Attributed Transition-based Domain Control Knowledge for Domain-Independent Planning

(IEEE Transactions on Knowledge and Data Engineering, preprint)

Lukáš Chrpa[1], Roman Barták[2], Jindřich Vodrážka[2], Marta Vomlelová[2]

[1]Faculty of Electrical Engineering, Czech Technical University in Prague

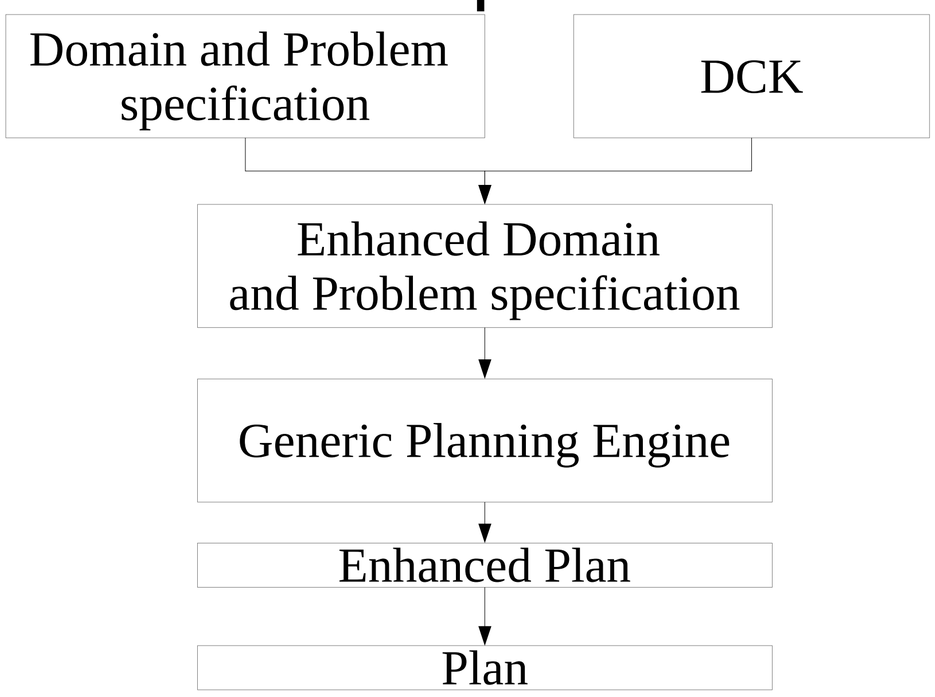
[2]Faculty of Mathematics and Physics, Charles University

EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research, Development and Education

MINISTRY OF EDUCATION, YOUTH AND SPORTS

Domain Control Knowledge (DCK) aims to **enhance** the planning process (can be specified by a domain expert)

Planner-independent DCK

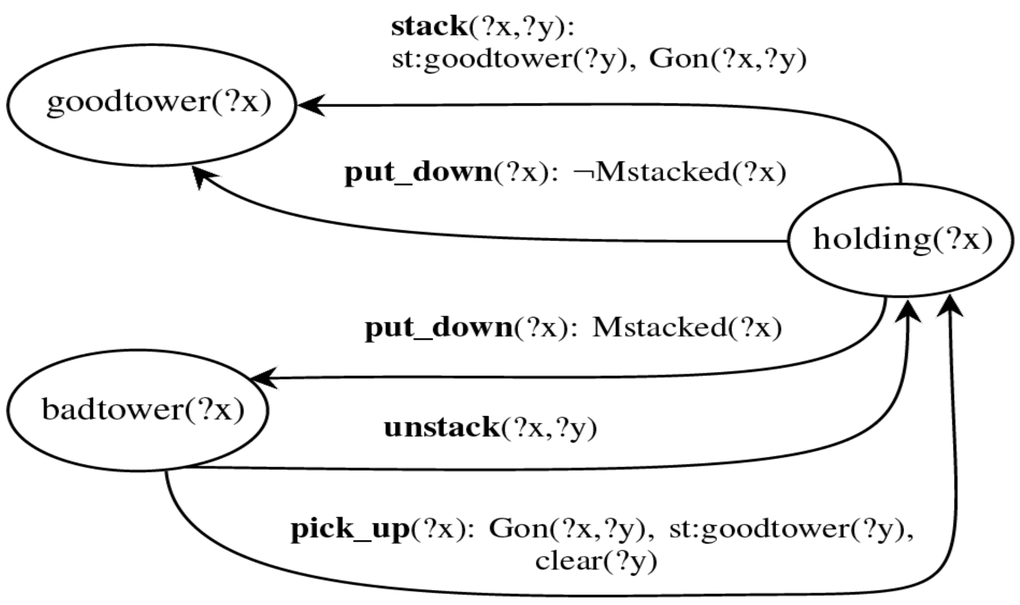


Elements of Attributed Transition-based (ATB) DCK

- ATB-DCK is an **automaton-like** structure over a domain model with
  - A set of **attributed DCK states**
  - A set of predicates representing **DCK memory**
  - **Transitions** in the form (s,o,C,M,s'), where
    - the transition **goes from s to s**' (s,s' are attributed DCK states)
    - o is the **associated operator** (can be "noop" operator)
    - C is a set of **constraints** (additional preconditions)
    - M is a set of **modifiers** (modifying DCK memory)

Example (BlocksWorld)

- A block can be
  - **goodtower** (it doesn't have to be moved)
  - **badtower** (it has to be moved)
  - **held** (by a robotic hand)
- Need to connect such knowledge with the operators



Encoding ATB-DCK into PDDL

- The idea is to encode **transitions** as **"enhanced" operators** and encode **attributed states** as **predicates**

```
(:action pick-up
   :parameters (?x - block ?y - block)
   :precondition (and (clear ?x) (ontable ?x) (handempty)(g_on ?x ?y)
(DCK_goodtower ?y) (clear ?y)(DCK_badtower ?x)
                   )
   :effect
   (and (not (ontable ?x)) (not (clear ?x))(not (handempty))(holding ?x) (DCK_holding
?x)(not (DCK_badtower ?x))
         ))

 (:action put-down_DCK-put-down-g
   :parameters (?x - block)
   :precondition (and (holding ?x)(not (mg_Stacked ?x))(DCK_holding ?x)
                   )
   :effect
   (and (not (holding ?x))(clear ?x)(handempty)(ontable ?x)(not (DCK_holding ?x))
(DCK_goodtower ?x)
         ))

 (:action put-down_DCK-put-down-b
   :parameters (?x - block)
   :precondition (and (holding ?x)(mg_Stacked ?x)(DCK_holding ?x)
                   )
   :effect
   (and (not (holding ?x))(clear ?x)(handempty)(ontable ?x)(not (DCK_holding ?x))
(DCK_badtower ?x)
   ))
```

Experimental Results

	Original			ATB-DCK		
	C	P	Q	C	P	Q
barman (30)						
FF	0	9000	0.00	0	9000	0.00
lama	3	8142	2.72	**30**	42	**30.00**
mercury	27	1004	20.76	**30**	**40**	**30.00**
FDSS	26	1442	25.15	20	3268	19.84
BFWS	0	9000	0.00	0	9000	0.00
blocksworld (30)						
FF	0	9000	0.00	**30**	1	**30.00**
lama	29	364	15.06	**30**	**0**	**30.00**
mercury	19	3320	7.64	**30**	1	**30.00**
FDSS	26	1263	15.62	**30**	1	**30.00**
BFWS	4	7813	1.50	**30**	**0**	**30.00**
depots (30)						
FF	1	8703	0.67	**30**	**0**	**30.00**
lama	1	8722	0.41	**30**	1	**30.00**
mercury	0	9000	0.00	**30**	1	**30.00**
FDSS	20	3563	19.97	**30**	1	27.34
BFWS	12	5460	7.71	**30**	**0**	**30.00**
gripper (30)						
FF	0	9000	0.00	0	9000	0.00
lama	12	5575	11.18	**30**	**38**	**30.00**
mercury	0	9000	0.00	18	3832	18.00
FDSS	0	9000	0.00	10	6208	10.00
BFWS	0	9000	0.00	0	9000	0.00
spanner (30)						
FF	0	9000	0.00	**30**	8	**30.00**
lama	0	9000	0.00	**30**	13	**30.00**
mercury	0	9000	0.00	**30**	**4**	**30.00**
FDSS	0	9000	0.00	**30**	49	**30.00**
BFWS	0	9000	0.00	11	5701	11.00

(C)overage, (P)AR10 (in seconds) and IPC (Q)uality Score

- **Domains** in question are **easy to solve** (albeit not optimally)
- Planners **struggle** with **original** encodings
- Use of **ATB-DCK** can make **great performance boost**

This Research was funded by the Czech Science Foundation (project no. 18-07252S) and by the OP VVV funded project CZ.02.1.01/0.0/0.0/16_019/0000765 ``Research Center for Informatics".