STRIPS-2-DyPDL: Translating Automated Planning Problems into Domain-Independent Dynamic Programming Problems

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Classical Planning

- paradigm: declarative programming
- problem: planning — find sequences of actions* that achieve a goal condition
- algorithms: state-space search
- language: STRIPS [1] which has evolved into PDDL [2, 3]

* extensions for handling probabilistic actions exist

[1] Fikes and Nilsson, 1971
[2] McDermott et al., 1998
[3] Haslum et al., 2019

STRIPS

A **problem*** is a tuple $\langle F, A, s_0, g \rangle$ where

- F is a finite set of propositions
- A is a finite set of actions
- s_0 is the initial state — a set of propositions
- g is the goal condition — a set of propositions

A **solution*** is a sequence of actions that progresses s_0 to a state satisfying g

* Action costs are ignored in the presentation for simplicity

Classical Planning Benefits

Useful for compactly modelling long-horizon planning problems
⇒ PSPACE-hard*

Decades of theoretical and algorithmic research
⇒ reliable open-source tools

Automatic synthesis of domain-independent heuristics
⇒ highly performative

* PSPACE-complete in the propositional case (Bylander 1994), EXPSPACE-complete in the lifted case (Erol, Nau and Subrahmanian 1995), and undecidable in the general, numeric case (Helmert 2002)

Domain-Independent Dynamic Programming [4]

- paradigm: declarative programming
- problem: combinatorial optimisation
- algorithms: state-space search
- language: Dynamic Programming Description Language (DyPDL)

[4] Kuroiwa and Beck, 2023

Dynamic Programming Description Language (DyPDL)

A **problem*** is a tuple $\langle V, T, S^0, B \rangle$ where

- V is a finite set of numeric and/or set variables
- T is a finite set of transitions
- S^0 is the target state — a total assignment of variables
- B is the base case — a partial assignment of variables

A **solution*** is a sequence of transitions that progresses S^0 to a state satisfying B

* Action costs are ignored in the presentation for simplicity

DyPDL Combinatorial Optimisation Benefits

Inspired by and leverages powerful planning representations and search algorithms in the literature [4]

Features for declaratively encoding domain control knowledge [5]

Highly competitive performance w.r.t. industry grade MIP and CP solvers [4]

[4] Kuroiwa and Beck, 2023
[5] Beck et al., CP 2025

Contribution: STRIPS → DyPDL

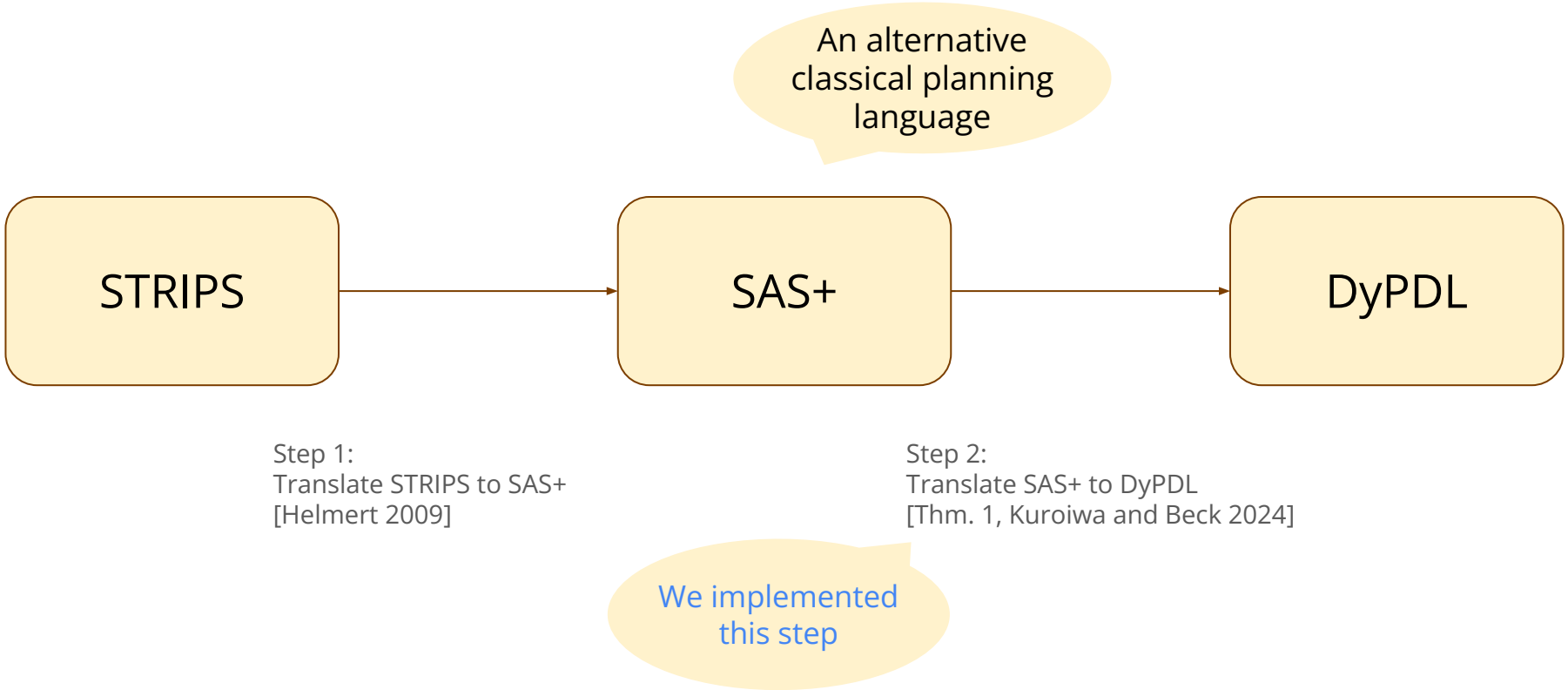
- DyPDL is primarily designed for combinatorial optimisation problems
- DyPDL is inspired by classical planning formalisms and algorithms
- DyPDL can be used to solve classical planning problems

→ we introduce a translator from the STRIPS planning language into DyPDL

For the planning community:
New approach for solving planning problems

For the CO community:
New benchmarks for evaluating DyPDL solvers

Method


An alternative classical planning language
STRIPS
SAS+
DyPDL
Step 1:
Translate STRIPS to SAS+
[Helmert 2009]
Step 2:
Translate SAS+ to DyPDL
[Thm. 1, Kuroiwa and Beck 2024]
We implemented this step

Experiments

- Benchmarks: STRIPS problems from International Planning Competition (IPC) 1998-2023
- Approaches: DyPDL solvers and STRIPS solvers
- Resources: 30 minutes runtime; 8GB memory
- Metrics: IPC satisficing, agile, and optimal scores

Experiments — Quality Focused Planning (IPC satisficing score ↑)

- CABS has the best quality and speed balance out of all DIDP solvers
- higher score than blind A* search in STRIPS planners

	Search Only							Search++		
	DIDP					STRIPS				
Domain	acps	apps	caasdy	cabs	lnbs	blind-fd	decstar	lama	scorpion	symk
blocks	**18.0**	15.1	**18.0**	**18.0**	15.0	21.0	–	34.6	28.0	31.0
depot	3.0	3.0	**4.0**	3.0	2.1	6.0	–	9.0	9.0	6.0
driverlog	4.0	4.0	**6.0**	5.0	3.0	8.0	–	14.0	14.0	14.0
elevators	0.0	0.0	**1.0**	**1.0**	0.0	2.0	–	9.6	3.0	3.0
floortile	0.0	0.0	0.0	0.9	**1.0**	0.0	–	8.0	22.0	27.0
freecell	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	2.0	–	2.0	2.0	2.0
gripper	16.7	16.9	7.0	**17.5**	17.3	8.0	–	20.0	7.0	19.0
hiking	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	2.0	–	2.0	2.0	2.0
logistics	**12.0**	11.9	**12.0**	**12.0**	7.6	13.0	–	35.2	35.0	26.0
maintenance	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	0.0	–	0.0	0.0	0.0
miconic	75.2	**86.1**	45.0	72.3	66.3	55.0	–	114.7	114.0	111.0
movie	**30.0**	**30.0**	**30.0**	**30.0**	**30.0**	30.0	–	30.0	29.0	30.0
mprime	3.8	3.8	**4.0**	**4.0**	**4.0**	4.0	–	4.0	4.0	4.0
mystery	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**	5.0	–	5.0	5.0	5.0
nomystery	**3.0**	**3.0**	**3.0**	**3.0**	2.8	3.0	–	3.0	3.0	3.0
pegsol	**48.0**	47.8	44.0	**48.0**	**48.0**	46.0	–	49.5	50.0	49.0
pipesworld	14.6	13.3	**16.0**	14.0	9.7	18.0	–	18.0	18.0	18.0
rovers	**10.1**	7.4	5.0	7.7	8.0	6.0	–	16.7	13.0	14.0
satellite	4.0	4.0	4.0	**4.6**	4.0	6.0	–	9.7	9.0	9.0
scanalyzer	6.0	6.2	**9.0**	8.3	6.0	9.0	–	9.0	9.0	9.0
schedule	15.3	14.4	12.0	19.8	**29.0**	15.0	–	107.4	40.0	38.0
sokoban	14.0	15.0	12.0	15.8	**16.9**	25.0	–	42.7	41.0	17.0
storage	12.2	12.0	**13.0**	12.2	11.0	15.0	–	15.0	15.0	15.0
termes	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	0.0	–	10.8	0.0	3.0
thoughtful	1.3	**1.4**	1.0	1.0	0.9	2.0	–	2.0	2.0	2.0
tpp	**10.1**	8.5	5.0	8.6	9.2	6.0	–	11.0	12.0	8.0
transport	5.6	5.2	**6.0**	**6.0**	3.8	6.0	–	6.0	6.0	6.0
visitall	**1.7**	1.1	0.0	0.3	1.3	0.0	–	2.9	1.0	0.0
woodworking	5.0	5.0	5.0	**5.2**	4.3	7.0	–	7.0	7.0	7.0
zenotravel	**7.0**	5.1	**7.0**	**7.0**	4.2	8.0	–	10.8	11.0	11.0
Total	329.6	329.3	278.0	**333.9**	314.5	328.0	–	609.5	511.0	489.0
Best in Domain (DIDP)	14	9	**18**	**18**	11	–	–	–	–	–
Best in Domain (Overall)	6	6	9	8	6	13	–	27	17	16

Experiments — Speed Focused Planning (IPC agile score ↑)

- ACPS and LNBS are the fastest DIDP solvers
- higher score than blind A* search in STRIPS planners

	Search Only					Search++				
	DIDP					STRIPS				
Domain	acps	apps	caasdy	cabs	lnbs	blind-fd	decstar	lama	scorpion	symk
blocks	14.9	14.2	15.3	14.6	**15.8**	16.8	35.0	34.9	–	–
depot	3.0	3.0	2.4	3.3	**3.5**	3.0	8.9	9.0	–	–
driverlog	3.9	3.8	4.2	4.0	**4.3**	5.4	14.0	14.0	–	–
elevators	**0.7**	**0.7**	0.6	0.6	0.6	1.1	10.0	10.0	–	–
floortile	0.0	0.0	0.0	0.1	**0.5**	0.0	6.9	3.3	–	–
freecell	**2.0**	**2.0**	1.7	**2.0**	**2.0**	2.0	2.0	2.0	–	–
gripper	**20.0**	**20.0**	5.7	**20.0**	**20.0**	6.4	20.0	20.0	–	–
hiking	1.4	1.4	**1.6**	1.3	1.2	2.0	2.0	2.0	–	–
logistics	**11.9**	11.8	11.0	11.1	11.5	12.0	36.0	36.0	–	–
maintenance	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	0.0	4.7	0.0	–	–
miconic	111.8	**113.4**	39.3	82.2	86.0	43.2	115.0	115.0	–	–
movie	**30.0**	**30.0**	**30.0**	**30.0**	**30.0**	30.0	30.0	30.0	–	–
mprime	**4.0**	**4.0**	3.9	3.5	3.6	4.0	4.0	4.0	–	–
mystery	**5.0**	**5.0**	**5.0**	4.8	**5.0**	5.0	5.0	5.0	–	–
nomystery	**1.0**	**1.0**	0.6	0.4	0.5	2.1	3.0	3.0	–	–
pegsol	**47.8**	47.7	37.0	46.8	47.6	41.3	47.2	49.6	–	–
pipesworld	**17.5**	17.4	13.3	16.9	17.0	15.9	18.0	18.0	–	–
rovers	**16.0**	**16.0**	4.2	15.6	**16.0**	4.5	17.0	17.0	–	–
satellite	5.0	4.8	3.7	5.6	**5.9**	4.1	10.0	10.0	–	–
scanalyzer	7.4	**7.8**	6.0	7.3	7.3	6.8	9.0	9.0	–	–
schedule	26.7	21.6	9.9	22.5	**31.0**	11.9	107.0	108.0	–	–
sokoban	9.4	10.6	8.8	9.7	**13.4**	10.5	33.1	31.3	–	–
storage	14.3	**14.6**	11.7	12.8	12.9	13.2	15.0	15.0	–	–
termes	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	0.0	6.1	7.3	–	–
thoughtful	0.5	**1.2**	0.1	0.0	1.0	0.9	2.0	2.0	–	–
tpp	**12.0**	11.7	5.0	8.6	10.6	5.3	12.0	12.0	–	–
transport	5.3	5.0	4.4	5.4	**5.7**	5.5	6.0	6.0	–	–
visitall	2.9	2.9	0.0	2.4	**3.0**	0.0	2.7	3.0	–	–
woodworking	5.6	**6.6**	4.3	5.6	5.7	4.7	7.0	7.0	–	–
zenotravel	**7.0**	6.9	5.9	6.9	6.9	6.9	11.0	11.0	–	–
Total	**386.9**	385.1	235.6	343.9	368.6	264.5	599.7	594.4	–	–
Best in Domain (DIDP)	**16**	15	5	5	**16**	–	–	–	–	–
Best in Domain (Overall)	6	5	2	3	5	5	26	26	–	–

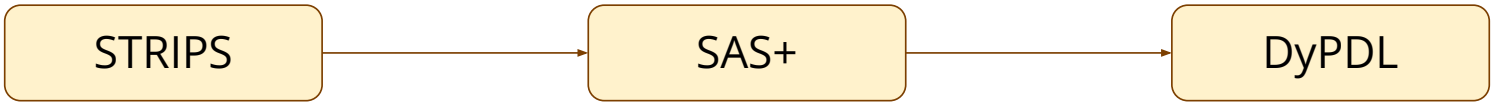
Experiments — Provably Optimal Planning (IPC optimal score ↑)

- CAASDy finds optimal solutions fastest out of all DIDP solvers
- blind A* search in STRIPS planners perform better than DIDP because they are designed for STRIPS problems, and not DIDP

	Search Only						Search++			
	DIDP					STRIPS				
Domain	acps	apps	caasdy	cabs	lnbs	blind-fd	decstar	lama	scorpion	symk
blocks	**18**	15	**18**	**18**	15	21	–	–	28	31
depot	**3**	**3**	**3**	**3**	2	6	–	–	9	6
driverlog	4	4	**5**	**5**	3	8	–	–	14	14
elevators	**0**	**0**	**0**	**0**	**0**	2	–	–	3	3
floortile	**0**	**0**	**0**	**0**	**0**	0	–	–	22	27
freecell	**2**	**2**	**2**	**2**	**2**	2	–	–	2	2
gripper	**7**	6	**7**	**7**	5	8	–	–	7	19
hiking	**2**	**2**	**2**	**2**	**2**	2	–	–	2	2
logistics	**12**	11	**12**	**12**	6	13	–	–	35	26
maintenance	**0**	**0**	**0**	**0**	**0**	0	–	–	0	0
miconic	**45**	**45**	**45**	**45**	**45**	55	–	–	114	111
movie	**30**	**30**	**30**	**30**	**30**	30	–	–	29	30
mprime	**1**	**1**	**1**	**1**	**1**	4	–	–	4	4
mystery	**2**	**2**	**2**	**2**	**2**	5	–	–	5	5
nomystery	**3**	**3**	**3**	**3**	1	3	–	–	3	3
pegsol	**42**	**42**	**42**	**42**	**42**	46	–	–	50	49
pipesworld	**14**	12	**14**	**14**	6	18	–	–	18	18
rovers	**4**	**4**	**4**	**4**	**4**	6	–	–	13	14
satellite	**4**	**4**	**4**	**4**	**4**	6	–	–	9	9
scanalyzer	6	6	**9**	6	6	9	–	–	9	9
schedule	**3**	**3**	**3**	**3**	**3**	15	–	–	40	38
sokoban	**10**	**10**	**10**	**10**	9	25	–	–	41	17
storage	**12**	**12**	**12**	**12**	10	15	–	–	15	15
termes	**0**	**0**	**0**	**0**	**0**	0	–	–	0	3
thoughtful	**0**	**0**	**0**	**0**	**0**	2	–	–	2	2
tpp	**5**	**5**	**5**	**5**	**5**	6	–	–	12	8
transport	4	4	**6**	**6**	3	6	–	–	6	6
visitall	**0**	**0**	**0**	**0**	**0**	0	–	–	1	0
woodworking	**5**	4	**5**	**5**	4	7	–	–	7	7
zenotravel	**7**	5	**7**	**7**	4	8	–	–	11	11
Total	245	235	**251**	248	214	328	–	–	511	489
Best in Domain (DIDP)	27	21	**31**	29	17	–	–	–	–	–
Best in Domain (Overall)	5	5	7	6	4	13	–	–	25	22

STRIPS-2-DyPDL: Translating Automated Planning Problems into Domain-Independent Dynamic Programming Problems

A translator from STRIPS planning problems into DyPDL dynamic programming problems



For the planning community:
New approach for solving planning problems

For the CO community:
New benchmarks for evaluating DyPDL solvers

IPC Satisficing Results

Domain	acps	apps	casady	cabs	lnbs	blind-fd	decstar	lama	scorpion	symk
blocks	**18.0**	15.1	**18.0**	**18.0**	15.0	21.0	–	34.6	28.0	31.0
depot	3.0	3.0	**4.0**	3.0	2.1	6.0	–	9.0	9.0	6.0
driverlog	4.0	4.0	**6.0**	5.0	3.0	8.0	–	14.0	14.0	14.0
elevators	0.0	0.0	**1.0**	**1.0**	0.0	2.0	–	9.6	3.0	3.0
floortile	0.0	0.0	0.0	**1.0**	0.0	0.0	–	8.0	22.0	27.0
freecell	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	2.0	–	2.0	2.0	2.0
gripper	16.7	16.9	7.0	**17.5**	17.3	8.0	–	20.0	7.0	19.0
hiking	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	2.0	–	2.0	2.0	2.0
logistics	**12.0**	11.9	**12.0**	**12.0**	7.6	13.0	–	35.2	35.0	26.0
maintenance	**0.0**	**0.0**	**0.0**	**0.0**	0.0	0.0	–	0.0	0.0	0.0
miconic	75.2	**86.1**	45.0	72.3	66.3	55.0	–	114.7	114.0	111.0
movie	**30.0**	**30.0**	**30.0**	**30.0**	**30.0**	30.0	–	30.0	29.0	30.0
mprime	3.8	3.8	**4.0**	**4.0**	**4.0**	4.0	–	4.0	4.0	4.0
mystery	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**	5.0	–	5.0	5.0	5.0
nomystery	**3.0**	**3.0**	**3.0**	**3.0**	2.8	3.0	–	3.0	3.0	3.0
pegsol	**48.0**	47.8	44.0	**48.0**	**48.0**	46.0	–	49.5	50.0	49.0
pipesworld	14.6	13.3	**16.0**	14.0	9.7	18.0	–	18.0	18.0	18.0
rovers	**10.1**	7.4	5.0	7.7	8.0	6.0	–	16.7	13.0	14.0
satellite	4.0	4.0	4.0	**4.6**	4.0	6.0	–	9.7	9.0	9.0
scanalyzer	6.0	6.2	**9.0**	8.3	6.0	9.0	–	9.0	9.0	9.0
schedule	15.3	14.4	12.0	19.8	**29.0**	15.0	–	107.4	40.0	38.0
sokoban	14.0	15.0	12.0	15.8	**16.9**	25.0	–	42.7	41.0	17.0
storage	12.2	12.0	**13.0**	12.2	11.0	15.0	–	15.0	15.0	15.0
termes	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	0.0	–	10.8	0.0	3.0
thoughtful	1.3	**1.4**	1.0	1.0	0.9	2.0	–	2.0	2.0	2.0
tpp	**10.1**	8.5	5.0	8.6	9.2	6.0	–	11.0	12.0	8.0
transport	5.6	5.2	**6.0**	**6.0**	3.8	6.0	–	6.0	6.0	6.0
visitall	**1.7**	1.1	0.0	0.3	1.3	0.0	–	2.9	1.0	0.0
woodworking	5.0	5.0	5.0	**5.2**	4.3	7.0	–	7.0	7.0	7.0
zenotravel	**7.0**	5.1	**7.0**	**7.0**	4.2	8.0	–	10.8	11.0	11.0
Total	329.6	329.3	278.0	**333.9**	314.5	328.0	–	609.5	511.0	489.0
Best in Domain (DIDP)	14	9	**18**	**18**	11	–	–	–	–	–
Best in Domain (Overall)	6	6	9	8	6	13	–	27	17	16

IPC Agile Results

Domain	acps	apps	casady	cabs	lnbs	blind-fd	decstar	lama	scorpion	symk
blocks	14.9	14.2	15.3	14.6	**15.8**	16.8	35.0	34.9	–	–
depot	3.0	3.0	2.4	3.3	**3.5**	3.0	8.9	9.0	–	–
driverlog	3.9	3.8	4.2	4.0	**4.3**	5.4	14.0	14.0	–	–
elevators	**0.7**	**0.7**	0.6	0.6	0.6	1.1	10.0	10.0	–	–
floortile	0.0	0.0	0.0	0.1	**0.5**	0.0	6.9	3.3	–	–
freecell	**2.0**	**2.0**	1.7	**2.0**	**2.0**	2.0	2.0	2.0	–	–
gripper	**20.0**	**20.0**	5.7	**20.0**	**20.0**	6.4	20.0	20.0	–	–
hiking	1.4	1.4	**1.6**	1.3	1.2	2.0	2.0	2.0	–	–
logistics	**11.9**	11.8	11.0	11.1	11.5	12.0	36.0	36.0	–	–
maintenance	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	0.0	4.7	0.0	–	–
miconic	111.8	**113.4**	39.3	82.2	86.0	43.2	115.0	115.0	–	–
movie	**30.0**	**30.0**	**30.0**	**30.0**	**30.0**	30.0	30.0	30.0	–	–
mprime	**4.0**	**4.0**	3.9	3.5	3.6	4.0	4.0	4.0	–	–
mystery	**5.0**	**5.0**	**5.0**	4.8	**5.0**	5.0	5.0	5.0	–	–
nomystery	**1.0**	**1.0**	0.6	0.4	0.5	2.1	3.0	3.0	–	–
pegsol	**47.8**	47.7	37.0	46.8	47.6	41.3	47.2	49.6	–	–
pipesworld	**17.5**	17.4	13.3	16.9	17.0	15.9	18.0	18.0	–	–
rovers	**16.0**	**16.0**	4.2	15.6	**16.0**	4.5	17.0	17.0	–	–
satellite	5.0	4.8	3.7	5.6	**5.9**	4.1	10.0	10.0	–	–
scanalyzer	7.4	**7.8**	6.0	7.3	7.3	6.8	9.0	9.0	–	–
schedule	26.7	21.6	9.9	22.5	**31.0**	11.9	107.0	108.0	–	–
sokoban	9.4	10.6	8.8	9.7	**13.4**	10.5	33.1	31.3	–	–
storage	14.3	**14.6**	11.7	12.8	12.9	13.2	15.0	15.0	–	–
termes	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	0.0	6.1	7.3	–	–
thoughtful	0.5	**1.2**	0.1	0.0	1.0	0.9	2.0	2.0	–	–
tpp	**12.0**	11.7	5.0	8.6	10.6	5.3	12.0	12.0	–	–
transport	5.3	5.0	4.4	5.4	**5.7**	5.5	6.0	6.0	–	–
visitall	2.9	2.9	0.0	2.4	**3.0**	0.0	2.7	3.0	–	–
woodworking	5.6	**6.6**	4.3	5.6	5.7	4.7	7.0	7.0	–	–
zenotravel	**7.0**	6.9	5.9	6.9	6.9	6.9	11.0	11.0	–	–
Total	**386.9**	385.1	235.6	343.9	368.6	264.5	599.7	594.4	–	–
Best in Domain (DIDP)	**16**	15	5	5	**16**	–	–	–	–	–
Best in Domain (Overall)	6	5	2	3	5	5	26	26	–	–

IPC Optimal Results

Domain	acps	apps	casady	cabs	lnbs	blind-fd	decstar	lama	scorpion	symk
blocks	**18**	15	**18**	**18**	15	21	–	–	28	31
depot	**3**	**3**	**3**	**3**	2	6	–	–	9	6
driverlog	4	4	**5**	**5**	3	8	–	–	14	14
elevators	**0**	**0**	**0**	**0**	**0**	2	–	–	3	3
floortile	**0**	**0**	**0**	**0**	**0**	0	–	–	22	27
freecell	**2**	**2**	**2**	**2**	**2**	2	–	–	2	2
gripper	**7**	6	**7**	**7**	5	8	–	–	7	19
hiking	**2**	**2**	**2**	**2**	**2**	2	–	–	2	2
logistics	**12**	11	**12**	**12**	6	13	–	–	35	26
maintenance	**0**	**0**	**0**	**0**	**0**	0	–	–	0	0
miconic	**45**	**45**	**45**	**45**	**45**	55	–	–	114	111
movie	**30**	**30**	**30**	**30**	**30**	30	–	–	29	30
mprime	**1**	**1**	**1**	**1**	**1**	4	–	–	4	4
mystery	**2**	**2**	**2**	**2**	**2**	5	–	–	5	5
nomystery	**3**	**3**	**3**	**3**	1	3	–	–	3	3
pegsol	**42**	**42**	**42**	**42**	**42**	46	–	–	50	49
pipesworld	**14**	12	**14**	**14**	6	18	–	–	18	18
rovers	**4**	**4**	**4**	**4**	**4**	6	–	–	13	14
satellite	**4**	**4**	**4**	**4**	**4**	6	–	–	9	9
scanalyzer	6	6	**9**	6	6	9	–	–	9	9
schedule	**3**	**3**	**3**	**3**	**3**	15	–	–	40	38
sokoban	**10**	**10**	**10**	**10**	9	25	–	–	41	17
storage	**12**	**12**	**12**	**12**	10	15	–	–	15	15
termes	**0**	**0**	**0**	**0**	**0**	0	–	–	0	3
thoughtful	**0**	**0**	**0**	**0**	**0**	2	–	–	2	2
tpp	**5**	**5**	**5**	**5**	**5**	6	–	–	12	8
transport	4	4	**6**	**6**	3	6	–	–	6	6
visitall	**0**	**0**	**0**	**0**	**0**	0	–	–	1	0
woodworking	**5**	4	**5**	**5**	4	7	–	–	7	7
zenotravel	**7**	5	**7**	**7**	4	8	–	–	11	11
Total	245	235	**251**	248	214	328	–	–	511	489
Best in Domain (DIDP)	27	21	**31**	29	17	–	–	–	–	–
Best in Domain (Overall)	5	5	7	6	4	13	–	–	25	22