Unique Reconfiguration Sequence

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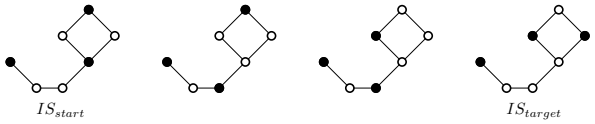
The independent Set Reconfiguration Problem (ISP) was the topic of the Core Challenge 2022[2]. For a detailed description, see their website.

Given an undirected graph G and two independent sets IS_{start} and IS_{target} of G, find a sequence of independent sets starting with IS_{target} and ending in IS_{target}, such that two consecutive sets only differ in one node.

The presented encoding was used to find the longest valid reconfiguration sequence, therefore we added a uniqueness constraint to the problem definition: No independent set in the sequence may appear more than once.



The encoding for a given makespan is straight-forward:

- For each step we have one variable for each node v in G, encoding if v is part of the current independent set.
- For each set we add one clause for each edge in G to enforce independence.
- For two adjacent steps we add the constraint that the number of variables $\top$ in one and $\bot$ in the other is exactly one, we do this in both directions. For the at-most-one part, we use a Cartesian-product-encoding [1].
- Lastly, we ensure that each set is different from every previous set in at least one variable.

The benchmark set contains 10 satisfiable and 10 unsatisfiable benchmarks. There are three reasons why an endcoding might be unsatisfiable:

1) The makespan is too low to reach the target set.
2) There are shorter reconfiguration sequences that reach the target, but under the uniquness constraint it is not possible to reach it with the given makespan.
3) The ISP is unsolveable independent of the makespan.

We included examples for all cases.

The benchmarks are named according to the following convention:

`reconf<10/20>_<makespan>_<ISP name>.cnf`

Where a 10 indicates satisfiablity and a 20 unsatisfiablity. The last part is a shortened version of the original ISP instance name from the Core Challenge.

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References

[1] Jingchao Chen. "A New SAT Encoding of the At-Most-One Constraint". In: *Proc. Constraint Modelling and Reformulation* (2010), p. 8.

[2] Takehiro Ito, Yoshio Okamoto, and Takehide Soh. *Core Challenge 2022*. URL: https://core-challenge.github.io/2022/.