Planning graph characterization through structural properties

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Introduction

This is a reseach based in the analysis of the planning graphs from the GraphPlan algorithm, an algoritm that creates a planning graph structure in a polynomial time. Planning problems are in the complexity class *PSPACE-complete*, to solve a planning problem is needed at least a polynomial amount of space. The study of the planning problems can help to improve the planner performance with reasonable resources.

This work tries to identify structural properties through the graph analysis of the planning graphs from the problems stablish in the International Planning Competition (IPC) from 1998 and using the result to corroborate the analysis.

Automated Planning

Automated planning studies studies how to emulate the human reasoning side of acting. A planning problem is based on a model of the environment, where the initial conditions are the description of that environment including the objects in it and their descriptions, a set of available actions, where each action requires a set of conditions to be fulfilled before can be carried out, and a goal, that captures the conditions to be fufilled by the secquence of actions, this sequence is know as the plan and the planning solver is known as the planner.

Classical Planning

There exists a lot of automated planning problem forms based on assumption restrictions about the way of modeling a environment, the restricted model of automated planning consists in the following restriction assumptions.

A0 Finite: The system has a finite set of states.

A1 Fully observable: one completely knows the state of the system.

A2 Deterministic: every action takesjust to a one state.

A3 Static: the system stays in the same state until an action is taken, there are no outside actions or further events.

A4 Restricted goals: the planner just tries to reach the final state, avoiding certain states or utility functions are not handled.

A5 Sequential Plans: The solution plan is an ordered finite sequence of actions

A6 Implicit Time: Actions have no duration, the state transition is immediate.

A7 Offline planning: The planner is concerted about system while the planning process is being performed, there is no system supervision or new and restricted actions or variables after the

GraphPlan

The two of the most used planners to solve automated classical planning problems are GraphPlan and SATPLAN and both are equally expresive,
Planning as satisfability (SATPLAN), consist in represent the planning conditions as a Propositional Satisfiability Problem, while GraphPlan uses a a directed, leveled graph with two kinds of nodes and three kinds of edges.
These two structures of represent the planning classical problems were the principal influence in the IPC of 1998, and all the planners were based in one of them.

IPC

The International Planning Competition (IPC) is organized by the International Conference on Automated Planning and Scheduling (ICAPS) since 1998 and reunites planners developed by researchers from all over the world to create planning domains problems and to make a comparison among existing planners and measure the progress in the field.

Computational Complexity

In computer science, the study of the use of resource needed to execute an algorithm is known as algorithm analysis and the study of how to describe a problem in terms of computational resources used to solve it is known as computational complexity. The computational complexity uses a series of classes known as complexity classes where a set of problems is categorized based on the resources required to solve it.

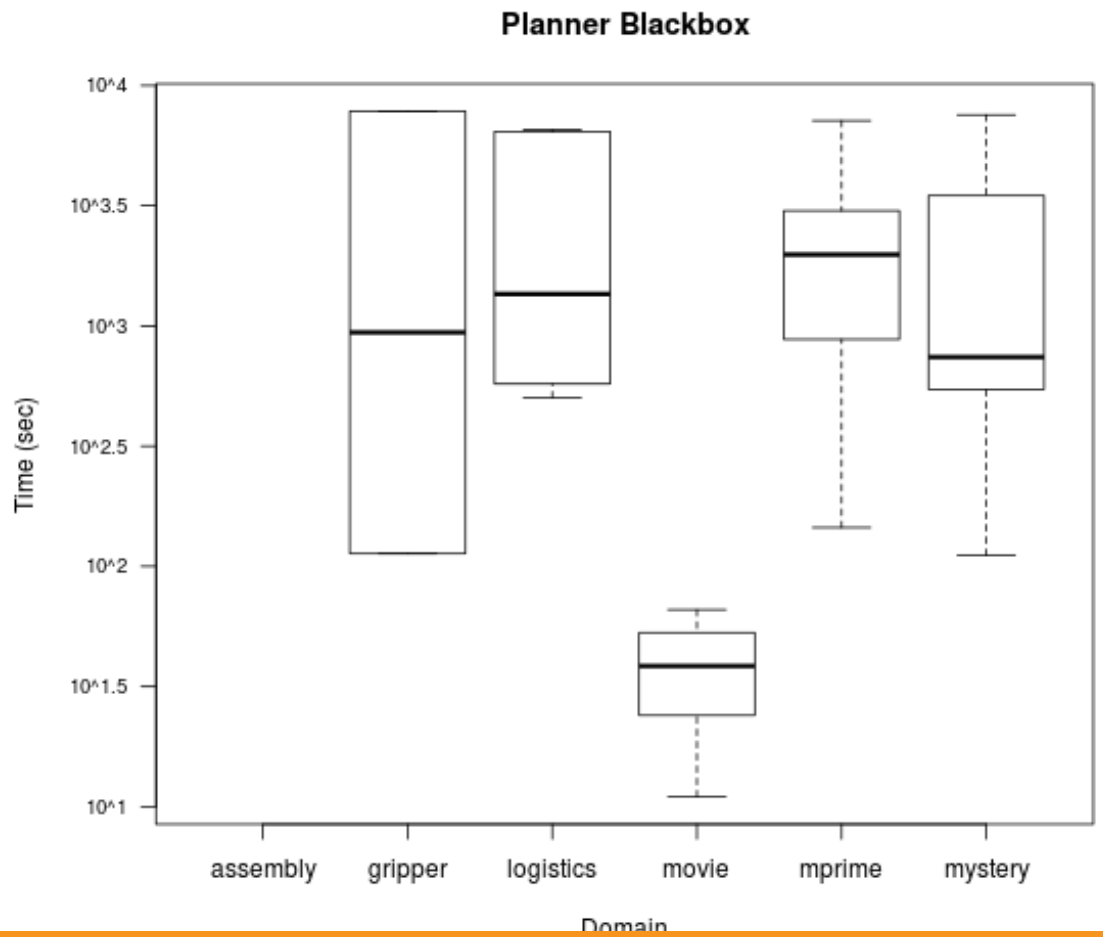
Metodology

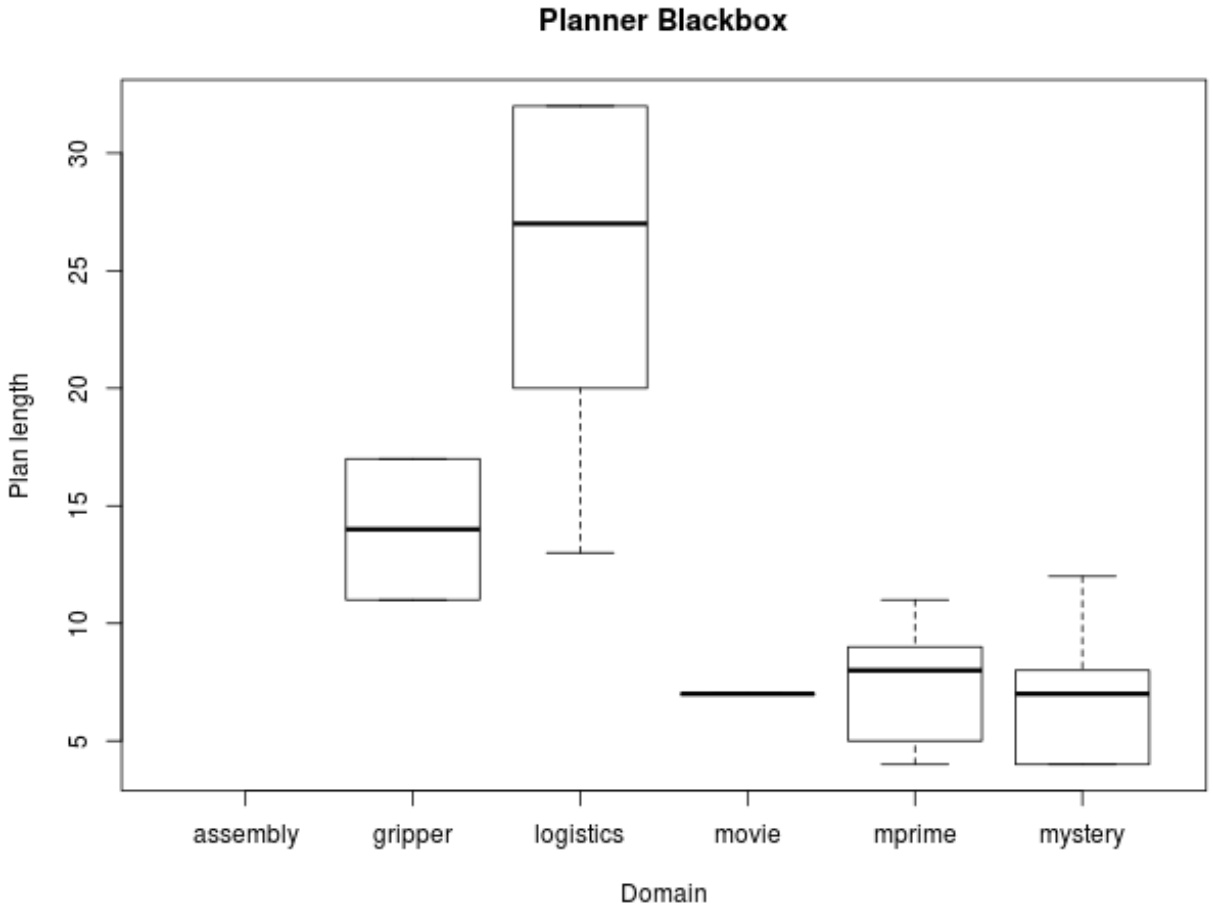
The methodology of the present work consists in studying the benchmark problems proposed in the IPC using the planning graphs generated from the GraphPlan algorithm, to identify graph properties that are factors in the algorithms solver performance reported in the IPC and identify structural properties among problems to categorize them and establish metrics asds.

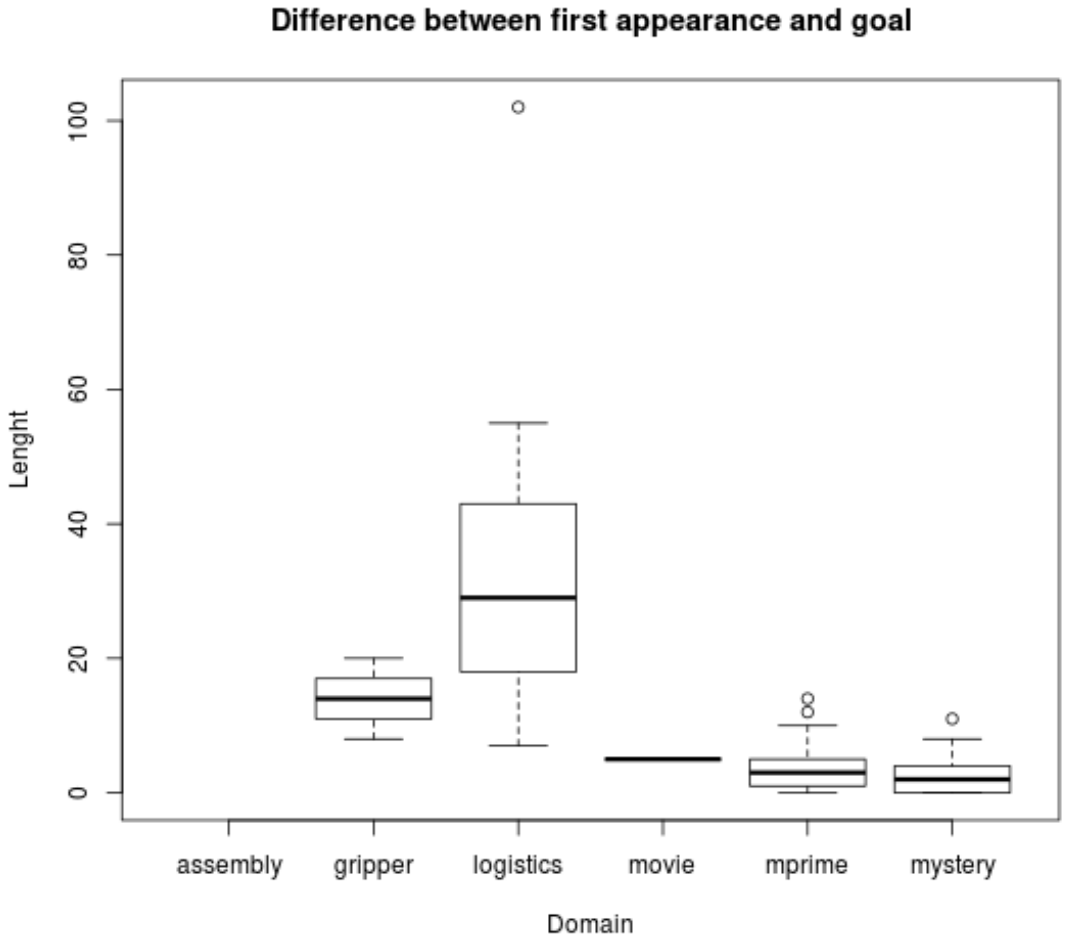
Domain	Problems	Solved	Graph
assembly	30	0	0
gripper	30	3	30
logistics	30	10	30
movie	30	30	30
mprime	30	23	30
mystery	30	19	30

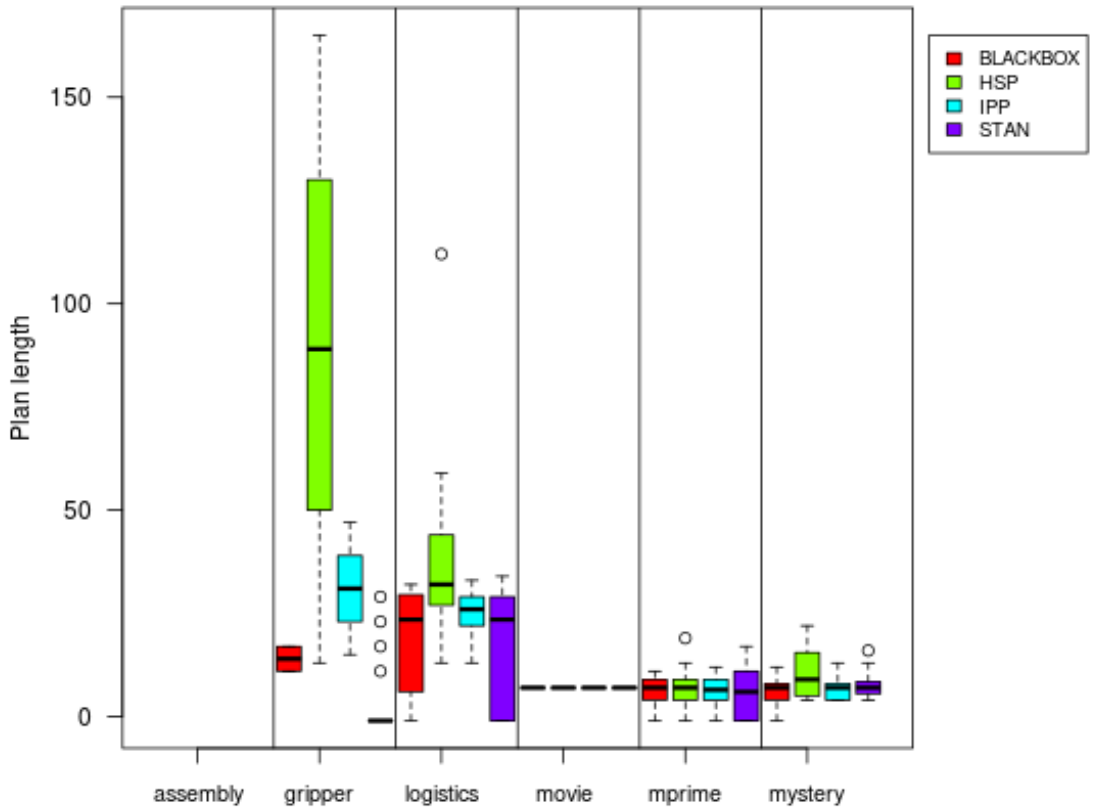
Table: Domains used by competiton

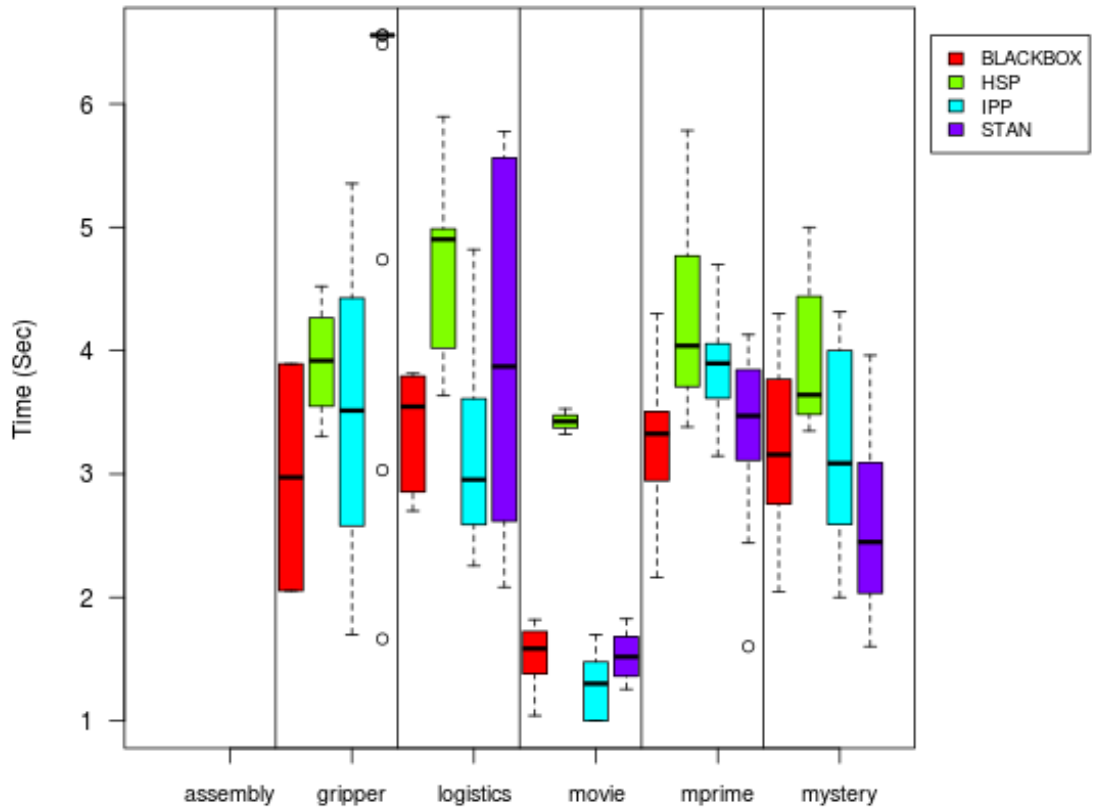
Results

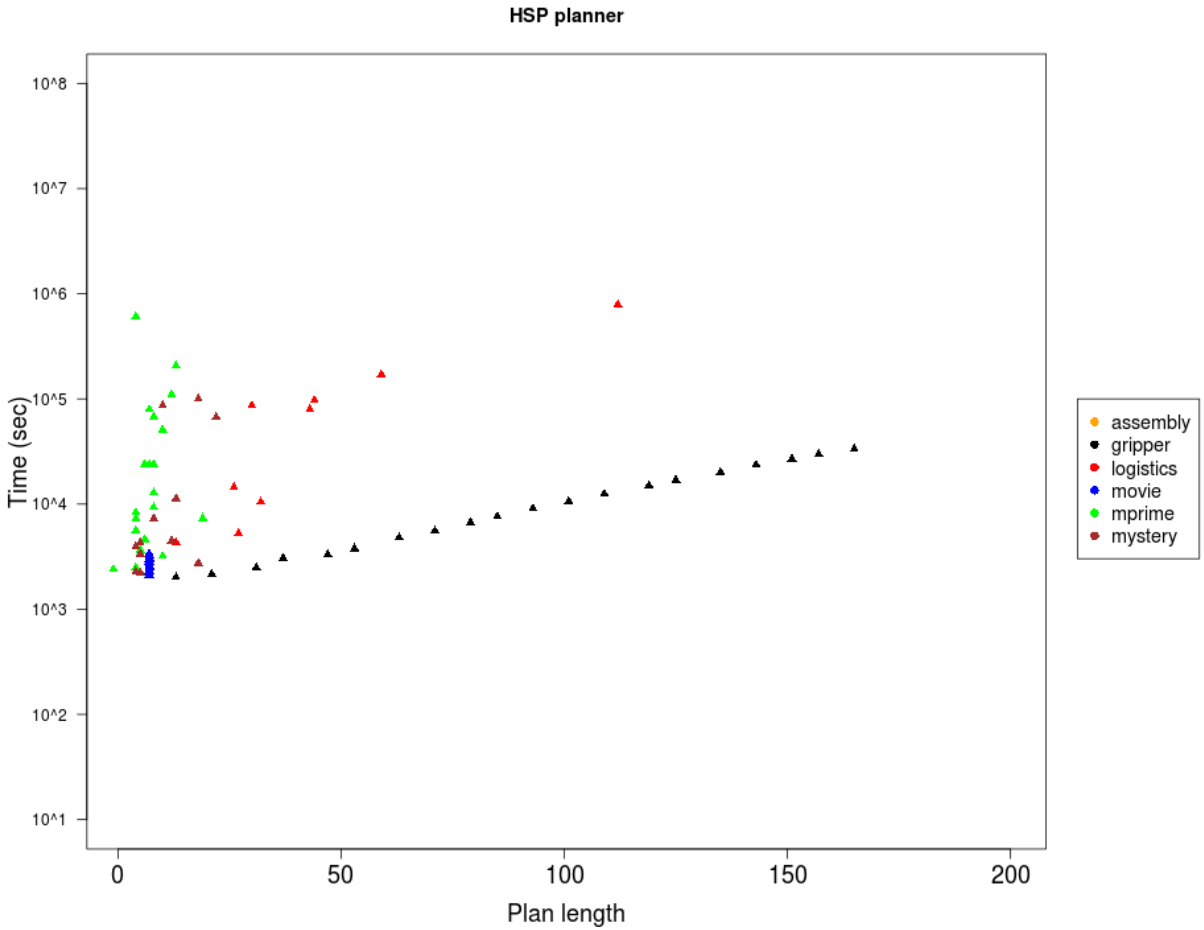

Planner Blackbox
Time (sec)
10^4
10^3.5
10^3
10^2.5
10^2
10^1.5
10^1
assembly
gripper
logistics
movie
mprime
mystery
Domain

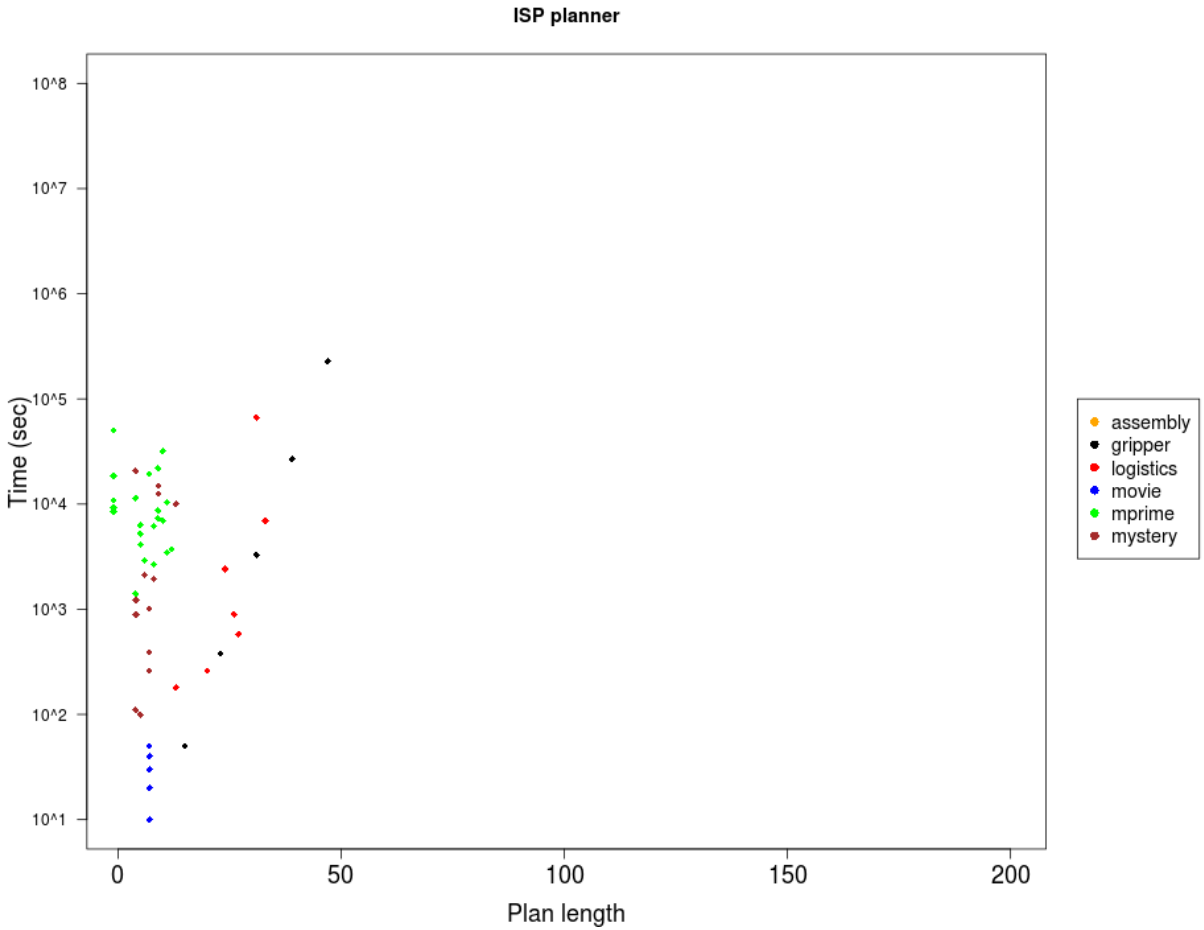

Planner Blackbox
Plan length
5
10
15
20
25
30
assembly
gripper
logistics
movie
mprime
mystery
Domain

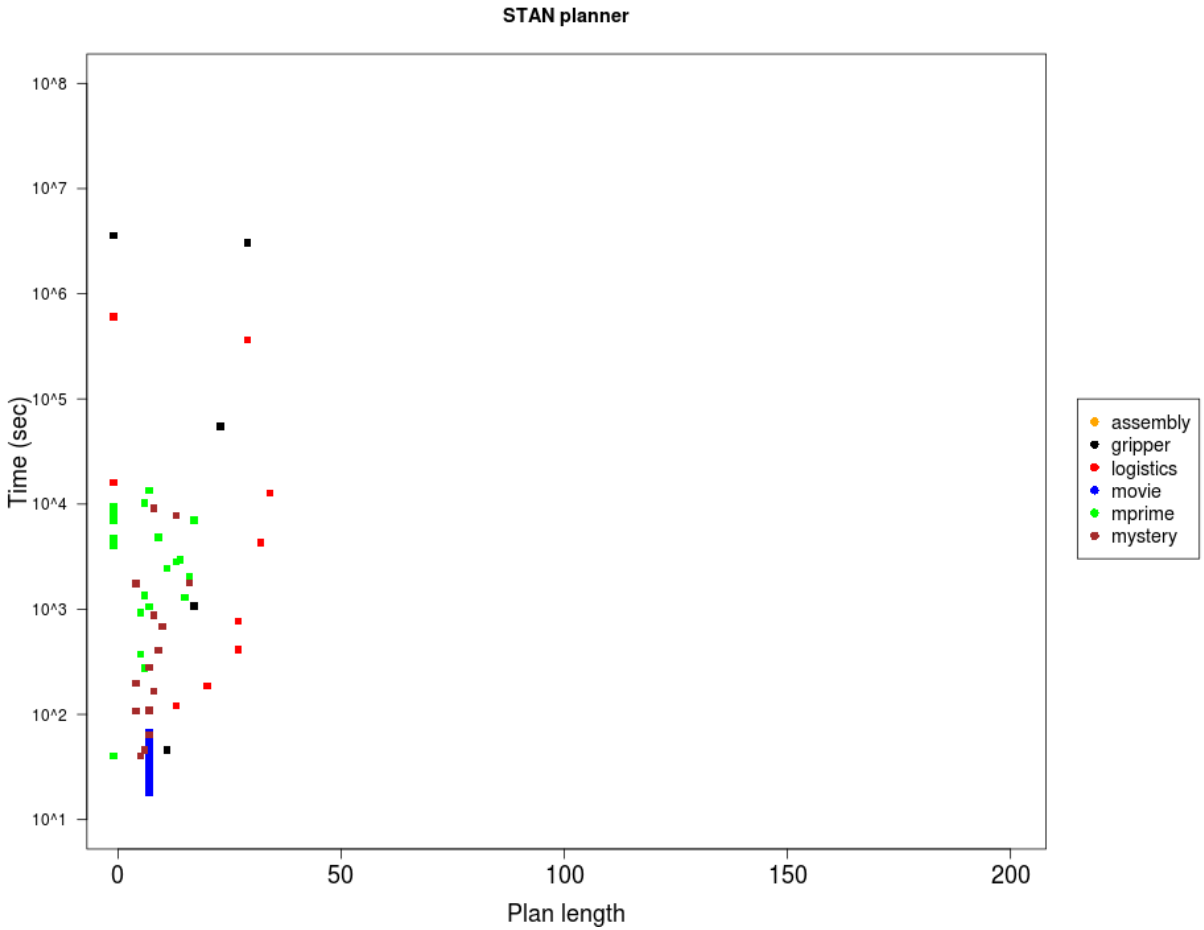

Difference between first appearance and goal
Lenght
0
20
40
60
80
100
assembly
gripper
logistics
movie
mprime
mystery
Domain

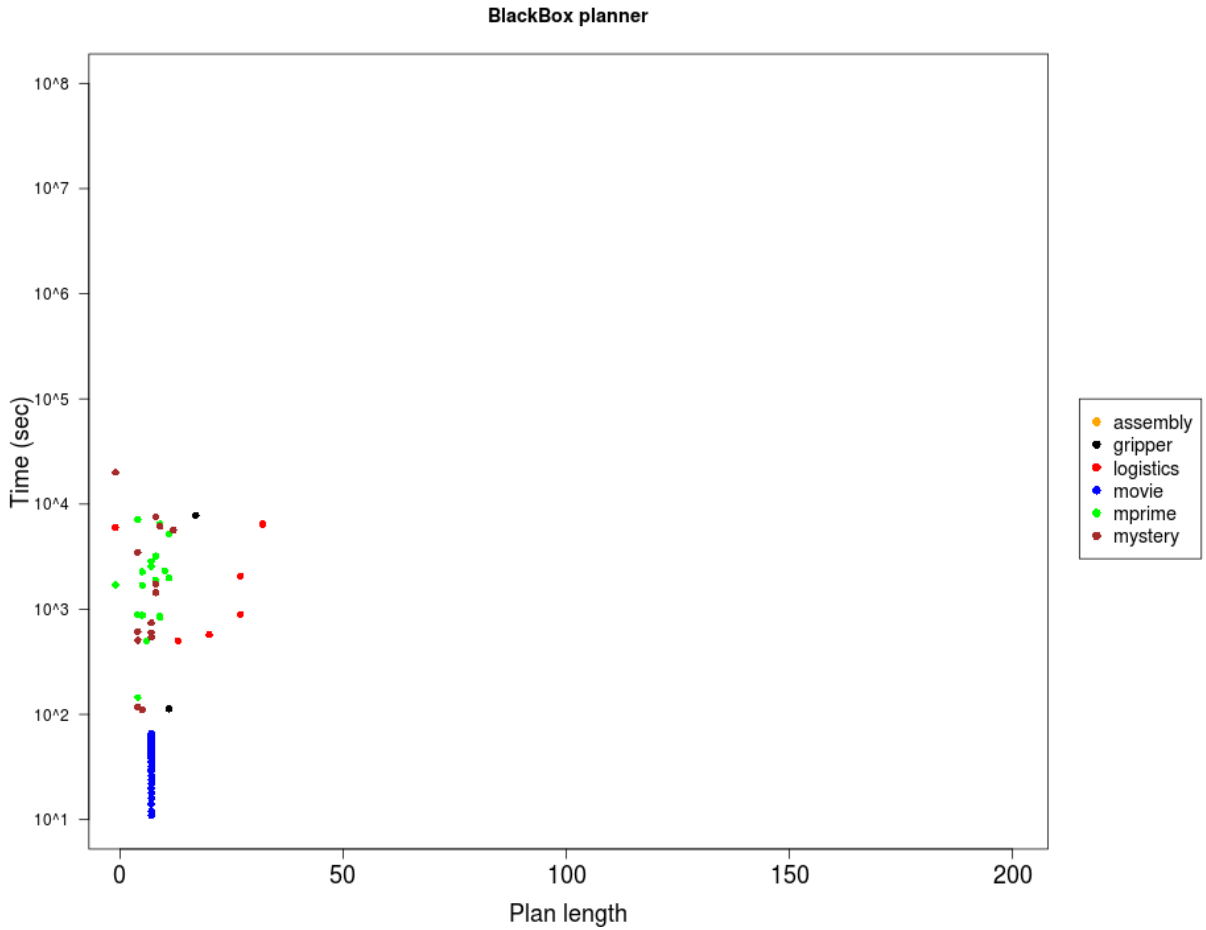

Plan length
150
100
50
0
assembly
gripper
logistics
movie
mprime
mystery
BLACKBOX
HSP
IPP
STAN

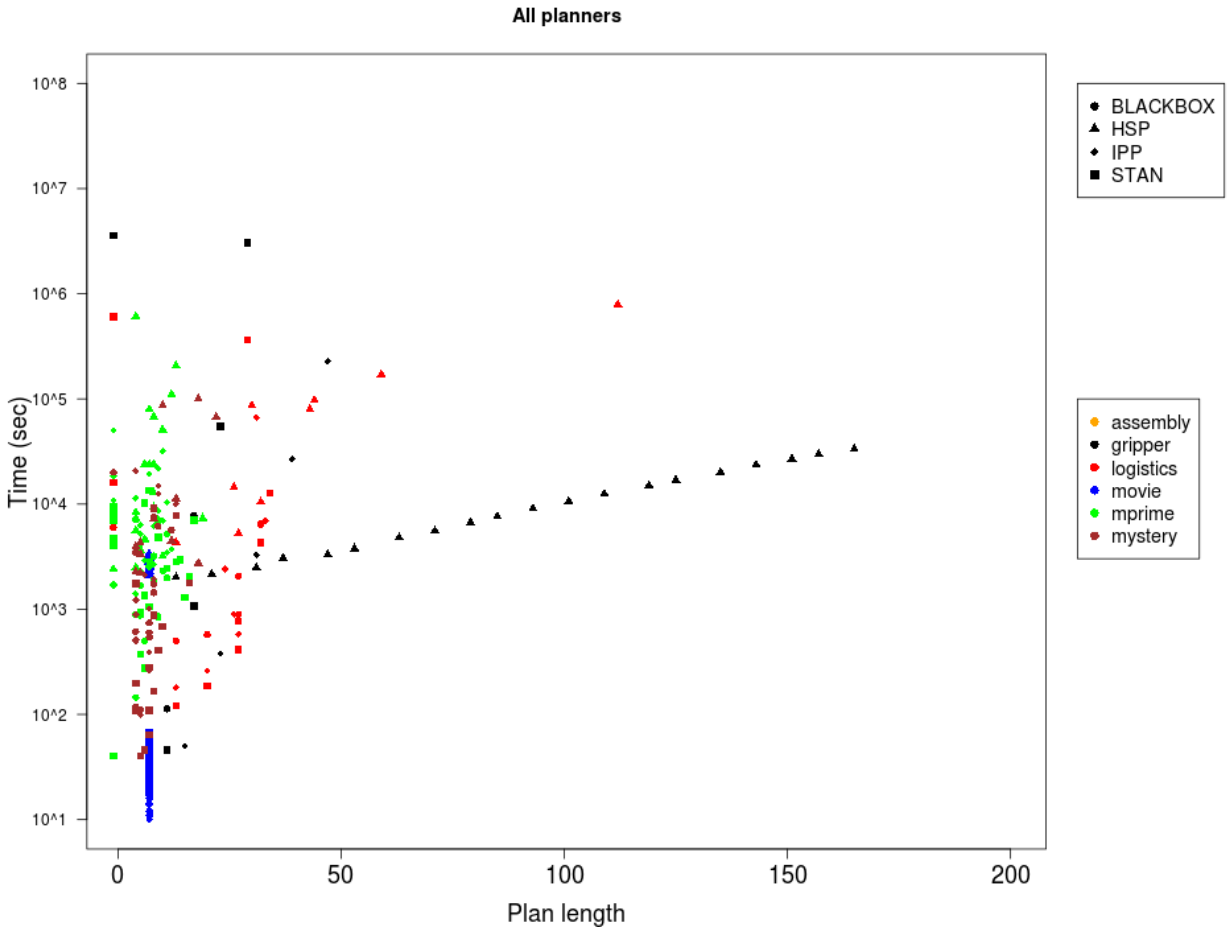

Time (Sec)
1
2
3
4
5
6
assembly
gripper
logistics
movie
mprime
mystery
BLACKBOX
HSP
IPP
STAN

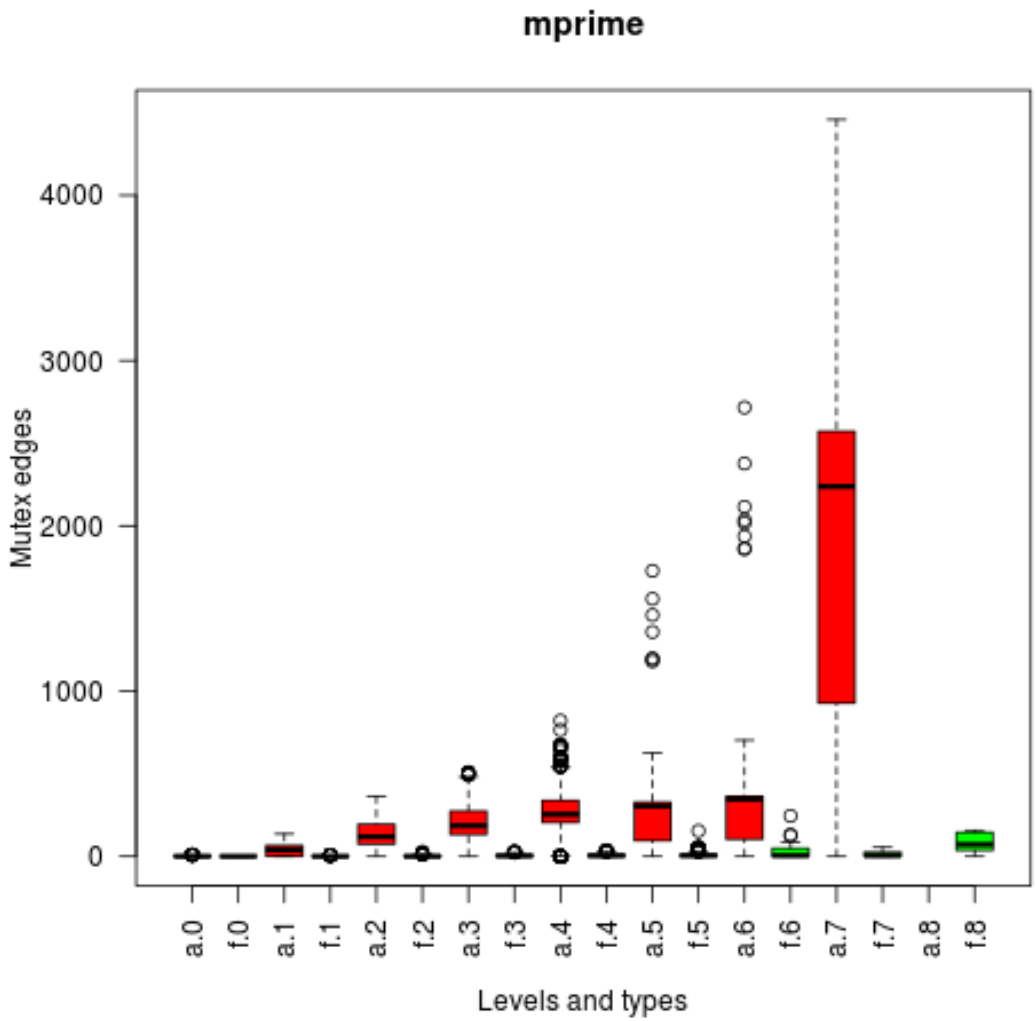

HSP planner
Time (sec)
10^8
10^7
10^6
10^5
10^4
10^3
10^2
10^1
0
50
100
150
200
Plan length
assembly
gripper
logistics
movie
mprime
mystery


ISP planner
Time (sec)
10^8
10^7
10^6
10^5
10^4
10^3
10^2
10^1
0
50
100
150
200
Plan length
assembly
gripper
logistics
movie
mprime
mystery


STAN planner
Time (sec)
10^8
10^7
10^6
10^5
10^4
10^3
10^2
10^1
0
50
100
150
200
Plan length
assembly
gripper
logistics
movie
mprime
mystery


BlackBox planner
Time (sec)
10^8
10^7
10^6
10^5
10^4
10^3
10^2
10^1
0
50
100
150
200
Plan length
assembly
gripper
logistics
movie
mprime
mystery


All planners
Time (sec)
10^8
10^7
10^6
10^5
10^4
10^3
10^2
10^1
0
50
100
150
200
Plan length
BLACKBOX
HSP
IPP
STAN
assembly
gripper
logistics
movie
mprime
mystery


mprime
Mutex edges
4000
3000
2000
1000
0
a.0
f.0
a.1
f.1
a.2
f.2
a.3
f.3
a.4
f.4
a.5
f.5
a.6
f.6
a.7
f.7
a.8
f.8
Levels and types


gripper
Mutex edges
300
250
200
150
100
50
Levels and types