewell 2001]
- Algorithms focus on the threshold model
[Theraulaz et al 1998, Campos et al 2000, Cicirello+Smith 2004] (and extensions by others)
- Why threshold and not any of the others?

Threshold model



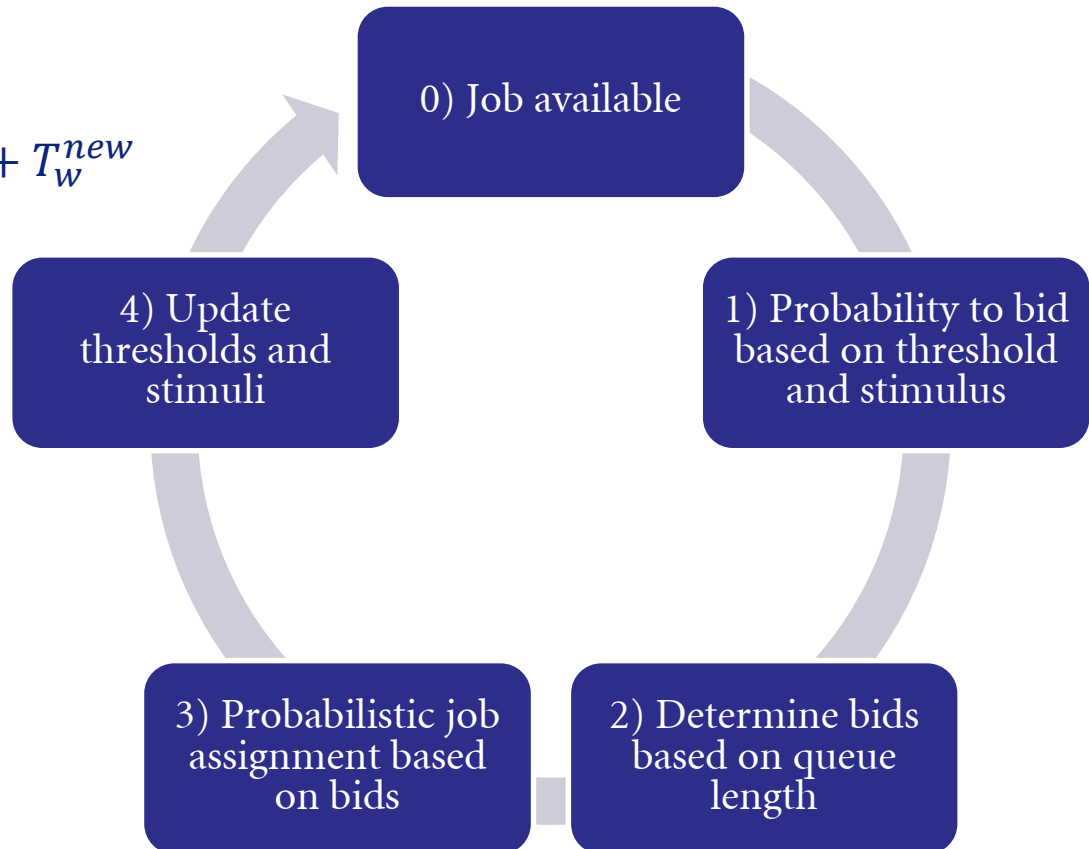
Ant task allocation [Nouyan et al 2002,2005]

$$1) P_w(\text{bid} | \theta_{w,j}, S_i) = \frac{S_i^2}{S_i^2 + \theta_{w,j}^2}$$

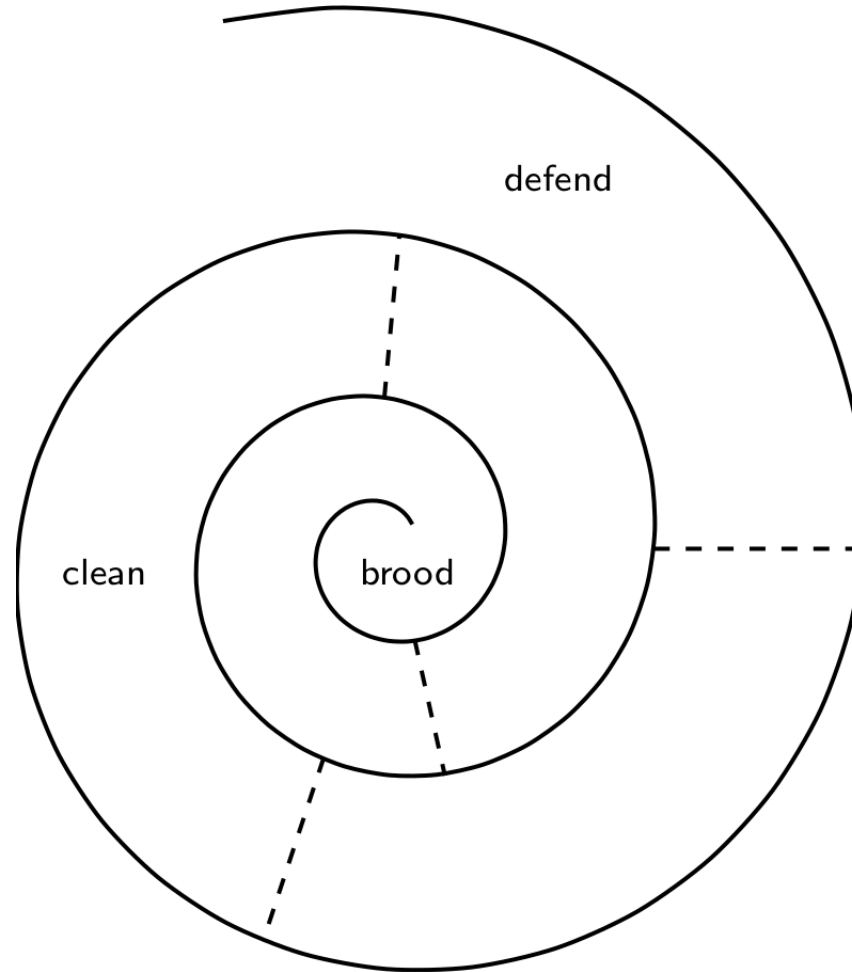
$$2) F_w = 1.0 + T_w^{\text{proc}} + T_w^{\text{setup}} + T_w^{\text{new}}$$

$$3) P_w(F_1, \dots, F_m) = \frac{\frac{1}{F_w^2}}{\sum_{i=1}^m \frac{1}{F_i^2}}$$

$$4) \begin{aligned} \theta'_{w,j} &= \theta_{w,j} - \gamma_1 \\ \theta'_{w,j} &= \theta_{w,j} - \gamma_2 \\ \theta'_{w,j} &= \theta_{w,j} - \delta_1 \\ \theta'_{w,j} &= \theta_{w,j} + \delta_2 \\ \theta'_{w,j} &= \theta_{w,j} - \delta_3^t \end{aligned}$$

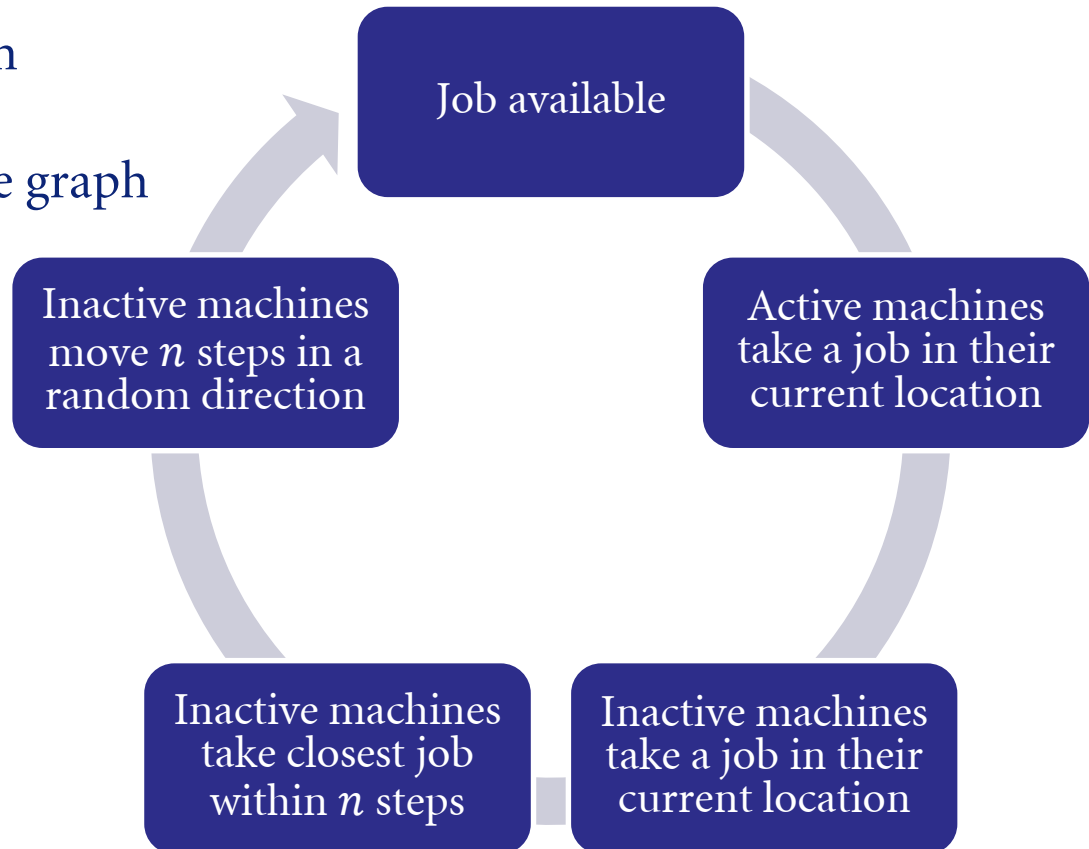


Foraging for Work model



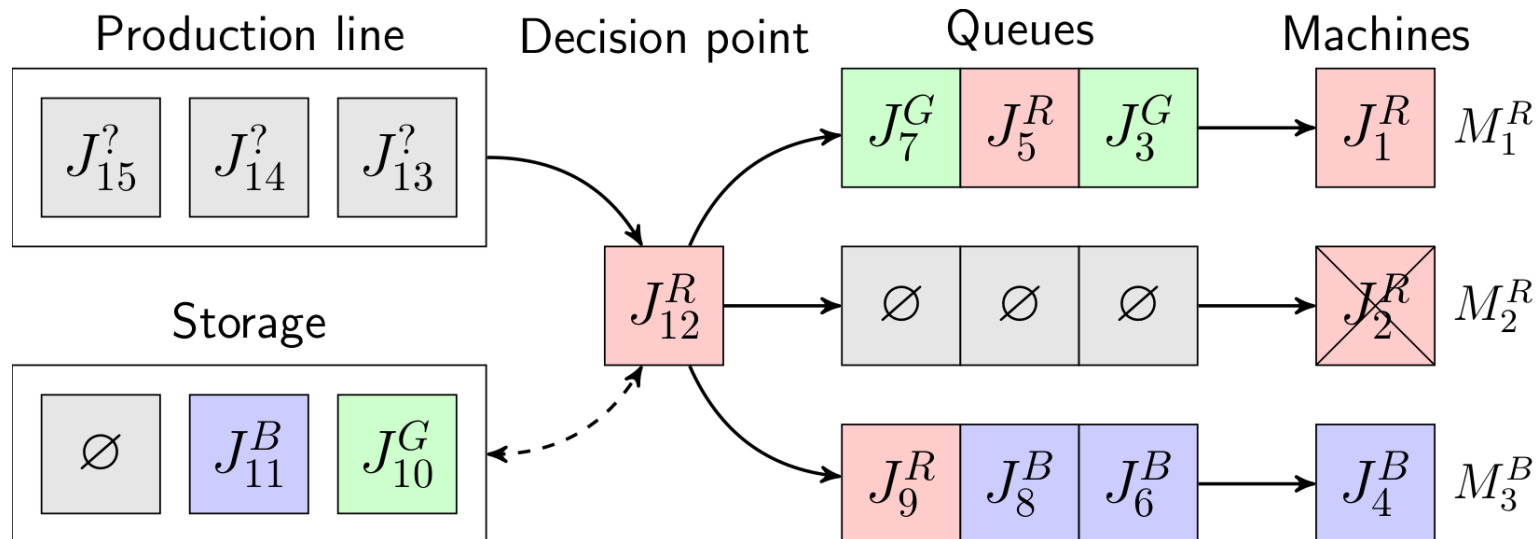
Foraging for work

- Task types in circular graph
- Machines move around the graph
- Step size n determines how many nodes a worker can move

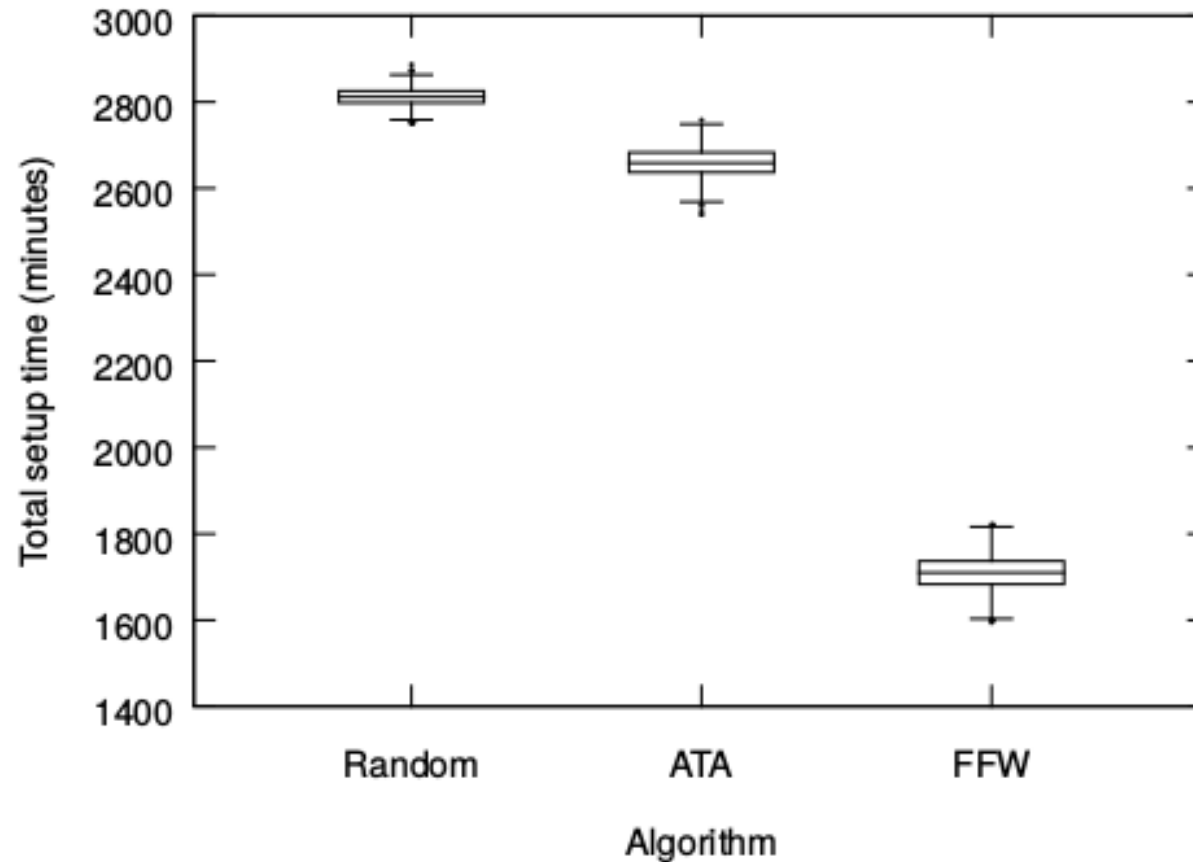


Experiment: Simulated paintshop

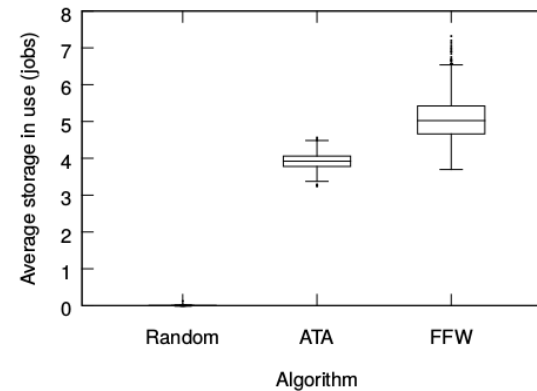
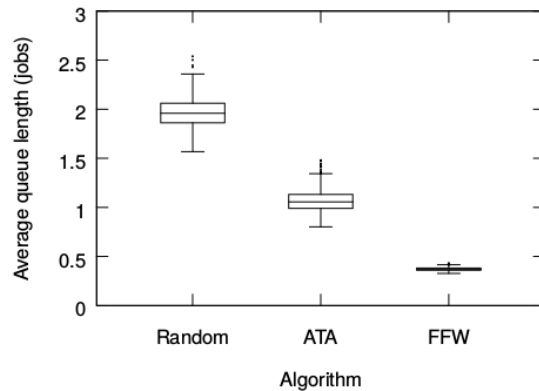
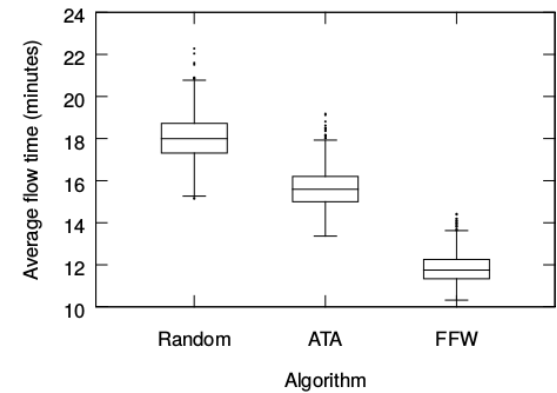
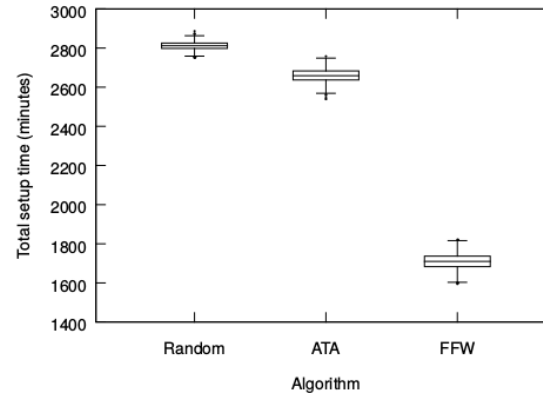
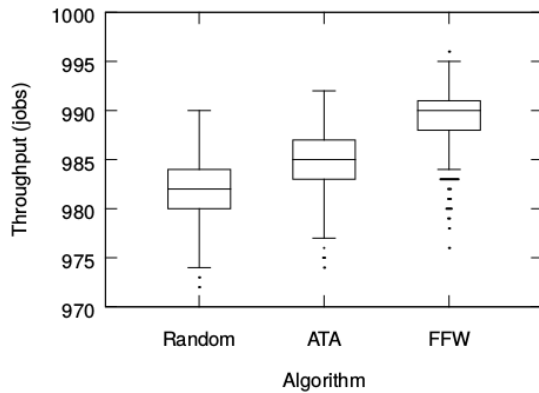
- 1000 minutes
- 1 job released per minute
- 3 minute processing time
- 3 minute setup time
- 8 machines
- 5 queue spaces per machine
- 20 job types
- 5% random machine breakdown $\in [1, \dots, 20]$ min



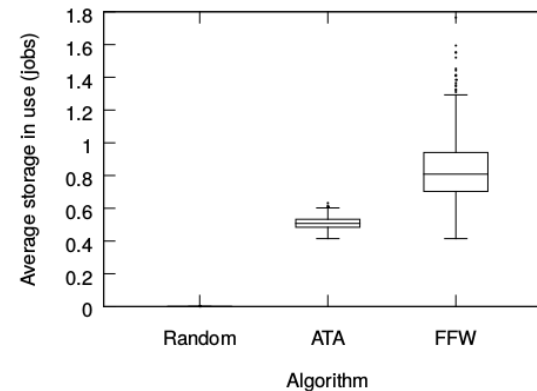
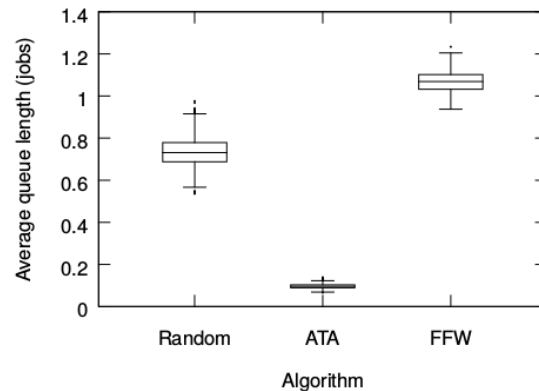
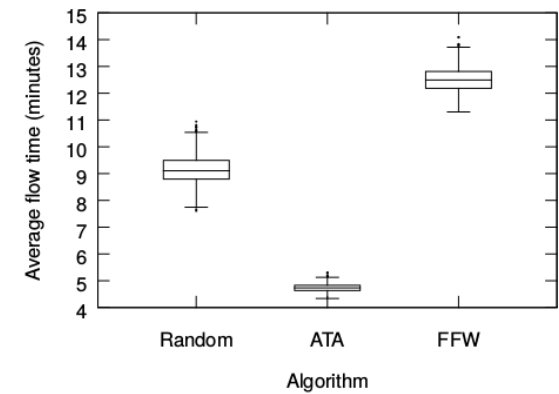
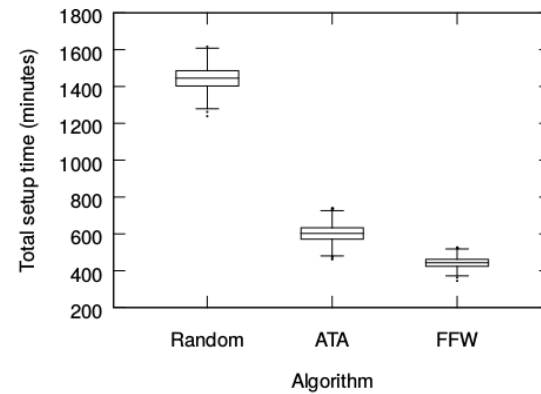
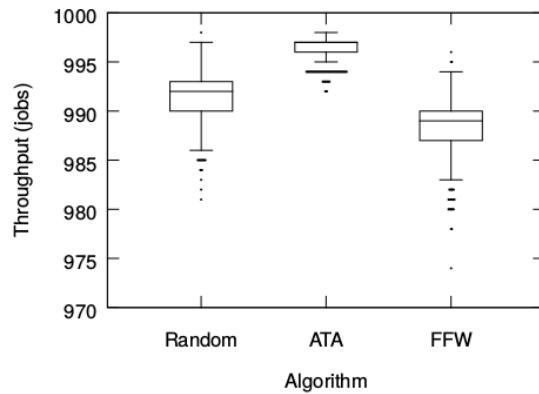
Uniform task distribution



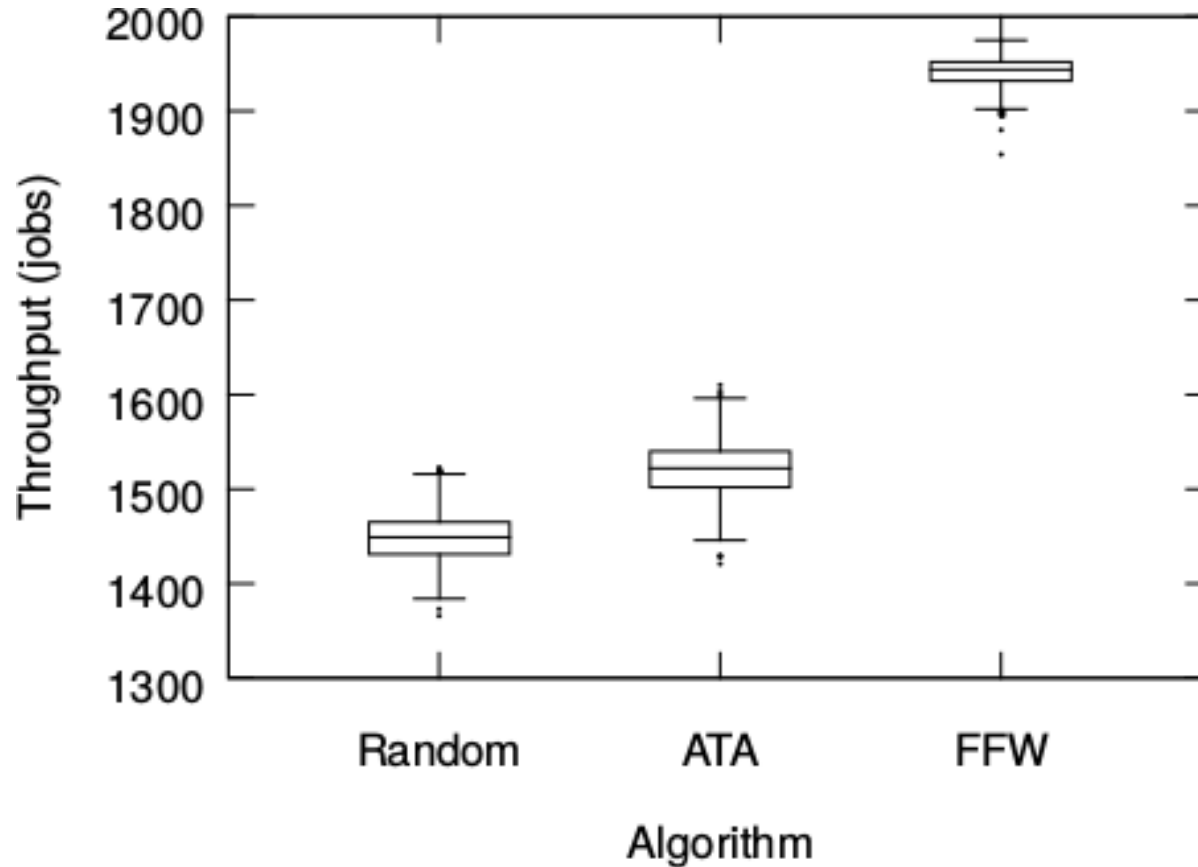
Uniform task distribution



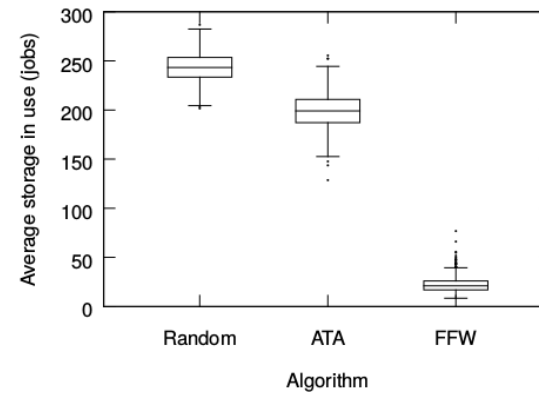
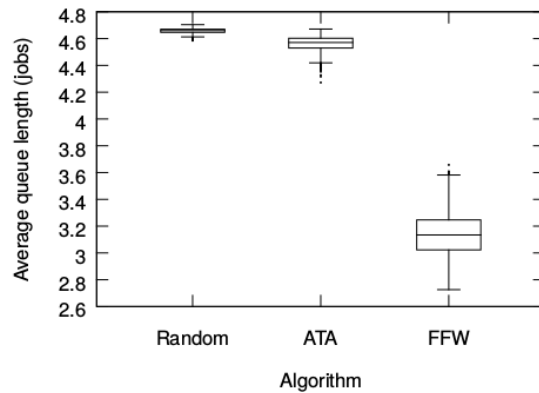
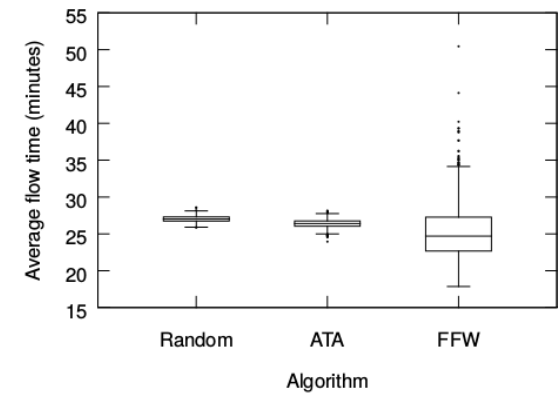
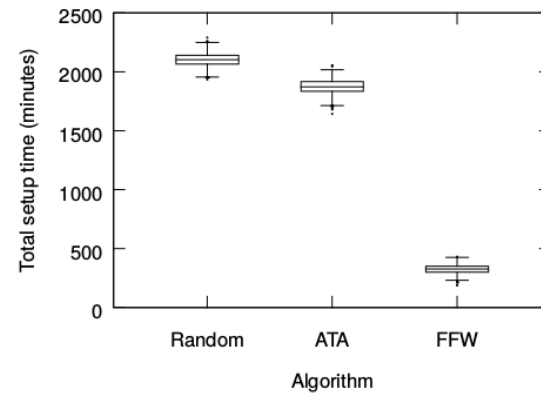
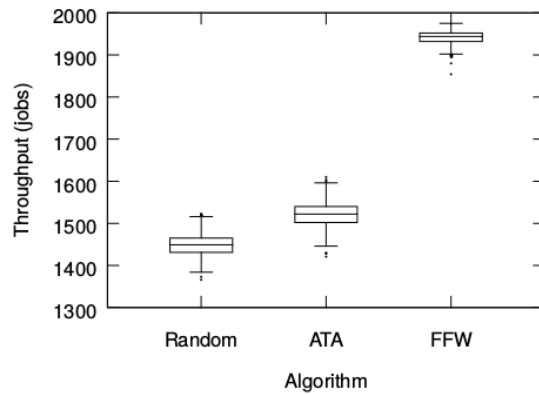
Non uniform task distribution (one each 70%, 15%, 7%, 4%, and the rest 0.25%)



Non uniform + double task load



Non uniform + double task load



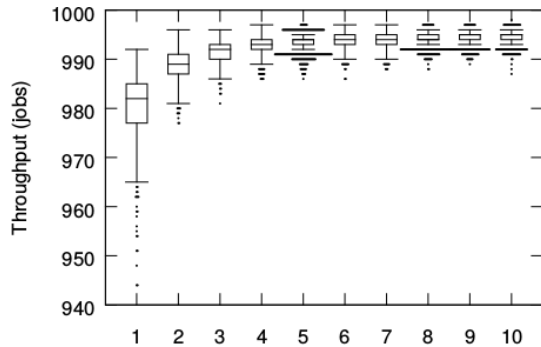
Future work

- Hybrid algorithms (e.g. ATA+FFW)
- Other models of division of labour
- Test on other problems
- Extension to job shop scheduling

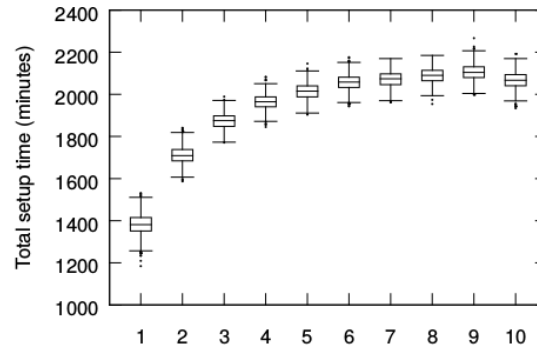
Summary

- **Goal:** Investigate alternatives to threshold based online scheduling
- **Plan:** Evaluate foraging for work (FFW)
- **Result:** FFW compared to ATA
 - ~30% fewer setups for uniform task distributions
 - Competitive on non-uniform distributions
 - Able to handle heavy load
- **Future:** Evaluate on other problems, hybrid algorithms, extend to job shops, etc.

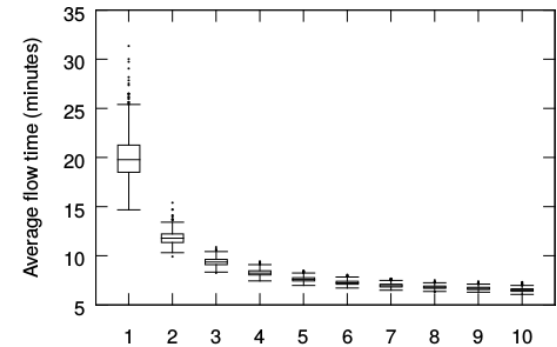
Uniform FFW



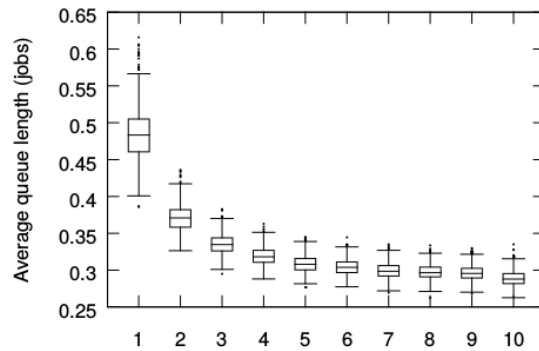
Step size



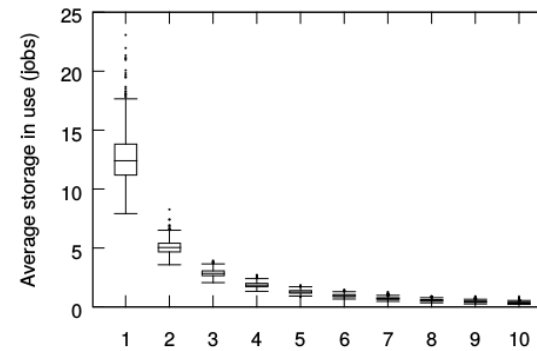
Step size



Step size

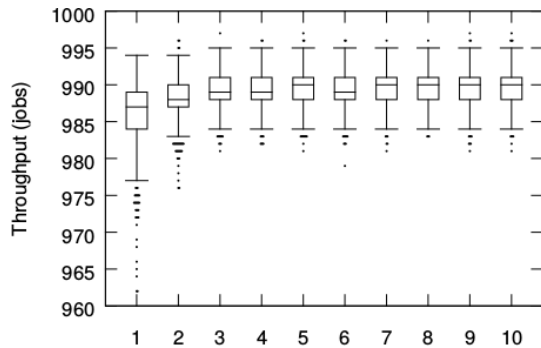


Step size

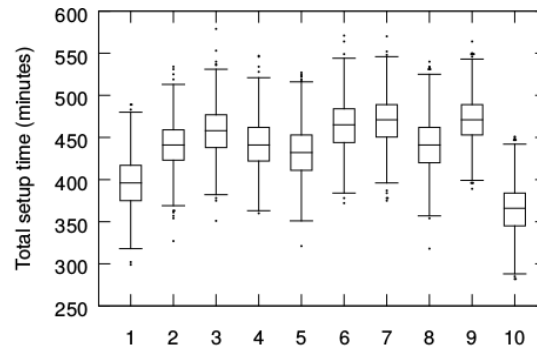


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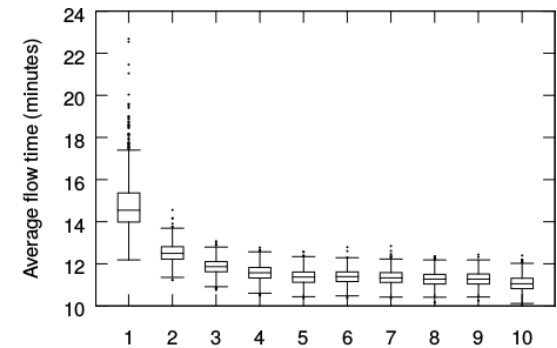
Non uniform FFW



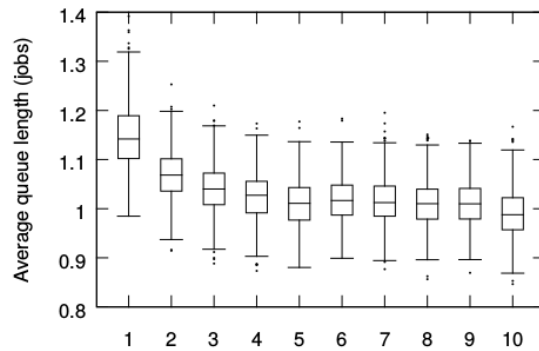
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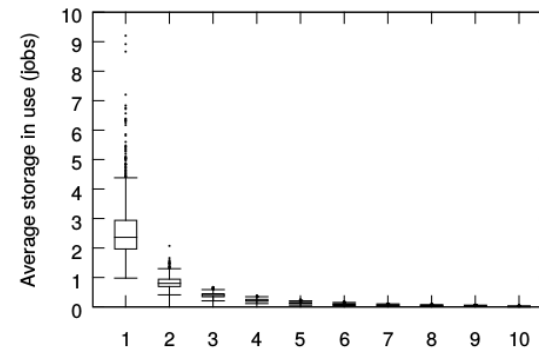
Step size



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Step size



Step size

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