# Designing Participatory Budgeting Mechanisms Grounded in Judgment Aggregation

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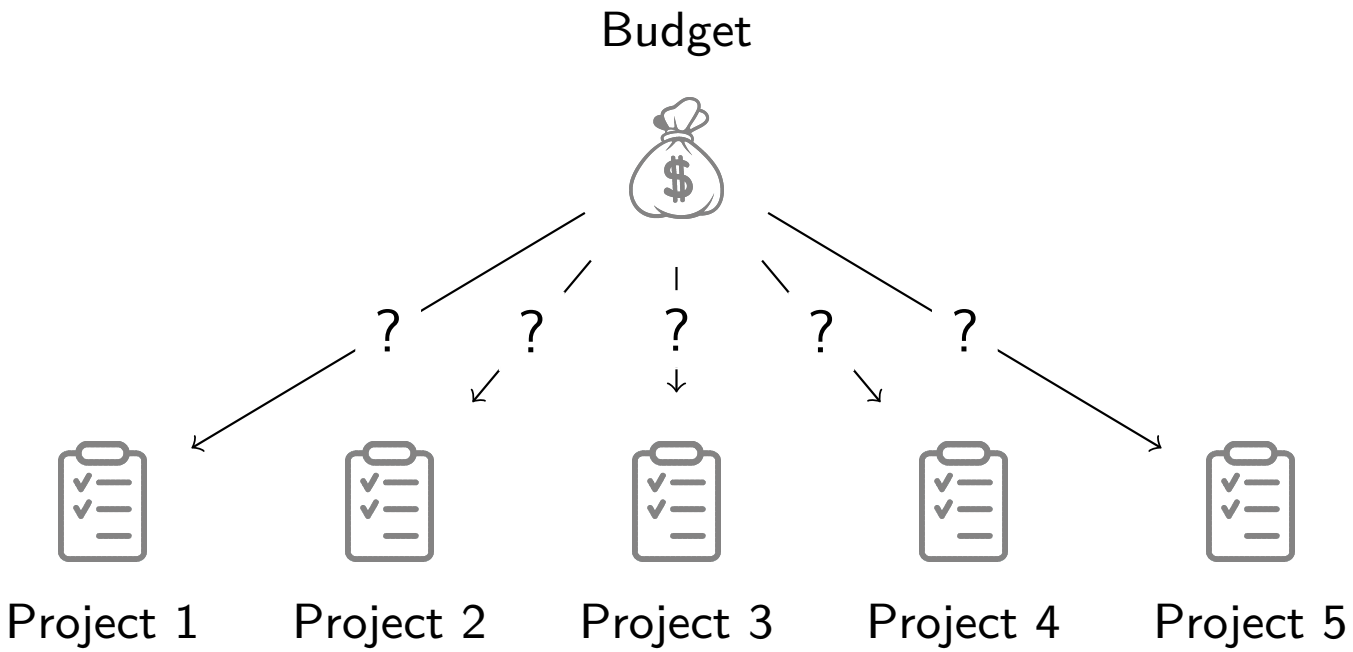
KR 2020

# Participatory Budgeting

Budget

[1] Cabannes "Participatory budgeting: A significant contribution to participatory democracy" (2004)
[2] Dias, Enriquez, and Julio *The Participatory Budgeting World Atlas* (2019)

# Participatory Budgeting

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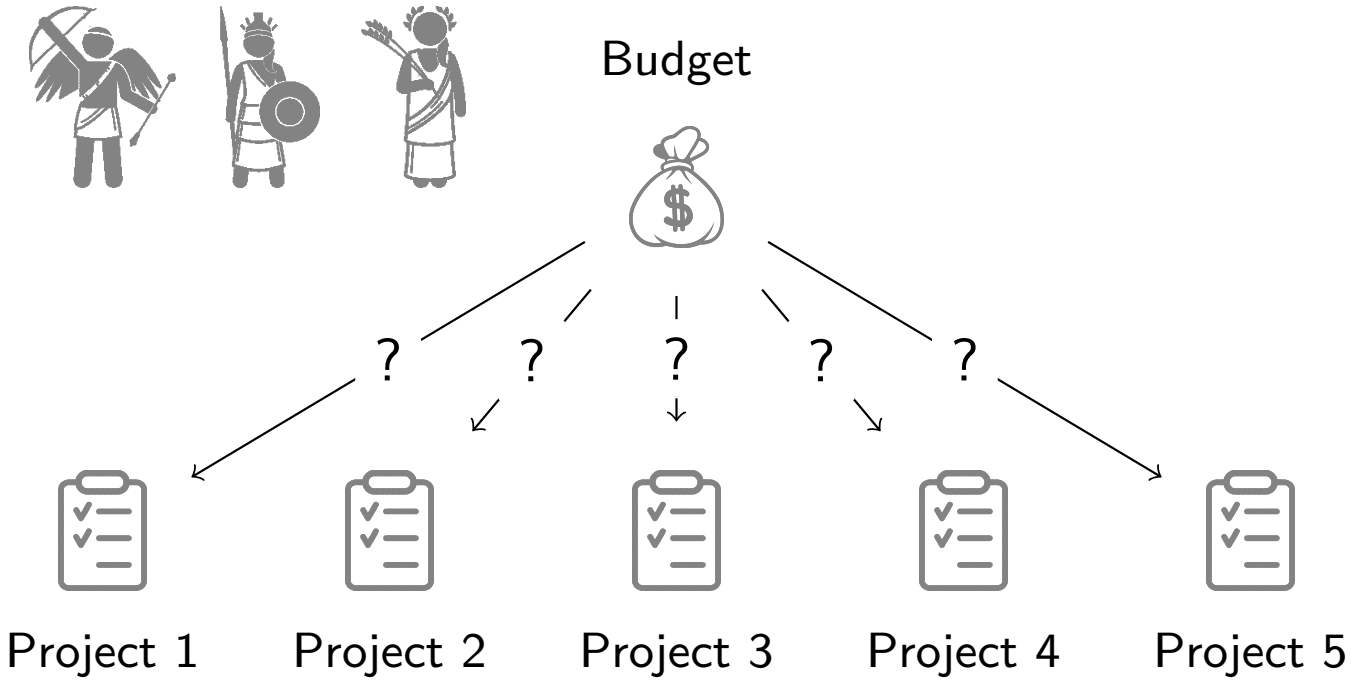


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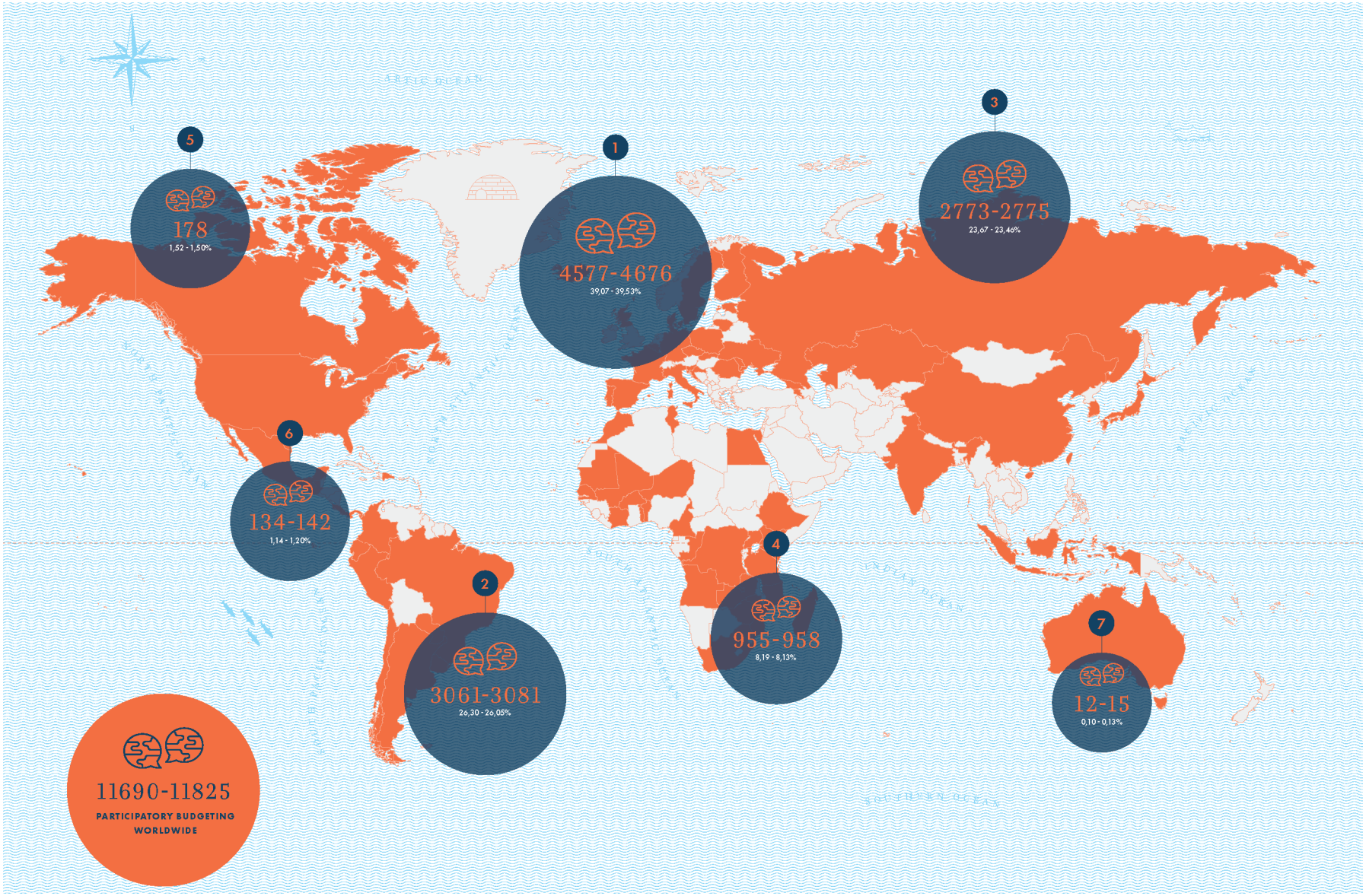
# PB around the world



# The problem

| Project 1 | Project 2 | Project 3 | Project 4 | Project 5 |
|---|---|---|---|---|
| $c(p_1) = 3$ | $c(p_2) = 4$ | $c(p_3) = 2$ | $c(p_4) = 7$ | $c(p_5) = 1$ |

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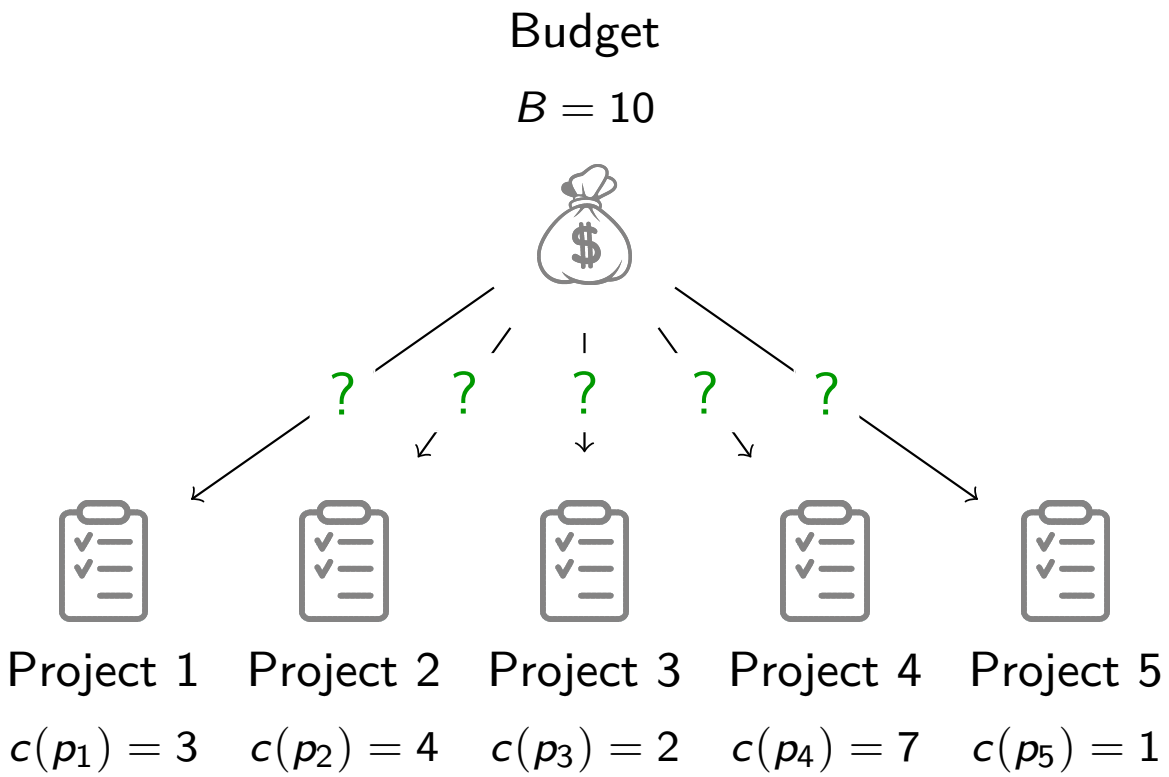
Budget
$B = 10$
?
?
?
?
?
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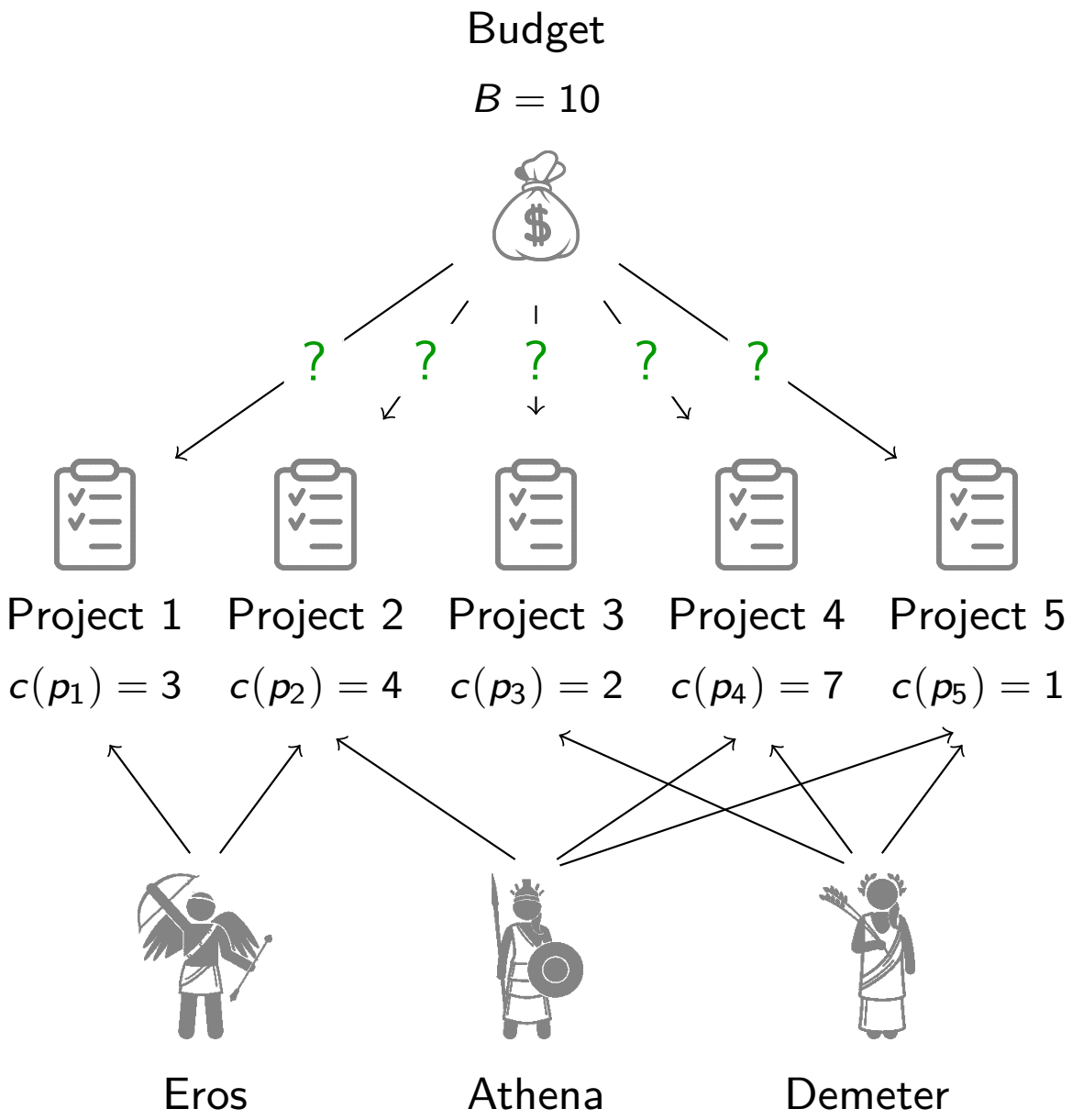
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Eros
Athena
Demeter

# Current approach in ComSoC

Most of the works in the Computation Social Choice literature consider *Participatory Budgeting* as a generalization of *Multiwinner voting*:

- They both consider approval votes;
- When all projects are of cost 1, the two frameworks are indeed equivalent;
- PB would then be a multiwinner voting setting with costs on the alternatives.

 Each time a new feature is to be added, one needs to redefine *everything* to account for the new setting.

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[3] Aziz and Shah "Participatory Budgeting: Models and Approaches" (2020)

# Our approach

Instead of generalizing already existing frameworks, can we use *highly expressive* ones while *keeping nice properties*?

# Judgment Aggregation

We will try to solve PB problems with the help of *Judgment Aggregation* (JA):

- Agents submit *approval ballots* over a set of issues;
- Using a *JA rule*, an aggregation of ballots is determined;
- The outcome must satisfy a *propositional formula* over the issues.

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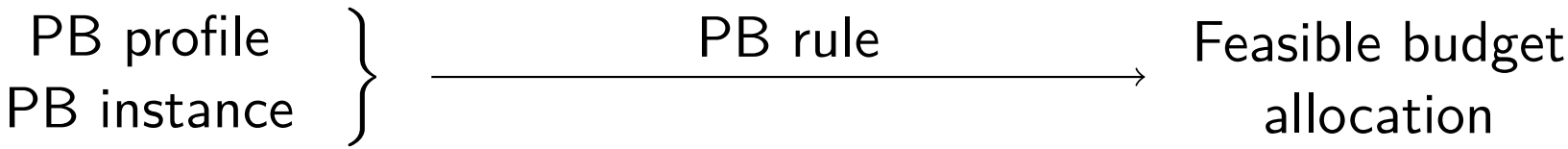
[4] Endriss "Judgment Aggregation" (2016)

# The Reduction

PB profile
PB instance

# The Reduction



# The Reduction

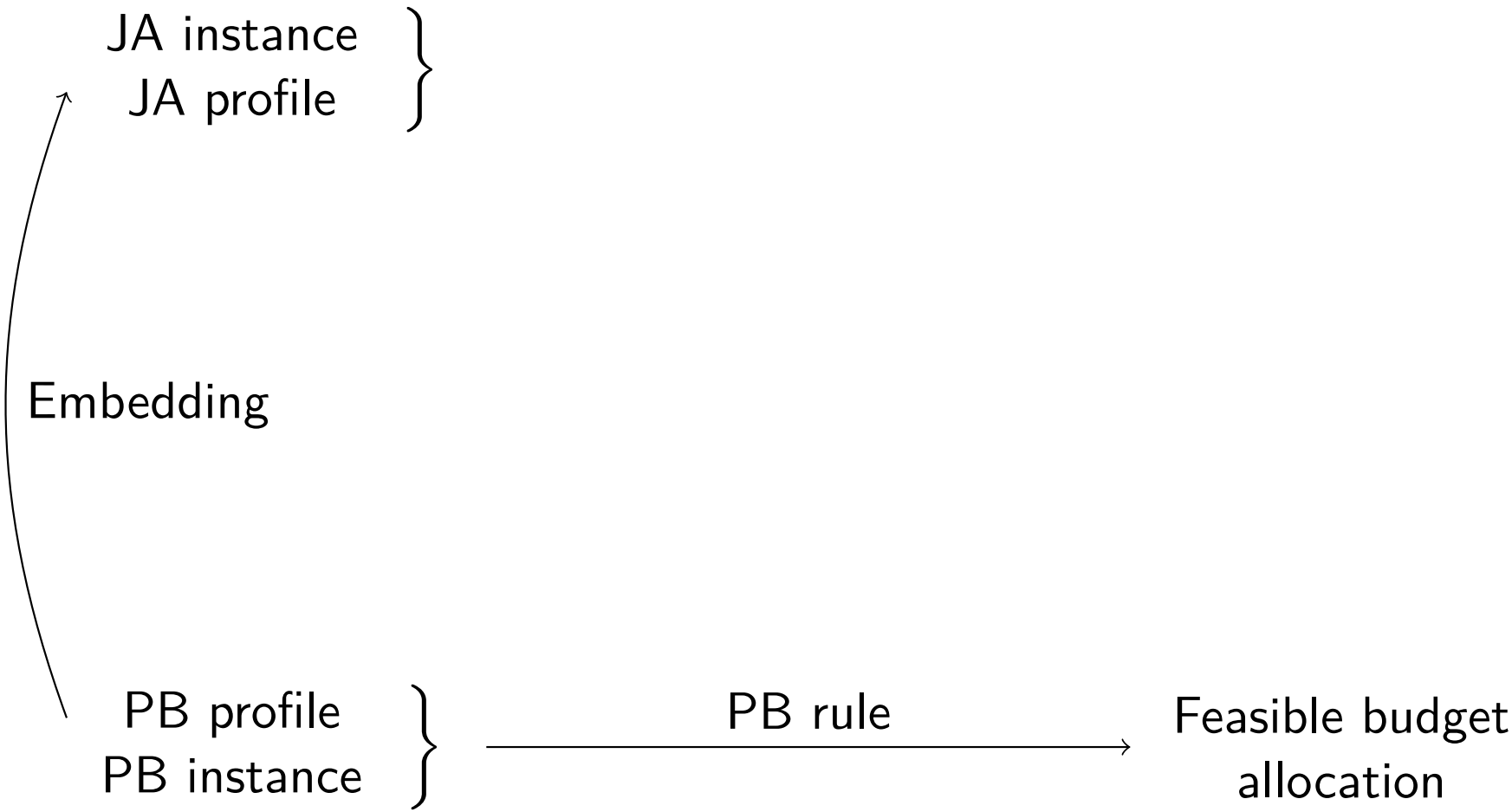
JA instance
JA profile

PB profile
PB instance

PB rule

Feasible budget allocation

# The Reduction



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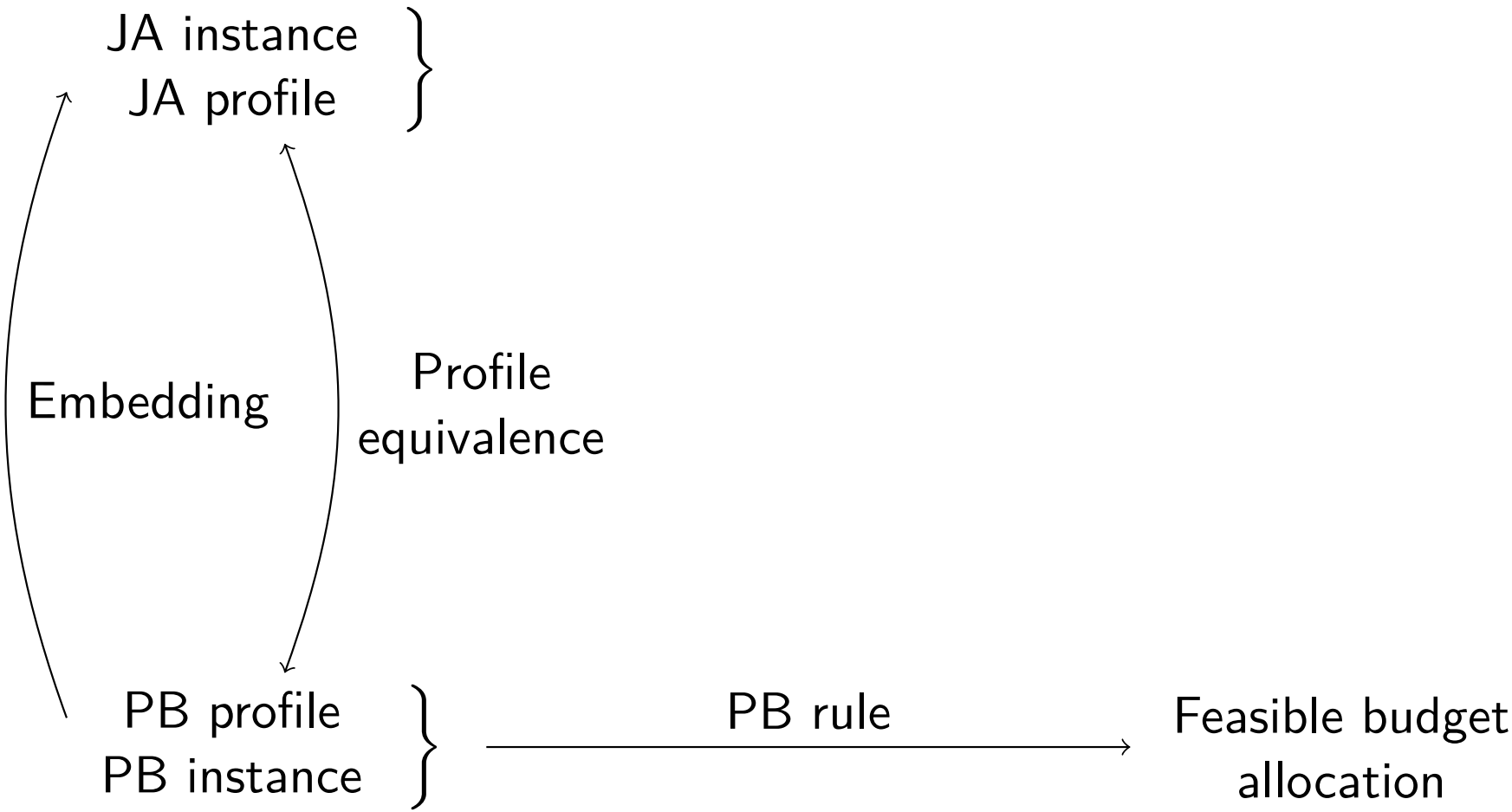

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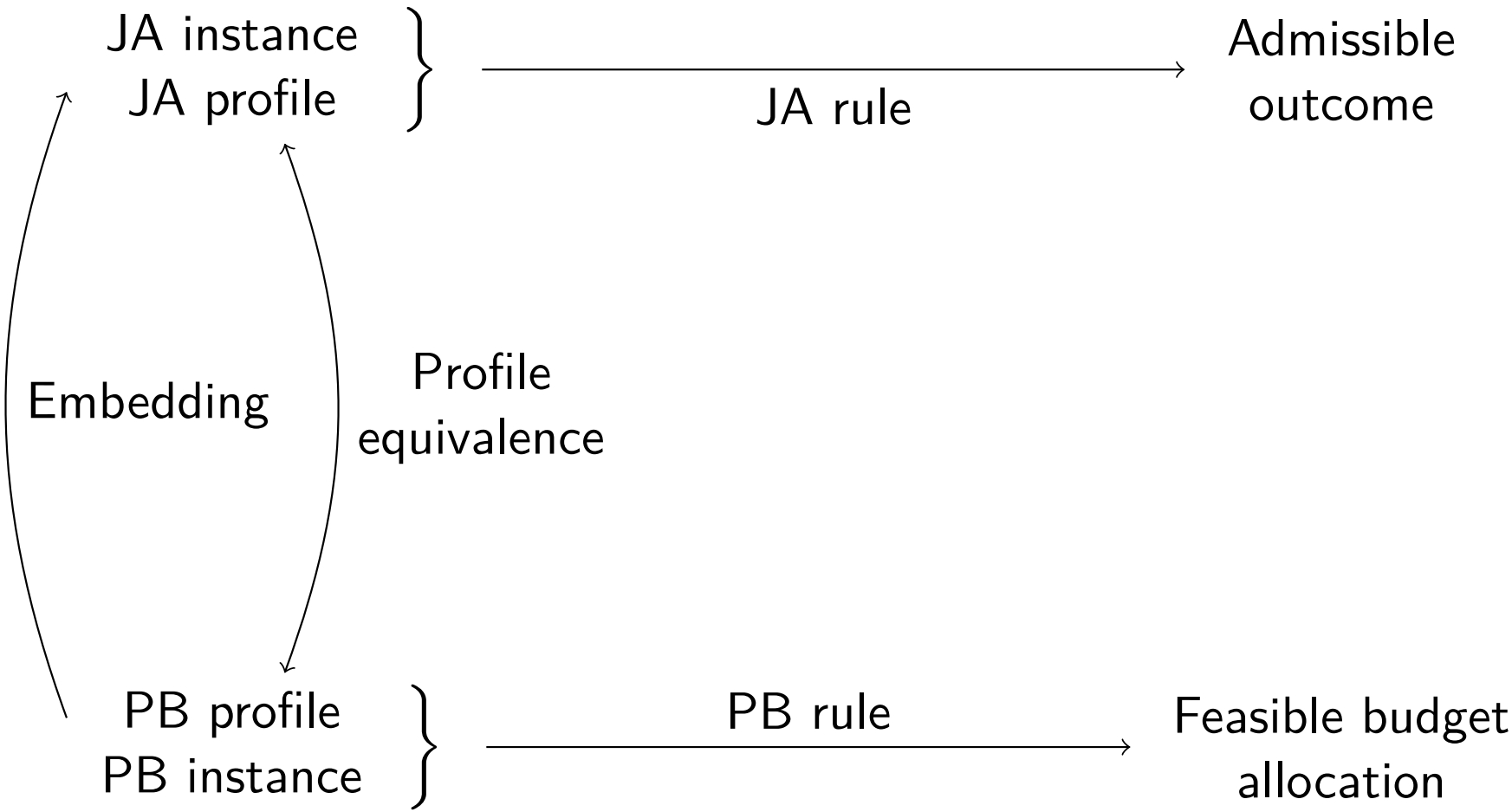

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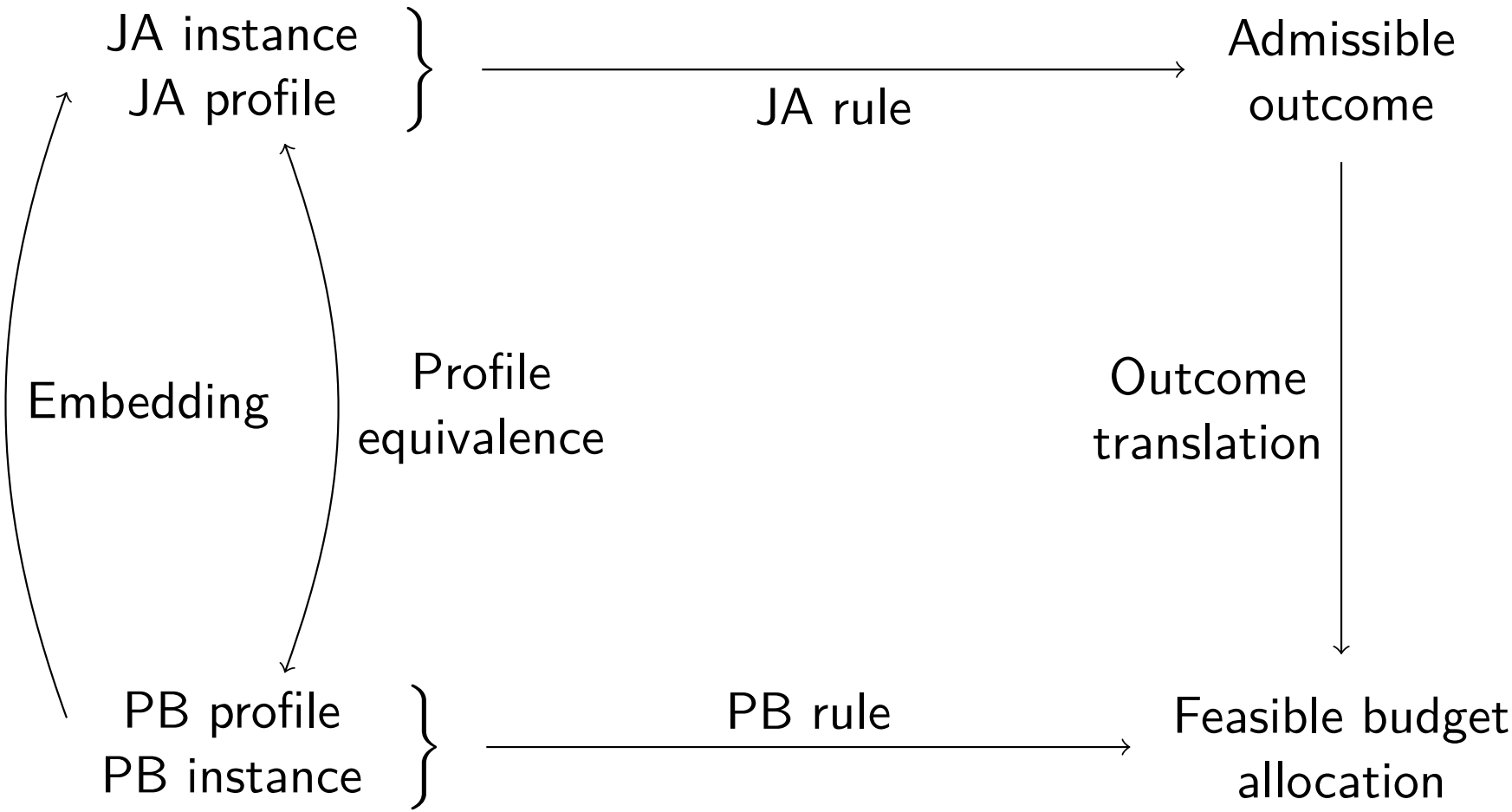

# DNNF circuits

*Problem*: computing the outcome of JA rules usually is $\Theta_2^P$-complete.

↪ But not always, e.g. not if the input is represented as a *DNNF circuit*.

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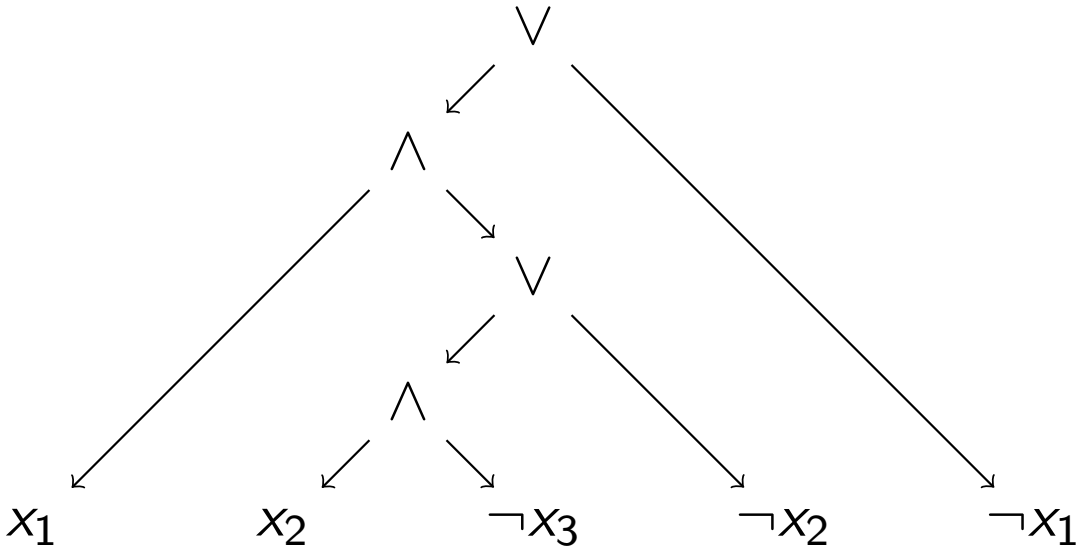


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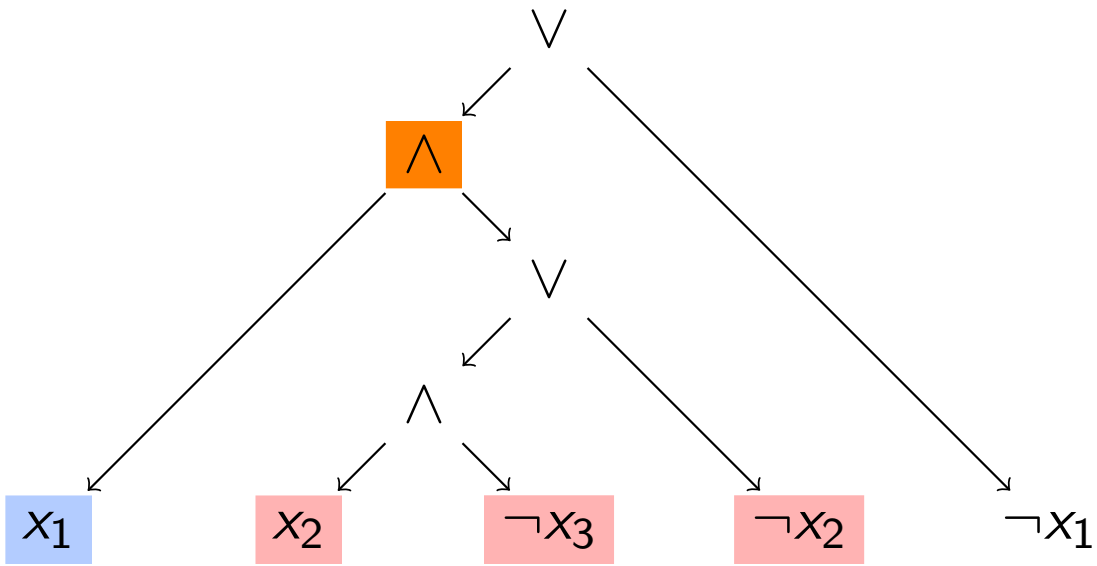


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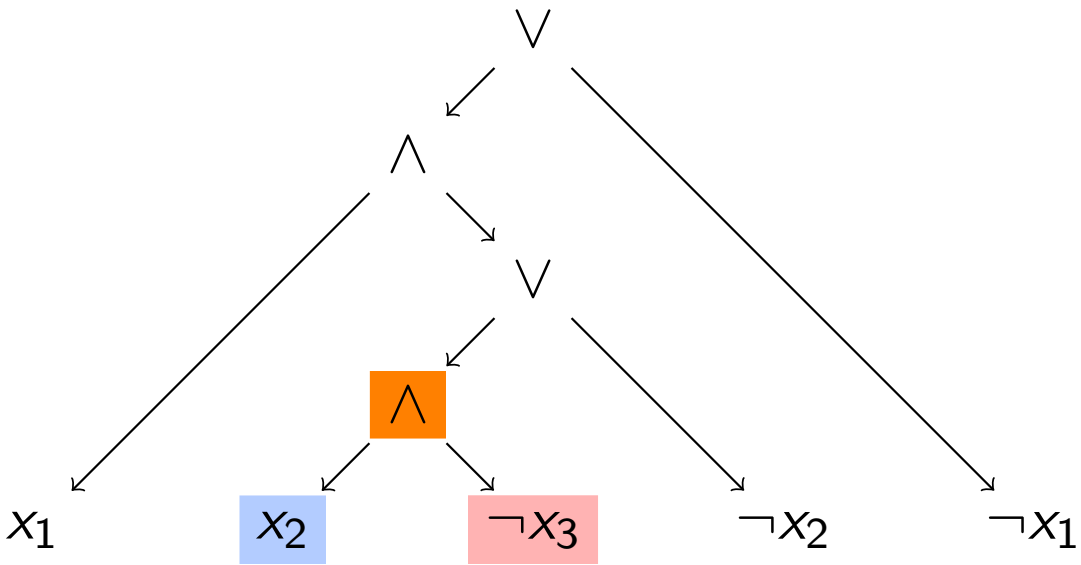


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# Encoding Budgeting Problems in DNNF

$B = 2$

$c(p_1) = 1$

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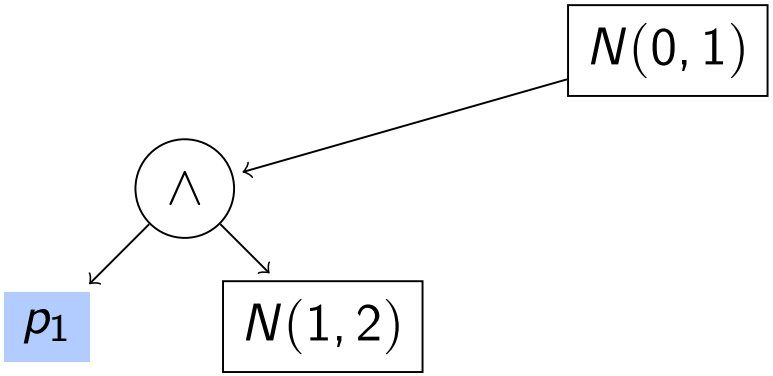

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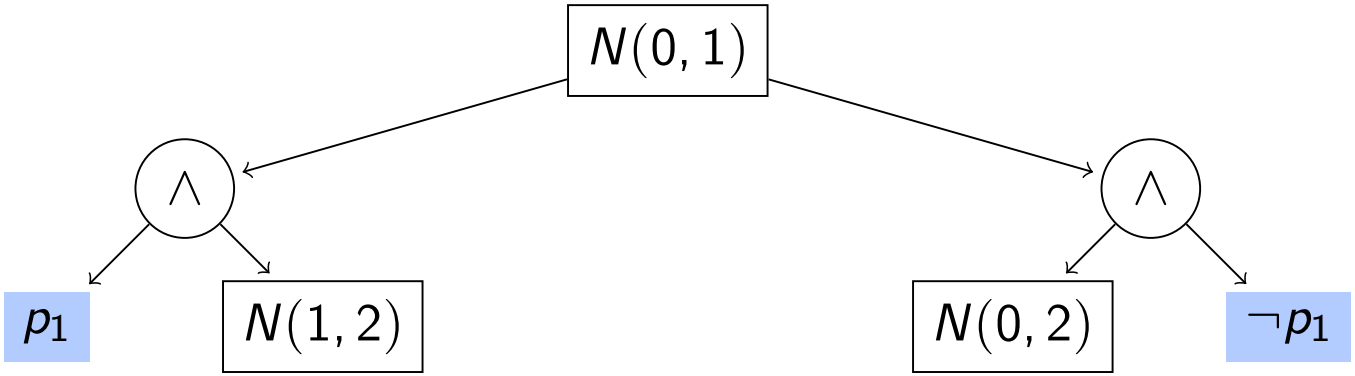

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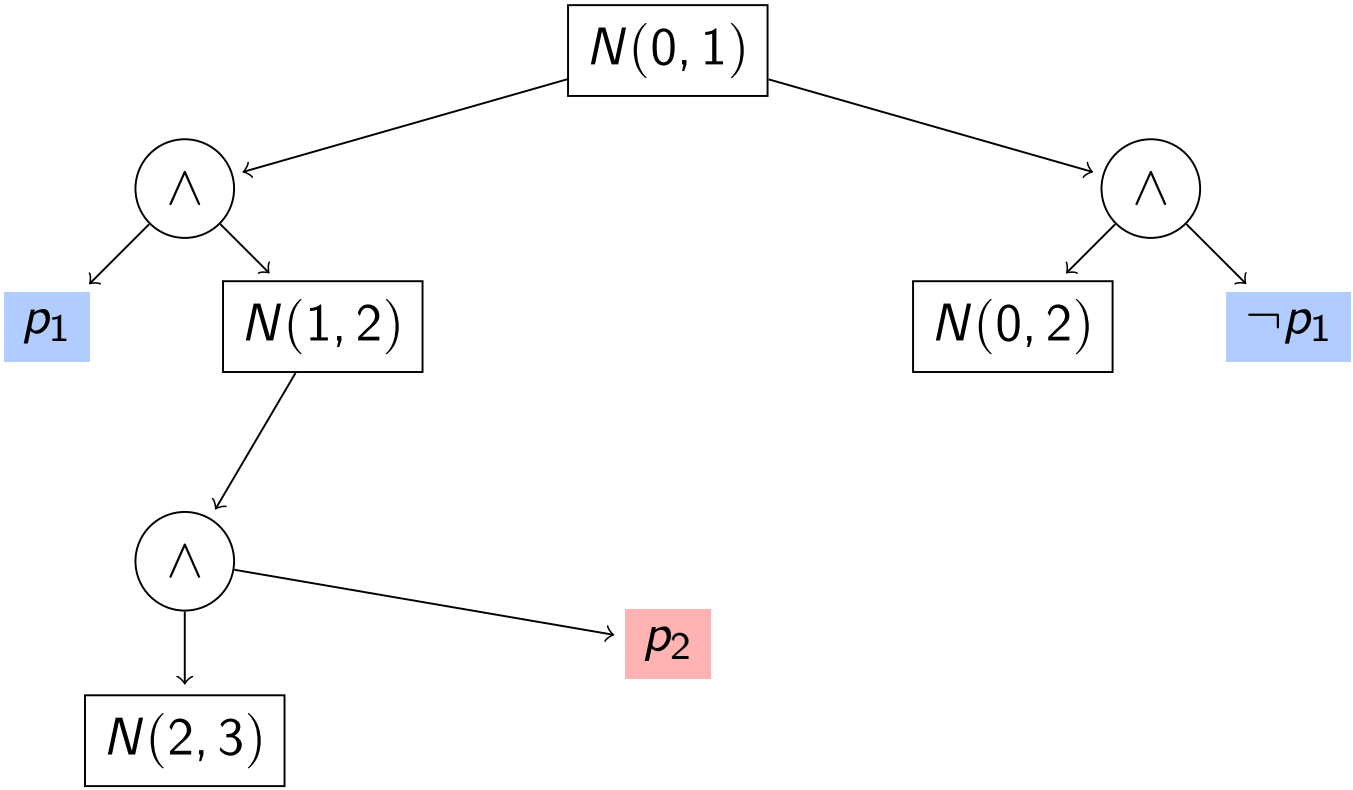

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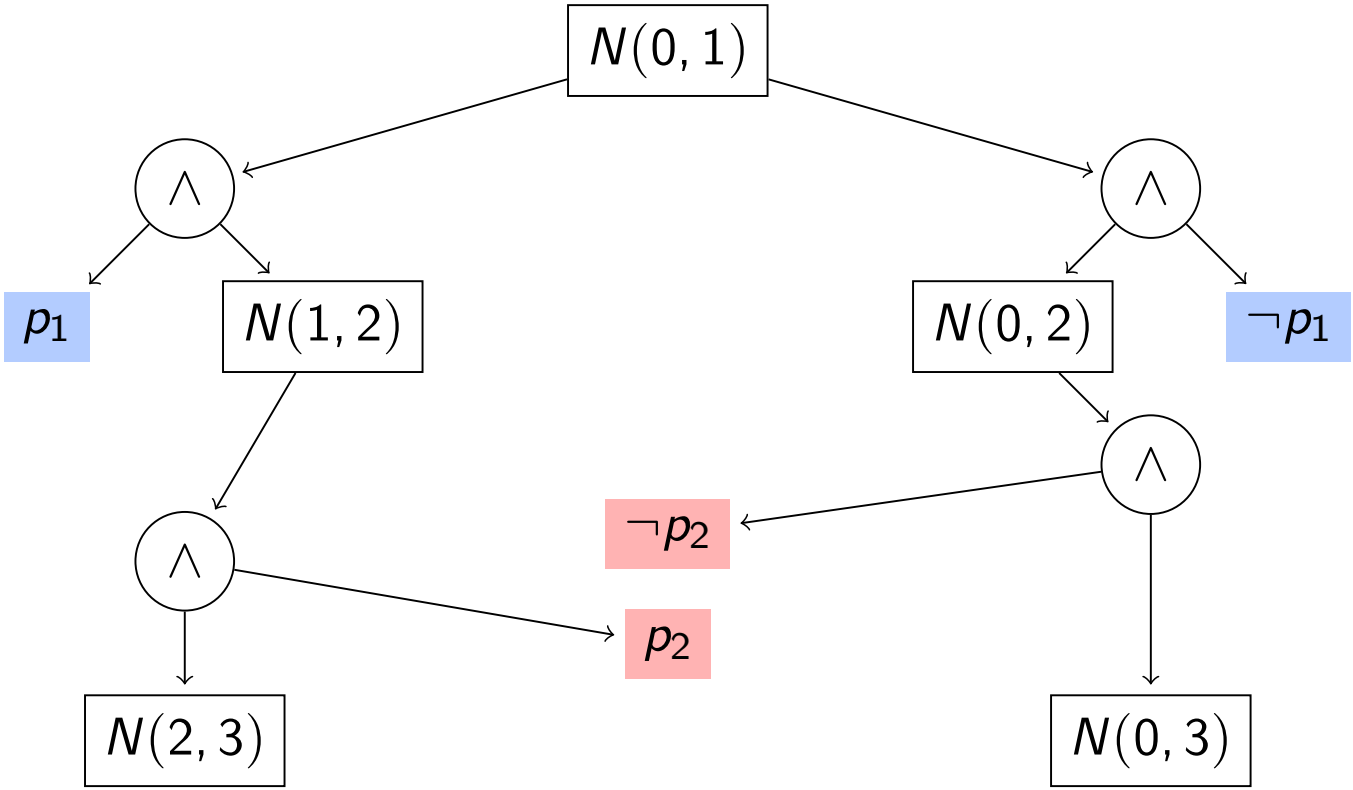

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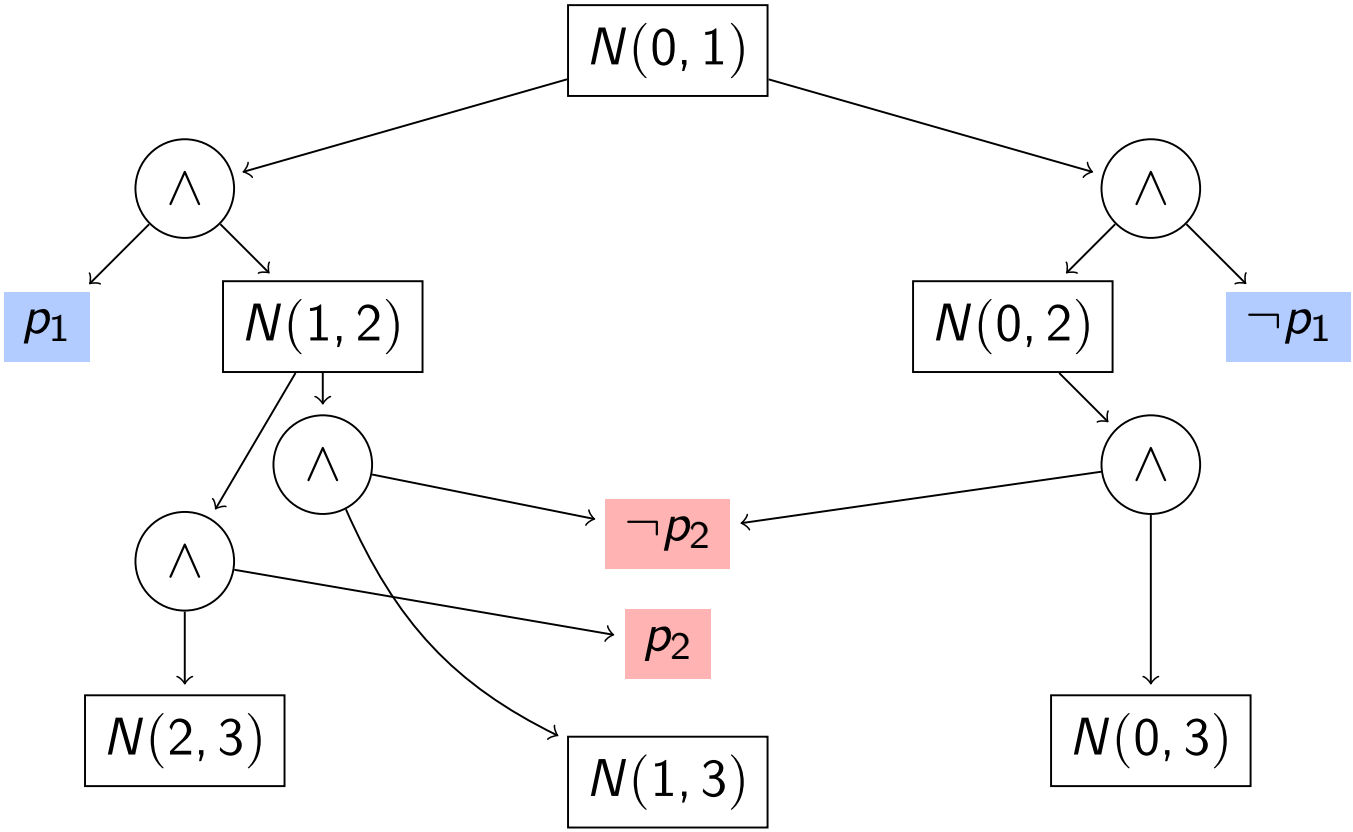

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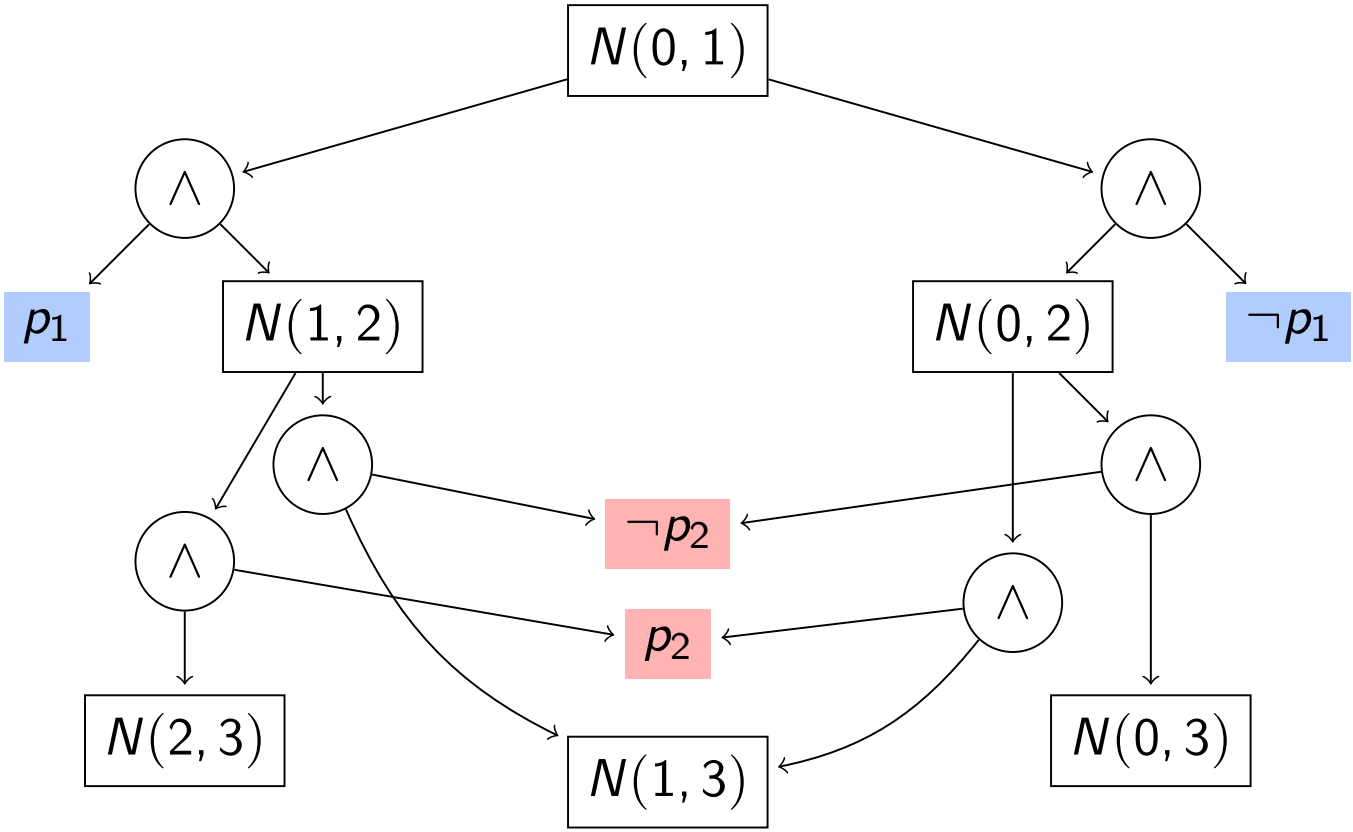

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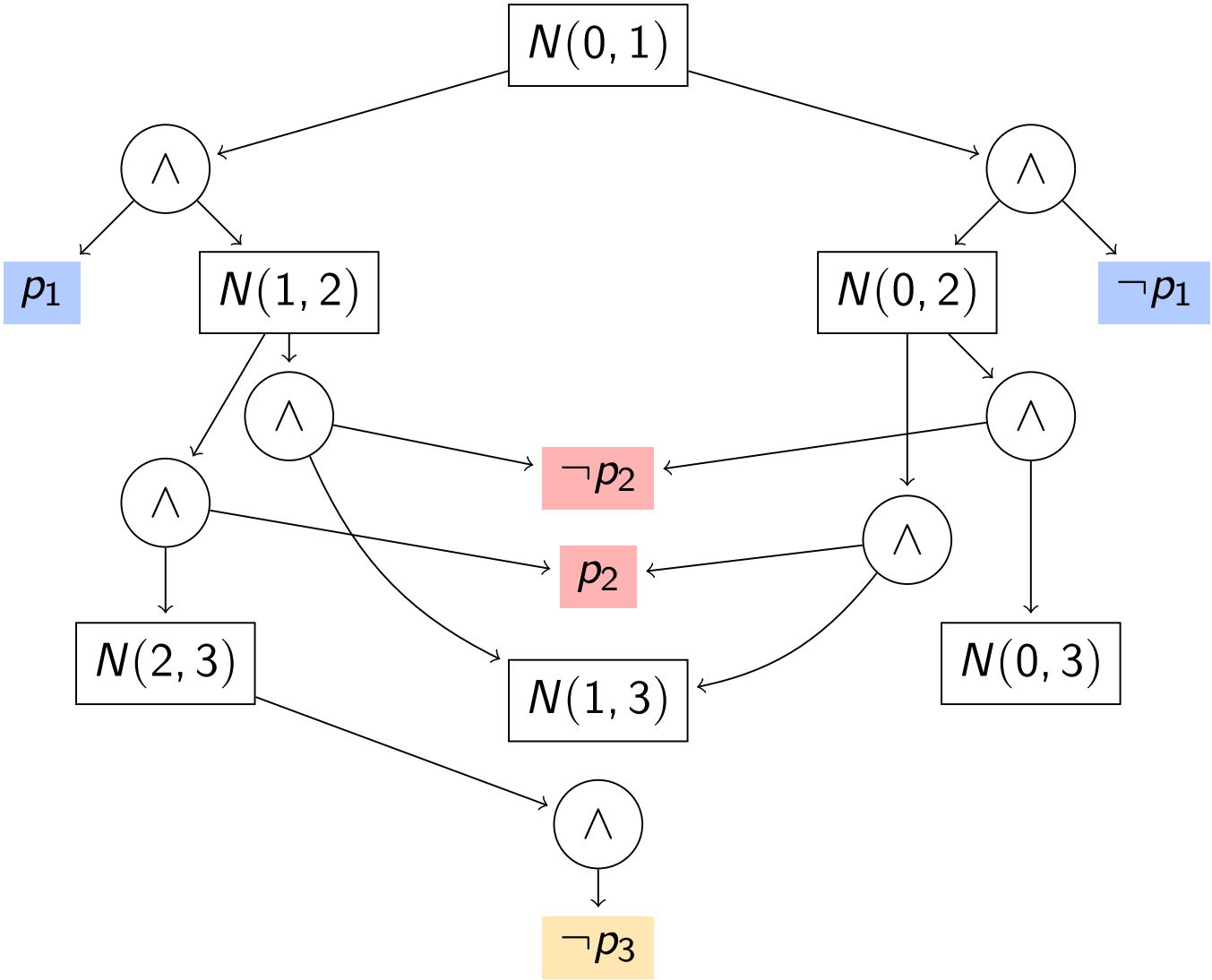

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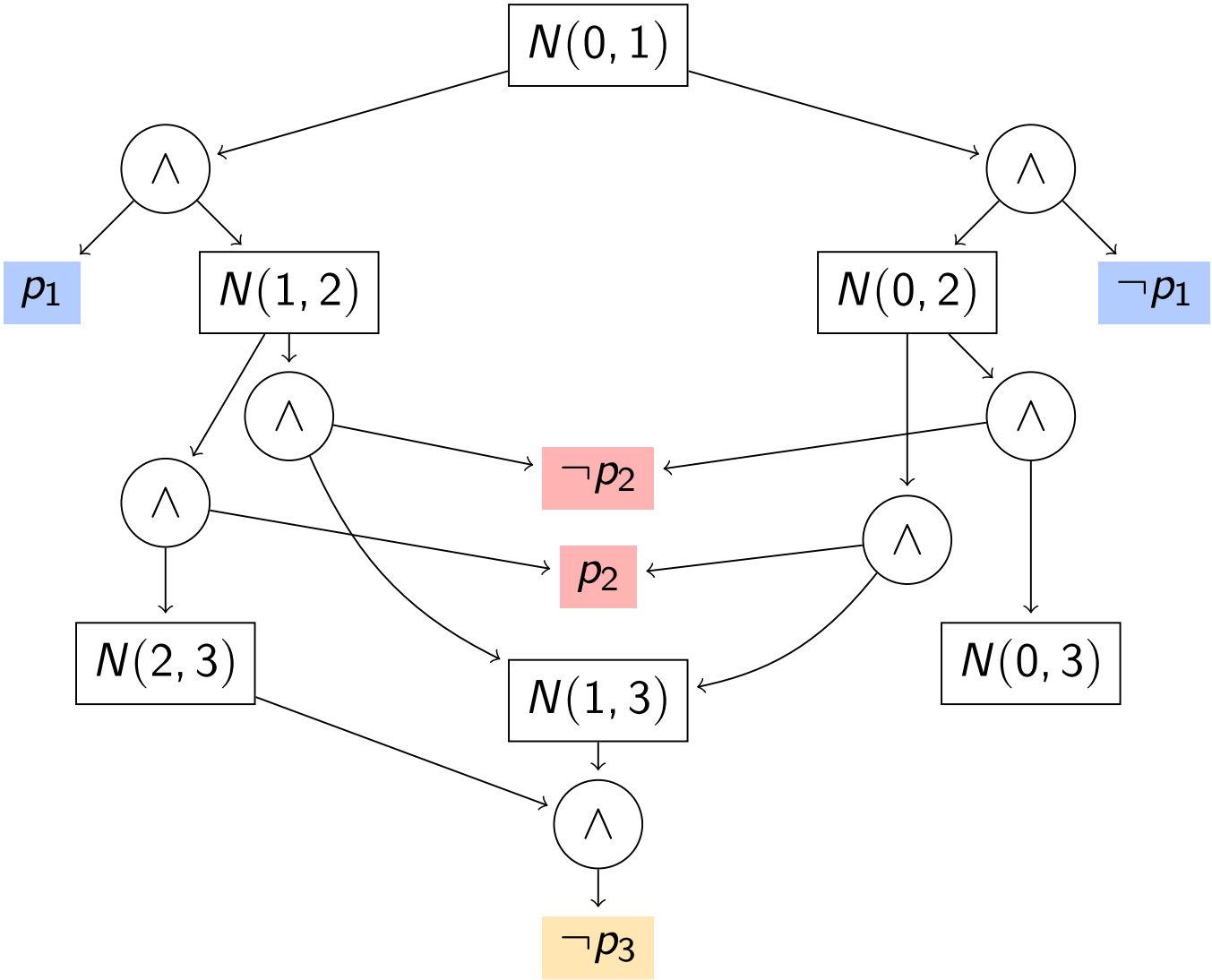

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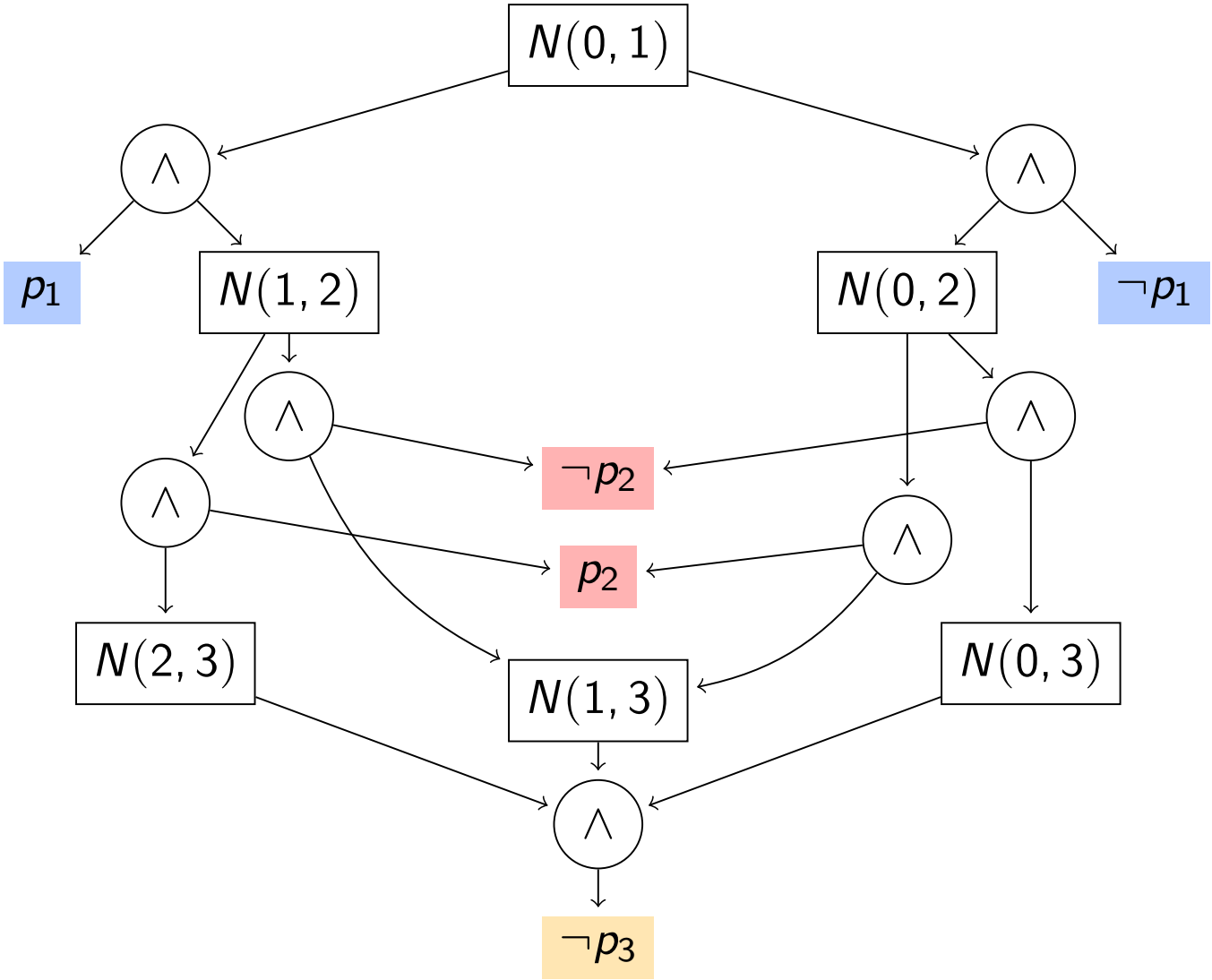

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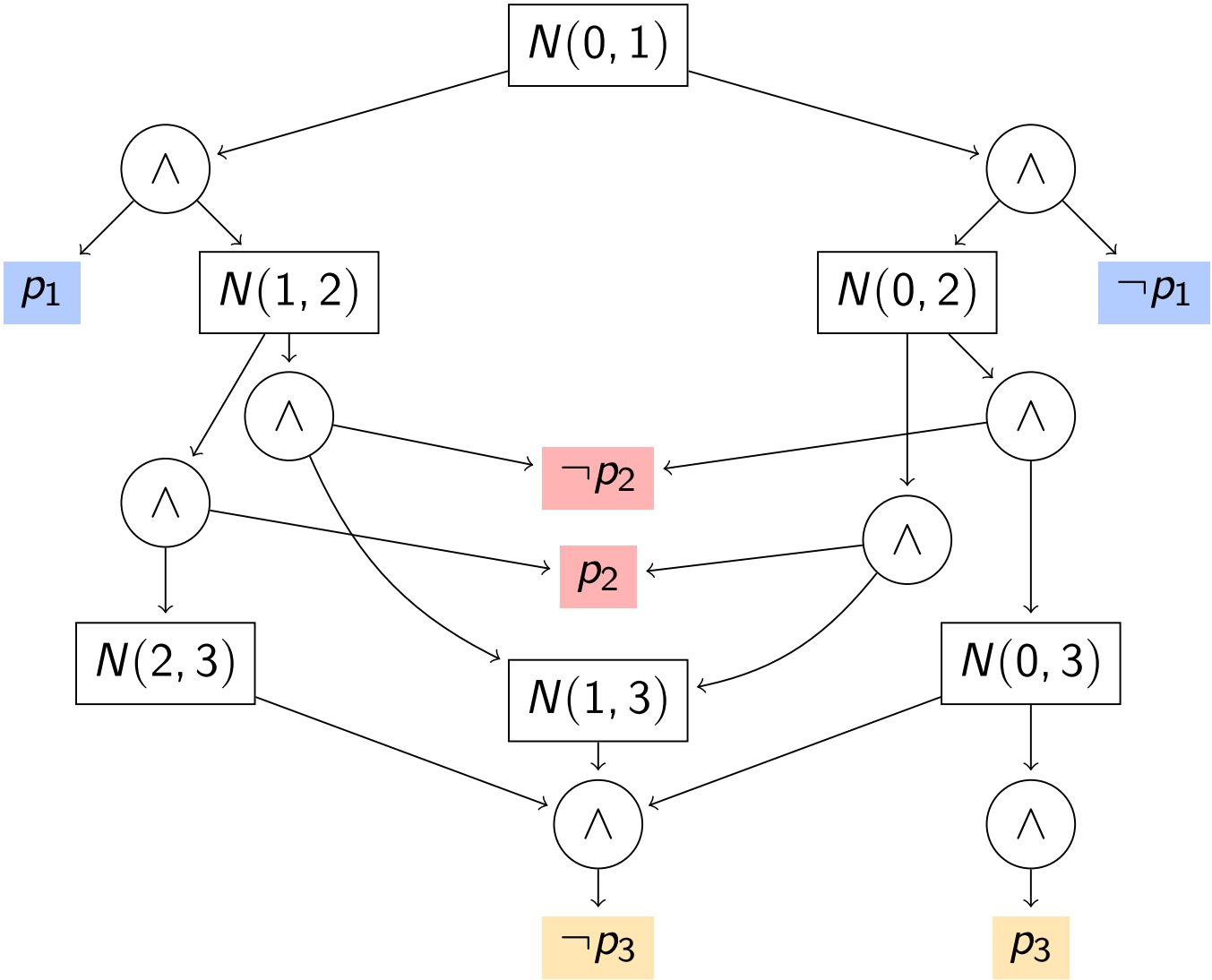

# Adding dependencies and/or quotas over the projects

THEOREM:

Computing a feasible budget allocation with dependencies and/or quotas is NP-complete.

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PB with dependencies and/or quotas can be embedded into JA via parametrized embeddings.

# Conclusion

We presented:

- *Embeddings* from PB to JA;
- That allowed for great *expressivity*;
- And analyzed actual *performance* of JA rules for PB.

 This work shows interesting interconnections between Social Choice and Knowledge Representation.

Any questions?

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