

# Metis 2018

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## Abstract

Metis 2018 is a Fast Downward based planner that uses the pruning techniques partial order reduction and structural symmetries. The two variants that participate in the competition use the LM-cut and the landmark heuristic. The former essentially is a remake of Metis that participated in the IPC 2014, and the latter only differs in the used heuristic and the symmetry-based pruning algorithm.

## Metis 2018

Metis is a planner that participated in the IPC 2014 (Alkhazraji et al. 2014), called Metis 2014 henceforth. Our planner, Metis 2018, is a remake of Metis 2014, and comes with similar three core components:

- an admissible heuristic: LM-cut (Helmert and Domshlak 2009) or the max heuristic over LM-cut and the landmark heuristic with the landmark generation method of LAMA (Richter, Helmert, and Westphal 2008) and  $h^m$  landmarks with  $m = 2$  (Keyder, Richter, and Helmert 2010),
- pruning based on structural symmetries (Shleyfman et al. 2015) using DKS (Domshlak, Katz, and Shleyfman 2012) or orbit space search (OSS) (Domshlak, Katz, and Shleyfman 2015), and
- pruning based on partial order reduction using strong stubborn sets (Wehrle and Helmert 2014).

Notable differences to Metis 2014 are that we do not use the incremental computation of the LM-cut heuristic (Pommerening and Helmert 2013) and that we include the landmark heuristic for one of our planner variants. Furthermore, we do not only use OSS, but also the DKS algorithm for symmetry-based pruning in one of the variants. The partial order reduction component is the same as in Metis 2014.

In addition to the above differences in ingredients of the planner, Metis 2018 is implemented on top of a recent version of Fast Downward (Helmert 2006). To support conditional effects, we implemented a variant of the LM-cut heuristic that considers effect conditions in the same way as Metis 2014 does. However, we refrain from choosing the regular LM-cut heuristic or variant that supports conditional effects depending on the requirements of the input planning task, and instead always use the latter implementation that

comes with a small overhead due to the need for different data structures.

The implementation of symmetry-based pruning is the same in both versions, including the extension of the symmetry graph to support conditional effects, which was recently also defined formally by Sievers et al. (2017) in the context of structural symmetries of lifted representations.

Metis 2018 uses the implementation of strong stubborn sets available in Fast Downward, which is based on the original implementation of Alkhazraji et al. (2012) and Wehrle and Helmert (2012) that has also been used in Metis 2014. However, the current implementation has been improved in terms of efficiency since its original development.<sup>1</sup> To support conditional effects, we extended the implementation in the same way as in Metis 2014. We also use the same mechanism that disables pruning after the first 1000 expansions if only 1% or fewer states have been pruned at this point.

To conclude this abstract, we describe the variants of our planner submissions to the IPC 2018. Both use a post-processing step to transform the SAS<sup>+</sup> representation obtained through the translator of Fast Downward (Helmert 2009) by using the implementation of  $h^2$  mutexes by Alcázar and Torralba (2015). Furthermore, both use A\* search (Hart, Nilsson, and Raphael 1968) with an admissible heuristic and with the same configuration of strong stubborn sets described above for pruning. Regarding the other components, the two variants have the following differences:

- Metis 2018 version 1 essentially is a remake of Metis 2014 and uses OSS for symmetry-based pruning and the LM-cut heuristic.
- Metis 2018 version 2 uses DKS for symmetry-based pruning and the maximum heuristic over the LM-cut heuristic and the landmark heuristic, with the two landmark generation methods described above.

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<sup>1</sup>See <http://issues.fast-downward.org/issue499> and <http://issues.fast-downward.org/issue629>.

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