fUML Activity Diagrams with RAG-controlled rewriting

A *RACR*[1] solution of *The TTC 2015 Model Execution Case*

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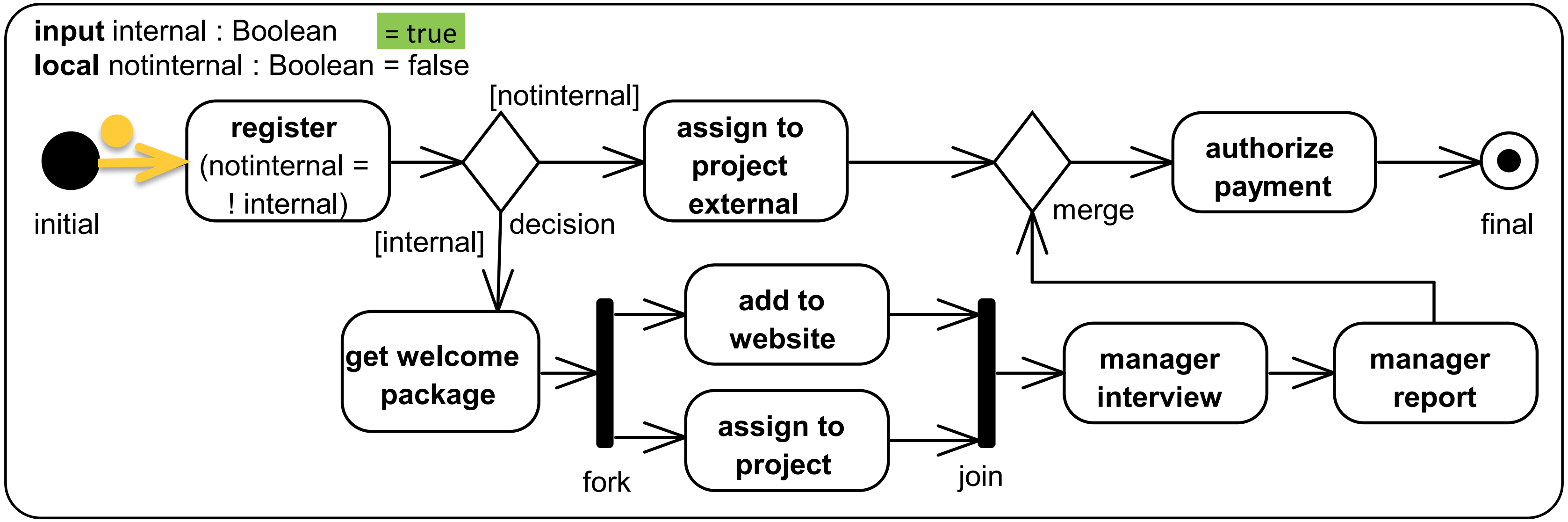
[1] https://github.com/christoff-buerger/racr

TTC 2015 background

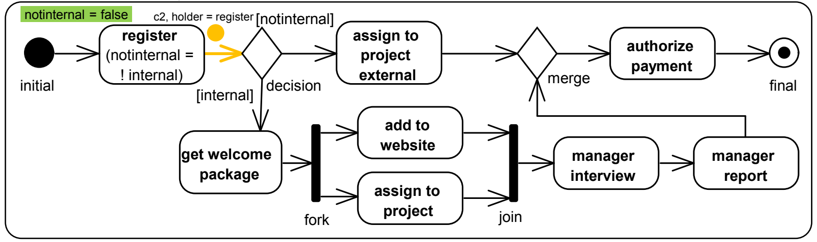
8^{th} Transformation Tool Contest

Task: execution of *fUML Activity Diagrams.*

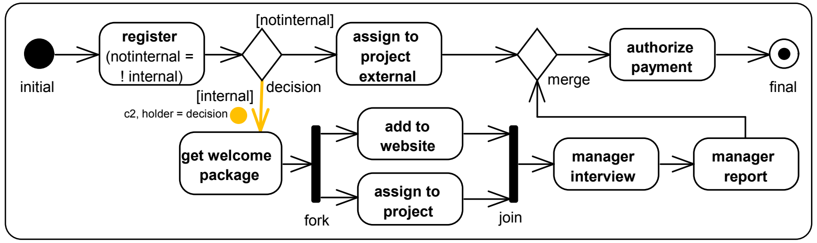


8th Transformation Tool Contest

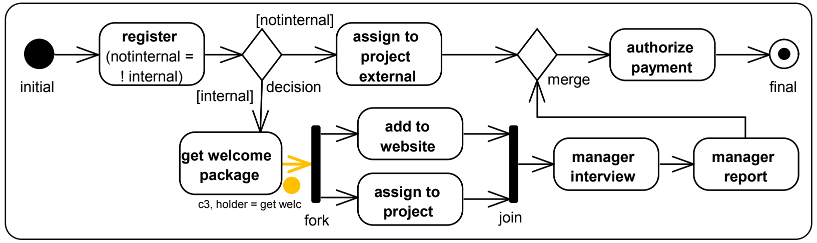
2. The action *register* consumes the token *c1*, executes the defined expression leading to an update of the variable *non-internal*, creates the control token *c2*, and offers it to the decision node *decision*.



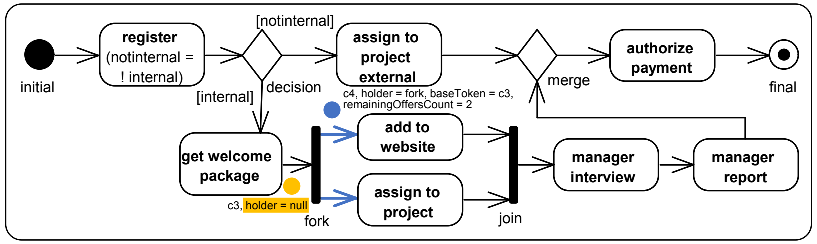
3. The decision node *decision* offers the control token *c2* to the opaque action *get welcome package*, because the variable *internal* defined as guard condition has the current value *true*.



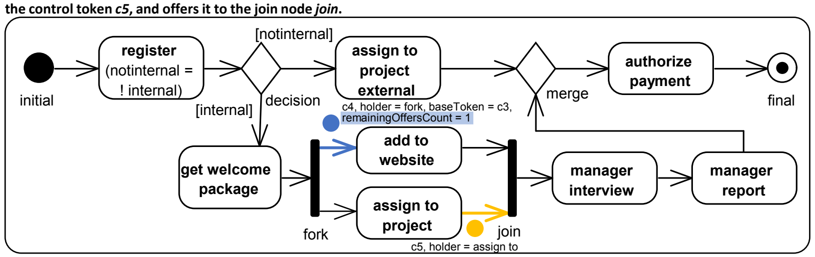
4. The action *get welcome package* consumes the control token *c2*, produces the control token *c3*, and offers it to the fork node.



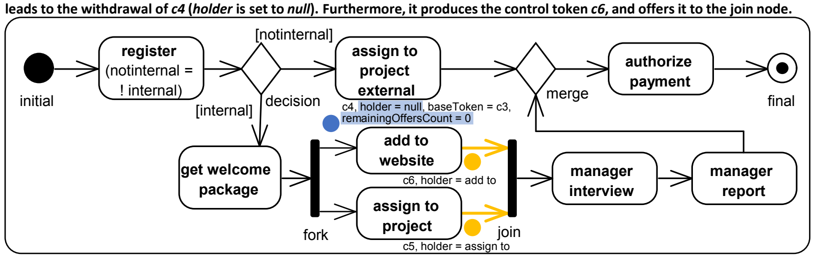
5. The fork node *fork* produces the forked token *c4* for the incoming control token *c3* (i.e., the forked token's base token). The remaining offers count is set to 2, because the fork node has two outgoing control flow edges. The forked token c4 is offered to the successor actions via two distinct offers.



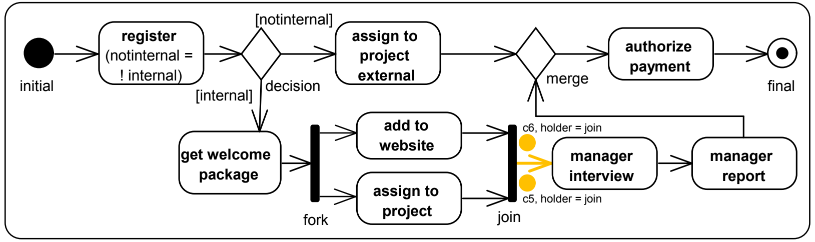
6. The action *assign to project* consumes its token offer for *c4* leading to an update of *c4*'s remaining offers count to 1, produces the control token *c5*, and offers it to the join node *join*.



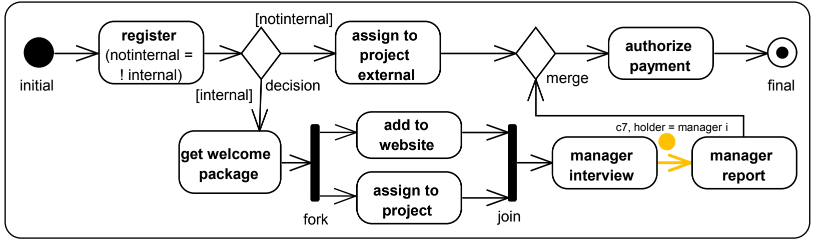
7. The action *add to website* consumes its token offer for *c4* leading to an update of *c4*'s remaining offers count to 0, which in turn leads to the withdrawal of *c4* (*holder* is set to *null*). Furthermore, it produces the control token *c6*, and offers it to the join node.



8. The join node *join* offers the incoming tokens c6 and c7 via one offer to the action *manager interview*.



9. The action *manager interview* consumes the control tokens *c5 and c6*, produces the control token *c7*, and offers it to the action *manager report.*



RACR solution background

General solution idea

Interpreter consisting of two parts …

- *Activity Diagram* → Petri net compiler (analyses)
- Petri net interpreter (state transformations)

… implemented using RAG-controlled rewriting.

RAG-controlled rewriting

- RAG-controlled rewriting = RAGs + graph rewriting
  - reference attribute grammar for declarative analyses
    - reference attributes induce semantic overlay graph on top of abstract syntax tree (AST) >> extend AST to ASG
    - enables deduction *and* analyses of graph structure

    >> deduced, memoized abstract syntax graph (ASG)
  - graph rewriting for ASG transformations
    - left hand: ASG pattern (ASTs connected via reference attributes)
    - right hand: manipulations on matched, underlying AST

    >> ASG changes with AST (updated by RAG)
  - seamless combination:
    - use of analyses to deduce rewrites
    - rewrites automatically update analyses

    mutual control

    >> incremental

RACR

- reference implementation of RAG-controlled rewriting in *Scheme*
- *R6RS* library; API for:
  - ASG schema definition (AST schema + attribution)
  - ASG querying (AST + attributes)
  - rewriting (imperative/RAG-controlled/fixpoint; primitive/pattern-based; or combination of all)

https://github.com/christoff-buerger/racr

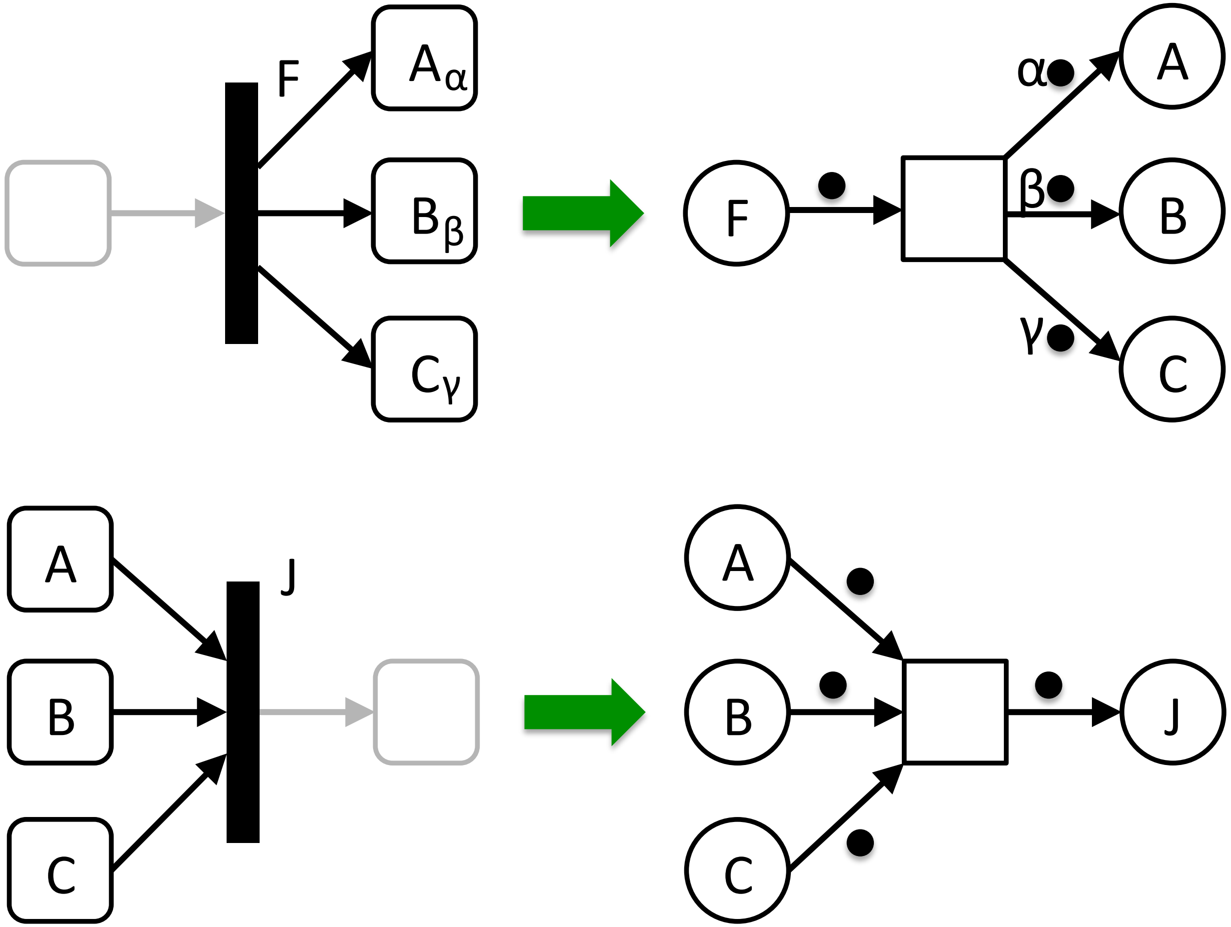
Solution

fUML Activity Diagram compiler

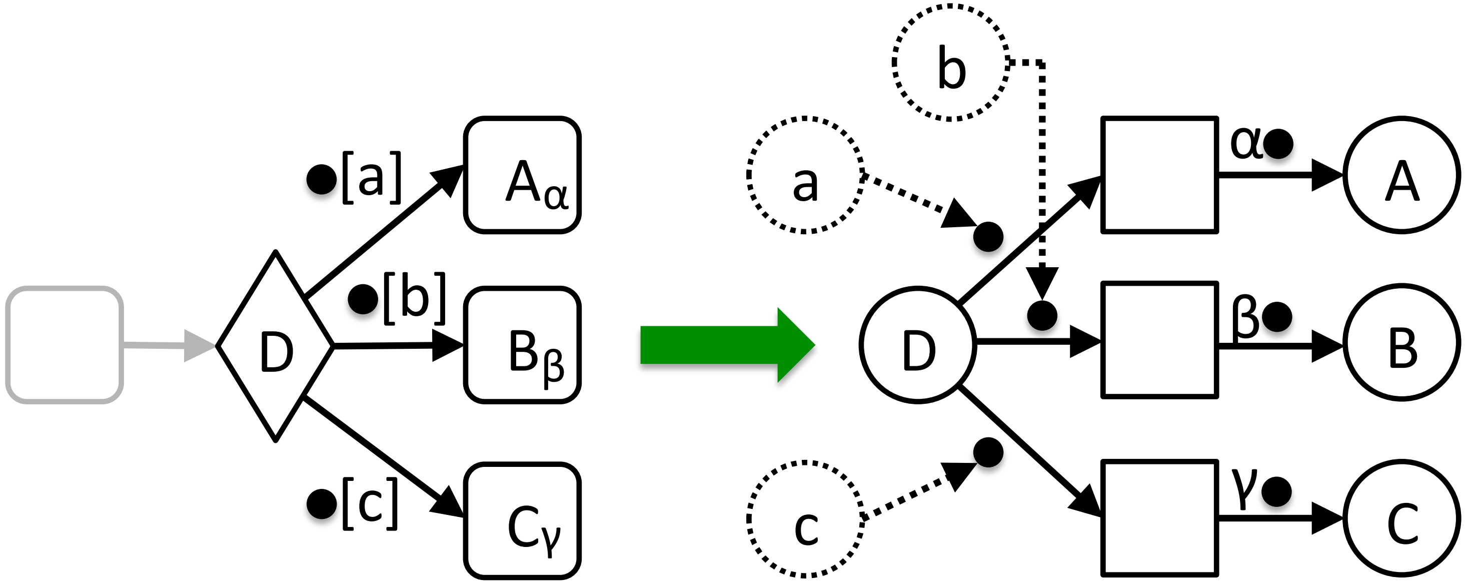
- attributes for:
  - name analysis (symbolic name resolution)
    - incoming & outgoing edges
    - variables

    } reference attributes
  - type analysis (expression types)
  - well-formedness analysis (only *TTC* solution that rejects malformed diagrams)
  - code generation (i.e., Petri net generation)

fUML Activity Diagram → Petri net

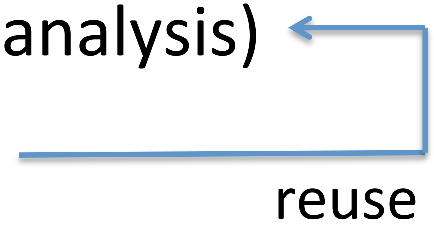


fUML Activity Diagram → Petri net



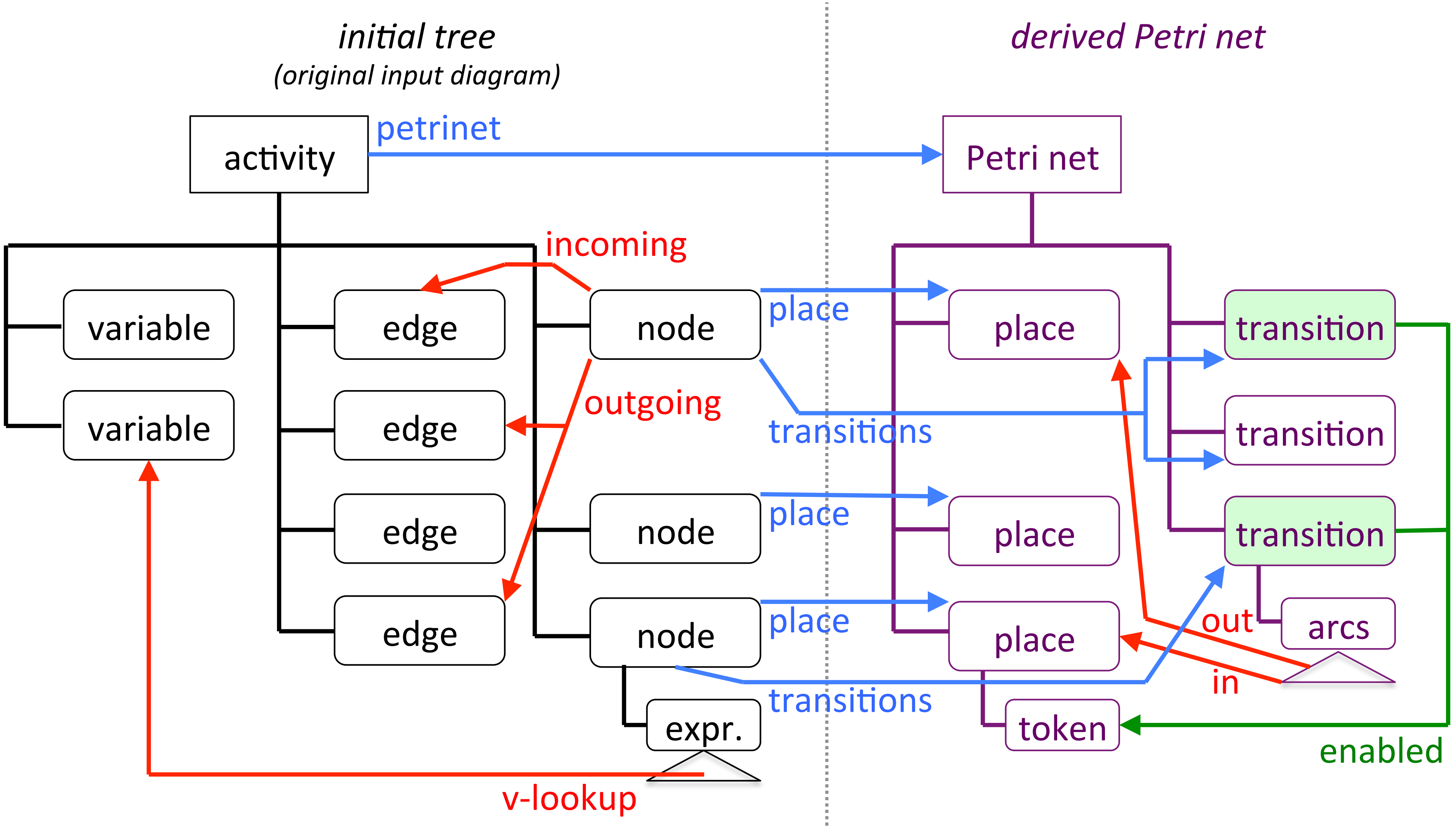
Petri net interpreter

- attributes for:
  - name analysis
  - well-formedness analysis
  - enabled analysis (kind of name analysis)
- rewrites for execution (firing)
  - delete consumed tokens
  - add produced tokens



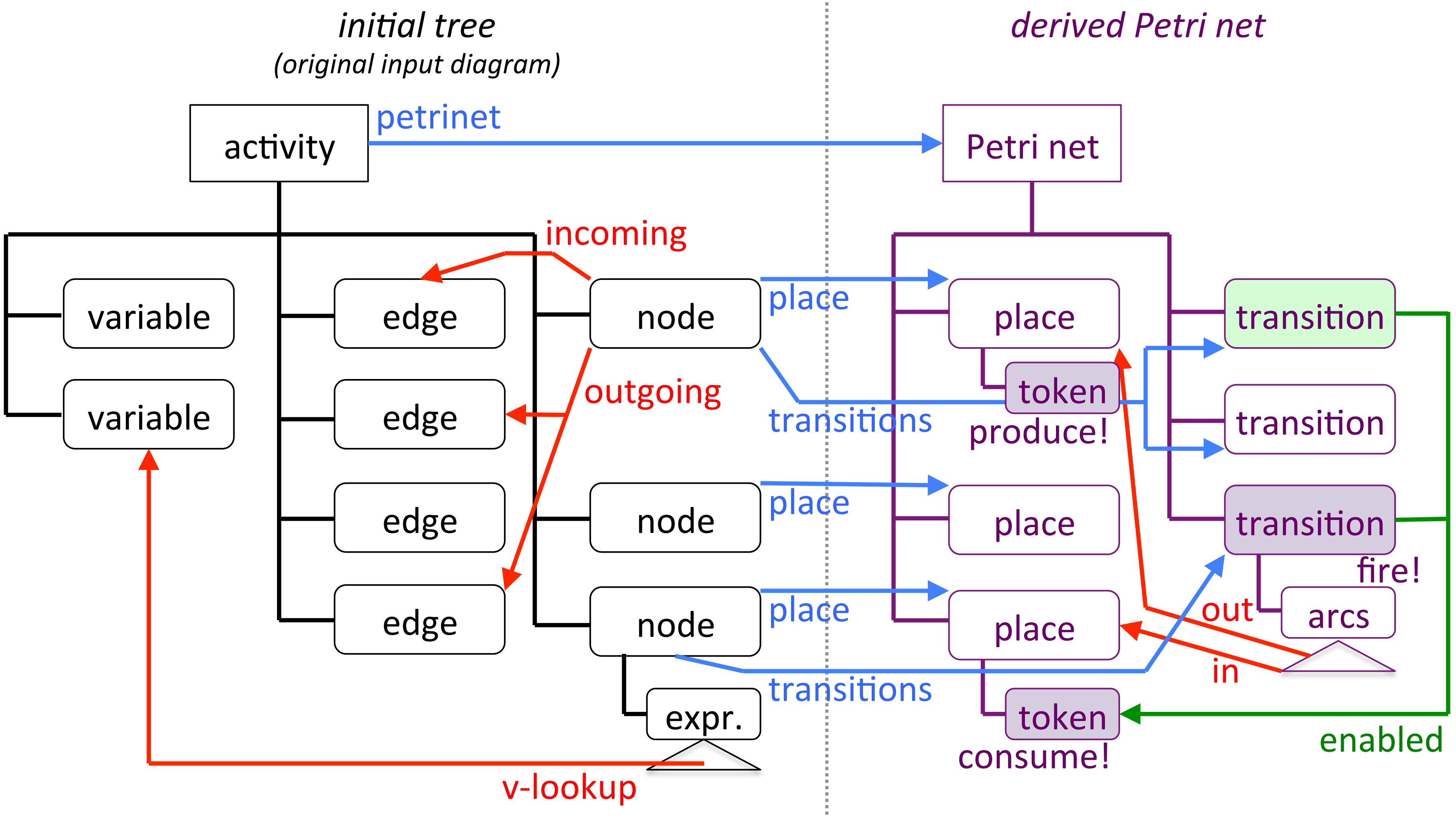
reuse

ASG



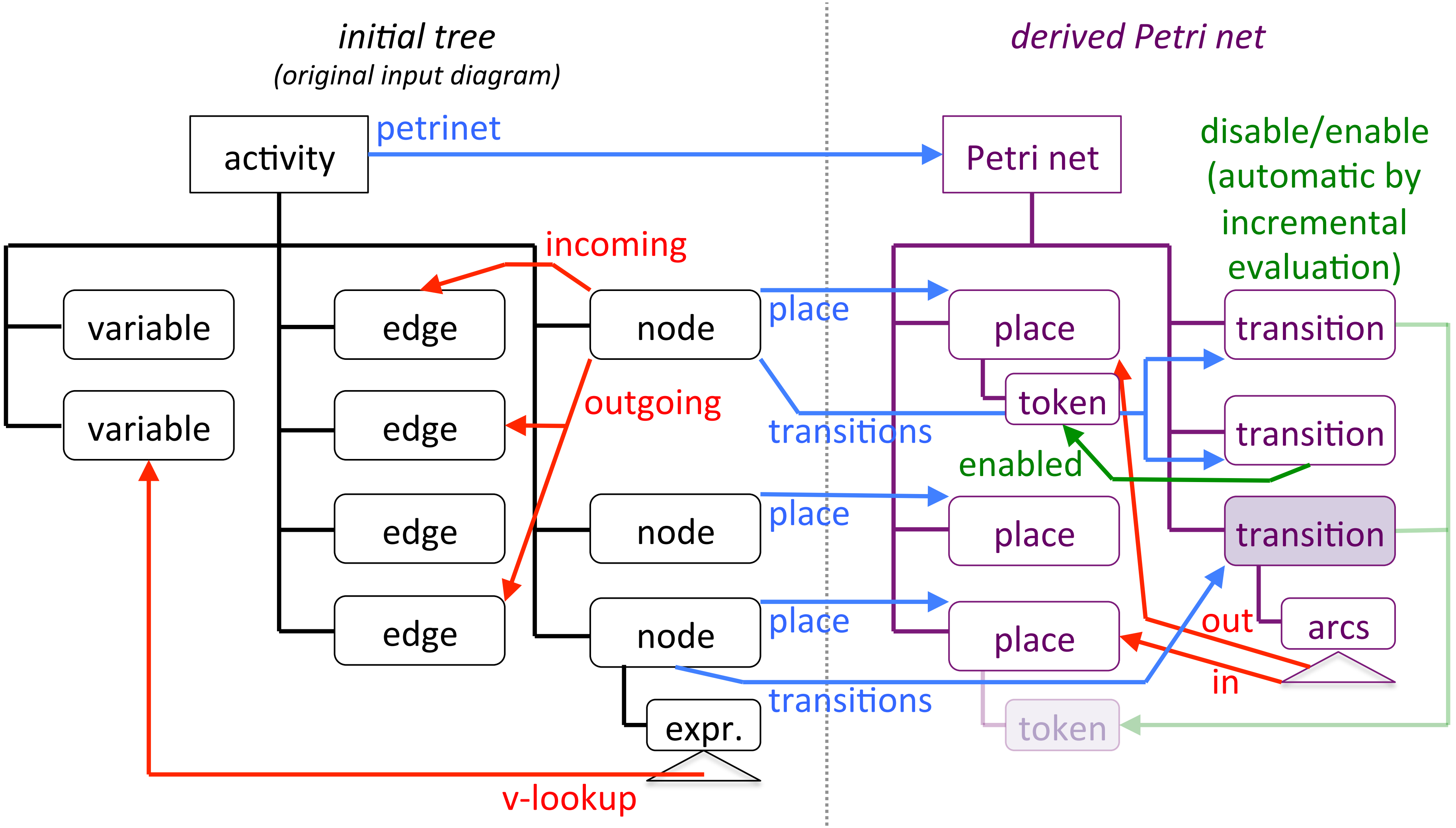
semantic overlay graph (excerpt): 🟥 name analysis 🟦🟪 code generation 🟩 enabled analysis

Execution (RAG-controlled rewriting)



semantic overlay graph (excerpt): 🟥 name analysis 🟦🟪 code generation 🟩 enabled analysis

Execution (RAG-controlled rewriting)



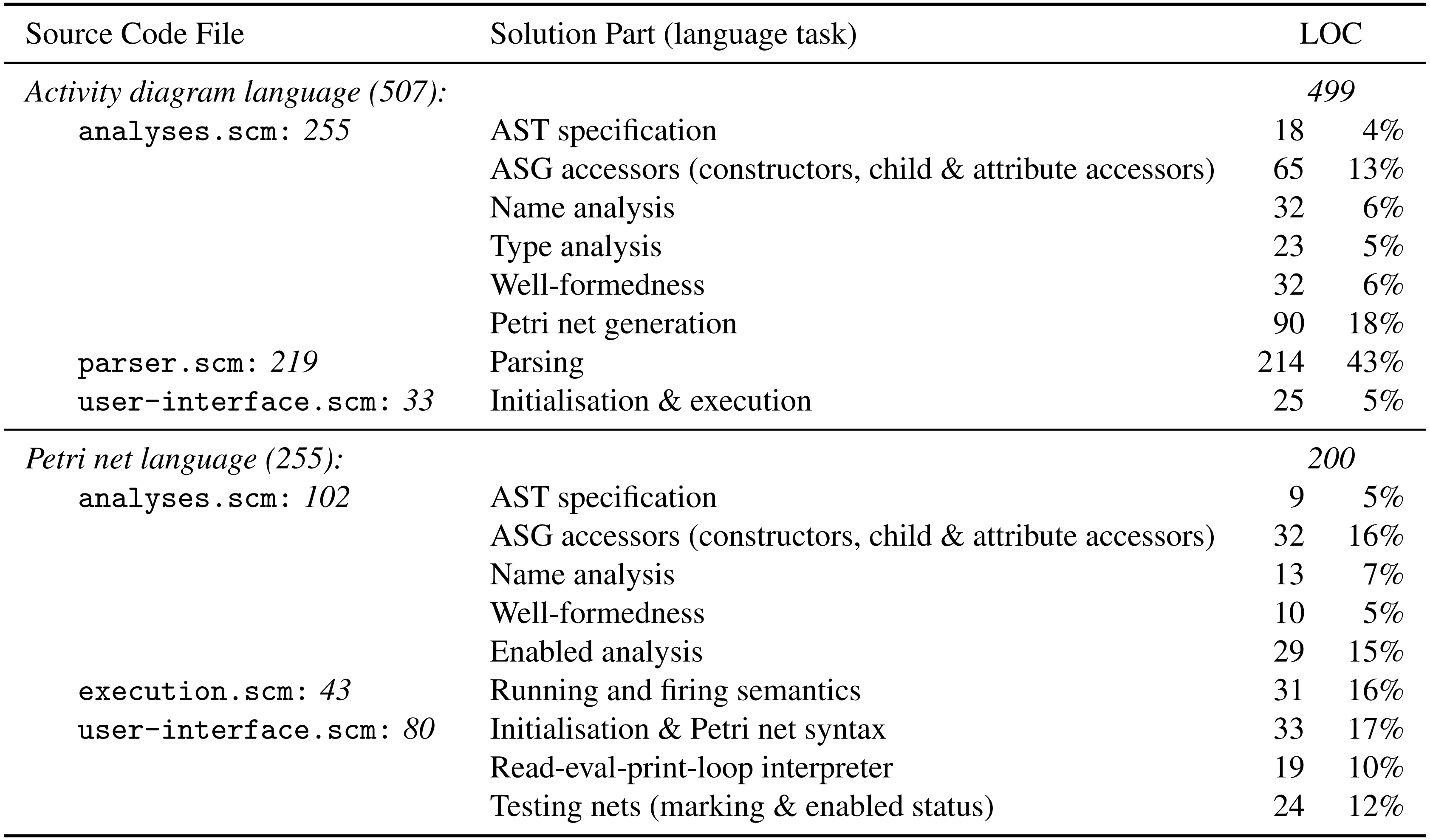
semantic overlay graph (excerpt): 🟥 name analysis 🟦🟪 code generation 🟩 enabled analysis

Evaluation

Implementation quality

- straightforward rewriting thanks to attribute-based analysis (rewrites leverage on analyses)
- focused rewriting (just actual state changes)
- efficient, although naïvely specified (incremental)
- declarative (automatic deduction of evaluation orders for intertwined analyses & rewriting)
- interactive (convenient runtime API for user-driven analyses & state changes)

Lines of code



Source Code File	Solution Part (language task)	LOC	
Activity diagram language (507):		*499*	
`analyses.scm`: *255*	AST specification	18	4%
	ASG accessors (constructors, child & attribute accessors)	65	13%
	Name analysis	32	6%
	Type analysis	23	5%
	Well-formedness	32	6%
	Petri net generation	90	18%
`parser.scm`: *219*	Parsing	214	43%
`user-interface.scm`: *33*	Initialisation & execution	25	5%
Petri net language (255):		*200*	
`analyses.scm`: *102*	AST specification	9	5%
	ASG accessors (constructors, child & attribute accessors)	32	16%
	Name analysis	13	7%
	Well-formedness	10	5%
	Enabled analysis	29	15%
`execution.scm`: *43*	Running and firing semantics	31	16%
`user-interface.scm`: *80*	Initialisation & Petri net syntax	33	17%
	Read-eval-print-loop interpreter	19	10%
	Testing nets (marking & enabled status)	24	12%

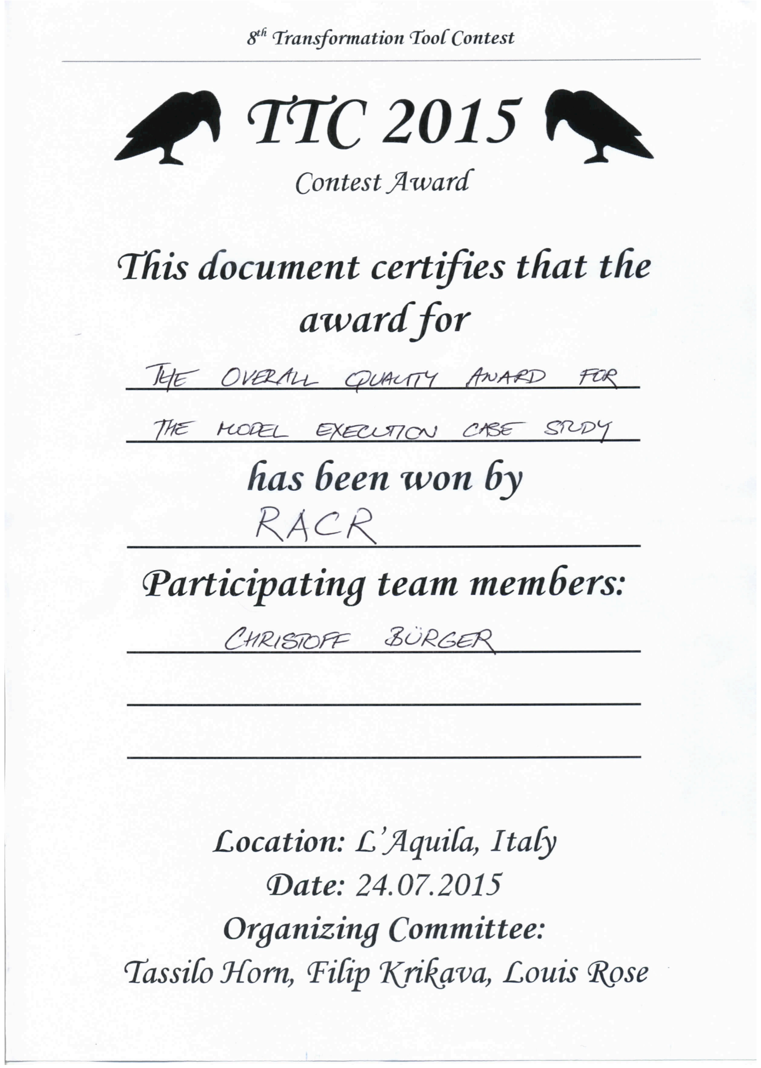
no further software artefacts

Performance

Tasks Performed	Test Cases (`testperformance_variant`)				Time Spend
(later tasks include previous ones)	1	2	3_1	3_2	*(lowest / highest / average)*
Activity diagram parsing	831 / 831	871 / 871	875 / 875	718 / 718	41% / 86% / 50%
Activity diagram well-formedness	926 / 95	1017 / 146	1079 / 204	739 / 21	3% / 11% / 7%
Petri net generation	1042 / 116	1061 / 44	1196 / 117	741 / 2	0% / 6% / 4%
Petri net well-formedness	1220 / 178	1230 / 169	1466 / 270	746 / 5	1% / 14% / 10%
Petri net execution	2026 / 806	1776 / 546	1912 / 446	831 / 85	10% / 40% / 29%
Petri net execution (enabled passes)	2618 / 1398	1344 / 114	1572 / 106	836 / 90	7% / 53% / 27%

execution times in ms
(cf. solution description)

Conclusion



8th Transformation Tool Contest

TTC 2015

Contest Award

This document certifies that the award for

THE OVERALL QUALITY AWARD FOR

THE MODEL EXECUTION CASE STUDY

has been won by

RACR

Participating team members:

CHRISTOFF BÜRGER

Location: L'Aquila, Italy

Date: 24.07.2015

Organizing Committee:

Tassilo Horn, Filip Krikava, Louis Rose

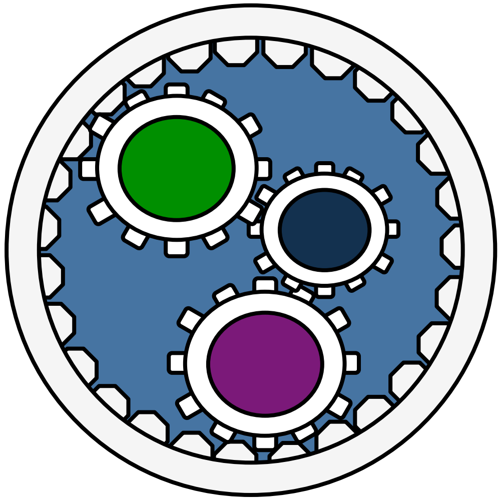
Benefits of RAG-controlled rewriting

interactive

…

incremental
meta programming

model transformation



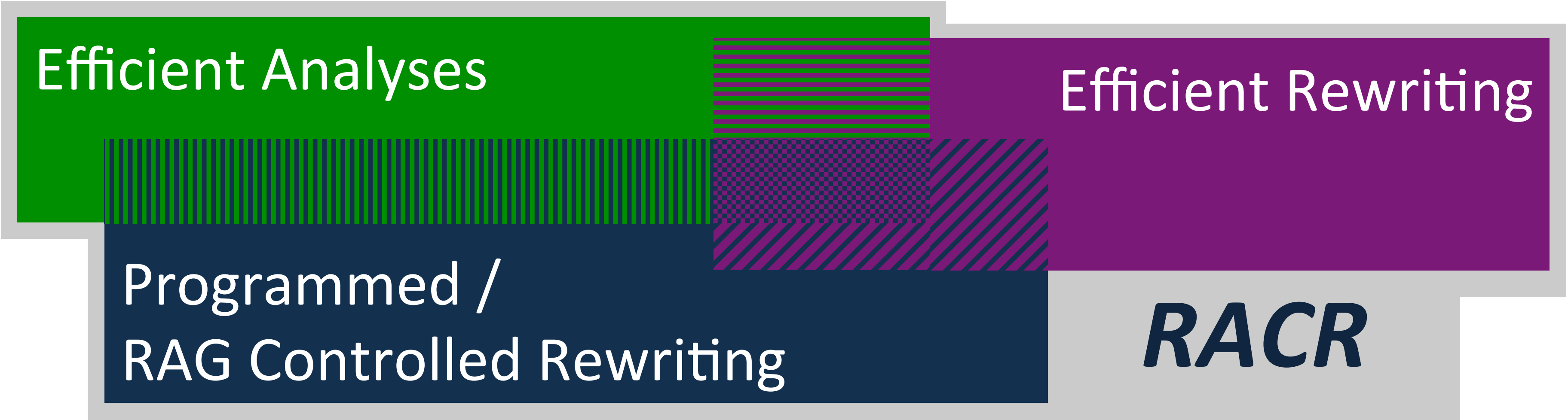
runtime models

declarative

IDEs

incremental reasoning

…



Efficient Analyses

Efficient Rewriting

Programmed /
RAG Controlled Rewriting

RACR