Stateful Partial-Order Reduction Methods for Concurrent Systems with Blocking Instructions

Sarah Larroze-Jardiné

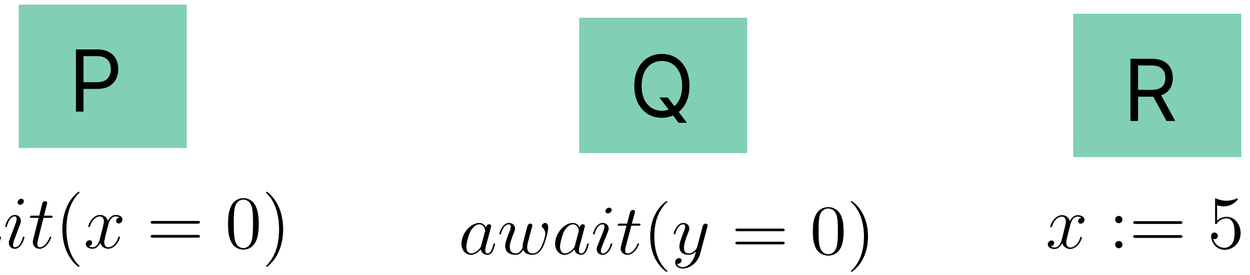
PhD Defense - December 16, 2025, Bordeaux, France

Supervised by Frédéric Herbreteau and Igor Walukiewicz

Verification

Concurrent Programs

shared int x, y = 0



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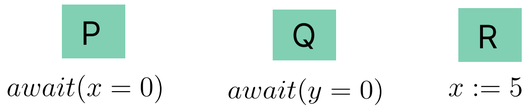

Reachability Problem

Is there a bad state reachable?

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shared int x, y = 0

P

$await(x = 0)$

Q

$await(y = 0)$

R

$x := 5$

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Model Checking

Given a concurrent program and a property to verify (here reachability), decide whether the property is satisfied or not

State-space exploration

Program

shared int x, y = 0

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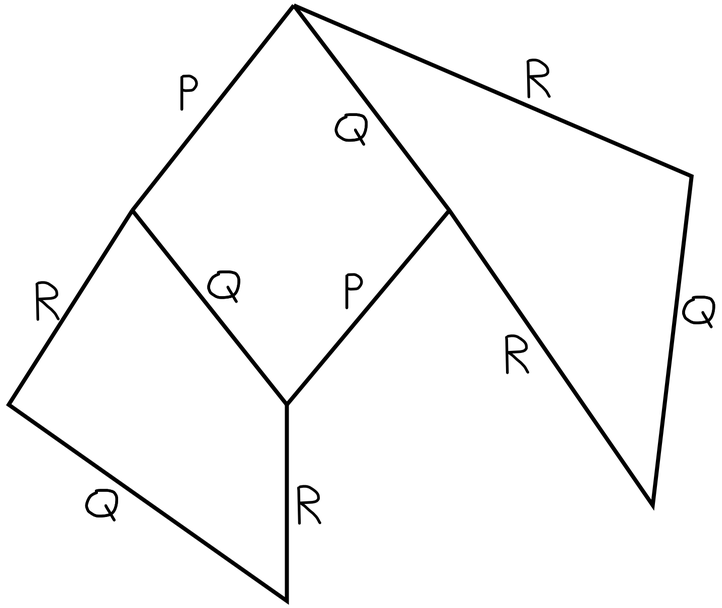
Execution of the program



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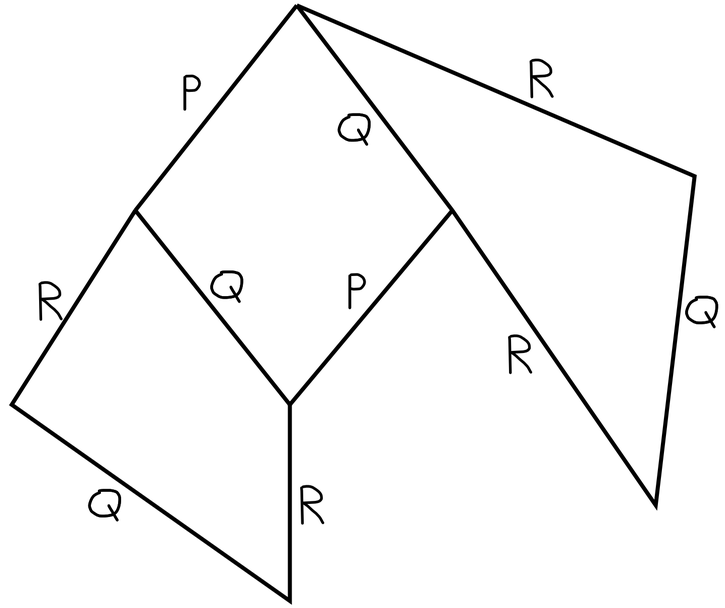

COMBINATORIAL EXPLOSION!

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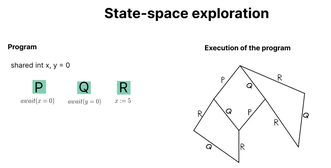

COMBINATORIAL EXPLOSION!

Mazurkiewicz’s trace equivalence

independency, equivalence, explore at least one run per equivalence class

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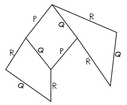

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Partial-order reduction

produces a reduced state space that is sound and complete, literature, notion of optimality

Stateless

Stateless = we only enumerate traces
define optimality for stateless

Partial-order reduction

produces a reduced state space that is sound and complete, literature, notion of optimality

Stateful

Stateful = we store the states
define optimality for stateful

Excellent POR algorithm

Here state what an excellent POR algorithm is

theorem concur25 there is no excellent POR algorithm

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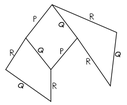

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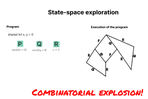

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Contributions of this thesis

- client/server systems as a unified framework
- POR graph with covering, i.e. all ingredients of our algorithms
- lexicographic stateful por
- por with race reversals
- Implementation and experiments

Client/server systems

show an example and give the intuition that a client represents a shared ressource

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POR graphs with covering

Source sets

notion of first
exploration with source sets sound and complete

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Sleep sets

Introduce sleep sets
Pb of sleep blocked execution

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Node subsumption

example with node duplication
give intuition why it is a simulation relation

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Races

POR with race reversals

Explore not below

POR with race reversals

Races

Explore not below

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POR with race reversals

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Not below vs above

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Conclusion and future work

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