

UniAGENT: Reduced Time-Expansion Graphs and Goal Decomposition in Sub-optimal Cooperative Path Finding *

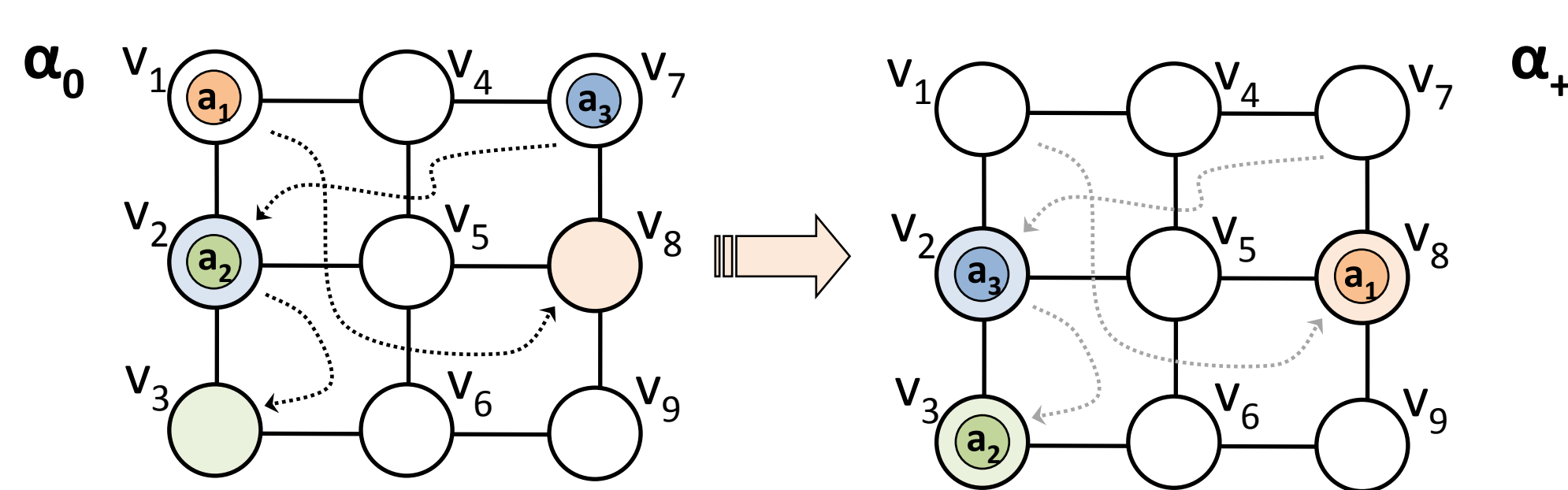
Pavel Surynek
Charles University in Prague, Czech Republic



Cooperative Path-Finding

- a task to **relocate agents** to their goals in a non-colliding way
- agents move over undirected graph
 - an agent can move to unoccupied vertex

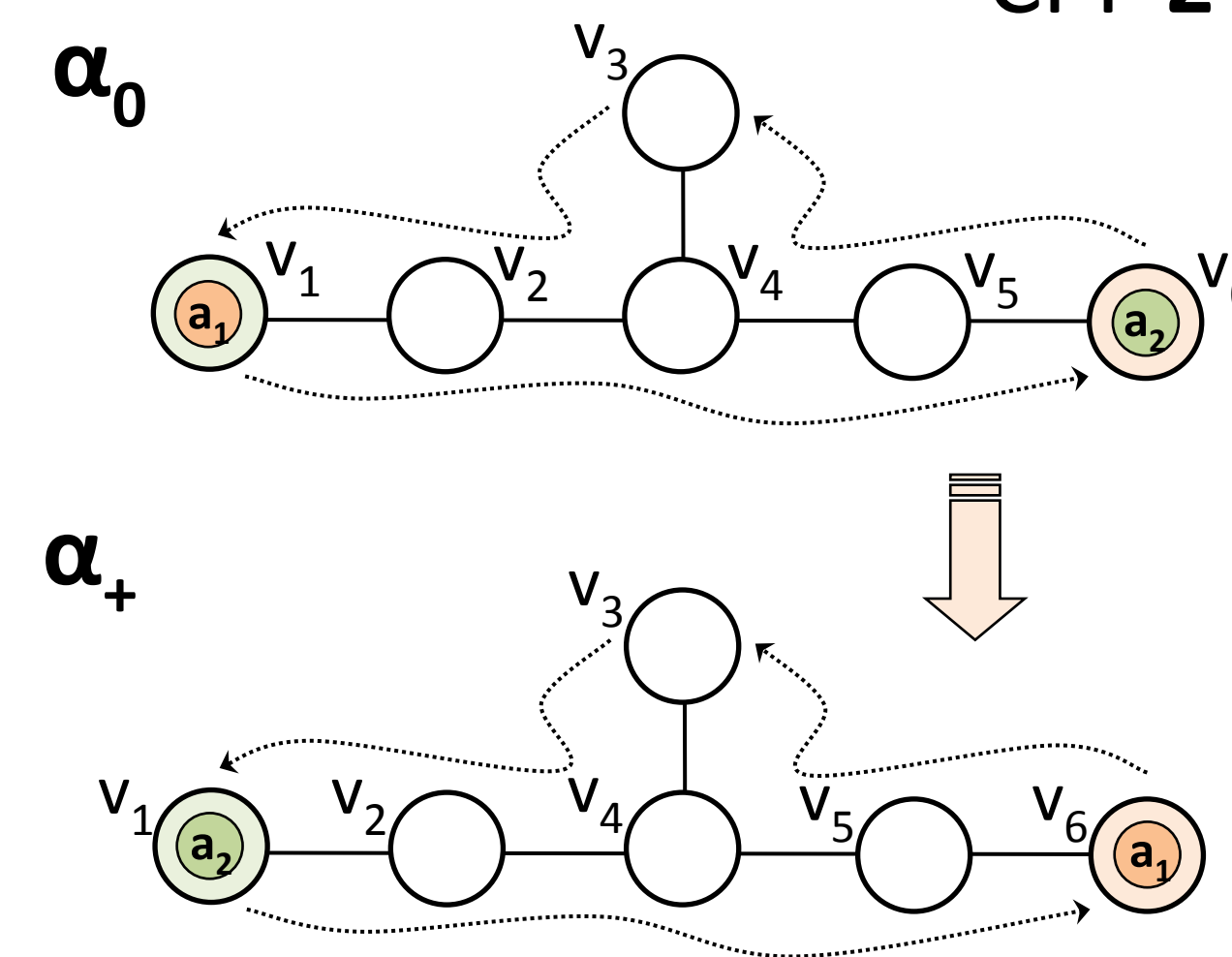
$$\text{CPF } \Sigma = (G, \{a_1, a_2, a_3\}, \alpha_0, \alpha_+)$$



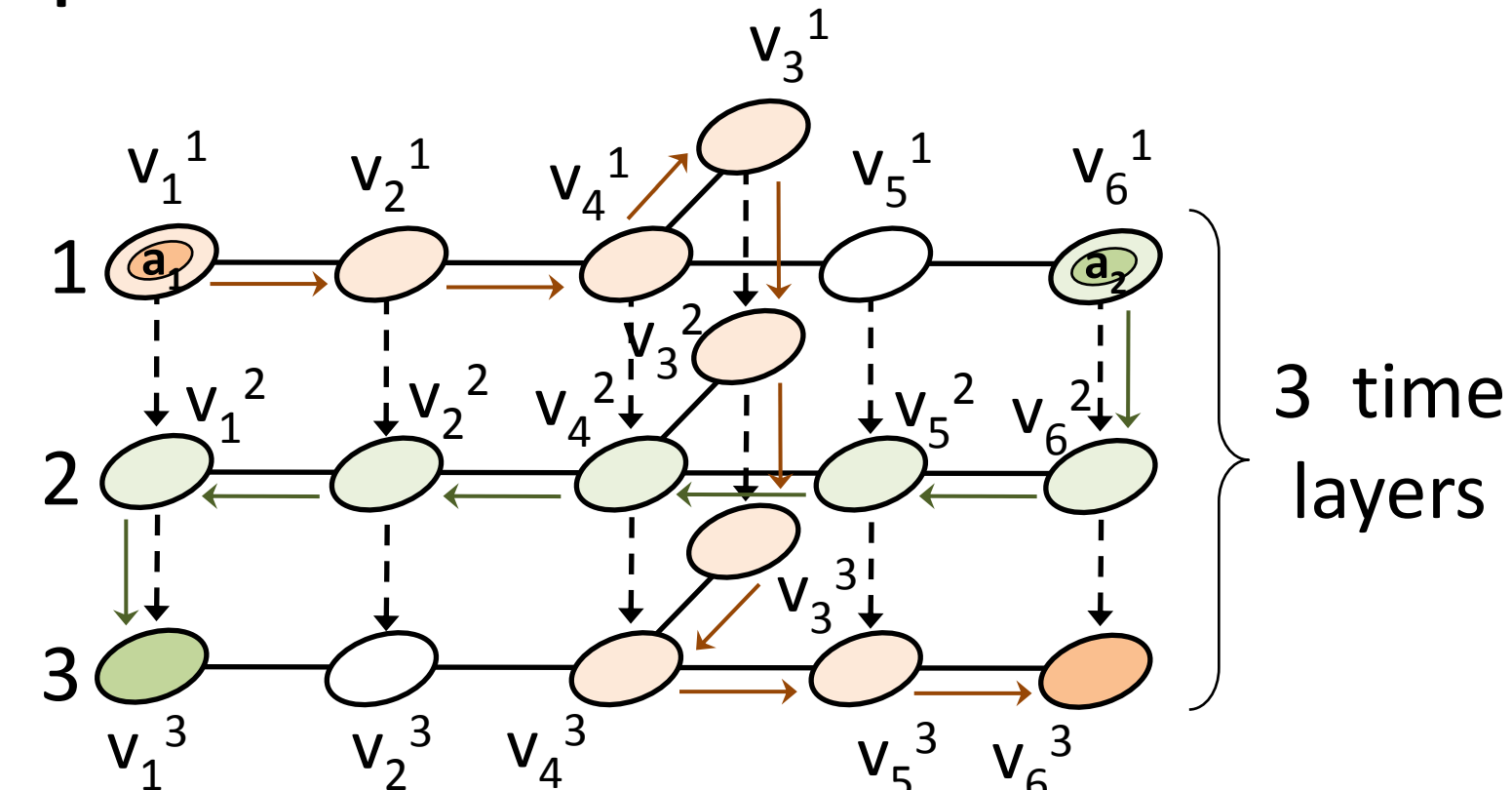
	α_0	α_1	α_2	α_3	$\alpha_4 = \alpha_+$
a_1	v_1	v_1	v_2	v_5	v_8
a_2	v_2	v_3	v_3	v_3	v_3
a_3	v_7	v_4	v_4	v_1	v_2

Reduced Time Expansion

$$\text{CPF } \Sigma = (G=(V,E), \{a_1, a_2\}, \alpha_0, \alpha_+)$$



$$\text{rExp}_T(G, 3)$$



	a_1	a_2
α_0	v_1	v_6
α_1	v_2	v_6
α_2	v_4	v_6
α_3	v_3	v_6
α_4	v_3	v_5
α_5	v_3	v_4
α_6	v_3	v_2
α_7	v_3	v_1
α_8	v_4	v_1
α_9	v_5	v_1
$\alpha_{10} = \alpha_+$	v_6	v_1

- solution of CPF** corresponds to **vertex disjoint paths** in reduced time expansion graph rExp_T
- no extra constraint except disjointness
 - easy modeling as propositional satisfiability
- produces makespan **sub-optimal** solution

Motivation

- rearranging** containers (agent = container)
- heavy traffic **control** (agent = car)
- data transfer** planning (agent = data packet)

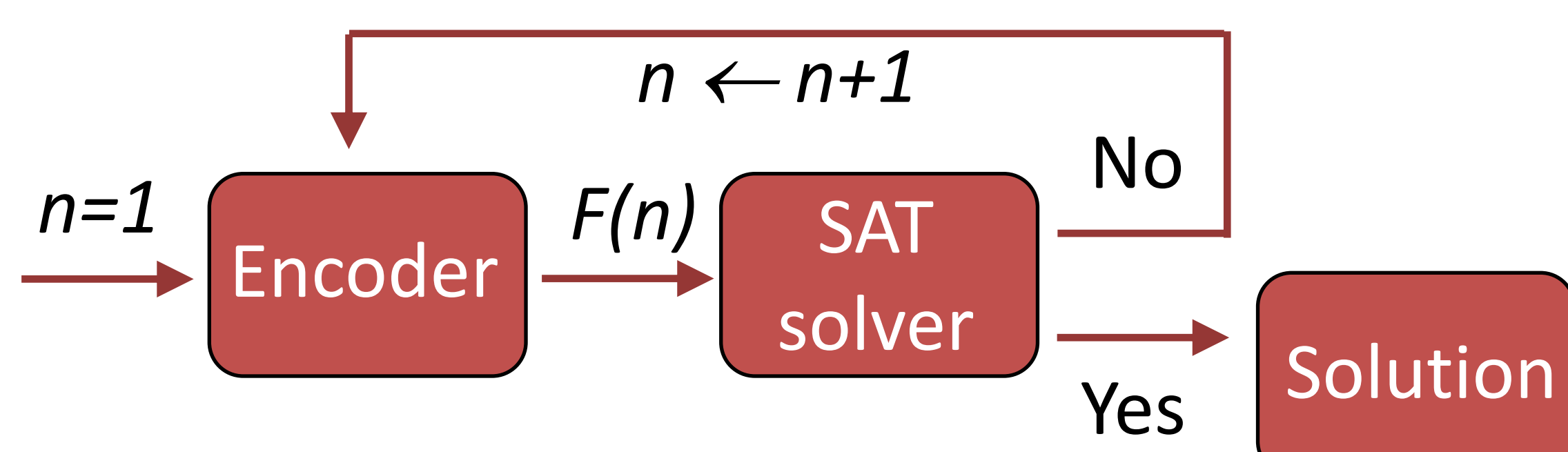


UniAGENT Solving

- place agents to their goals **one by one**
 - build a separate CPF for each agent placement
- initial arrangements and goals **differ little** for single agent placement
 - small number of layers in rExp_T to reach solvability
 - small SAT instances to solve

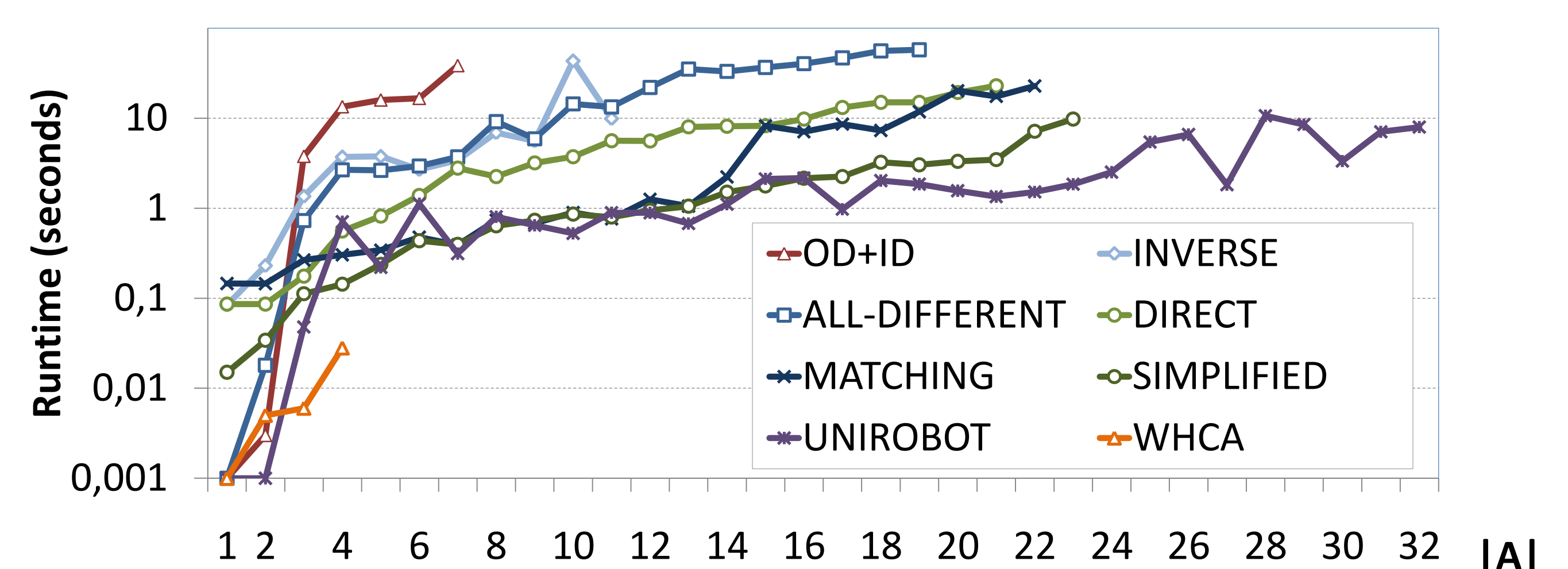
Reducing CPF to SAT

- expand** the graph modeling the environment over time
 - number of expansions n is specified
- encode** relocation of agents through expanded graphs as a propositional formula $F(n)$
 - ask **SAT solver** whether $F(n)$ is solvable



Experiments

Average runtime | Grid 8x8 | 20% obstacles



Makespan	A	1	4	8	12	16	20	24	28	32
optimal		5.3	8.4	11.0	11.7	12.4	12.3	-	-	-
WHCA*		5.6	9.3	-	-	-	-	-	-	-
UniAGENT		9.3	15.8	33.0	49.3	83.4	96.1	131.4	154.1	201.7

* The full version of this paper entitled *Reduced Time-Expansion Graphs and Goal Decomposition for Solving Cooperative Path Finding Sub-optimally* was published at IJCAI 2015.