A General Theory of Motion Planning Complexity: Characterizing Which Gadgets Make Games Hard

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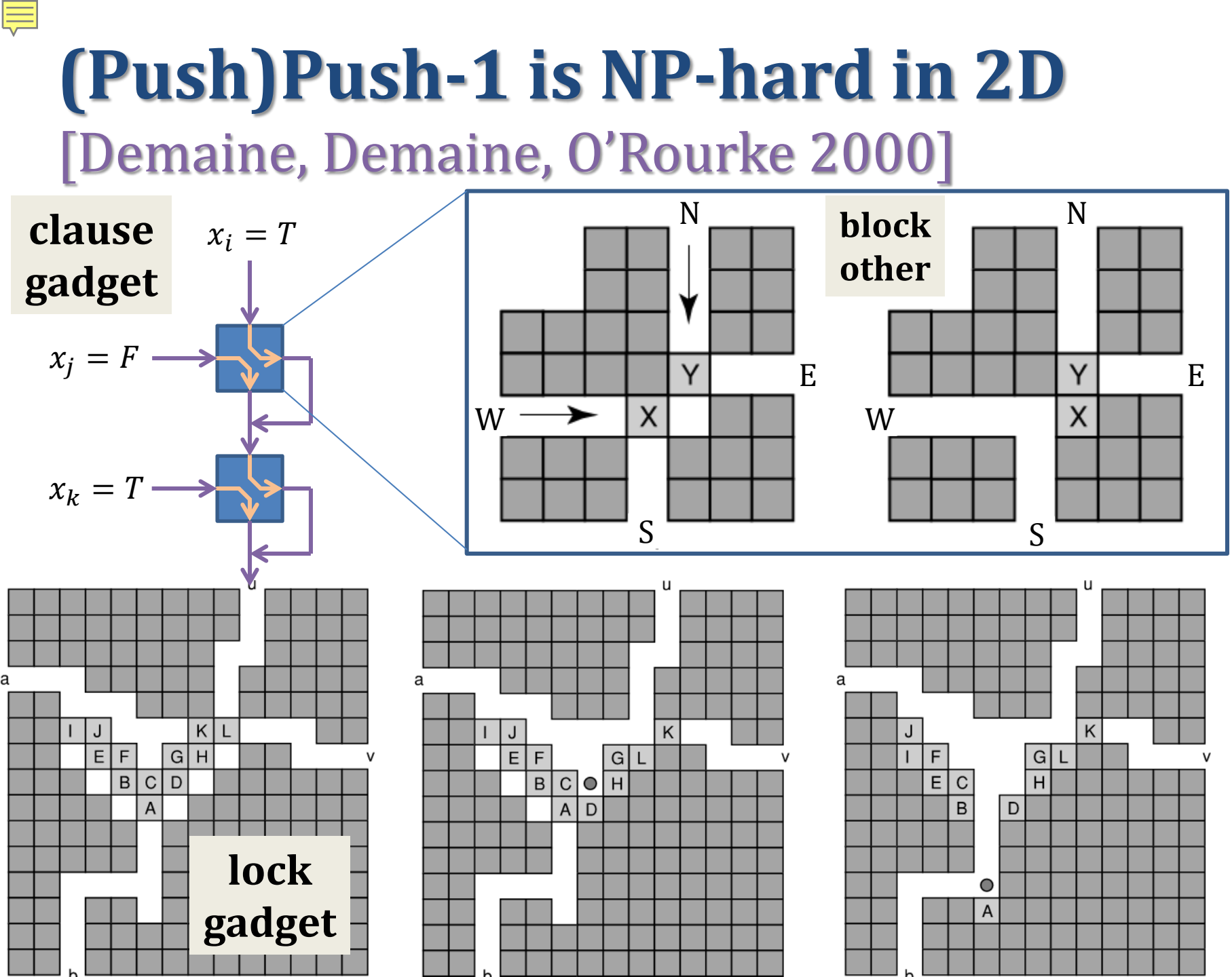
Abstract

We build a general theory for characterizing the computational complexity of motion planning of robot(s) through a graph of "gadgets", where each gadget has its own state defining a set of allowed traversals which in turn modify the gadget's state. We study two families of such

	1-Player Game	2-Player Game	Team Game
Polynomially Bounded (DAG)	**NL** vs. **NP-complete**: full characterization [§5]	**P** vs. **PSPACE-complete**: full characterization [§6]	**P** vs. **NEXPTIME**: full characterization [§7]
Polynomially Unbounded (reversible, deterministic gadgets)	**NL** vs. **PSPACE-complete**: full characterization [§2] **Planar**: equivalent [§2.3]	**P** vs. **EXPTIME-complete**: partial characterization [§3]	**P** vs. **RE-complete** (⇒ **Undecidable**): partial characterization [§4]

(Push)Push-1 is NP-hard in 2D

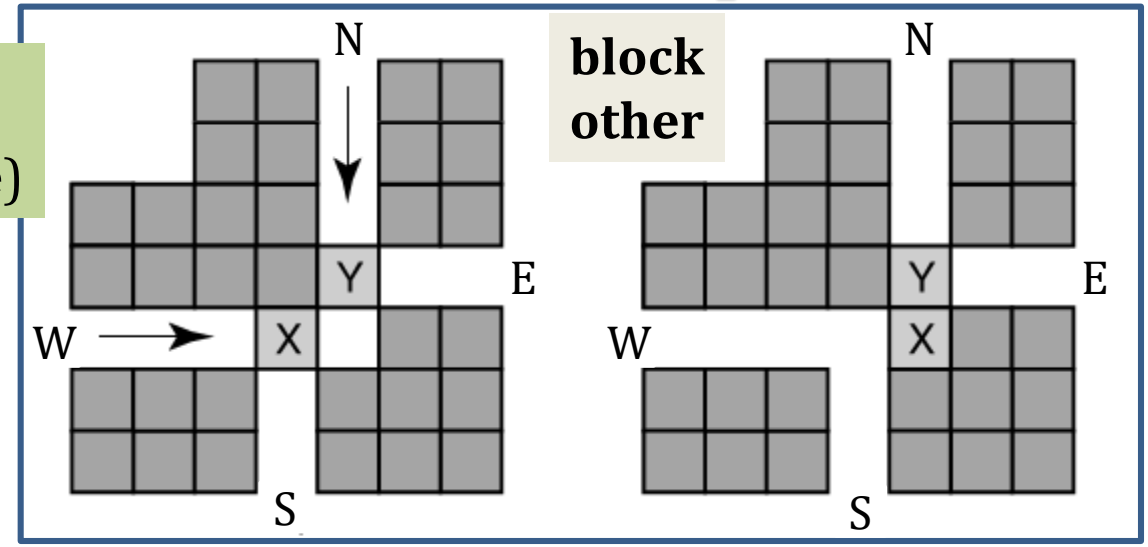
[Demaine, Demaine, O'Rourke 2000]



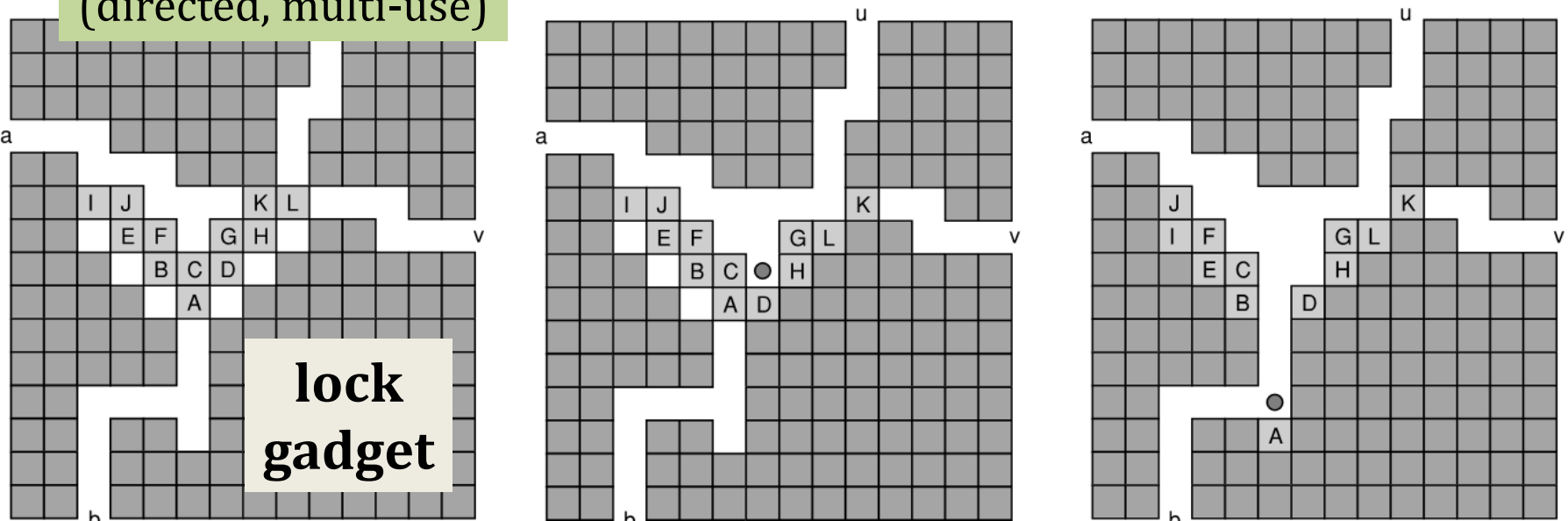
(Push)Push-1 is NP-hard in 2D

[Demaine, Demaine, O'Rourke 2000]

closing door
(directed, multi-use)



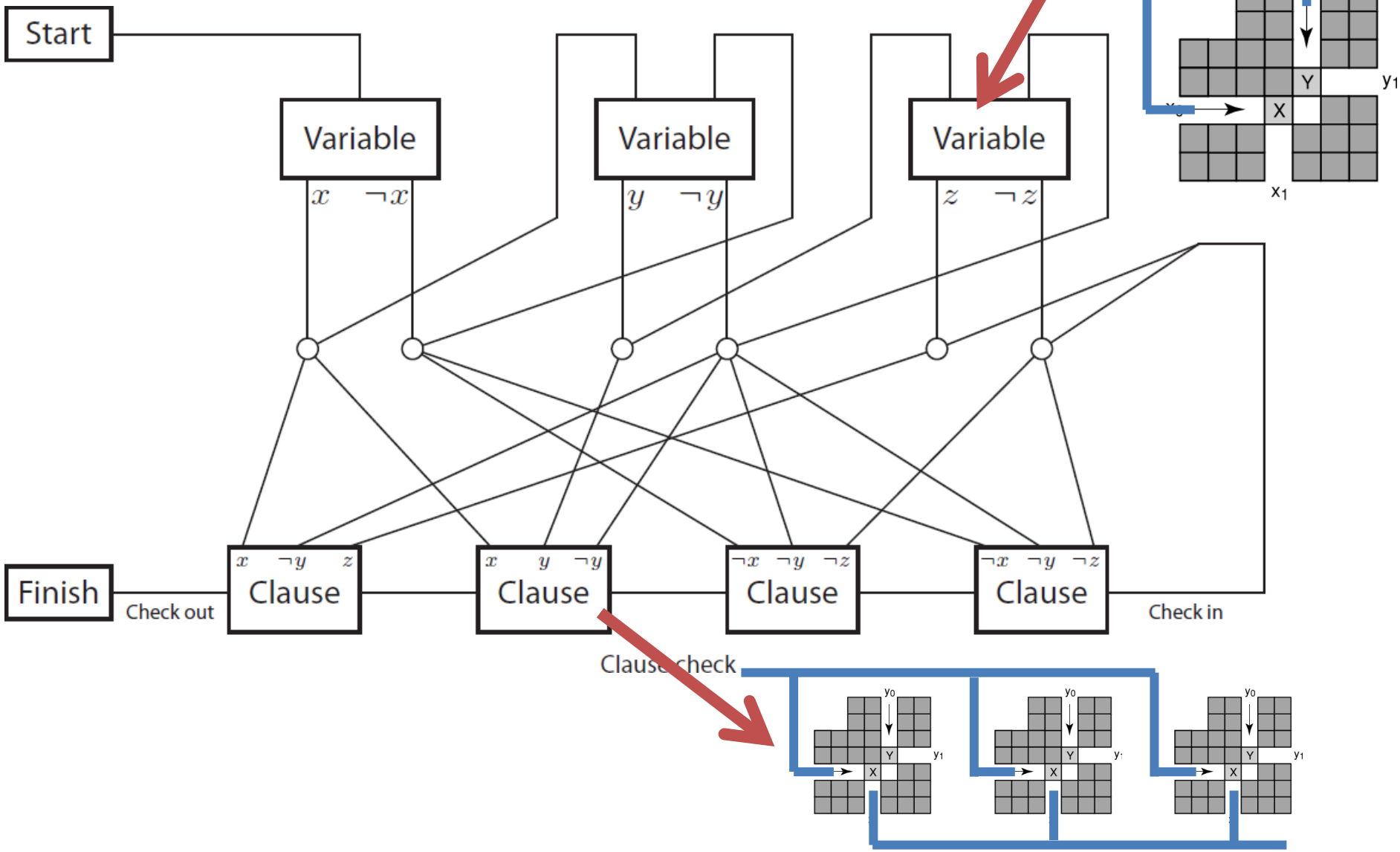
opening door
(directed, multi-use)



Closing Door is NP-hard

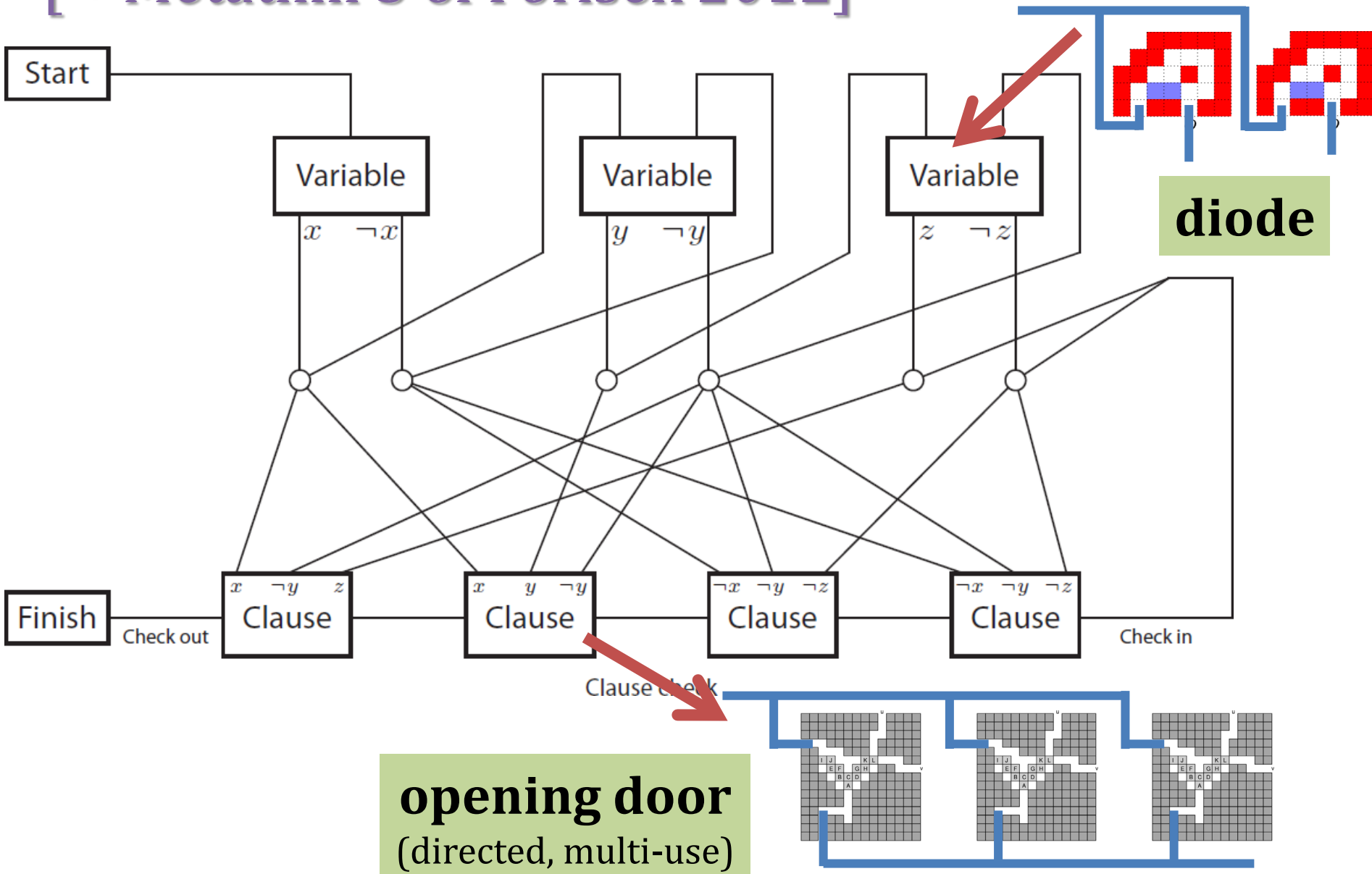
[≈ Metathm 4b of Viglietta 2012]

closing door
(directed, multi-use)



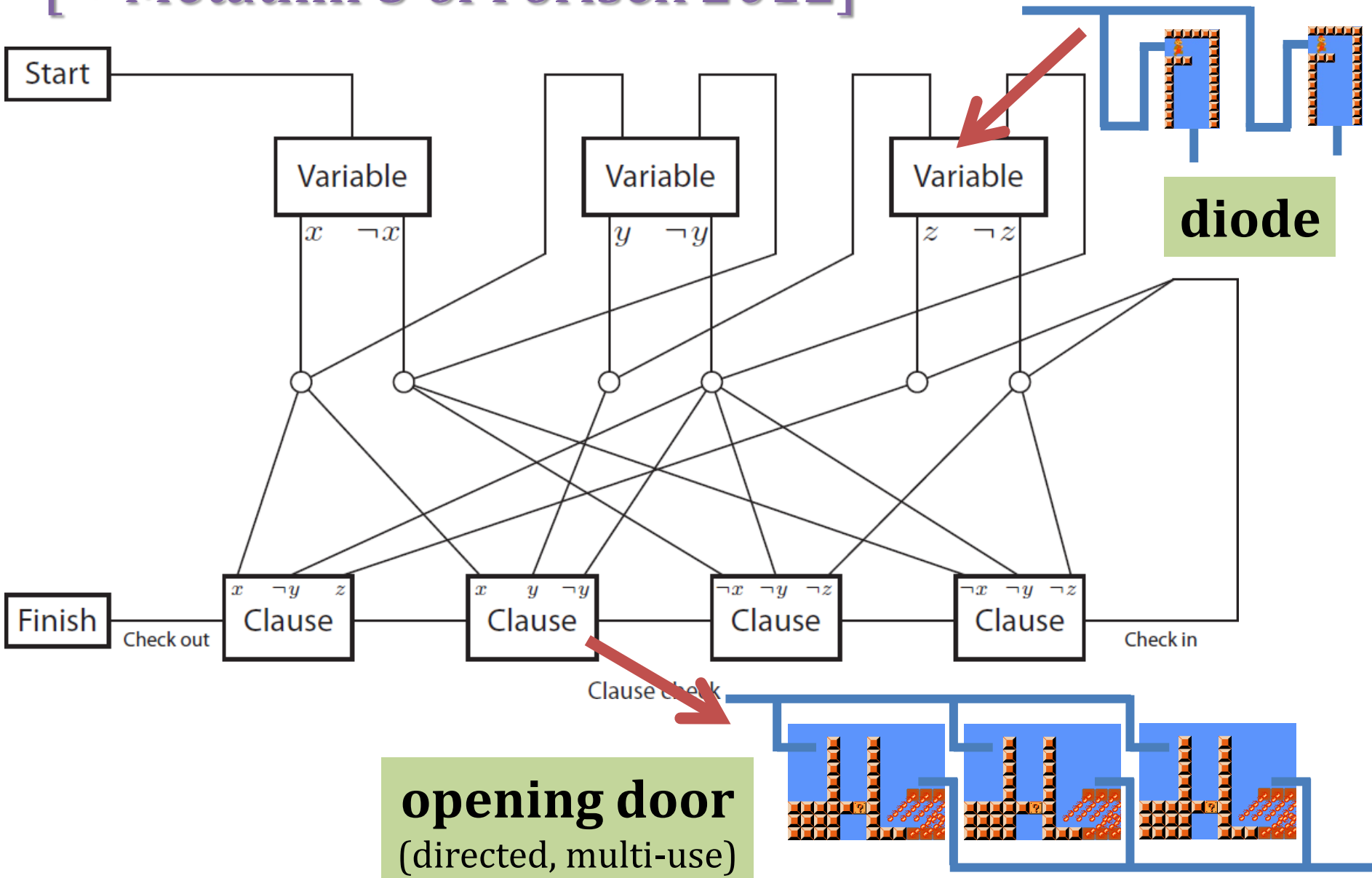
Opening Door + Diode is NP-hard

[≈ Metathm 3 of Forišek 2012]



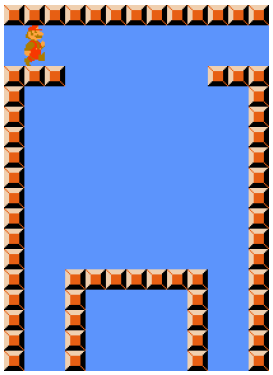
Opening Door + Diode is NP-hard

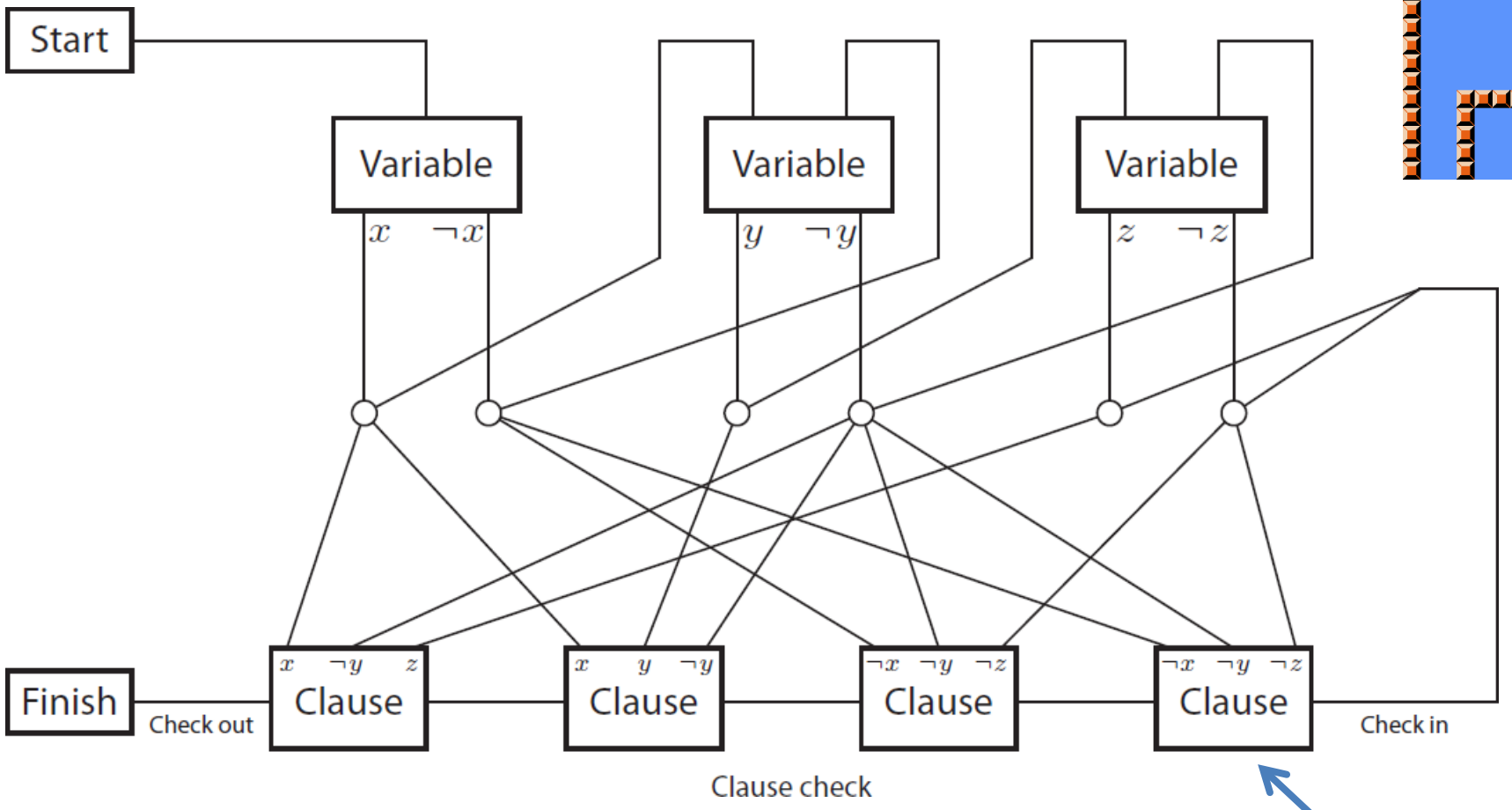
[≈ Metathm 3 of Forišek 2012]

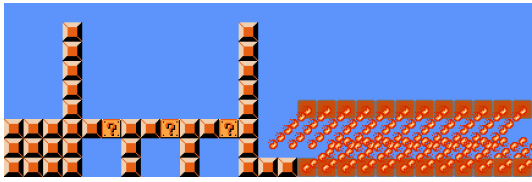


Super Mario Bros. is NP-Hard

[Aloupis, Demaine, Guo, Viglietta 2014]







(old proof for contrast)