Frontiers of automatic analysis of concurrent systems

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University of Warsaw

Open Day of Doctoral Studies, 2023-05-08

Concurrency bugs

Concurrency bugs

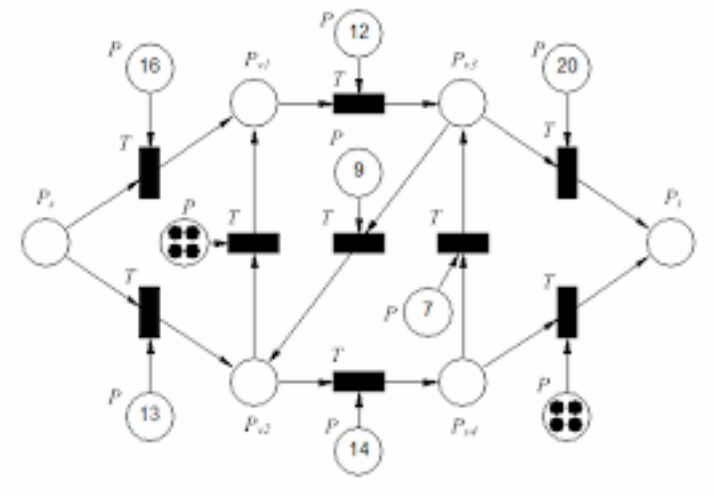
Concurrent systems

- are inherently difficult to analyze
- call for rigorous mathematical modelling and (possibly automatic) analysis - formal verification

Automatic analysis

concurrent system

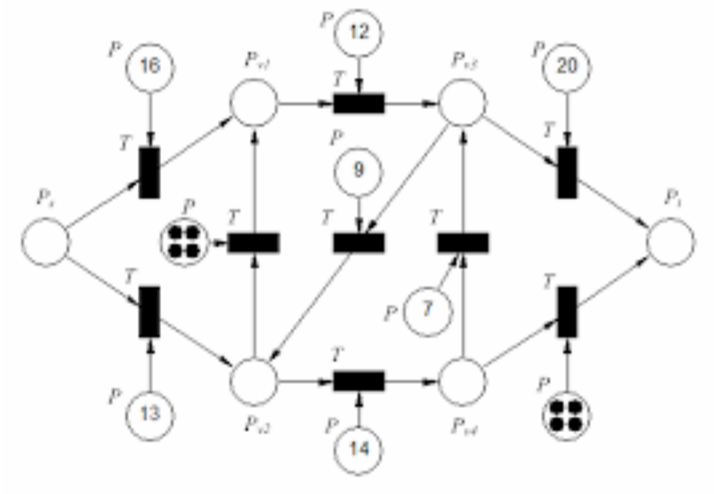
mathematical model



Automatic analysis

concurrent system

mathematical model

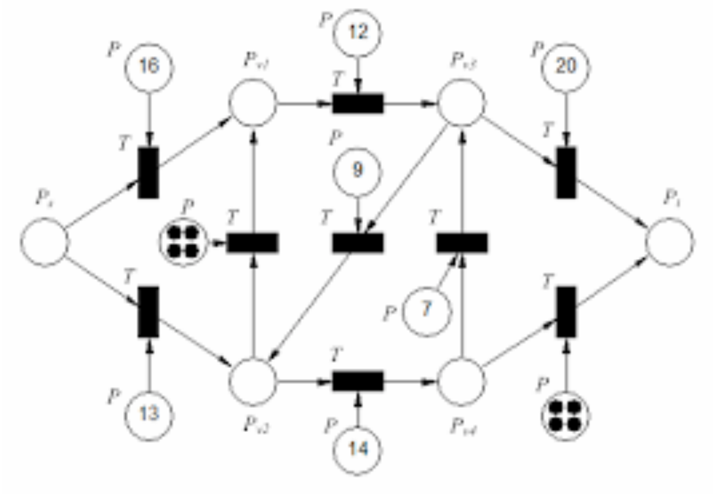


analyze (verify) model, not system

Automatic analysis

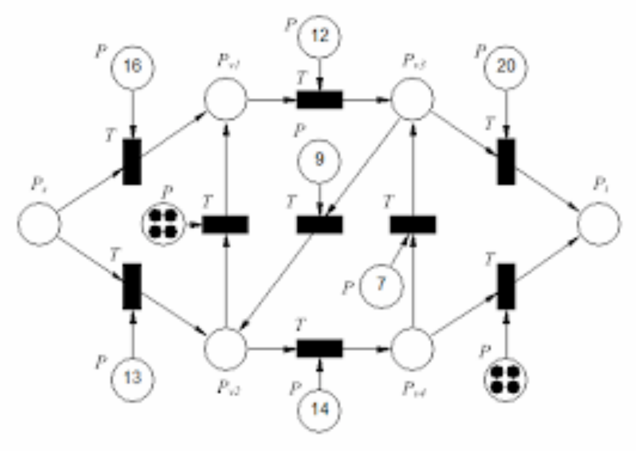
concurrent system

mathematical model



analyze (verify) model, not system

What kind of models?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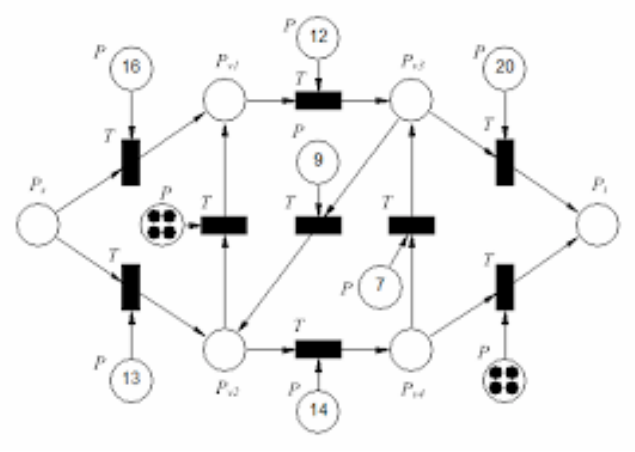
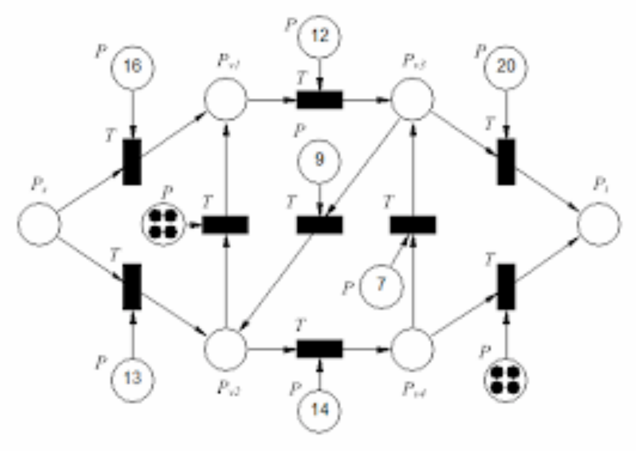
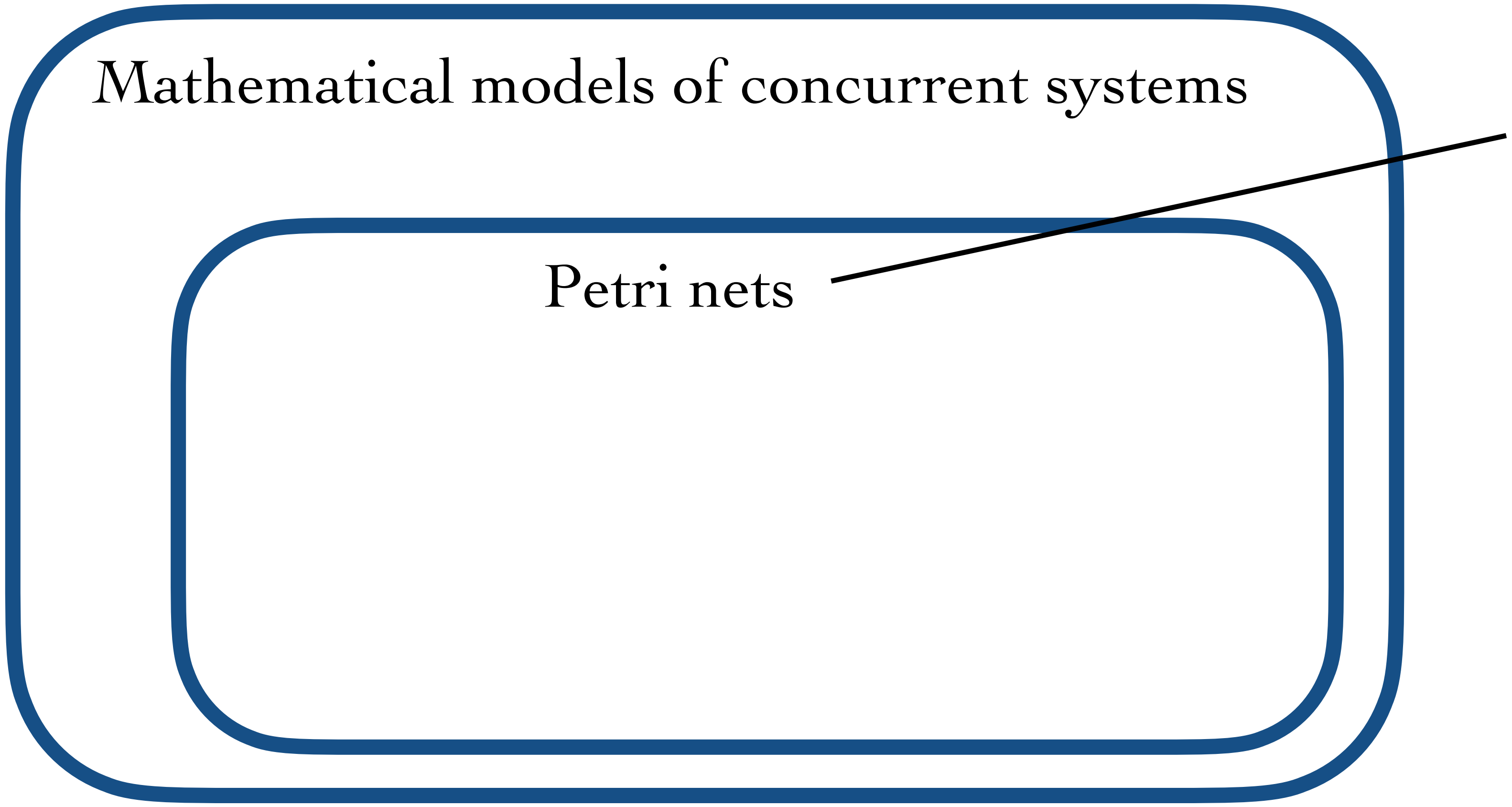


Mathematical models of concurrent systems

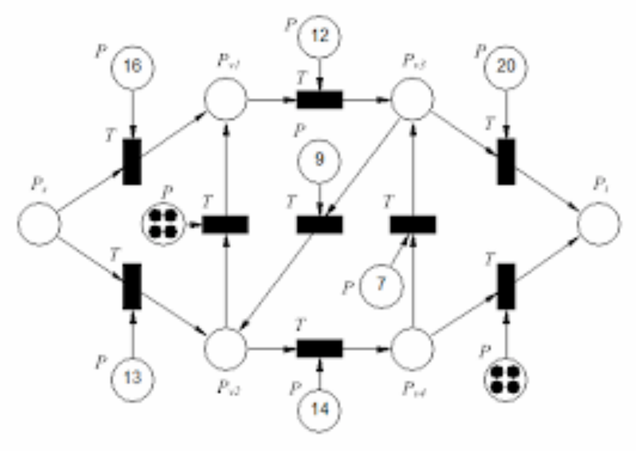


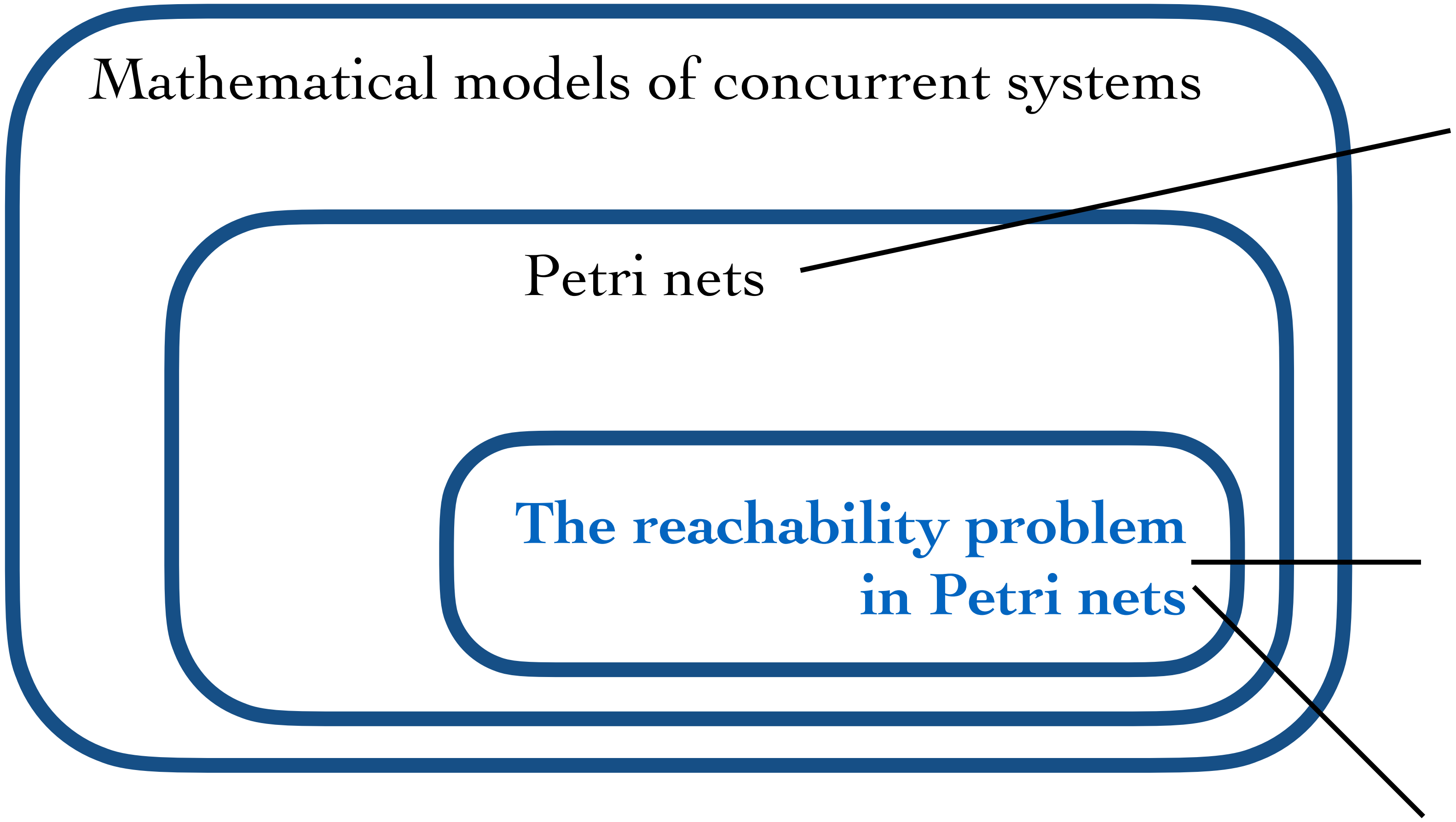


Mathematical models of concurrent systems

Petri nets

modelling hardware, software,
but also chemical, biological
and business processes





Mathematical models of concurrent systems

Petri nets

The reachability problem in Petri nets

modelling hardware, software, but also chemical, biological and business processes

central problem in formal verification of concurrent systems

equivalent to various problems in:

- concurrency
- logic
- language theory
- process calculi
- linear algebra

The reachability problem in Petri nets

where is concurrency?

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- tokens ● to be allocated on slots ○

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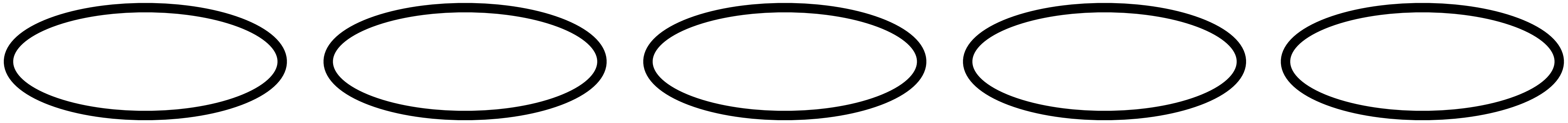

The reachability problem in Petri nets

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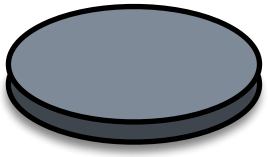
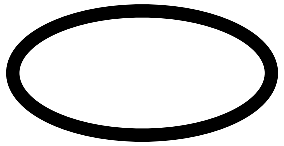
- tokens  to be allocated on slots 

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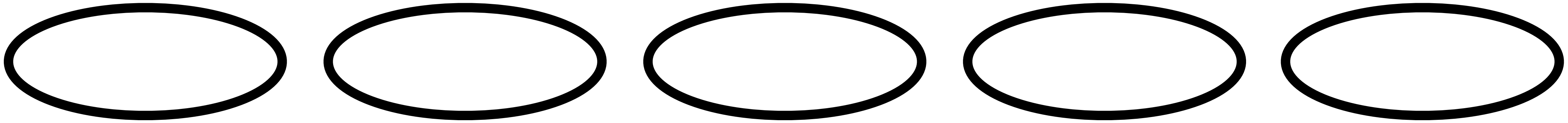

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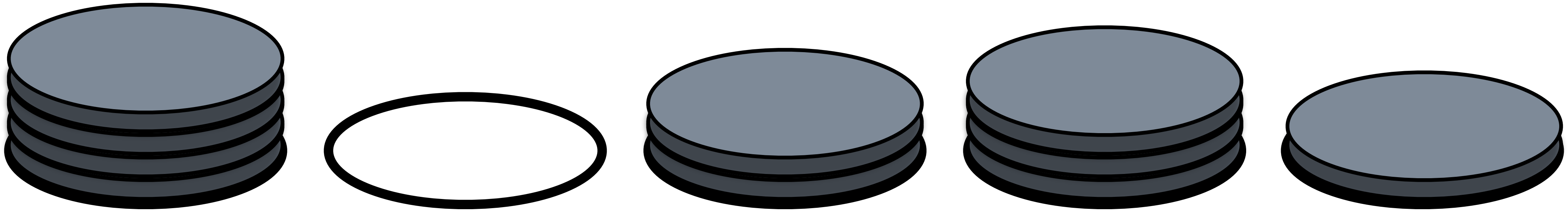

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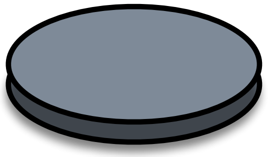
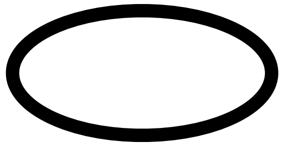
- tokens  to be allocated on slots 

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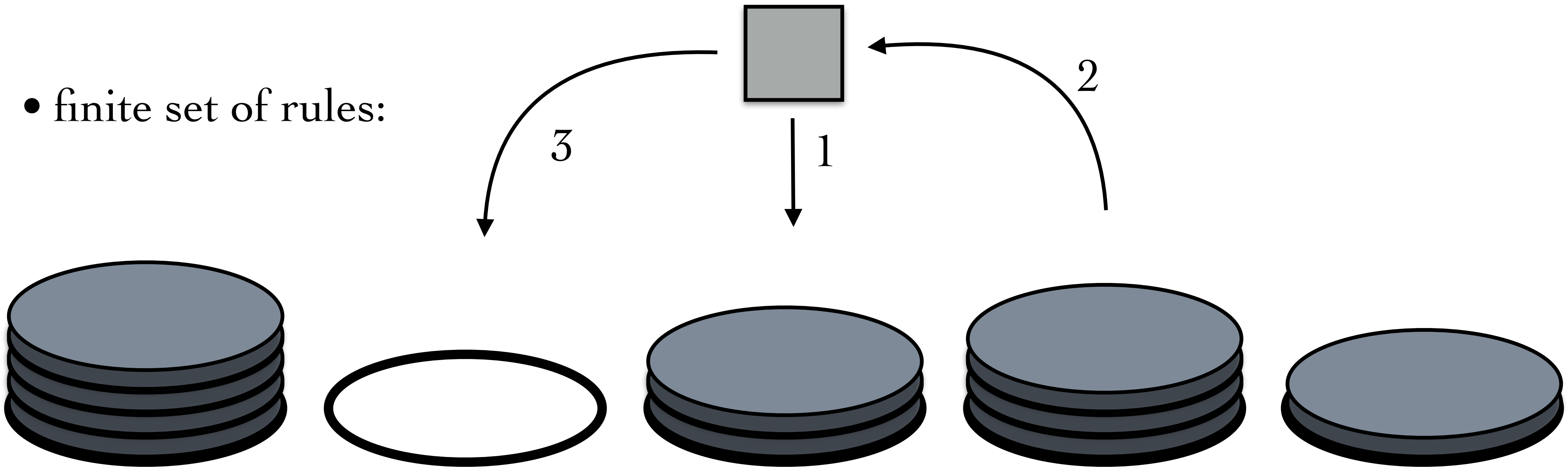

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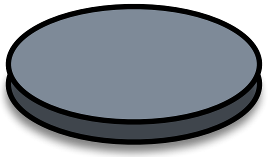
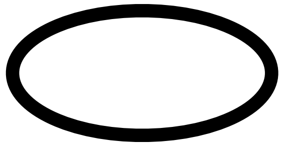
- tokens  to be allocated on slots 

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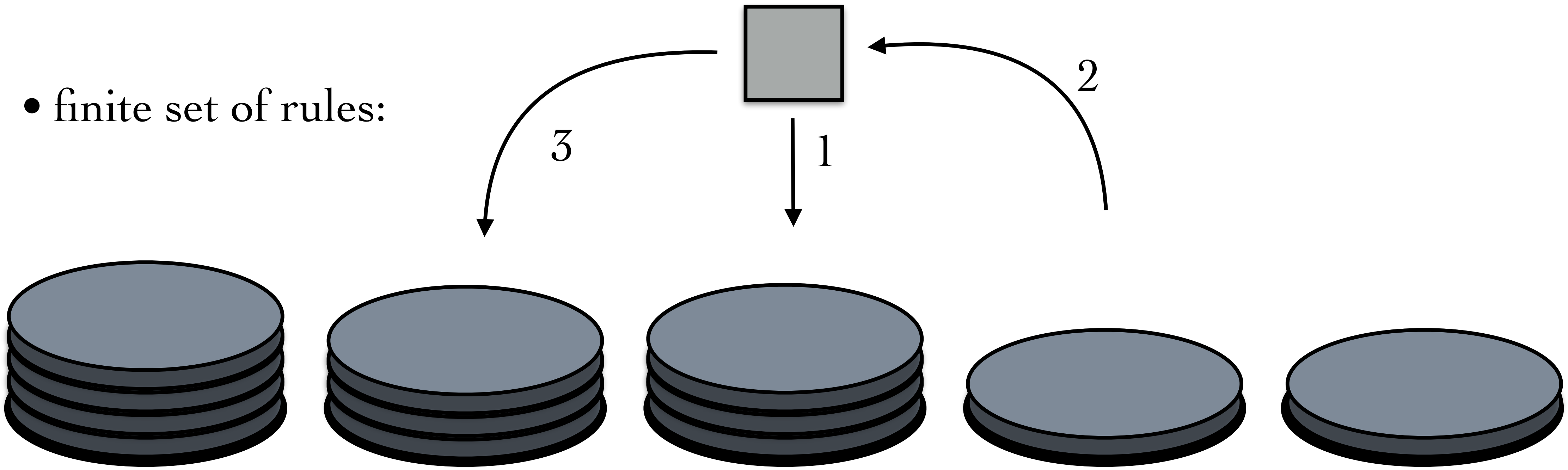

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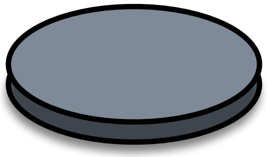
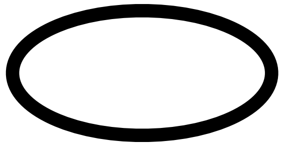
- tokens  to be allocated on slots 

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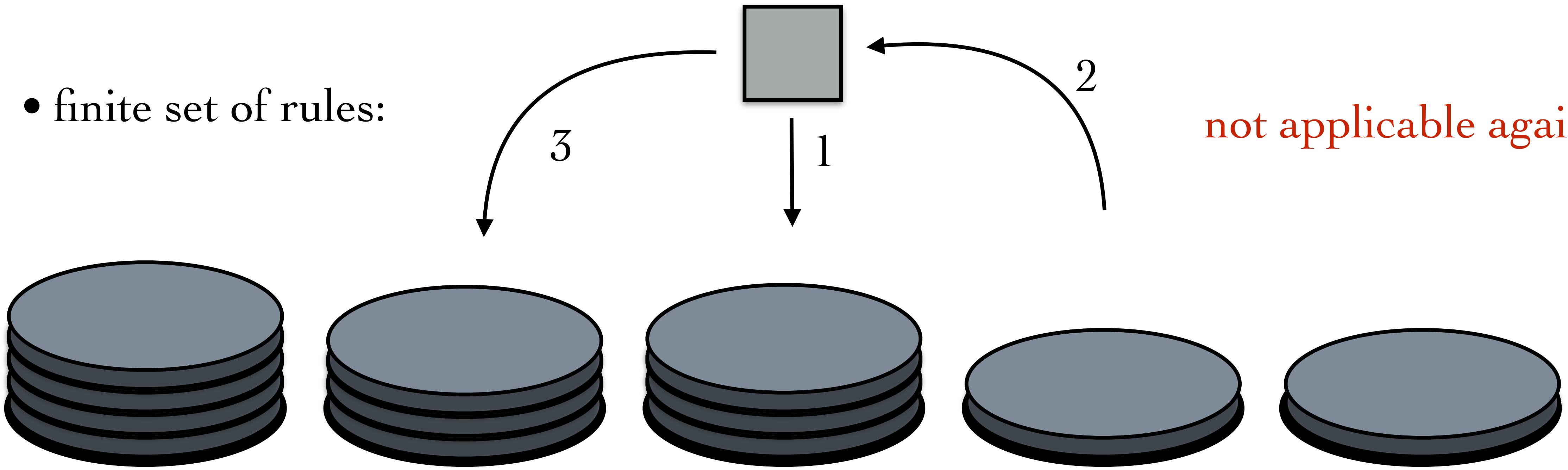

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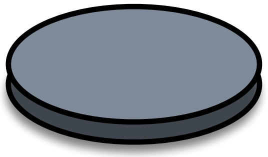
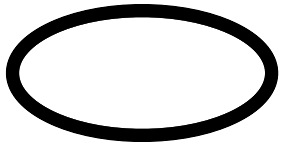
- tokens  to be allocated on slots 

Given:

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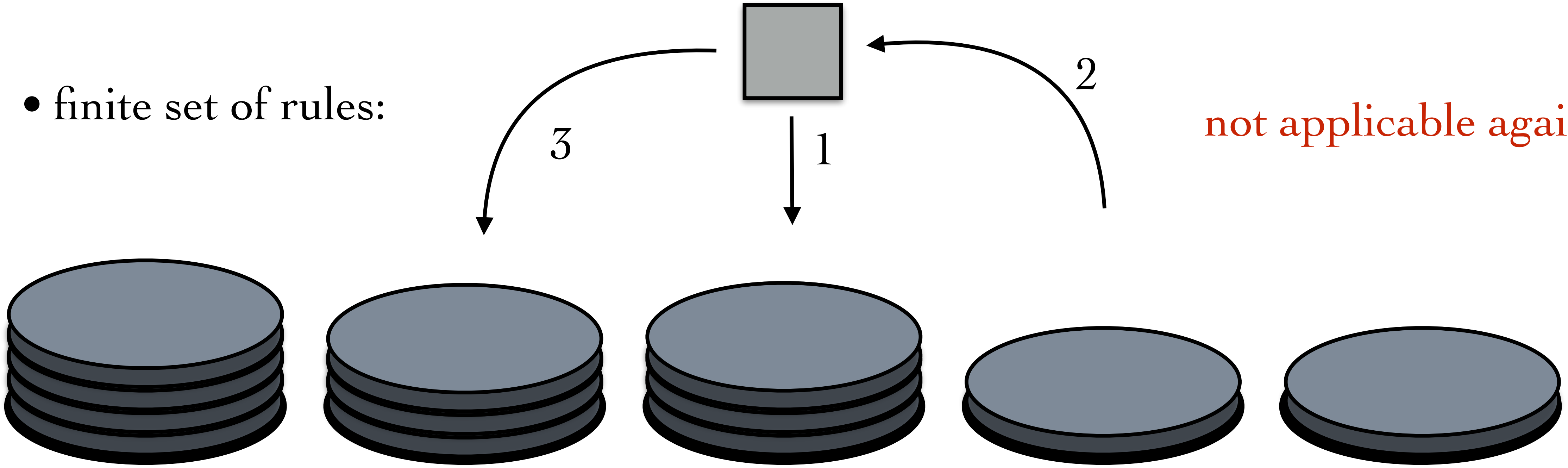

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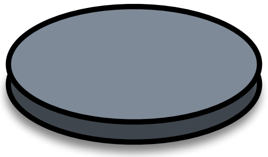
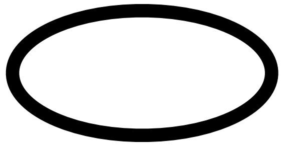
- tokens  to be allocated on slots 

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is there a sequence of rule applications?

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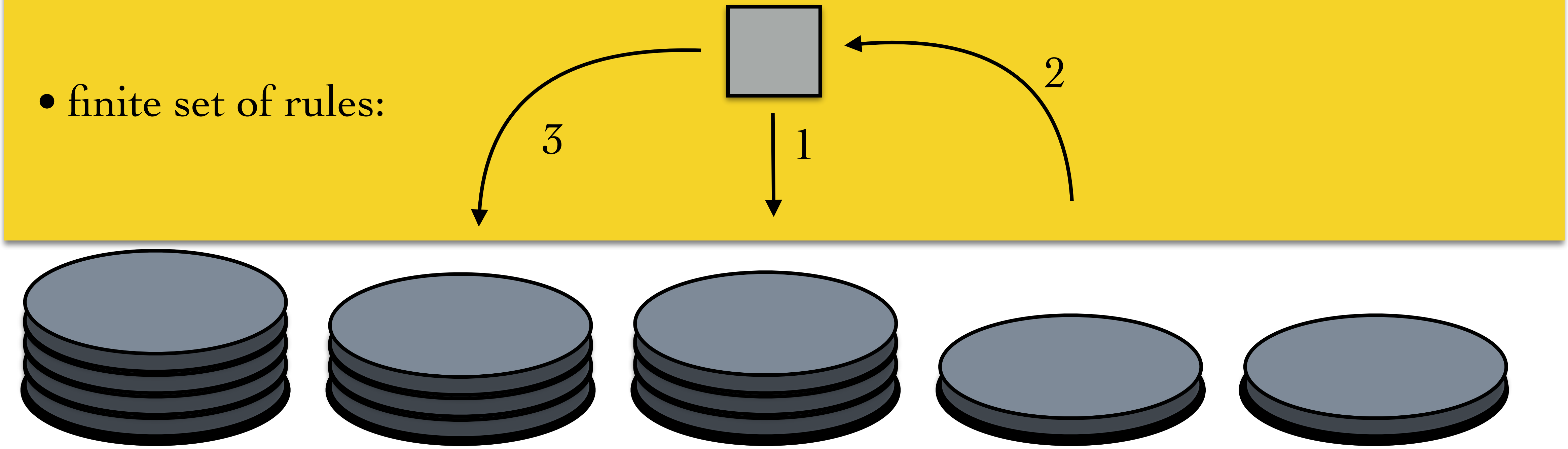

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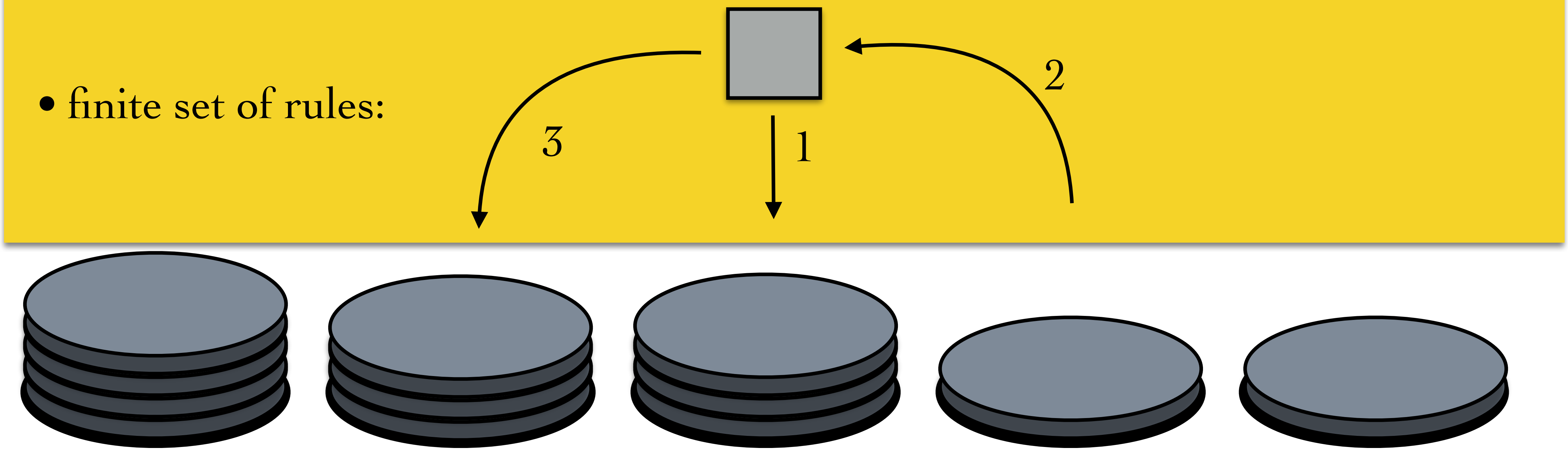
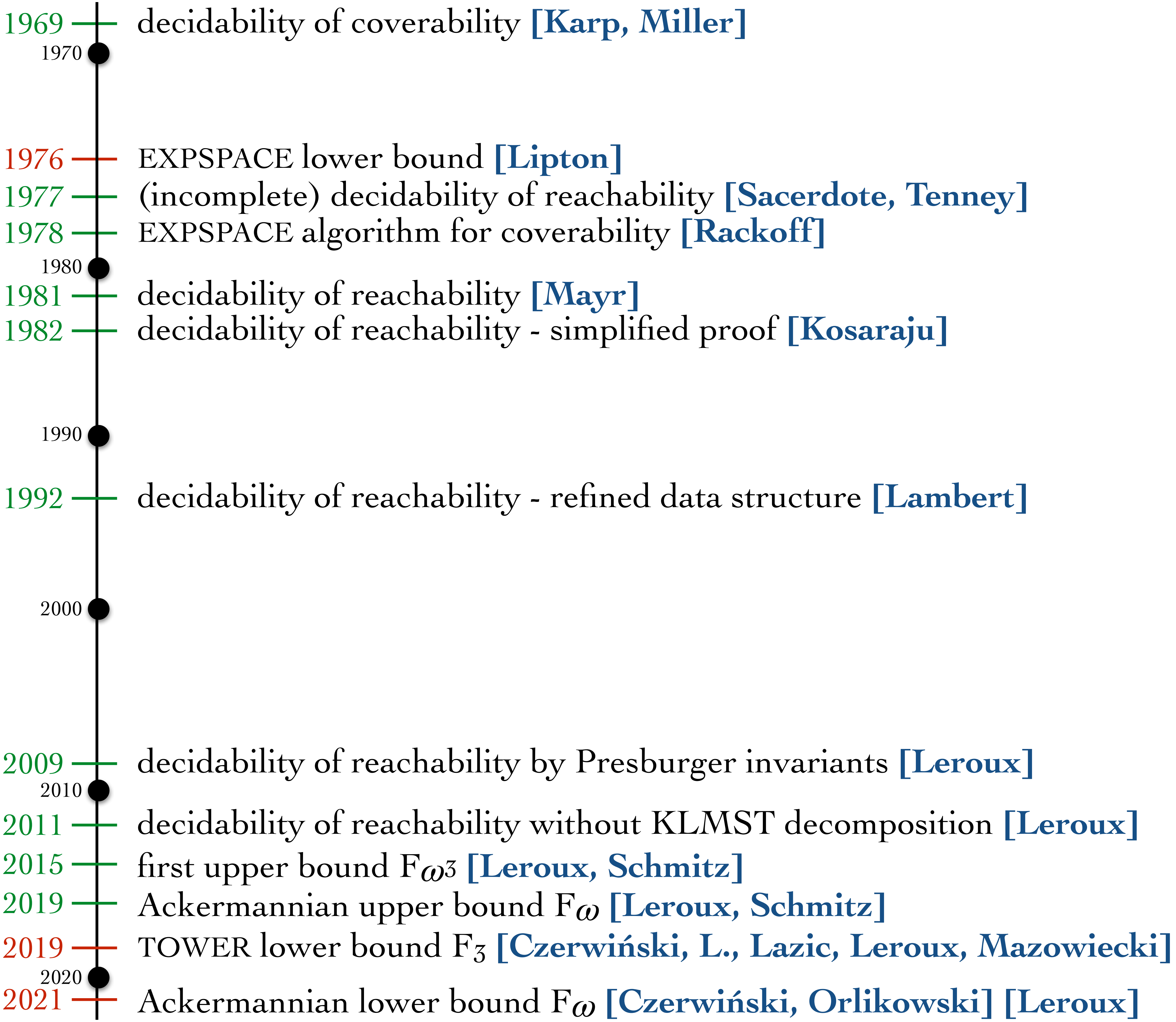


Research goal: study decidability and complexity of the problem



1969 decidability of coverability **[Karp, Miller]**

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2009 decidability of reachability by Presburger invariants **[Leroux]**

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2015 first upper bound F_{ω^3} **[Leroux, Schmitz]**

2019 Ackermannian upper bound F_ω **[Leroux, Schmitz]**

2019 TOWER lower bound F_3 **[Czerwiński, L., Lazic, Leroux, Mazowiecki]**

2021 Ackermannian lower bound F_ω **[Czerwiński, Orlikowski] [Leroux]**

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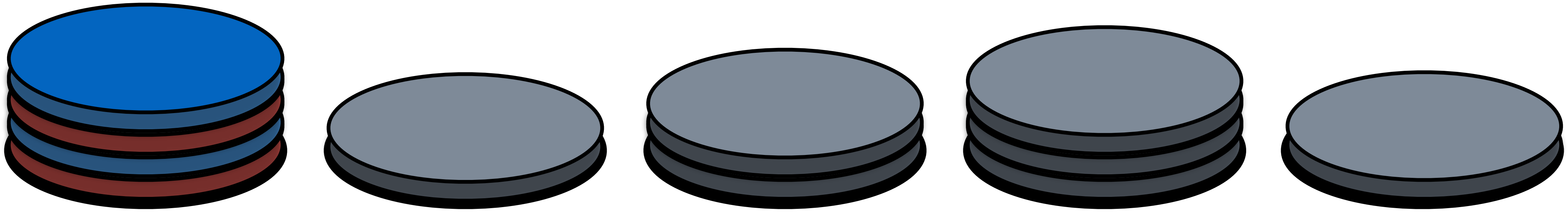
Research goal:

develop further these new ideas

Generalisations

Generalisations

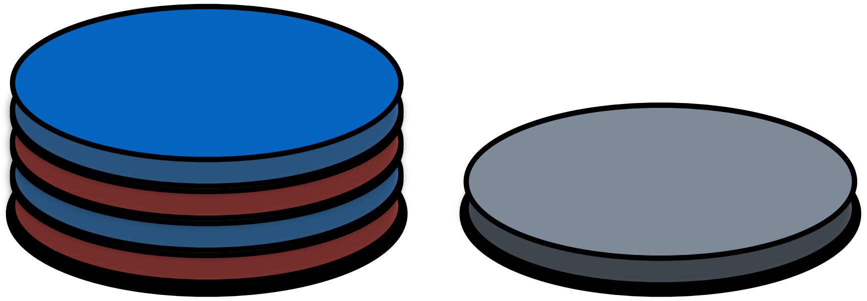
- pushdown Petri nets



pushdown
stack

Generalisations

- pushdown Petri nets



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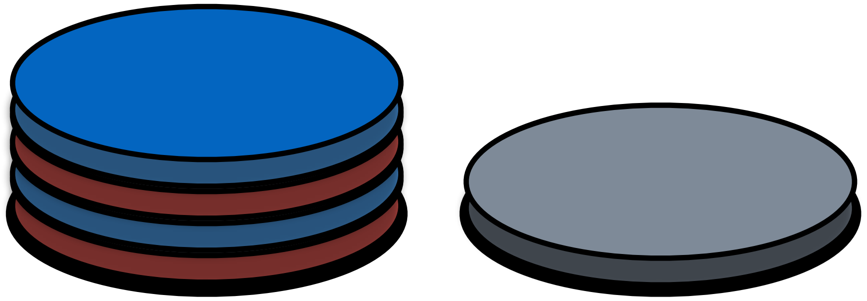
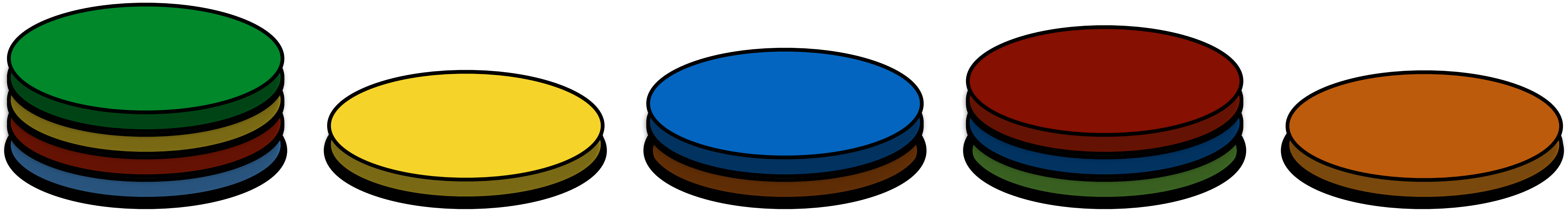


pushdown
stack

- data Petri nets



Restrictions

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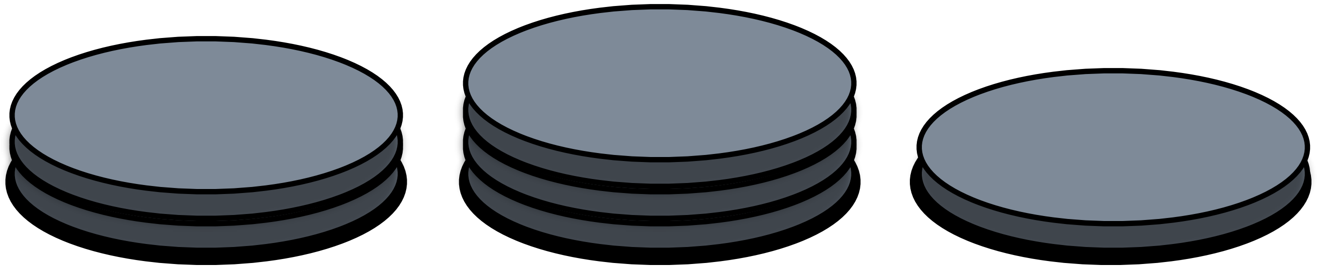
- dimension 3 *



*slightly cheating here

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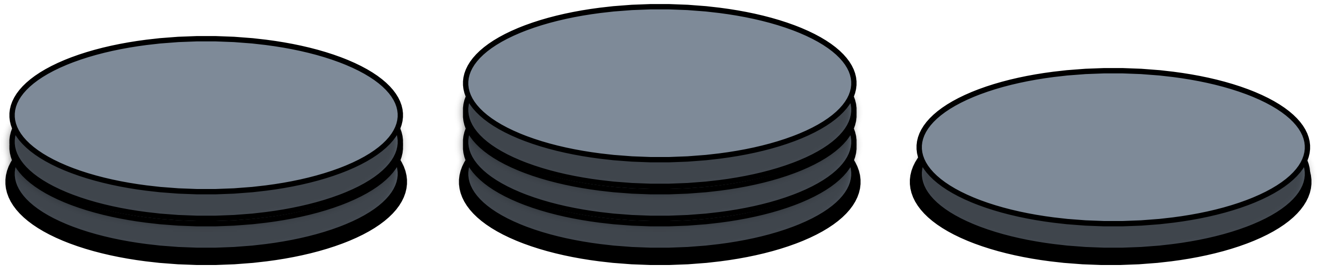
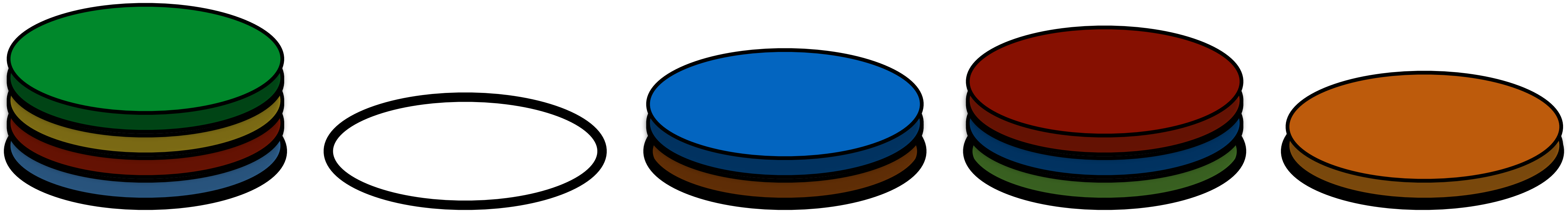
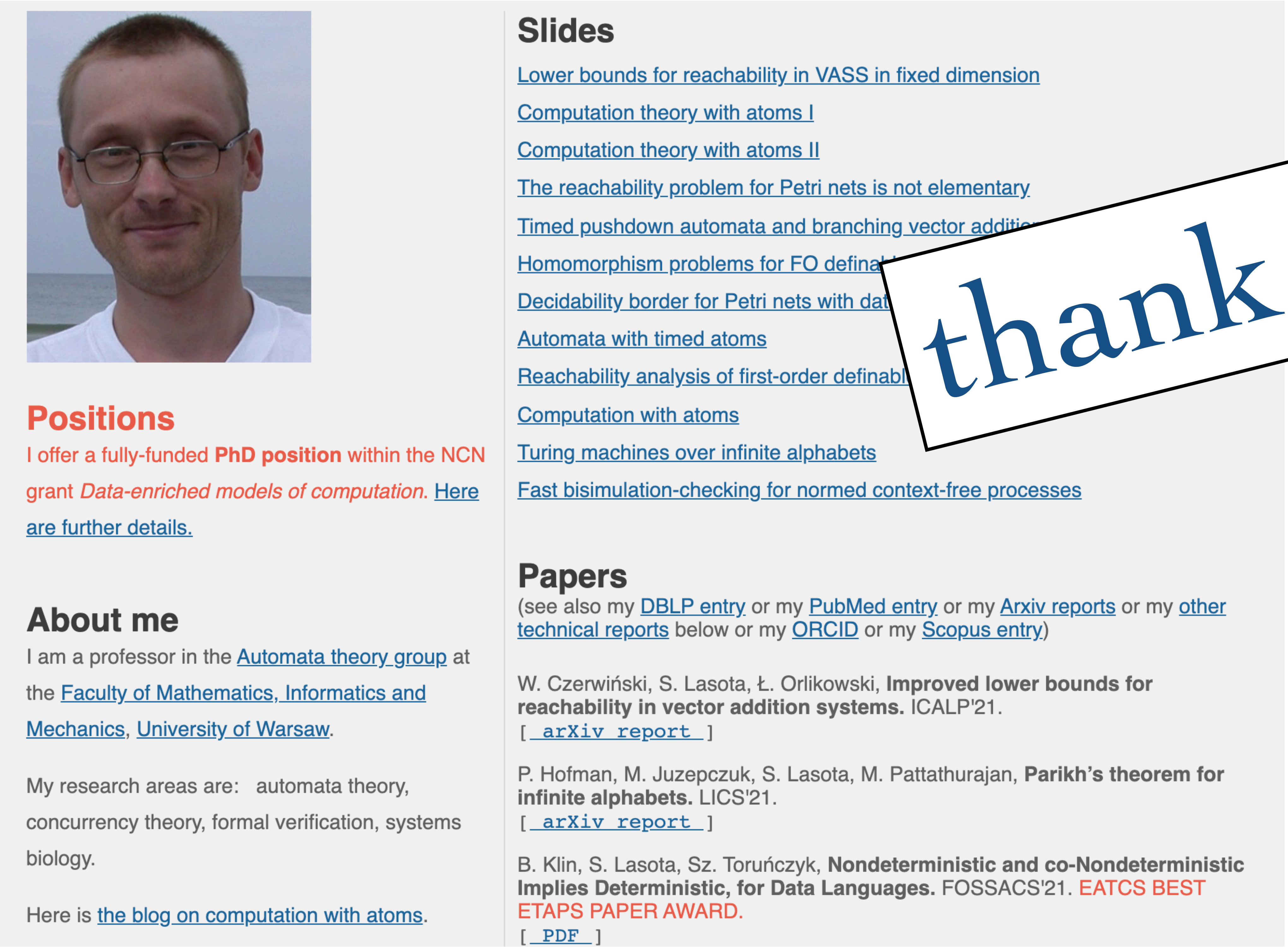


- fixed dimension

*slightly cheating here





Positions

I offer a fully-funded **PhD position** within the NCN grant *Data-enriched models of computation*. Here are further details.

About me

I am a professor in the Automata theory group at the Faculty of Mathematics, Informatics and Mechanics, University of Warsaw.

My research areas are: automata theory, concurrency theory, formal verification, systems biology.

Here is the blog on computation with atoms.

Slides

Lower bounds for reachability in VASS in fixed dimension

Computation theory with atoms I

Computation theory with atoms II

The reachability problem for Petri nets is not elementary

Timed pushdown automata and branching vector additio

Homomorphism problems for FO defina

Decidability border for Petri nets with dat

Automata with timed atoms

Reachability analysis of first-order definabl

Computation with atoms

Turing machines over infinite alphabets

Fast bisimulation-checking for normed context-free processes

Papers

(see also my DBLP entry or my PubMed entry or my Arxiv reports or my other technical reports below or my ORCID or my Scopus entry)

W. Czerwiński, S. Lasota, Ł. Orlikowski, **Improved lower bounds for reachability in vector addition systems.** ICALP'21.
`[ arXiv report ]`

P. Hofman, M. Juzepczuk, S. Lasota, M. Pattathurajan, **Parikh's theorem for infinite alphabets.** LICS'21.
`[ arXiv report ]`

B. Klin, S. Lasota, Sz. Toruńczyk, **Nondeterministic and co-Nondeterministic Implies Deterministic, for Data Languages.** FOSSACS'21. EATCS BEST ETAPS PAPER AWARD.
`[ PDF ]`

thank you!