# Maintenance Scheduling in the Oil Industry Using SMT Techniques

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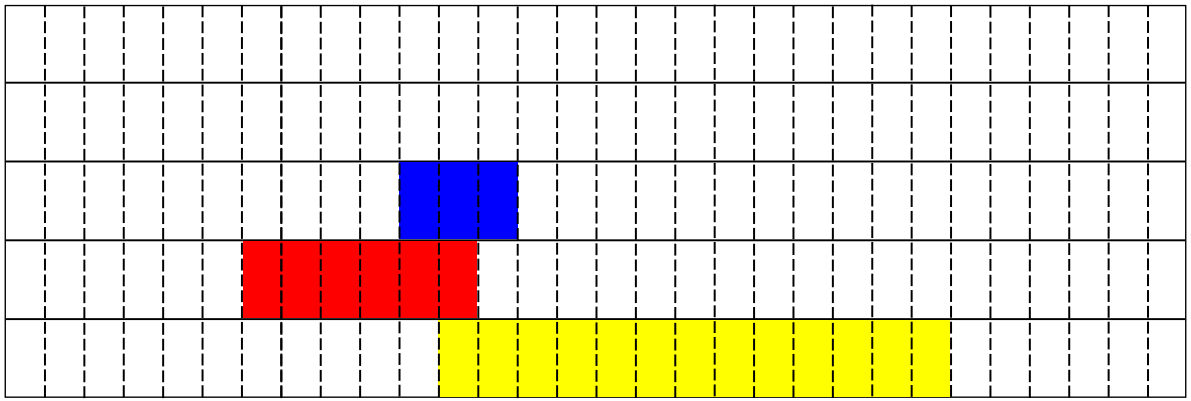
# The Project Scheduling Problem

# Multi Mode Resource Constrained Project Scheduling (MMRCPS)



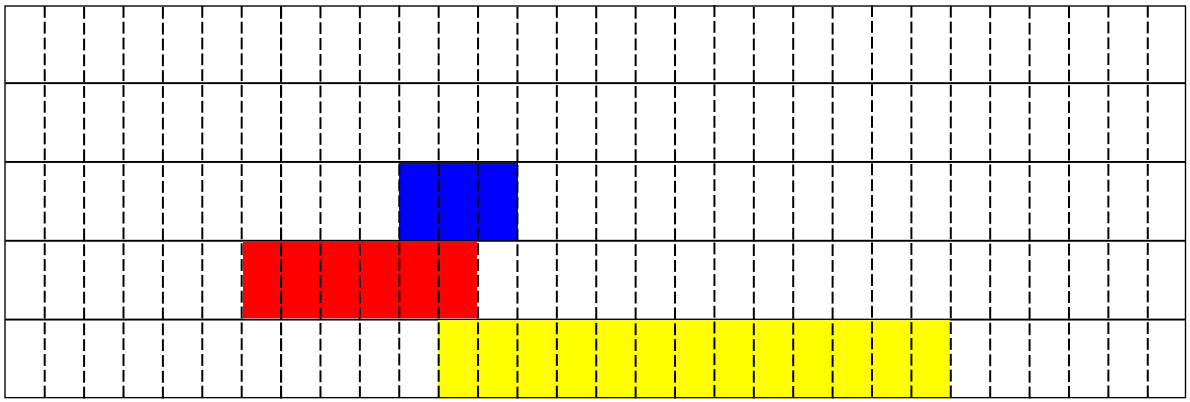
- Activities have interdependencies.
- An activity can be performed in several modes.
- Modes require different sets of resources.
- The mode influences the activity duration.
- Resources have limited capacity.
- Goal: minimize makespan (latest endtime).

# Scheduling In The Oil Industry

- Special case of MMRCPS.
- Every activity is performed at a location.
- Activities performed by one specialist from a crew.
- There are different crews with different capacity.
- An activity might require one crane.
- There are several cranes, at different locations.
- When a crane is used, the locations of the activity and of the crane are locked (safety constraint).
- Each activity has a constant duration.
- The safety constraints make the problem essentially more difficult than an RCPS.

# Improving the encoding

- Previous work on using Pseudo Boolean solvers for MMRCPS by Coelho et al.
- Rather than encoding startimes: track activity.
- Uses two variables per activity, $hasStarted_{ah}$, $active_{ah}$.

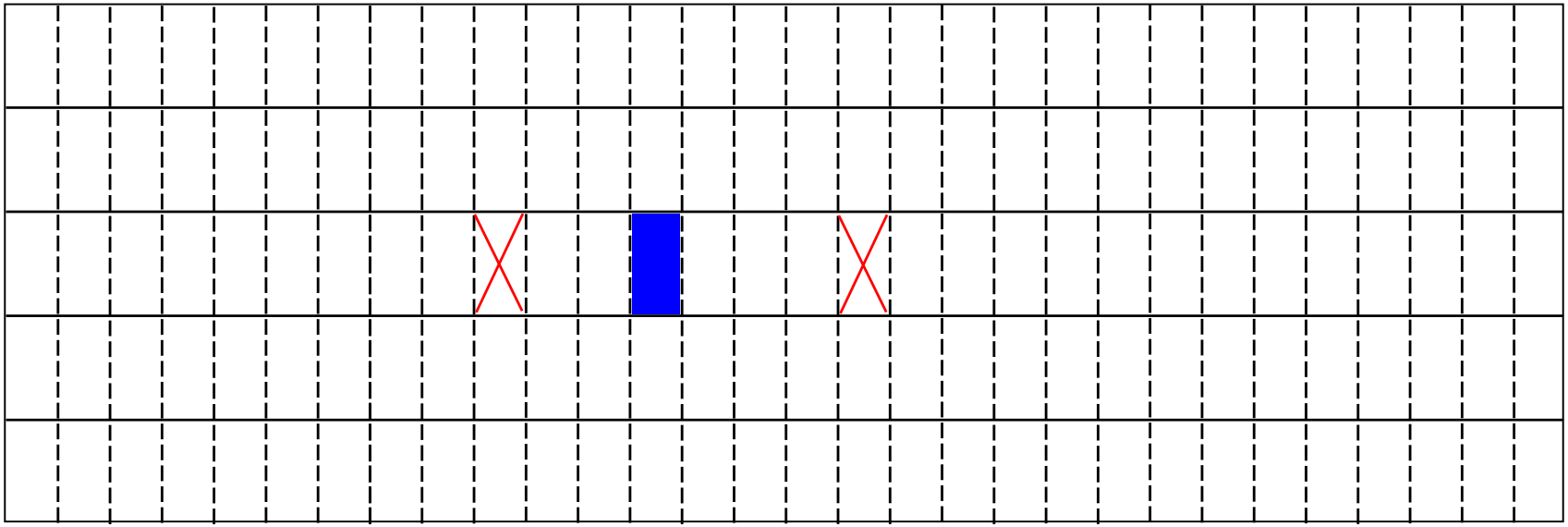


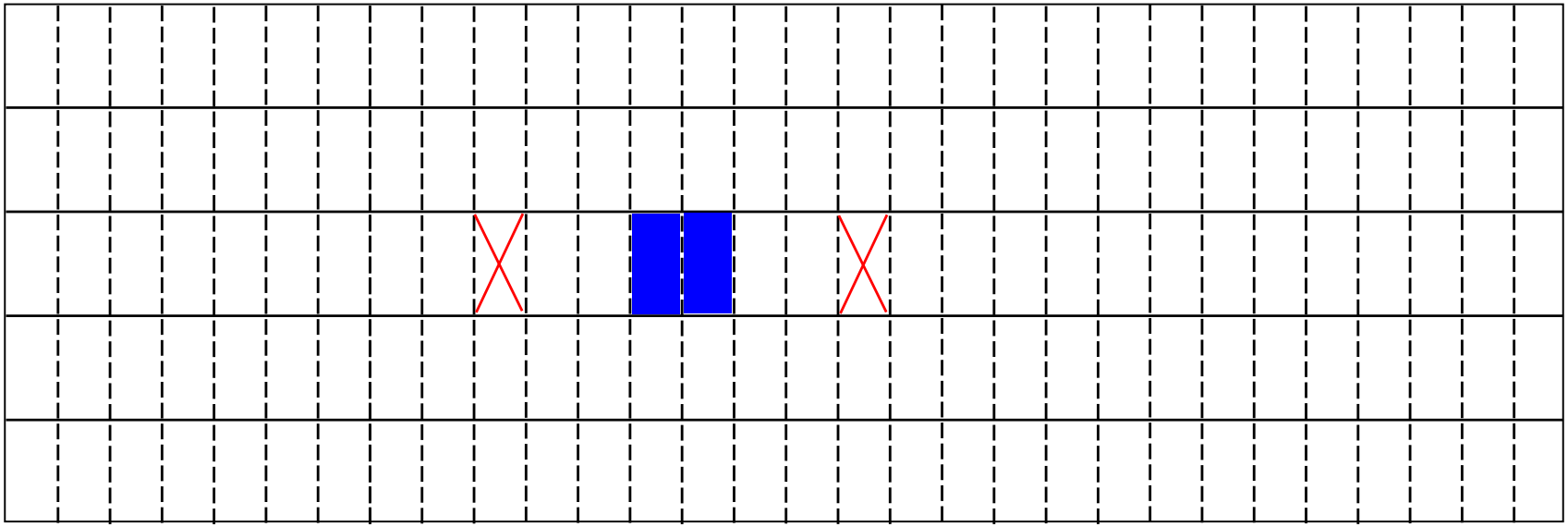
Quadratic number of clauses of the form:

$$\neg hasStarted_{a,h-d_a} \wedge hasStarted_{a,h} \rightarrow active_{a,h}$$

$$active_{a,h} \rightarrow \neg hasStarted_{a,h-d_a}$$

$$active_{a,h} \rightarrow hasStarted_{a,h}$$





Model crew resource constraints by:

$$\sum_{a \ uses \ r} active_{a,h} \leq capacity_r \text{ for all } h \text{ and resources } r.$$

Model crane resource constraints by:

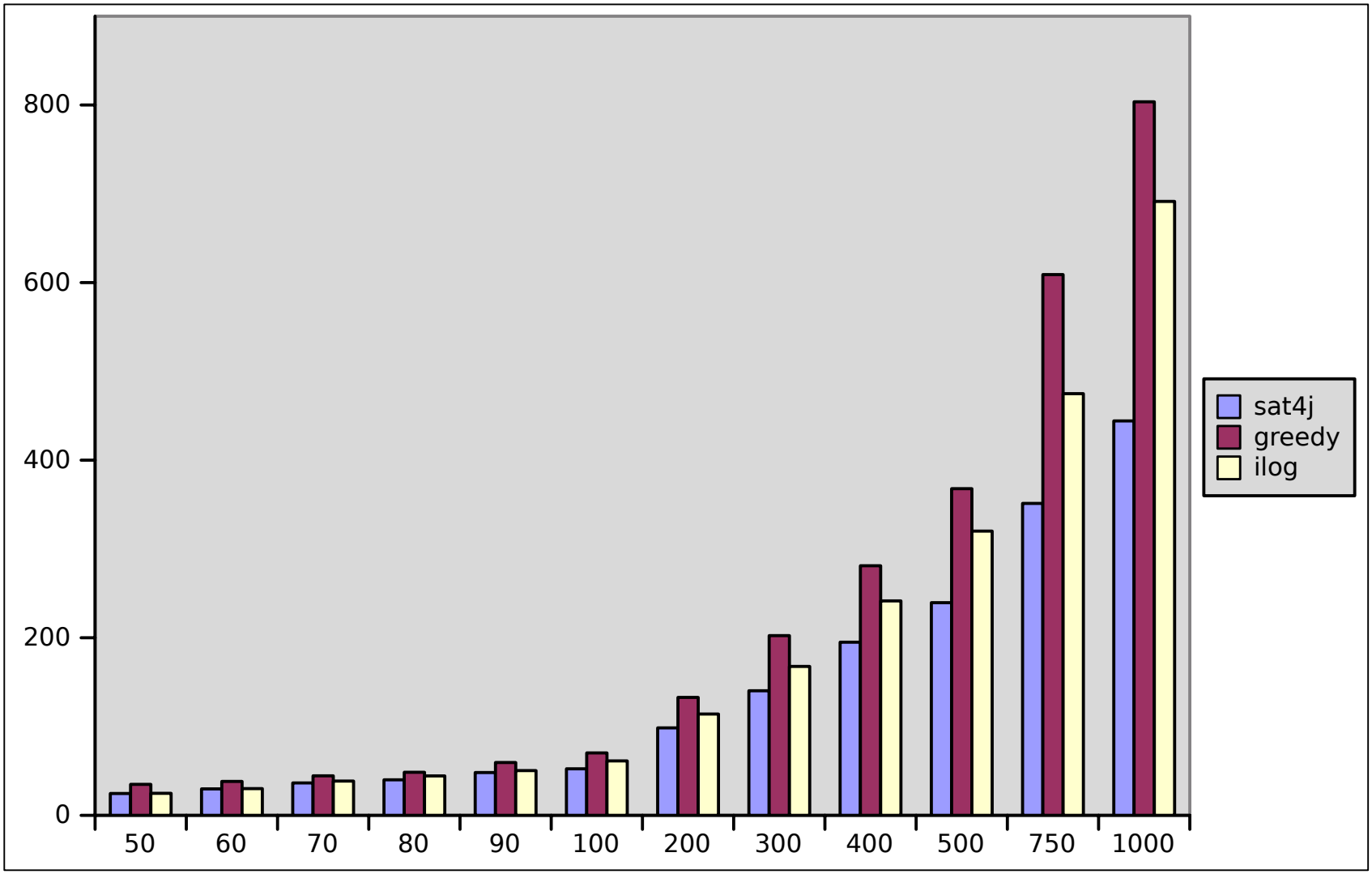
$$active_{a,h} \wedge choose_{a,c} \rightarrow \neg(active_{b,h} \wedge choose_{b,c}),$$

for all $h$, cranes $c$, and activities $a \neq b$ requiring a crane.

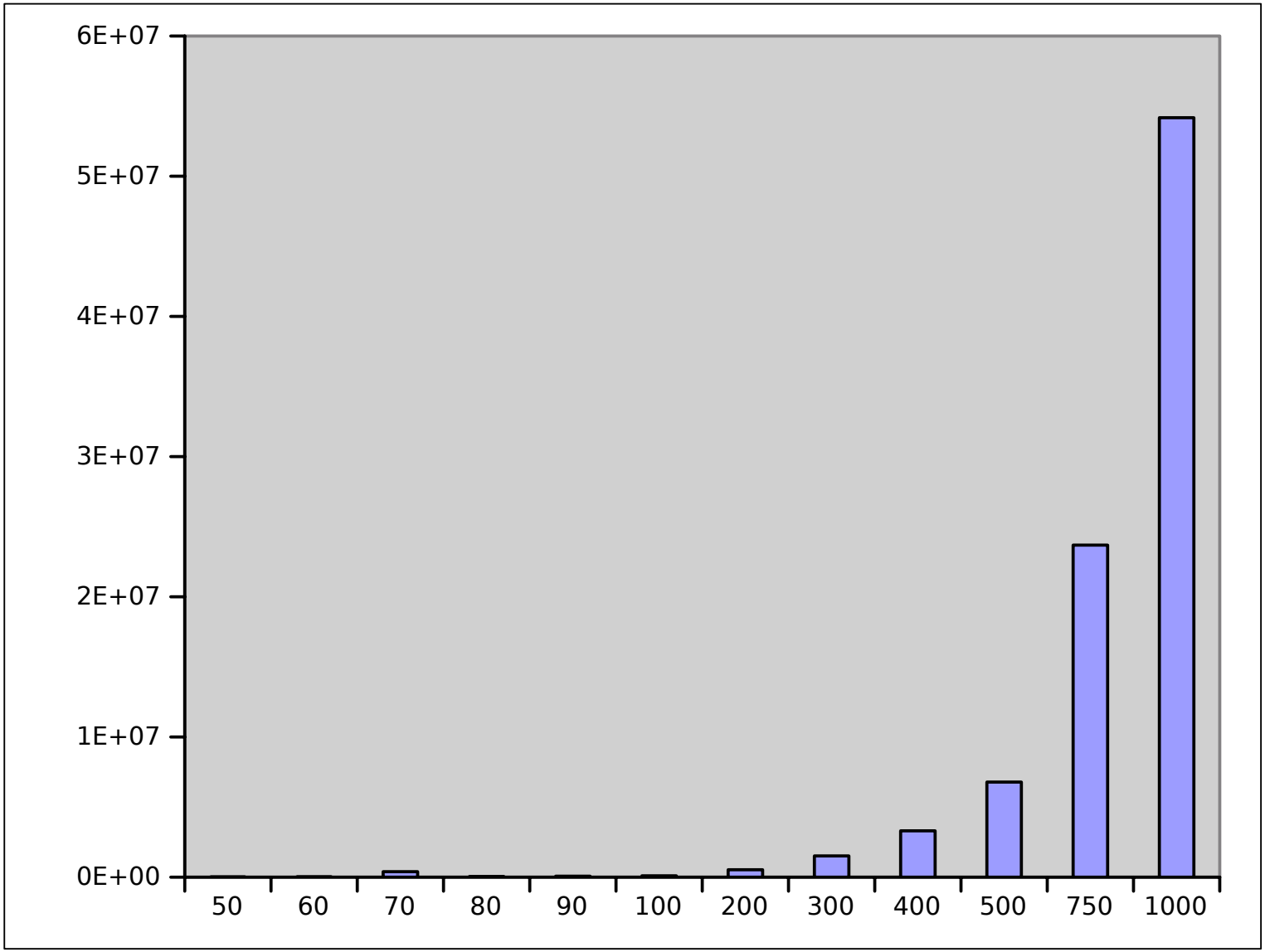
# Results

- 120 randomized benchmarks.
- Number of activities ranging between 50 and 1000.
- Reference: a naive greedy algorithm.
- A solver based on ILP did not perform well.
- Previous work: CP solver using Ilog Scheduler.
- Not all benchmarks were solved by the CP solver.
- All benchmarks were solved by PB solver.
- Solvers are given 10 minutes per benchmark.

# Results


800
600
400
200
0
50
60
70
80
90
100
200
300
400
500
750
1000
sat4j
greedy
ilog

# Number of clauses + PB-Constraints



# Further Research

- Generalize our results to MMRCPS.
- Incorporate additional constraints used in the oil industry.

Questions?