

Parameter:

$TASKS$	set of tasks
$MACHINES$	set of machines
$RESOURCES$	set of resources
$duration_{mt}$	machine specified duration
$rconsumption_{tr}$	Recourse consumption of every task
$precedes_{tt}$	G= (Tasks, Arcs)Activity graph (order constraints) prec[i,j] = 1: j depends on i
$rmax_{mr}$	maximum resource availability machine specified
$tired_m$	maximum machine usage
t_{max}	Latest completion time

Variables:

$start_t \in \{1, \dots, t_{max}\}$	start time of job $t \in T$
$x_{mt} \in \{0,1\}$	assign of task t to machine m

Objective function:

$$\min \max_{t \in T} start_t + duration_{mt}$$

Constraints:

$$\begin{aligned}
 start_i + duration_{mi} * x_{mi} &\leq start_j && \forall (i,j) \in Arcs \\
 \sum_{m \in machines} x_{mt} &= 1 && \forall t \in TASKS \\
 \sum_{t \in TASKS} x_{mt} &\leq tired_m && \forall m \in MACHINES \\
 cumulative (start, duration_{mt} | t \in TASKS, x_{mt} * &&& \\
 rconsumption_{tr} | t \in TASKS, rmax_{mr}) &&& \forall r \in RESOURCES, \forall m \in MACHINES
 \end{aligned}$$

Example

Solution: 8

Task 1: Machine 2; Start 1 Task 2: Machine 2; Start 4 Task 3: Machine 1; Start 5 Task 4: Machine 1; Start 3 Task 5: Machine 2; Start 5

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Instance: inst_3_10_2_1

Solution: 25

Task 1: Machine 3; Start 1 Task 2: Machine 1; Start 14 Task 3: Machine 2; Start 3 Task 4: Machine 3; Start 1 Task 5: Machine 3; Start 7 Task 6: Machine 2; Start 23 Task 7: Machine 2; Start 14 Task 8: Machine 1; Start 7 Task 9: Machine 2; Start 1 Task 10: Machine 1; Start 1

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Solution: 25

Task 1: Machine 3; Start 1 Task 2: Machine 1; Start 14 Task 3: Machine 2; Start 1 Task 4: Machine 3; Start 1 Task 5: Machine 3; Start 7 Task 6: Machine 2; Start 23 Task 7: Machine 2; Start 14 Task 8: Machine 1; Start 7 Task 9: Machine 1; Start 1 Task 10: Machine 1; Start 1

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Solution: 25

Task 1: Machine 3; Start 1 Task 2: Machine 3; Start 19 Task 3: Machine 1; Start 3 Task 4: Machine 2; Start 3 Task 5: Machine 2; Start 12 Task 6: Machine 3; Start 23 Task 7: Machine 2; Start 14 Task 8: Machine 1; Start 7 Task 9: Machine 1; Start 6 Task 10: Machine 3; Start 7

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Solution: 25

Task 1: Machine 3; Start 1 Task 2: Machine 3; Start 19 Task 3: Machine 1; Start 3 Task 4: Machine 3; Start 1 Task 5: Machine 2; Start 7 Task 6: Machine 3; Start 23 Task 7: Machine 2; Start 14 Task 8: Machine 3; Start 7 Task 9: Machine 2; Start 1 Task 10: Machine 2; Start 3

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Instance: inst_3_10_2_2

Solution: 14

Task 1: Machine 1; Start 9 Task 2: Machine 2; Start 3 Task 3: Machine 3; Start 11 Task 4: Machine 1; Start 3 Task 5: Machine 2; Start 3 Task 6: Machine 2; Start 9 Task 7: Machine 1; Start 4 Task 8: Machine 3; Start 3 Task 9: Machine 3; Start 9 Task 10: Machine 2; Start 1

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Solution: 14

Task 1: Machine 1; Start 9 Task 2: Machine 2; Start 3 Task 3: Machine 3; Start 11 Task 4: Machine 1; Start 3 Task 5: Machine 3; Start 3 Task 6: Machine 2; Start 9 Task 7: Machine 3; Start 4 Task 8: Machine 3; Start 3 Task 9: Machine 3; Start 9 Task 10: Machine 2; Start 1

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Solution: 14

Task 1: Machine 1; Start 10 Task 2: Machine 2; Start 6 Task 3: Machine 3; Start 13 Task 4:
Machine 1; Start 3 Task 5: Machine 3; Start 6 Task 6: Machine 2; Start 11 Task 7: Machine 3;
Start 7 Task 8: Machine 3; Start 3 Task 9: Machine 3; Start 9 Task 10: Machine 2; Start 1

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Instance: inst_3_10_2_3

Solution: 18

Task 1: Machine 3; Start 10 Task 2: Machine 3; Start 15 Task 3: Machine 2; Start 9 Task 4:
Machine 3; Start 9 Task 5: Machine 2; Start 1 Task 6: Machine 3; Start 1 Task 7: Machine 3;
Start 17 Task 8: Machine 3; Start 16 Task 9: Machine 2; Start 1 Task 10: Machine 2; Start 15

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Solution: 18

Task 1: Machine 3; Start 10 Task 2: Machine 3; Start 15 Task 3: Machine 2; Start 9 Task 4:
Machine 3; Start 9 Task 5: Machine 2; Start 1 Task 6: Machine 3; Start 5 Task 7: Machine 3;
Start 17 Task 8: Machine 3; Start 16 Task 9: Machine 2; Start 10
Task 10: Machine 2; Start 15

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Solution: 18

Task 1: Machine 3; Start 10 Task 2: Machine 3; Start 15 Task 3: Machine 2; Start 9 Task 4:
Machine 3; Start 9 Task 5: Machine 2; Start 1 Task 6: Machine 3; Start 1 Task 7: Machine 3;
Start 17 Task 8: Machine 3; Start 16 Task 9: Machine 3; Start 2 Task 10: Machine 2; Start 15

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inst_3_10_2_4

Solution: 25

Task 1: Machine 1; Start 17 Task 2: Machine 1; Start 10 Task 3: Machine 2; Start 21 Task 4:
Machine 1; Start 10 Task 5: Machine 1; Start 1 Task 6: Machine 1; Start 12 Task 7: Machine
2; Start 1 Task 8: Machine 1; Start 17 Task 9: Machine 2; Start 17 Task 10: Machine 2; Start
17

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Solution: 25

Task 1: Machine 2; Start 22 Task 2: Machine 3; Start 14 Task 3: Machine 2; Start 21 Task 4:
Machine 1; Start 10 Task 5: Machine 3; Start 4 Task 6: Machine 1; Start 20 Task 7: Machine
2; Start 1 Task 8: Machine 1; Start 17 Task 9: Machine 2; Start 18 Task 10: Machine 2; Start
17

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Solution: 25

Task 1: Machine 1; Start 17 Task 2: Machine 1; Start 10 Task 3: Machine 2; Start 21 Task 4:
Machine 1; Start 10 Task 5: Machine 2; Start 1 Task 6: Machine 1; Start 12 Task 7: Machine
2; Start 1 Task 8: Machine 1; Start 17 Task 9: Machine 2; Start 17 Task 10: Machine 2; Start
17

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Solution: 25

Task 1: Machine 1; Start 20 Task 2: Machine 1; Start 10 Task 3: Machine 2; Start 21 Task 4:
Machine 1; Start 10 Task 5: Machine 2; Start 2 Task 6: Machine 1; Start 14 Task 7: Machine

2; Start 1 Task 8: Machine 1; Start 17 Task 9: Machine 2; Start 18 Task 10: Machine 2; Start 17

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inst_3_10_2_5

Solution: 15

Task 1: Machine 1; Start 6 Task 2: Machine 2; Start 1 Task 3: Machine 1; Start 12 Task 4: Machine 2; Start 1 Task 5: Machine 1; Start 12 Task 6: Machine 1; Start 13 Task 7: Machine 3; Start 6 Task 8: Machine 2; Start 13 Task 9: Machine 1; Start 3 Task 10: Machine 3; Start 1

=====

Solution: 15

Task 1: Machine 1; Start 6 Task 2: Machine 2; Start 1 Task 3: Machine 1; Start 12 Task 4: Machine 2; Start 10 Task 5: Machine 1; Start 12 Task 6: Machine 1; Start 14 Task 7: Machine 3; Start 11 Task 8: Machine 2; Start 13 Task 9: Machine 1; Start 3 Task 10: Machine 3; Start 1

=====

Solution: 15

Task 1: Machine 1; Start 6 Task 2: Machine 2; Start 1 Task 3: Machine 1; Start 12 Task 4: Machine 2; Start 3 Task 5: Machine 1; Start 12 Task 6: Machine 2; Start 13 Task 7: Machine 3; Start 10 Task 8: Machine 2; Start 13 Task 9: Machine 1; Start 3 Task 10: Machine 3; Start 1

=====

Solution: 15

Task 1: Machine 1; Start 6 Task 2: Machine 2; Start 1 Task 3: Machine 1; Start 12 Task 4: Machine 2; Start 2 Task 5: Machine 1; Start 12 Task 6: Machine 1; Start 13 Task 7: Machine 3; Start 8 Task 8: Machine 2; Start 13 Task 9: Machine 1; Start 3 Task 10: Machine 3; Start 1

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inst_5_20_3_1

Solution: 16

Task 1: Machine 2; Start 15 Task 2: Machine 3; Start 14 Task 3: Machine 4; Start 10 Task 4: Machine 4; Start 3 Task 5: Machine 2; Start 7 Task 6: Machine 2; Start 15 Task 7: Machine 4; Start 2 Task 8: Machine 1; Start 11 Task 9: Machine 2; Start 1 Task 10: Machine 3; Start 6 Task 11: Machine 3; Start 8 Task 12: Machine 4; Start 4 Task 13: Machine 1; Start 10 Task 14: Machine 5; Start 10 Task 15: Machine 2; Start 4 Task 16: Machine 1; Start 2 Task 17: Machine 1; Start 8 Task 18: Machine 4; Start 7 Task 19: Machine 1; Start 8 Task 20: Machine 3; Start 1

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Solution: 16

Task 1: Machine 2; Start 15 Task 2: Machine 3; Start 14 Task 3: Machine 4; Start 13 Task 4: Machine 4; Start 6 Task 5: Machine 2; Start 7 Task 6: Machine 2; Start 15 Task 7: Machine 1; Start 2 Task 8: Machine 1; Start 15 Task 9: Machine 2; Start 1 Task 10: Machine 4; Start 9 Task 11: Machine 3; Start 8 Task 12: Machine 2; Start 6 Task 13: Machine 1; Start 10 Task 14: Machine 5; Start 11 Task 15: Machine 2; Start 4 Task 16: Machine 2; Start 8 Task 17: Machine 3; Start 13 Task 18: Machine 2; Start 13 Task 19: Machine 1; Start 11 Task 20: Machine 3; Start 1

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Solution: 16

Task 1: Machine 2; Start 13 Task 2: Machine 3; Start 13 Task 3: Machine 4; Start 10 Task 4: Machine 4; Start 2 Task 5: Machine 4; Start 5 Task 6: Machine 2; Start 15 Task 7: Machine 4; Start 2 Task 8: Machine 3; Start 14 Task 9: Machine 2; Start 1 Task 10: Machine 3; Start 5 Task 11: Machine 3; Start 8 Task 12: Machine 2; Start 4 Task 13: Machine 1; Start 10 Task 14: Machine 1; Start 10 Task 15: Machine 2; Start 4 Task 16: Machine 1; Start 2 Task 17: Machine 5; Start 6 Task 18: Machine 2; Start 11 Task 19: Machine 1; Start 8 Task 20: Machine 3; Start 1

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inst_5_20_3_2

Solution: 22

Task 1: Machine 3; Start 8 Task 2: Machine 5; Start 8 Task 3: Machine 3; Start 9 Task 4: Machine 4; Start 1 Task 5: Machine 4; Start 8 Task 6: Machine 1; Start 18 Task 7: Machine 5; Start 8 Task 8: Machine 5; Start 3 Task 9: Machine 2; Start 1 Task 10: Machine 3; Start 19 Task 11: Machine 4; Start 12 Task 12: Machine 5; Start 1 Task 13: Machine 2; Start 8 Task 14: Machine 1; Start 10 Task 15: Machine 5; Start 13 Task 16: Machine 4; Start 15 Task 17: Machine 4; Start 1 Task 18: Machine 3; Start 6 Task 19: Machine 2; Start 15 Task 20: Machine 2; Start 14

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Solution: 22

Task 1: Machine 3; Start 6 Task 2: Machine 4; Start 10 Task 3: Machine 3; Start 11 Task 4: Machine 4; Start 1 Task 5: Machine 1; Start 9 Task 6: Machine 3; Start 17 Task 7: Machine 5; Start 8 Task 8: Machine 5; Start 3 Task 9: Machine 2; Start 7 Task 10: Machine 3; Start 19 Task 11: Machine 5; Start 12 Task 12: Machine 5; Start 1 Task 13: Machine 2; Start 9 Task 14: Machine 1; Start 11 Task 15: Machine 2; Start 11 Task 16: Machine 4; Start 18 Task 17: Machine 4; Start 1 Task 18: Machine 3; Start 9 Task 19: Machine 3; Start 15 Task 20: Machine 5; Start 12

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Solution: 22

Task 1: Machine 3; Start 9 Task 2: Machine 5; Start 9 Task 3: Machine 3; Start 8 Task 4: Machine 4; Start 1 Task 5: Machine 4; Start 8 Task 6: Machine 1; Start 15 Task 7: Machine 4; Start 8 Task 8: Machine 5; Start 3 Task 9: Machine 4; Start 1 Task 10: Machine 3; Start 19 Task 11: Machine 2; Start 12 Task 12: Machine 5; Start 1 Task 13: Machine 2; Start 3 Task 14: Machine 1; Start 8 Task 15: Machine 5; Start 13 Task 16: Machine 4; Start 17 Task 17: Machine 3; Start 1 Task 18: Machine 3; Start 8 Task 19: Machine 3; Start 15 Task 20: Machine 2; Start 12

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inst_5_20_3_3

Solution: 18

Task 1: Machine 2; Start 6 Task 2: Machine 1; Start 5 Task 3: Machine 3; Start 15 Task 4: Machine 4; Start 8 Task 5: Machine 1; Start 14 Task 6: Machine 2; Start 1 Task 7: Machine 3; Start 5 Task 8: Machine 3; Start 1 Task 9: Machine 1; Start 11 Task 10: Machine 3; Start 12 Task 11: Machine 4; Start 8 Task 12: Machine 4; Start 5 Task 13: Machine 3; Start 11 Task 14: Machine 2; Start 9 Task 15: Machine 1; Start 4 Task 16: Machine 4; Start 16 Task 17: Machine 1; Start 17 Task 18: Machine 3; Start 14 Task 19: Machine 2; Start 4 Task 20: Machine 3; Start 8

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Solution: 18

Task 1: Machine 4; Start 5 Task 2: Machine 4; Start 5 Task 3: Machine 3; Start 15 Task 4:
Machine 4; Start 8 Task 5: Machine 1; Start 14 Task 6: Machine 2; Start 2 Task 7: Machine 3;
Start 5 Task 8: Machine 3; Start 1 Task 9: Machine 1; Start 11 Task 10: Machine 3; Start 12
Task 11: Machine 4; Start 8 Task 12: Machine 4; Start 6 Task 13: Machine 3; Start 11 Task
14: Machine 2; Start 9 Task 15: Machine 2; Start 6 Task 16: Machine 4; Start 16 Task 17:
Machine 1; Start 17 Task 18: Machine 3; Start 14 Task 19: Machine 2; Start 1 Task 20:
Machine 3; Start 8

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Solution: 18

Task 1: Machine 1; Start 5 Task 2: Machine 1; Start 8 Task 3: Machine 4; Start 12 Task 4:
Machine 4; Start 8 Task 5: Machine 1; Start 14 Task 6: Machine 2; Start 1 Task 7: Machine 3;
Start 5 Task 8: Machine 3; Start 1 Task 9: Machine 1; Start 11 Task 10: Machine 3; Start 12
Task 11: Machine 4; Start 8 Task 12: Machine 4; Start 5 Task 13: Machine 3; Start 8 Task 14:
Machine 2; Start 8 Task 15: Machine 2; Start 4 Task 16: Machine 4; Start 16 Task 17:
Machine 1; Start 17 Task 18: Machine 3; Start 14 Task 19: Machine 2; Start 6 Task 20:
Machine 3; Start 8

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inst_5_20_3_4

Solution: 26

Task 1: Machine 3; Start 1 Task 2: Machine 4; Start 23 Task 3: Machine 3; Start 16 Task 4:
Machine 1; Start 15 Task 5: Machine 3; Start 2 Task 6: Machine 4; Start 22 Task 7: Machine
1; Start 10 Task 8: Machine 4; Start 14 Task 9: Machine 1; Start 13 Task 10: Machine 3; Start
9 Task 11: Machine 3; Start 13 Task 12: Machine 4; Start 1 Task 13: Machine 3; Start 13
Task 14: Machine 5; Start 13 Task 15: Machine 4; Start 16 Task 16: Machine 3; Start 9 Task
17: Machine 3; Start 15 Task 18: Machine 4; Start 13 Task 19: Machine 5; Start 1 Task 20:
Machine 2; Start 9

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Solution: 26

Task 1: Machine 3; Start 1 Task 2: Machine 4; Start 24 Task 3: Machine 3; Start 16 Task 4:
Machine 1; Start 15 Task 5: Machine 3; Start 7 Task 6: Machine 4; Start 23 Task 7: Machine
1; Start 11 Task 8: Machine 4; Start 14 Task 9: Machine 1; Start 13 Task 10: Machine 3; Start
9 Task 11: Machine 4; Start 16 Task 12: Machine 4; Start 2 Task 13: Machine 3; Start 14
Task 14: Machine 3; Start 20 Task 15: Machine 4; Start 25 Task 16: Machine 3; Start 11 Task
17: Machine 3; Start 22 Task 18: Machine 4; Start 13 Task 19: Machine 5; Start 6 Task 20:
Machine 2; Start 10

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Solution: 26

Task 1: Machine 4; Start 1 Task 2: Machine 2; Start 23 Task 3: Machine 3; Start 16 Task 4:
Machine 1; Start 15 Task 5: Machine 3; Start 2 Task 6: Machine 4; Start 20 Task 7: Machine
3; Start 9 Task 8: Machine 4; Start 12 Task 9: Machine 1; Start 13 Task 10: Machine 3; Start
9 Task 11: Machine 4; Start 13 Task 12: Machine 3; Start 1 Task 13: Machine 3; Start 13
Task 14: Machine 3; Start 19 Task 15: Machine 4; Start 25 Task 16: Machine 3; Start 11 Task
17: Machine 3; Start 15 Task 18: Machine 3; Start 13 Task 19: Machine 5; Start 1 Task 20:
Machine 2; Start 9

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inst_5_20_3_5

Solution: 20

Task 1: Machine 5; Start 14 Task 2: Machine 3; Start 15 Task 3: Machine 4; Start 12 Task 4: Machine 4; Start 7 Task 5: Machine 5; Start 4 Task 6: Machine 1; Start 4 Task 7: Machine 4; Start 4 Task 8: Machine 1; Start 8 Task 9: Machine 3; Start 11 Task 10: Machine 3; Start 9 Task 11: Machine 2; Start 18 Task 12: Machine 2; Start 10 Task 13: Machine 2; Start 9 Task 14: Machine 1; Start 1 Task 15: Machine 5; Start 15 Task 16: Machine 4; Start 12 Task 17: Machine 3; Start 6 Task 18: Machine 3; Start 1 Task 19: Machine 2; Start 4 Task 20: Machine 3; Start 4

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Solution: 20

Task 1: Machine 5; Start 14 Task 2: Machine 3; Start 15 Task 3: Machine 4; Start 13 Task 4: Machine 4; Start 5 Task 5: Machine 5; Start 4 Task 6: Machine 1; Start 7 Task 7: Machine 4; Start 6 Task 8: Machine 1; Start 8 Task 9: Machine 3; Start 12 Task 10: Machine 1; Start 18 Task 11: Machine 2; Start 18 Task 12: Machine 2; Start 11 Task 13: Machine 2; Start 10 Task 14: Machine 1; Start 1 Task 15: Machine 5; Start 18 Task 16: Machine 4; Start 12 Task 17: Machine 3; Start 8 Task 18: Machine 3; Start 2 Task 19: Machine 4; Start 4 Task 20: Machine 3; Start 6

=====

Solution: 20

Task 1: Machine 5; Start 14 Task 2: Machine 3; Start 15 Task 3: Machine 4; Start 9 Task 4: Machine 4; Start 4 Task 5: Machine 4; Start 6 Task 6: Machine 1; Start 6 Task 7: Machine 1; Start 4 Task 8: Machine 2; Start 8 Task 9: Machine 3; Start 9 Task 10: Machine 4; Start 10 Task 11: Machine 2; Start 18 Task 12: Machine 1; Start 10 Task 13: Machine 1; Start 8 Task 14: Machine 1; Start 1 Task 15: Machine 5; Start 15 Task 16: Machine 4; Start 7 Task 17: Machine 3; Start 6 Task 18: Machine 3; Start 2 Task 19: Machine 2; Start 4 Task 20: Machine 3; Start 4

inst_5_50_3_1

Solution: 44

Task 1: Machine 1; Start 36 Task 2: Machine 2; Start 19 Task 3: Machine 3; Start 32 Task 4: Machine 1; Start 3 Task 5: Machine 2; Start 23 Task 6: Machine 4; Start 20 Task 7: Machine 4; Start 11 Task 8: Machine 1; Start 32 Task 9: Machine 3; Start 5 Task 10: Machine 1; Start 5 Task 11: Machine 1; Start 4 Task 12: Machine 3; Start 2 Task 13: Machine 4; Start 29 Task 14: Machine 2; Start 16 Task 15: Machine 4; Start 28 Task 16: Machine 1; Start 26 Task 17: Machine 2; Start 15 Task 18: Machine 4; Start 12 Task 19: Machine 4; Start 37 Task 20: Machine 4; Start 26 Task 21: Machine 1; Start 36 Task 22: Machine 5; Start 28 Task 23: Machine 2; Start 1 Task 24: Machine 4; Start 26 Task 25: Machine 5; Start 5 Task 26: Machine 2; Start 24 Task 27: Machine 1; Start 9 Task 28: Machine 1; Start 22 Task 29: Machine 5; Start 35 Task 30: Machine 1; Start 17 Task 31: Machine 2; Start 9 Task 32: Machine 2; Start 19 Task 33: Machine 3; Start 9 Task 34: Machine 2; Start 32 Task 35: Machine 5; Start 11 Task 36: Machine 5; Start 1 Task 37: Machine 1; Start 34 Task 38: Machine 4; Start 11 Task 39: Machine 5; Start 19 Task 40: Machine 3; Start 12 Task 41: Machine 5; Start 36 Task 42: Machine 2; Start 36 Task 43: Machine 3; Start 38 Task 44: Machine 1; Start 40 Task 45: Machine 4; Start 17 Task 46: Machine 3; Start 8 Task 47: Machine 4; Start 43 Task 48: Machine 4; Start 17 Task 49: Machine 2; Start 6 Task 50: Machine 1; Start 24

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Solution: 44

Task 1: Machine 1; Start 41 Task 2: Machine 2; Start 20 Task 3: Machine 3; Start 32 Task 4: Machine 1; Start 2 Task 5: Machine 2; Start 23 Task 6: Machine 1; Start 20 Task 7: Machine 3; Start 14 Task 8: Machine 1; Start 33 Task 9: Machine 3; Start 8 Task 10: Machine 1; Start 5 Task 11: Machine 4; Start 3 Task 12: Machine 3; Start 4 Task 13: Machine 1; Start 29 Task 14: Machine 2; Start 18 Task 15: Machine 4; Start 28 Task 16: Machine 5; Start 27 Task 17: Machine 2; Start 15 Task 18: Machine 4; Start 12 Task 19: Machine 2; Start 36 Task 20: Machine 1; Start 26 Task 21: Machine 1; Start 36 Task 22: Machine 5; Start 31 Task 23: Machine 2; Start 1 Task 24: Machine 4; Start 26 Task 25: Machine 3; Start 6 Task 26: Machine 2; Start 24 Task 27: Machine 1; Start 9 Task 28: Machine 3; Start 20 Task 29: Machine 5; Start 35 Task 30: Machine 2; Start 19 Task 31: Machine 1; Start 11 Task 32: Machine 4; Start 21 Task 33: Machine 2; Start 11 Task 34: Machine 5; Start 33 Task 35: Machine 5; Start 12 Task 36: Machine 5; Start 1 Task 37: Machine 1; Start 34 Task 38: Machine 4; Start 11 Task 39: Machine 2; Start 22 Task 40: Machine 2; Start 14 Task 41: Machine 5; Start 38 Task 42: Machine 1; Start 36 Task 43: Machine 4; Start 38 Task 44: Machine 5; Start 39 Task 45: Machine 4; Start 17 Task 46: Machine 3; Start 7 Task 47: Machine 1; Start 42 Task 48: Machine 3; Start 18 Task 49: Machine 5; Start 10 Task 50: Machine 1; Start 24

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Solution: 44

Task 1: Machine 1; Start 36 Task 2: Machine 2; Start 19 Task 3: Machine 3; Start 32 Task 4: Machine 1; Start 1 Task 5: Machine 3; Start 23 Task 6: Machine 4; Start 19 Task 7: Machine 1; Start 12 Task 8: Machine 1; Start 32 Task 9: Machine 3; Start 6 Task 10: Machine 1; Start 5 Task 11: Machine 1; Start 3 Task 12: Machine 3; Start 1 Task 13: Machine 4; Start 29 Task 14: Machine 2; Start 15 Task 15: Machine 4; Start 28 Task 16: Machine 1; Start 27 Task 17: Machine 2; Start 14 Task 18: Machine 4; Start 11 Task 19: Machine 4; Start 36 Task 20: Machine 4; Start 26 Task 21: Machine 4; Start 36 Task 22: Machine 5; Start 28 Task 23: Machine 2; Start 1 Task 24: Machine 4; Start 26 Task 25: Machine 5; Start 6 Task 26: Machine 2; Start 24 Task 27: Machine 1; Start 9 Task 28: Machine 4; Start 22 Task 29: Machine 4; Start 34 Task 30: Machine 2; Start 18 Task 31: Machine 2; Start 9 Task 32: Machine 2; Start 21 Task 33: Machine 3; Start 9 Task 34: Machine 2; Start 33 Task 35: Machine 5; Start 11 Task 36: Machine 5; Start 1 Task 37: Machine 1; Start 34 Task 38: Machine 4; Start 11 Task 39: Machine 2; Start 19 Task 40: Machine 3; Start 13 Task 41: Machine 1; Start 36 Task 42: Machine 2; Start 36 Task 43: Machine 3; Start 38 Task 44: Machine 2; Start 38 Task 45: Machine 4; Start 17 Task 46: Machine 3; Start 5 Task 47: Machine 2; Start 41 Task 48: Machine 4; Start 17 Task 49: Machine 5; Start 5 Task 50: Machine 1; Start 24

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inst_5_50_3_2

Solution: 41

Task 1: Machine 4; Start 4 Task 2: Machine 5; Start 8 Task 3: Machine 3; Start 11 Task 4: Machine 2; Start 25 Task 5: Machine 1; Start 5 Task 6: Machine 2; Start 15 Task 7: Machine 4; Start 25 Task 8: Machine 3; Start 4 Task 9: Machine 5; Start 16 Task 10: Machine 1; Start 24 Task 11: Machine 5; Start 29 Task 12: Machine 4; Start 11 Task 13: Machine 3; Start 30 Task 14: Machine 5; Start 31 Task 15: Machine 3; Start 38 Task 16: Machine 2; Start 4 Task 17: Machine 2; Start 11 Task 18: Machine 5; Start 4 Task 19: Machine 2; Start 17 Task 20: Machine 2; Start 38 Task 21: Machine 4; Start 33 Task 22: Machine 1; Start 30 Task 23: Machine 1; Start 39 Task 24: Machine 4; Start 17 Task 25: Machine 5; Start 26 Task 26:

Machine 5; Start 1 Task 27: Machine 2; Start 10 Task 28: Machine 3; Start 27 Task 29:
Machine 1; Start 23 Task 30: Machine 4; Start 9 Task 31: Machine 3; Start 17 Task 32:
Machine 4; Start 37 Task 33: Machine 2; Start 38 Task 34: Machine 3; Start 32 Task 35:
Machine 4; Start 31 Task 36: Machine 4; Start 22 Task 37: Machine 5; Start 20 Task 38:
Machine 5; Start 33 Task 39: Machine 3; Start 1 Task 40: Machine 3; Start 36 Task 41:
Machine 2; Start 8 Task 42: Machine 2; Start 37 Task 43: Machine 4; Start 40 Task 44:
Machine 4; Start 30 Task 45: Machine 3; Start 8 Task 46: Machine 1; Start 28 Task 47:
Machine 2; Start 18 Task 48: Machine 3; Start 28 Task 49: Machine 4; Start 36 Task 50:
Machine 3; Start 31

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Solution: 41

Task 1: Machine 4; Start 4 Task 2: Machine 1; Start 8 Task 3: Machine 3; Start 14 Task 4:
Machine 2; Start 26 Task 5: Machine 1; Start 5 Task 6: Machine 2; Start 15 Task 7: Machine
4; Start 25 Task 8: Machine 3; Start 5 Task 9: Machine 5; Start 16 Task 10: Machine 4; Start
22 Task 11: Machine 5; Start 30 Task 12: Machine 4; Start 11 Task 13: Machine 3; Start 30
Task 14: Machine 5; Start 31 Task 15: Machine 4; Start 40 Task 16: Machine 2; Start 4 Task
17: Machine 2; Start 13 Task 18: Machine 5; Start 9 Task 19: Machine 2; Start 17 Task 20:
Machine 2; Start 38 Task 21: Machine 4; Start 33 Task 22: Machine 1; Start 30 Task 23:
Machine 5; Start 37 Task 24: Machine 4; Start 19 Task 25: Machine 3; Start 27 Task 26:
Machine 5; Start 1 Task 27: Machine 2; Start 12 Task 28: Machine 3; Start 27 Task 29:
Machine 4; Start 18 Task 30: Machine 4; Start 9 Task 31: Machine 3; Start 19 Task 32:
Machine 4; Start 38 Task 33: Machine 2; Start 39 Task 34: Machine 3; Start 32 Task 35:
Machine 4; Start 31 Task 36: Machine 4; Start 23 Task 37: Machine 5; Start 20 Task 38:
Machine 5; Start 33 Task 39: Machine 3; Start 1 Task 40: Machine 3; Start 36 Task 41:
Machine 2; Start 8 Task 42: Machine 1; Start 37 Task 43: Machine 4; Start 39 Task 44:
Machine 4; Start 30 Task 45: Machine 5; Start 10 Task 46: Machine 1; Start 28 Task 47:
Machine 1; Start 19 Task 48: Machine 3; Start 28 Task 49: Machine 4; Start 36 Task 50:
Machine 3; Start 31

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Solution: 41

Task 1: Machine 4; Start 4 Task 2: Machine 5; Start 8 Task 3: Machine 1; Start 13 Task 4:
Machine 2; Start 25 Task 5: Machine 1; Start 5 Task 6: Machine 4; Start 12 Task 7: Machine
4; Start 25 Task 8: Machine 2; Start 4 Task 9: Machine 5; Start 15 Task 10: Machine 4; Start
20 Task 11: Machine 5; Start 29 Task 12: Machine 2; Start 11 Task 13: Machine 3; Start 30
Task 14: Machine 5; Start 29 Task 15: Machine 4; Start 38 Task 16: Machine 2; Start 4 Task
17: Machine 2; Start 12 Task 18: Machine 3; Start 4 Task 19: Machine 2; Start 17 Task 20:
Machine 2; Start 36 Task 21: Machine 4; Start 33 Task 22: Machine 1; Start 30 Task 23:
Machine 5; Start 36 Task 24: Machine 5; Start 17 Task 25: Machine 5; Start 25 Task 26:
Machine 4; Start 1 Task 27: Machine 5; Start 10 Task 28: Machine 4; Start 25 Task 29:
Machine 1; Start 17 Task 30: Machine 4; Start 9 Task 31: Machine 3; Start 17 Task 32:
Machine 4; Start 37 Task 33: Machine 2; Start 37 Task 34: Machine 3; Start 30 Task 35:
Machine 5; Start 31 Task 36: Machine 4; Start 21 Task 37: Machine 5; Start 20 Task 38:
Machine 5; Start 33 Task 39: Machine 1; Start 1 Task 40: Machine 3; Start 36 Task 41:
Machine 2; Start 8 Task 42: Machine 2; Start 38 Task 43: Machine 2; Start 37 Task 44:
Machine 4; Start 29 Task 45: Machine 3; Start 8 Task 46: Machine 1; Start 28 Task 47:
Machine 4; Start 17 Task 48: Machine 3; Start 28 Task 49: Machine 4; Start 36 Task 50:
Machine 4; Start 32

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inst_5_50_3_3

Solution: 37

Task 1: Machine 3; Start 21 Task 2: Machine 4; Start 25 Task 3: Machine 5; Start 13 Task 4: Machine 4; Start 17 Task 5: Machine 1; Start 35 Task 6: Machine 3; Start 25 Task 7: Machine 5; Start 35 Task 8: Machine 4; Start 8 Task 9: Machine 5; Start 18 Task 10: Machine 2; Start 33 Task 11: Machine 1; Start 32 Task 12: Machine 3; Start 32 Task 13: Machine 2; Start 22 Task 14: Machine 5; Start 9 Task 15: Machine 4; Start 12 Task 16: Machine 1; Start 8 Task 17: Machine 4; Start 35 Task 18: Machine 2; Start 4 Task 19: Machine 5; Start 11 Task 20: Machine 5; Start 1 Task 21: Machine 2; Start 25 Task 22: Machine 4; Start 8 Task 23: Machine 2; Start 17 Task 24: Machine 5; Start 26 Task 25: Machine 3; Start 31 Task 26: Machine 4; Start 1 Task 27: Machine 5; Start 16 Task 28: Machine 1; Start 15 Task 29: Machine 2; Start 26 Task 30: Machine 3; Start 27 Task 31: Machine 4; Start 29 Task 32: Machine 2; Start 8 Task 33: Machine 5; Start 1 Task 34: Machine 5; Start 20 Task 35: Machine 2; Start 9 Task 36: Machine 1; Start 18 Task 37: Machine 5; Start 11 Task 38: Machine 1; Start 9 Task 39: Machine 3; Start 1 Task 40: Machine 3; Start 4 Task 41: Machine 2; Start 31 Task 42: Machine 4; Start 21 Task 43: Machine 3; Start 1 Task 44: Machine 1; Start 22 Task 45: Machine 1; Start 2 Task 46: Machine 4; Start 22 Task 47: Machine 1; Start 35 Task 48: Machine 5; Start 21 Task 49: Machine 3; Start 11 Task 50: Machine 1; Start 6

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Solution: 37

Task 1: Machine 3; Start 21 Task 2: Machine 4; Start 29 Task 3: Machine 5; Start 16 Task 4: Machine 4; Start 17 Task 5: Machine 1; Start 36 Task 6: Machine 3; Start 25 Task 7: Machine 5; Start 35 Task 8: Machine 4; Start 8 Task 9: Machine 5; Start 19 Task 10: Machine 2; Start 33 Task 11: Machine 1; Start 32 Task 12: Machine 4; Start 32 Task 13: Machine 5; Start 25 Task 14: Machine 5; Start 10 Task 15: Machine 3; Start 16 Task 16: Machine 5; Start 8 Task 17: Machine 3; Start 35 Task 18: Machine 3; Start 4 Task 19: Machine 5; Start 11 Task 20: Machine 5; Start 1 Task 21: Machine 2; Start 25 Task 22: Machine 3; Start 6 Task 23: Machine 2; Start 17 Task 24: Machine 2; Start 26 Task 25: Machine 3; Start 31 Task 26: Machine 4; Start 1 Task 27: Machine 3; Start 11 Task 28: Machine 1; Start 17 Task 29: Machine 4; Start 27 Task 30: Machine 3; Start 27 Task 31: Machine 4; Start 30 Task 32: Machine 2; Start 8 Task 33: Machine 2; Start 2 Task 34: Machine 5; Start 20 Task 35: Machine 2; Start 9 Task 36: Machine 1; Start 18 Task 37: Machine 4; Start 11 Task 38: Machine 1; Start 10 Task 39: Machine 3; Start 5 Task 40: Machine 2; Start 4 Task 41: Machine 2; Start 31 Task 42: Machine 5; Start 23 Task 43: Machine 3; Start 1 Task 44: Machine 1; Start 24 Task 45: Machine 1; Start 2 Task 46: Machine 4; Start 24 Task 47: Machine 1; Start 35 Task 48: Machine 5; Start 21 Task 49: Machine 3; Start 15 Task 50: Machine 1; Start 6

=====

Solution: 37

Task 1: Machine 3; Start 21 Task 2: Machine 4; Start 25 Task 3: Machine 5; Start 13 Task 4: Machine 4; Start 17 Task 5: Machine 3; Start 35 Task 6: Machine 3; Start 25 Task 7: Machine 5; Start 35 Task 8: Machine 4; Start 7 Task 9: Machine 5; Start 17 Task 10: Machine 2; Start 33 Task 11: Machine 1; Start 32 Task 12: Machine 4; Start 32 Task 13: Machine 2; Start 21 Task 14: Machine 5; Start 10 Task 15: Machine 4; Start 11 Task 16: Machine 1; Start 8 Task 17: Machine 3; Start 35 Task 18: Machine 5; Start 4 Task 19: Machine 5; Start 11 Task 20: Machine 5; Start 1 Task 21: Machine 2; Start 25 Task 22: Machine 4; Start 7 Task 23: Machine 2; Start 17 Task 24: Machine 5; Start 25 Task 25: Machine 3; Start 31 Task 26: Machine 4; Start 1 Task 27: Machine 5; Start 15 Task 28: Machine 4; Start 14 Task 29: Machine 4; Start 25 Task 30: Machine 3; Start 27 Task 31: Machine 4; Start 28 Task 32:

Machine 2; Start 8 Task 33: Machine 5; Start 1 Task 34: Machine 5; Start 20 Task 35:
Machine 5; Start 9 Task 36: Machine 1; Start 18 Task 37: Machine 5; Start 11 Task 38:
Machine 3; Start 10 Task 39: Machine 4; Start 4 Task 40: Machine 3; Start 4 Task 41:
Machine 2; Start 31 Task 42: Machine 4; Start 21 Task 43: Machine 3; Start 1 Task 44:
Machine 1; Start 22 Task 45: Machine 1; Start 1 Task 46: Machine 4; Start 24 Task 47:
Machine 1; Start 35 Task 48: Machine 5; Start 21 Task 49: Machine 1; Start 11 Task 50:
Machine 1; Start 6

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inst_5_50_3_4

Solution: 43

Task 1: Machine 1; Start 29 Task 2: Machine 1; Start 19 Task 3: Machine 5; Start 37 Task 4:
Machine 2; Start 32 Task 5: Machine 2; Start 5 Task 6: Machine 5; Start 1 Task 7: Machine 2;
Start 28 Task 8: Machine 5; Start 3 Task 9: Machine 4; Start 27 Task 10: Machine 1; Start 32
Task 11: Machine 3; Start 28 Task 12: Machine 4; Start 24 Task 13: Machine 3; Start 29 Task
14: Machine 4; Start 33 Task 15: Machine 4; Start 37 Task 16: Machine 4; Start 39 Task 17:
Machine 2; Start 1 Task 18: Machine 4; Start 5 Task 19: Machine 1; Start 36 Task 20:
Machine 1; Start 36 Task 21: Machine 5; Start 1 Task 22: Machine 1; Start 29 Task 23:
Machine 3; Start 1 Task 24: Machine 2; Start 10 Task 25: Machine 3; Start 38 Task 26:
Machine 2; Start 18 Task 27: Machine 1; Start 6 Task 28: Machine 2; Start 26 Task 29:
Machine 2; Start 36 Task 30: Machine 3; Start 15 Task 31: Machine 1; Start 18 Task 32:
Machine 5; Start 20 Task 33: Machine 4; Start 19 Task 34: Machine 3; Start 11 Task 35:
Machine 5; Start 34 Task 36: Machine 3; Start 8 Task 37: Machine 2; Start 29 Task 38:
Machine 5; Start 26 Task 39: Machine 4; Start 15 Task 40: Machine 5; Start 23 Task 41:
Machine 3; Start 36 Task 42: Machine 4; Start 6 Task 43: Machine 3; Start 29 Task 44:
Machine 3; Start 20 Task 45: Machine 3; Start 10 Task 46: Machine 3; Start 25 Task 47:
Machine 3; Start 6 Task 48: Machine 2; Start 32 Task 49: Machine 4; Start 13 Task 50:
Machine 5; Start 41

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Solution: 43

Task 1: Machine 3; Start 29 Task 2: Machine 1; Start 18 Task 3: Machine 5; Start 37 Task 4:
Machine 2; Start 32 Task 5: Machine 2; Start 5 Task 6: Machine 1; Start 2 Task 7: Machine 2;
Start 28 Task 8: Machine 3; Start 1 Task 9: Machine 3; Start 26 Task 10: Machine 4; Start 32
Task 11: Machine 5; Start 29 Task 12: Machine 4; Start 23 Task 13: Machine 3; Start 30 Task
14: Machine 1; Start 32 Task 15: Machine 2; Start 39 Task 16: Machine 4; Start 39 Task 17:
Machine 2; Start 1 Task 18: Machine 4; Start 5 Task 19: Machine 5; Start 40 Task 20:
Machine 1; Start 37 Task 21: Machine 1; Start 1 Task 22: Machine 1; Start 30 Task 23:
Machine 1; Start 2 Task 24: Machine 2; Start 10 Task 25: Machine 3; Start 38 Task 26:
Machine 2; Start 18 Task 27: Machine 1; Start 5 Task 28: Machine 2; Start 26 Task 29:
Machine 2; Start 36 Task 30: Machine 3; Start 16 Task 31: Machine 2; Start 18 Task 32:
Machine 5; Start 20 Task 33: Machine 5; Start 19 Task 34: Machine 4; Start 7 Task 35:
Machine 5; Start 35 Task 36: Machine 3; Start 7 Task 37: Machine 4; Start 26 Task 38:
Machine 5; Start 26 Task 39: Machine 4; Start 15 Task 40: Machine 5; Start 25 Task 41:
Machine 3; Start 36 Task 42: Machine 3; Start 9 Task 43: Machine 3; Start 29 Task 44:
Machine 3; Start 20 Task 45: Machine 3; Start 7 Task 46: Machine 3; Start 23 Task 47:
Machine 3; Start 6 Task 48: Machine 2; Start 32 Task 49: Machine 4; Start 14 Task 50:
Machine 1; Start 42

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Solution: 43

Task 1: Machine 1; Start 33 Task 2: Machine 4; Start 18 Task 3: Machine 5; Start 37 Task 4: Machine 2; Start 36 Task 5: Machine 2; Start 5 Task 6: Machine 1; Start 2 Task 7: Machine 2; Start 33 Task 8: Machine 3; Start 3 Task 9: Machine 3; Start 28 Task 10: Machine 4; Start 32 Task 11: Machine 5; Start 30 Task 12: Machine 2; Start 24 Task 13: Machine 3; Start 30 Task 14: Machine 1; Start 33 Task 15: Machine 4; Start 37 Task 16: Machine 4; Start 39 Task 17: Machine 2; Start 1 Task 18: Machine 1; Start 5 Task 19: Machine 1; Start 36 Task 20: Machine 1; Start 37 Task 21: Machine 2; Start 4 Task 22: Machine 1; Start 31 Task 23: Machine 1; Start 1 Task 24: Machine 2; Start 10 Task 25: Machine 3; Start 39 Task 26: Machine 2; Start 18 Task 27: Machine 3; Start 6 Task 28: Machine 2; Start 27 Task 29: Machine 2; Start 37 Task 30: Machine 3; Start 16 Task 31: Machine 3; Start 20 Task 32: Machine 5; Start 20 Task 33: Machine 3; Start 19 Task 34: Machine 1; Start 9 Task 35: Machine 5; Start 35 Task 36: Machine 4; Start 4 Task 37: Machine 2; Start 30 Task 38: Machine 5; Start 26 Task 39: Machine 4; Start 15 Task 40: Machine 4; Start 24 Task 41: Machine 3; Start 36 Task 42: Machine 1; Start 7 Task 43: Machine 3; Start 29 Task 44: Machine 3; Start 21 Task 45: Machine 3; Start 13 Task 46: Machine 4; Start 25 Task 47: Machine 5; Start 10 Task 48: Machine 2; Start 32 Task 49: Machine 4; Start 14 Task 50: Machine 5; Start 42

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inst_5_50_3_5

Solution: 39

Task 1: Machine 4; Start 29 Task 2: Machine 2; Start 18 Task 3: Machine 2; Start 5 Task 4: Machine 3; Start 29 Task 5: Machine 2; Start 3 Task 6: Machine 4; Start 34 Task 7: Machine 4; Start 18 Task 8: Machine 3; Start 12 Task 9: Machine 3; Start 33 Task 10: Machine 4; Start 26 Task 11: Machine 1; Start 28 Task 12: Machine 1; Start 26 Task 13: Machine 3; Start 2 Task 14: Machine 3; Start 5 Task 15: Machine 1; Start 7 Task 16: Machine 5; Start 25 Task 17: Machine 2; Start 16 Task 18: Machine 3; Start 21 Task 19: Machine 1; Start 21 Task 20: Machine 2; Start 13 Task 21: Machine 2; Start 23 Task 22: Machine 3; Start 21 Task 23: Machine 5; Start 29 Task 24: Machine 5; Start 5 Task 25: Machine 3; Start 17 Task 26: Machine 4; Start 1 Task 27: Machine 4; Start 31 Task 28: Machine 2; Start 34 Task 29: Machine 5; Start 9 Task 30: Machine 5; Start 4 Task 31: Machine 1; Start 9 Task 32: Machine 5; Start 1 Task 33: Machine 3; Start 35 Task 34: Machine 1; Start 26 Task 35: Machine 5; Start 12 Task 36: Machine 2; Start 16 Task 37: Machine 3; Start 11 Task 38: Machine 5; Start 31 Task 39: Machine 2; Start 25 Task 40: Machine 1; Start 2 Task 41: Machine 1; Start 29 Task 42: Machine 2; Start 1 Task 43: Machine 2; Start 37 Task 44: Machine 4; Start 15 Task 45: Machine 3; Start 29 Task 46: Machine 4; Start 33 Task 47: Machine 2; Start 29 Task 48: Machine 3; Start 26 Task 49: Machine 1; Start 17 Task 50: Machine 2; Start 10

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Solution: 39

Task 1: Machine 4; Start 31 Task 2: Machine 1; Start 19 Task 3: Machine 2; Start 4 Task 4: Machine 2; Start 29 Task 5: Machine 2; Start 2 Task 6: Machine 4; Start 34 Task 7: Machine 4; Start 20 Task 8: Machine 3; Start 9 Task 9: Machine 3; Start 33 Task 10: Machine 2; Start 27 Task 11: Machine 3; Start 29 Task 12: Machine 3; Start 26 Task 13: Machine 3; Start 2 Task 14: Machine 3; Start 5 Task 15: Machine 1; Start 5 Task 16: Machine 5; Start 25 Task 17: Machine 2; Start 16 Task 18: Machine 3; Start 21 Task 19: Machine 1; Start 22 Task 20: Machine 5; Start 10 Task 21: Machine 1; Start 25 Task 22: Machine 3; Start 21 Task 23: Machine 5; Start 29 Task 24: Machine 2; Start 3 Task 25: Machine 3; Start 17 Task 26: Machine 4; Start 1 Task 27: Machine 2; Start 33 Task 28: Machine 1; Start 35 Task 29: Machine 5; Start 9 Task 30: Machine 5; Start 2 Task 31: Machine 1; Start 6 Task 32: Machine 5; Start 1 Task 33: Machine 3; Start 35 Task 34: Machine 1; Start 26 Task 35: Machine 5;

Start 12 Task 36: Machine 2; Start 17 Task 37: Machine 3; Start 11 Task 38: Machine 5; Start 33 Task 39: Machine 2; Start 26 Task 40: Machine 4; Start 2 Task 41: Machine 1; Start 29 Task 42: Machine 2; Start 1 Task 43: Machine 2; Start 37 Task 44: Machine 4; Start 12 Task 45: Machine 3; Start 32 Task 46: Machine 4; Start 33 Task 47: Machine 4; Start 26 Task 48: Machine 1; Start 26 Task 49: Machine 2; Start 17 Task 50: Machine 2; Start 9

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Solution: 39

Task 1: Machine 2; Start 31 Task 2: Machine 2; Start 20 Task 3: Machine 3; Start 4 Task 4: Machine 1; Start 29 Task 5: Machine 2; Start 3 Task 6: Machine 4; Start 34 Task 7: Machine 1; Start 20 Task 8: Machine 3; Start 14 Task 9: Machine 3; Start 33 Task 10: Machine 2; Start 28 Task 11: Machine 3; Start 31 Task 12: Machine 1; Start 27 Task 13: Machine 3; Start 2 Task 14: Machine 3; Start 9 Task 15: Machine 1; Start 7 Task 16: Machine 5; Start 25 Task 17: Machine 2; Start 16 Task 18: Machine 3; Start 21 Task 19: Machine 1; Start 22 Task 20: Machine 5; Start 10 Task 21: Machine 1; Start 24 Task 22: Machine 3; Start 21 Task 23: Machine 5; Start 31 Task 24: Machine 3; Start 5 Task 25: Machine 3; Start 17 Task 26: Machine 4; Start 1 Task 27: Machine 2; Start 33 Task 28: Machine 2; Start 35 Task 29: Machine 5; Start 9 Task 30: Machine 2; Start 2 Task 31: Machine 3; Start 7 Task 32: Machine 5; Start 1 Task 33: Machine 3; Start 35 Task 34: Machine 1; Start 26 Task 35: Machine 5; Start 12 Task 36: Machine 2; Start 18 Task 37: Machine 3; Start 11 Task 38: Machine 5; Start 33 Task 39: Machine 4; Start 25 Task 40: Machine 4; Start 2 Task 41: Machine 2; Start 30 Task 42: Machine 2; Start 1 Task 43: Machine 2; Start 37 Task 44: Machine 5; Start 19 Task 45: Machine 3; Start 32 Task 46: Machine 4; Start 33 Task 47: Machine 2; Start 27 Task 48: Machine 3; Start 26 Task 49: Machine 1; Start 18 Task 50: Machine 2; Start 13

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inst_10_100_5_1

Solution: 37

Task 1: Machine 10; Start 18 Task 2: Machine 2; Start 34 Task 3: Machine 3; Start 28 Task 4: Machine 5; Start 17 Task 5: Machine 3; Start 6 Task 6: Machine 7; Start 22 Task 7: Machine 1; Start 5 Task 8: Machine 5; Start 13 Task 9: Machine 8; Start 4 Task 10: Machine 9; Start 9 Task 11: Machine 4; Start 35 Task 12: Machine 2; Start 20 Task 13: Machine 1; Start 11 Task 14: Machine 5; Start 18 Task 15: Machine 8; Start 31 Task 16: Machine 3; Start 17 Task 17: Machine 4; Start 3 Task 18: Machine 8; Start 12 Task 19: Machine 8; Start 2 Task 20: Machine 6; Start 2 Task 21: Machine 1; Start 33 Task 22: Machine 1; Start 31 Task 23: Machine 3; Start 6 Task 24: Machine 10; Start 6 Task 25: Machine 5; Start 33 Task 26: Machine 3; Start 4 Task 27: Machine 10; Start 19 Task 28: Machine 10; Start 9 Task 29: Machine 4; Start 16 Task 30: Machine 9; Start 14 Task 31: Machine 10; Start 12 Task 32: Machine 10; Start 11 Task 33: Machine 7; Start 35 Task 34: Machine 2; Start 12 Task 35: Machine 9; Start 6 Task 36: Machine 3; Start 18 Task 37: Machine 6; Start 9 Task 38: Machine 8; Start 35 Task 39: Machine 9; Start 3 Task 40: Machine 6; Start 6 Task 41: Machine 6; Start 12 Task 42: Machine 5; Start 8 Task 43: Machine 10; Start 15 Task 44: Machine 1; Start 1 Task 45: Machine 2; Start 24 Task 46: Machine 1; Start 33 Task 47: Machine 8; Start 19 Task 48: Machine 10; Start 27 Task 49: Machine 8; Start 7 Task 50: Machine 10; Start 32 Task 51: Machine 6; Start 20 Task 52: Machine 2; Start 15 Task 53: Machine 4; Start 29 Task 54: Machine 10; Start 1 Task 55: Machine 8; Start 26 Task 56: Machine 1; Start 27 Task 57: Machine 6; Start 34 Task 58: Machine 1; Start 31 Task 59: Machine 10; Start 21 Task 60: Machine 3; Start 12 Task 61: Machine 6; Start 7 Task 62: Machine 4; Start 34 Task 63: Machine 5; Start 30 Task 64: Machine 8; Start 14 Task 65: Machine 3; Start 34 Task 66: Machine 3; Start 18 Task 67: Machine 4; Start 15 Task 68: Machine 9; Start 17 Task 69: Machine 9; Start 4 Task 70: Machine 4; Start 8 Task 71:

Machine 4; Start 31 Task 72: Machine 8; Start 28 Task 73: Machine 7; Start 22 Task 74:
Machine 4; Start 17 Task 75: Machine 9; Start 31 Task 76: Machine 10; Start 7 Task 77:
Machine 5; Start 12 Task 78: Machine 3; Start 15 Task 79: Machine 9; Start 16 Task 80:
Machine 3; Start 35 Task 81: Machine 5; Start 28 Task 82: Machine 6; Start 10 Task 83:
Machine 2; Start 8 Task 84: Machine 1; Start 1 Task 85: Machine 3; Start 35 Task 86:
Machine 1; Start 20 Task 87: Machine 5; Start 6 Task 88: Machine 10; Start 36 Task 89:
Machine 1; Start 17 Task 90: Machine 2; Start 9 Task 91: Machine 9; Start 3 Task 92:
Machine 2; Start 4 Task 93: Machine 5; Start 7 Task 94: Machine 1; Start 16 Task 95:
Machine 3; Start 10 Task 96: Machine 8; Start 9 Task 97: Machine 1; Start 23 Task 98:
Machine 10; Start 34 Task 99: Machine 4; Start 6 Task 100: Machine 4; Start 5

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inst_10_100_5_2

Solution: 37

Task 1: Machine 8; Start 6 Task 2: Machine 9; Start 20 Task 3: Machine 4; Start 1 Task 4:
Machine 4; Start 14 Task 5: Machine 4; Start 25 Task 6: Machine 7; Start 12 Task 7: Machine
5; Start 36 Task 8: Machine 2; Start 13 Task 9: Machine 6; Start 7 Task 10: Machine 1; Start
4 Task 11: Machine 2; Start 25 Task 12: Machine 4; Start 13 Task 13: Machine 6; Start 13
Task 14: Machine 5; Start 31 Task 15: Machine 3; Start 23 Task 16: Machine 9; Start 31 Task
17: Machine 8; Start 17 Task 18: Machine 8; Start 2 Task 19: Machine 10; Start 18 Task 20:
Machine 8; Start 11 Task 21: Machine 1; Start 22 Task 22: Machine 1; Start 1 Task 23:
Machine 1; Start 7 Task 24: Machine 3; Start 31 Task 25: Machine 3; Start 18 Task 26:
Machine 5; Start 4 Task 27: Machine 8; Start 36 Task 28: Machine 3; Start 34 Task 29:
Machine 8; Start 13 Task 30: Machine 4; Start 30 Task 31: Machine 10; Start 12 Task 32:
Machine 7; Start 14 Task 33: Machine 8; Start 21 Task 34: Machine 10; Start 26 Task 35:
Machine 7; Start 31 Task 36: Machine 4; Start 34 Task 37: Machine 2; Start 15 Task 38:
Machine 7; Start 1 Task 39: Machine 3; Start 19 Task 40: Machine 9; Start 29 Task 41:
Machine 3; Start 19 Task 42: Machine 1; Start 3 Task 43: Machine 5; Start 16 Task 44:
Machine 6; Start 5 Task 45: Machine 9; Start 18 Task 46: Machine 10; Start 28 Task 47:
Machine 10; Start 33 Task 48: Machine 9; Start 10 Task 49: Machine 5; Start 17 Task 50:
Machine 1; Start 34 Task 51: Machine 6; Start 8 Task 52: Machine 10; Start 34 Task 53:
Machine 2; Start 12 Task 54: Machine 9; Start 13 Task 55: Machine 10; Start 32 Task 56:
Machine 7; Start 33 Task 57: Machine 8; Start 14 Task 58: Machine 2; Start 32 Task 59:
Machine 8; Start 21 Task 60: Machine 4; Start 15 Task 61: Machine 6; Start 19 Task 62:
Machine 7; Start 8 Task 63: Machine 1; Start 9 Task 64: Machine 8; Start 7 Task 65: Machine
10; Start 20 Task 66: Machine 10; Start 14 Task 67: Machine 10; Start 23 Task 68: Machine
3; Start 24 Task 69: Machine 8; Start 35 Task 70: Machine 3; Start 8 Task 71: Machine 9;
Start 15 Task 72: Machine 4; Start 19 Task 73: Machine 6; Start 22 Task 74: Machine 5; Start
6 Task 75: Machine 10; Start 16 Task 76: Machine 7; Start 26 Task 77: Machine 9; Start 32
Task 78: Machine 4; Start 21 Task 79: Machine 3; Start 25 Task 80: Machine 9; Start 24 Task
81: Machine 9; Start 19 Task 82: Machine 3; Start 21 Task 83: Machine 2; Start 5 Task 84:
Machine 10; Start 9 Task 85: Machine 3; Start 10 Task 86: Machine 8; Start 12 Task 87:
Machine 5; Start 14 Task 88: Machine 7; Start 16 Task 89: Machine 3; Start 1 Task 90:
Machine 8; Start 8 Task 91: Machine 8; Start 30 Task 92: Machine 9; Start 2 Task 93:
Machine 10; Start 7 Task 94: Machine 3; Start 25 Task 95: Machine 1; Start 4 Task 96:
Machine 6; Start 28 Task 97: Machine 9; Start 30 Task 98: Machine 3; Start 33 Task 99:
Machine 10; Start 3 Task 100: Machine 5; Start 12

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inst_10_100_5_3

Solution: 36

Task 1: Machine 8; Start 17 Task 2: Machine 10; Start 10 Task 3: Machine 8; Start 26 Task 4: Machine 8; Start 27 Task 5: Machine 1; Start 22 Task 6: Machine 8; Start 1 Task 7: Machine 7; Start 15 Task 8: Machine 10; Start 21 Task 9: Machine 6; Start 23 Task 10: Machine 6; Start 22 Task 11: Machine 2; Start 24 Task 12: Machine 3; Start 13 Task 13: Machine 7; Start 17 Task 14: Machine 4; Start 19 Task 15: Machine 10; Start 25 Task 16: Machine 7; Start 6 Task 17: Machine 9; Start 25 Task 18: Machine 3; Start 18 Task 19: Machine 3; Start 5 Task 20: Machine 7; Start 3 Task 21: Machine 10; Start 15 Task 22: Machine 6; Start 1 Task 23: Machine 3; Start 12 Task 24: Machine 3; Start 12 Task 25: Machine 8; Start 15 Task 26: Machine 1; Start 10 Task 27: Machine 9; Start 31 Task 28: Machine 1; Start 9 Task 29: Machine 6; Start 19 Task 30: Machine 4; Start 10 Task 31: Machine 8; Start 19 Task 32: Machine 6; Start 14 Task 33: Machine 4; Start 3 Task 34: Machine 1; Start 11 Task 35: Machine 7; Start 13 Task 36: Machine 2; Start 13 Task 37: Machine 8; Start 32 Task 38: Machine 8; Start 17 Task 39: Machine 4; Start 28 Task 40: Machine 1; Start 23 Task 41: Machine 5; Start 22 Task 42: Machine 3; Start 17 Task 43: Machine 3; Start 30 Task 44: Machine 9; Start 18 Task 45: Machine 4; Start 8 Task 46: Machine 3; Start 16 Task 47: Machine 4; Start 11 Task 48: Machine 3; Start 19 Task 49: Machine 2; Start 14 Task 50: Machine 3; Start 21 Task 51: Machine 9; Start 20 Task 52: Machine 8; Start 31 Task 53: Machine 2; Start 27 Task 54: Machine 4; Start 13 Task 55: Machine 9; Start 27 Task 56: Machine 3; Start 21 Task 57: Machine 7; Start 12 Task 58: Machine 5; Start 13 Task 59: Machine 2; Start 14 Task 60: Machine 1; Start 3 Task 61: Machine 4; Start 10 Task 62: Machine 1; Start 27 Task 63: Machine 1; Start 8 Task 64: Machine 7; Start 8 Task 65: Machine 8; Start 17 Task 66: Machine 1; Start 35 Task 67: Machine 8; Start 20 Task 68: Machine 9; Start 1 Task 69: Machine 3; Start 34 Task 70: Machine 9; Start 27 Task 71: Machine 10; Start 14 Task 72: Machine 5; Start 15 Task 73: Machine 9; Start 12 Task 74: Machine 1; Start 14 Task 75: Machine 8; Start 33 Task 76: Machine 2; Start 32 Task 77: Machine 2; Start 10 Task 78: Machine 9; Start 32 Task 79: Machine 5; Start 3 Task 80: Machine 5; Start 21 Task 81: Machine 5; Start 16 Task 82: Machine 2; Start 15 Task 83: Machine 8; Start 24 Task 84: Machine 4; Start 6 Task 85: Machine 9; Start 30 Task 86: Machine 7; Start 7 Task 87: Machine 5; Start 32 Task 88: Machine 7; Start 17 Task 89: Machine 7; Start 18 Task 90: Machine 1; Start 12 Task 91: Machine 8; Start 3 Task 92: Machine 2; Start 25 Task 93: Machine 8; Start 21 Task 94: Machine 6; Start 2 Task 95: Machine 3; Start 23 Task 96: Machine 6; Start 9 Task 97: Machine 3; Start 31 Task 98: Machine 7; Start 2 Task 99: Machine 5; Start 12 Task 100: Machine 4; Start 9

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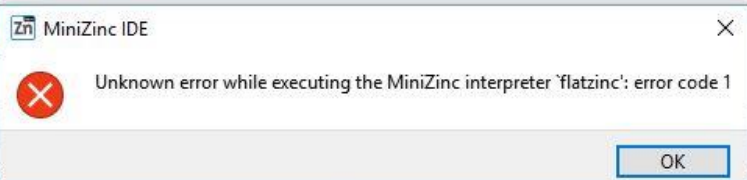
	gurobi (bundled)	chuffed (bundled)	G12lazyfd
inst_3_10_2_1	2,963	0,251	0,798
inst_3_10_2_2	2,391	0,173	0,808
inst_3_10_2_3	2,185	0,179	0,839
inst_3_10_2_4	2,037	0,152	0,753
inst_3_10_2_5	2,663	0,160	0,822
inst_5_20_3_1	55,277	0,457	6,605
inst_5_20_3_2	61	0,335	5,338
inst_5_20_3_3	96	0,456	7,962
inst_5_20_3_4	82	0,520	6,067
inst_5_20_3_5	101	0,467	22,62
inst_5_50_3_1	706,00	5,985	63
inst_5_50_3_2	715,00	5,239	62
inst_5_50_3_3	562,00	5,452	59,495
inst_5_50_3_4	602,00	5,992	58,68
inst_5_50_3_5	729,00	8,300	61
inst_10_100_5_1	over 2 hours running Time	159	run time Error
inst_10_100_5_2	over 2 hours running Time	163	run time Error
inst_10_100_5_3	over 2 hours running Time	171	run time Error

- Runtime of every Solver
- The data are given per second
- run time error of *G12lazyfd* solver with *inst_10_100* instances

```

3 int: tasks; % number of tasks
4 set of int: TASKS = 1..tasks;
5
6 int: machines; % number of machines
7 set of int: MACHINES = 1..machines;
8
9 % machi
10 array[M
11

```



MiniZinc IDE

Unknown error while executing the MiniZinc interpreter 'flatzinc': error code 1

OK

```

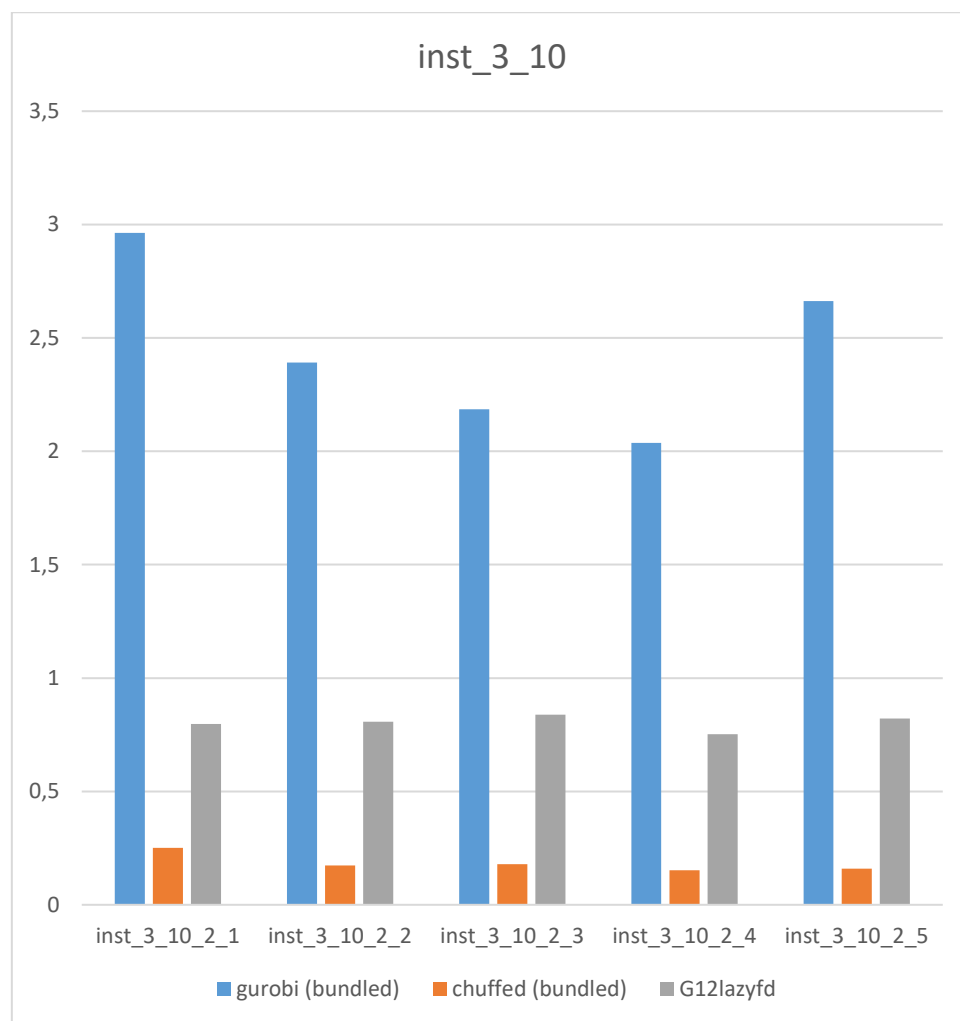
Machine 5;
Start 18 Task 90: Machine 1; Start 12 Task 91: Machine 8; Start 3
Task 92: Machine 2; Start 25 Task 93: Machine 8; Start 21 Task 94:
Machine 6; Start 2 Task 95: Machine 3; Start 23 Task 96: Machine 6;
Start 9 Task 97: Machine 3; Start 31 Task 98: Machine 7; Start 2
Task 99: Machine 5; Start 12 Task 100: Machine 4; Start 9
-----
=====
Finished in 2m 51s
Compiling HW2 - Kopie.mzn with data inst_10_100_5_3.dzn
Running HW2 - Kopie.mzn
Finished in 1m 4s
Finished in 1m 4s
Compiling HW2 - Kopie.mzn with data inst_10_100_5_3.dzn
Running HW2 - Kopie.mzn

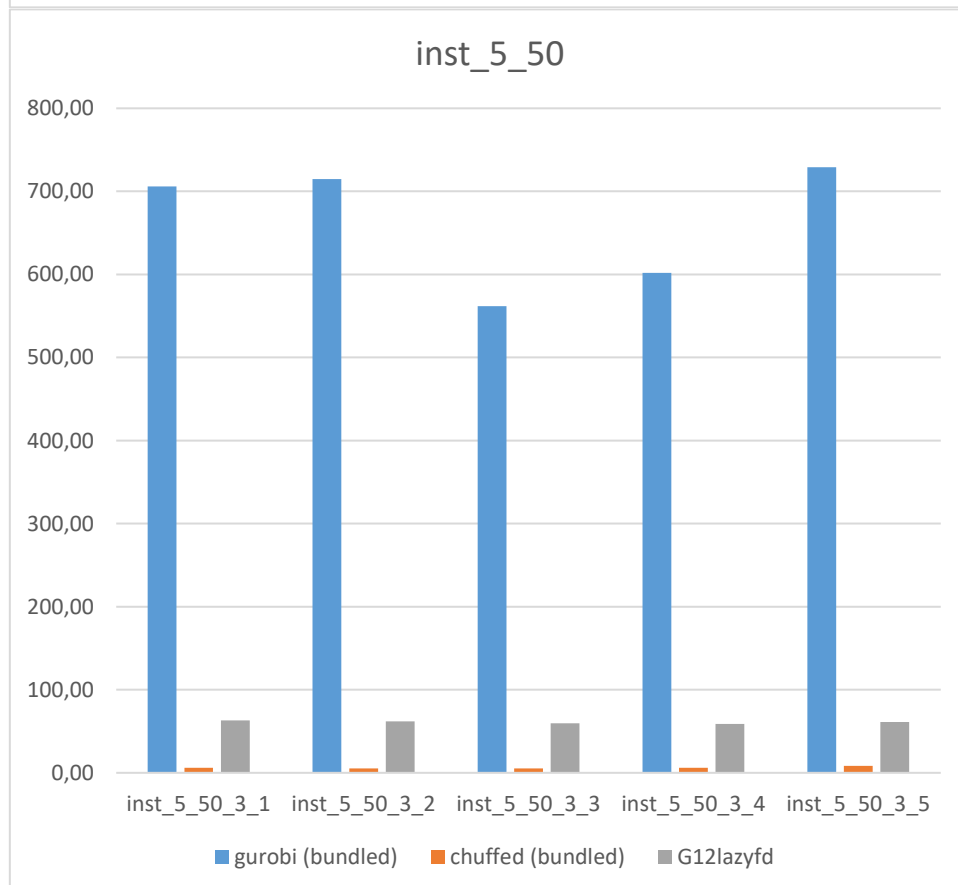
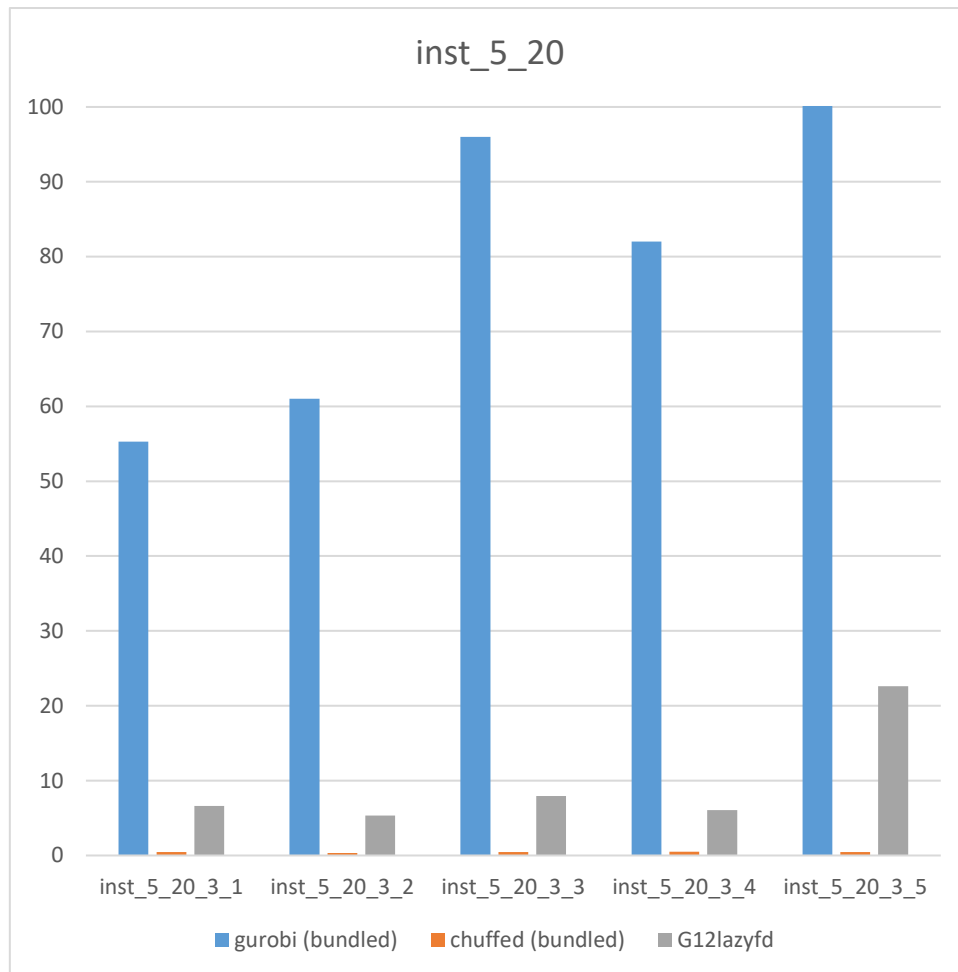
```

- Run time over 2 hours of *gurobi(bundled)* solver with **inst_10_100** instances

```
Machine 2; Start 4 Task 95: Machine 3; Start 9 Task 96: Machine 2; Start 7
Task 97: Machine 4; Start 23 Task 98: Machine 10; Start 33 Task 99:
Machine 4; Start 6 Task 100: Machine 3; Start 4
-----
Stopped.
Finished in 2h 12m 11s

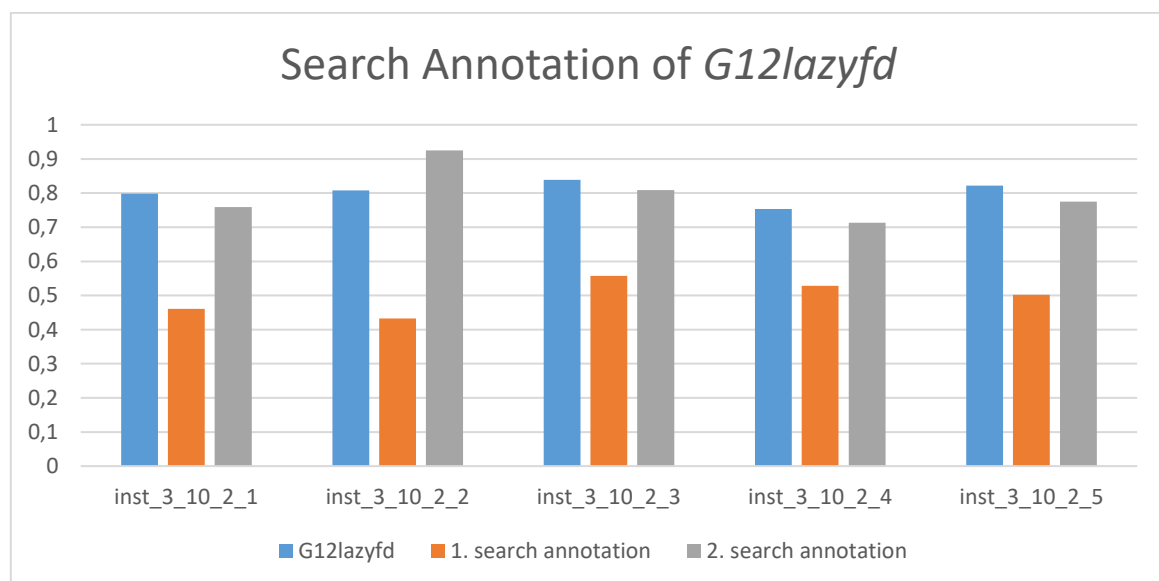
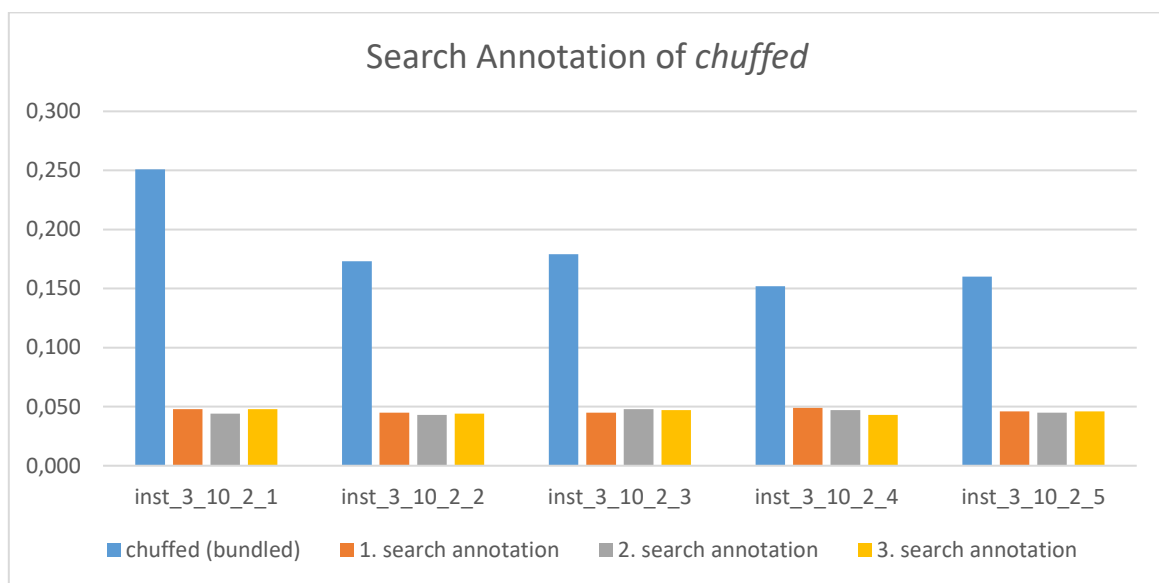
Ready. 2h 12m 11s
```





Search Annotation

- 1 `solve :: int_search (start, anti_first_fail , indomain_min , complete) minimize span;`
- 2 `solve :: int_search (start, impact , indomain_min , complete) minimize span;`
- 3 `solve :: int_search (start, occurrence , indomain_min , complete) minimize span;`



- warning: variable selection strategy `occurrence' is not supported by the LAZY solver backend.

Search Annotation of *Gurobi*

