

fUML Activity Diagrams with RAG-controlled Rewriting

*A RACR¹ Solution of The TTC 2015
Model Execution Case*

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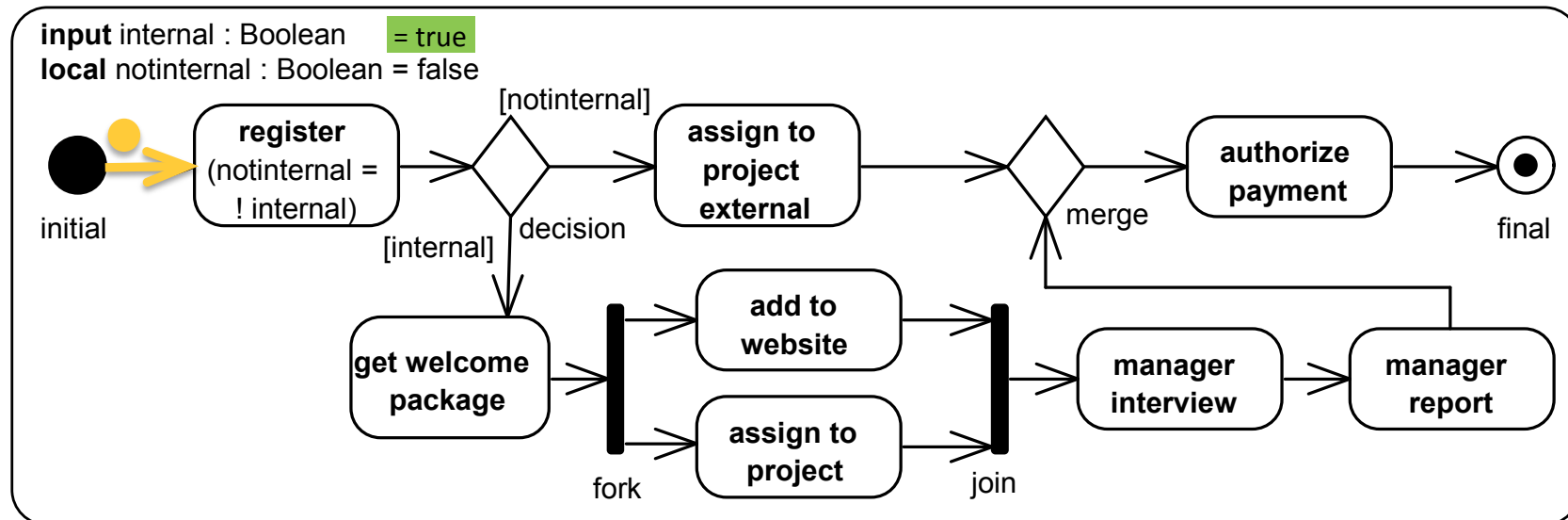
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¹ <https://github.com/christoff-buerger/racr>

TTC 2015 Background

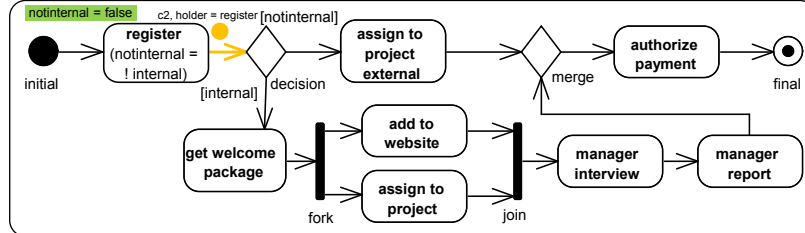
8th Transformation Tool Contest

Task: execution of *fUML Activity Diagrams*.

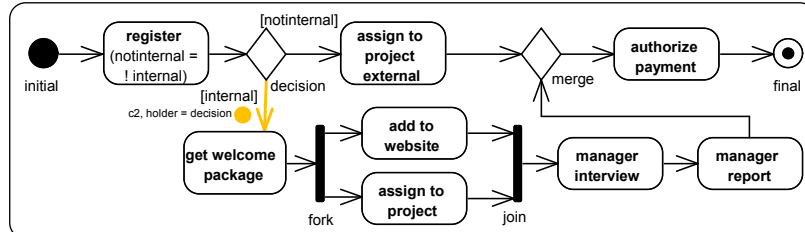


8th Transformation Tool Contest

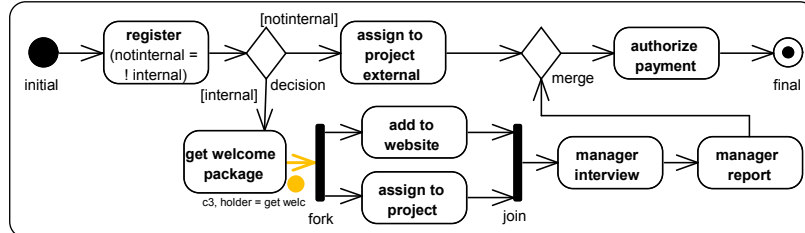
2. The action *register* consumes the token *c1*, executes the defined expression leading to an update of the variable *non-internal*, creates the control token *c2*, and offers it to the decision node *decision*.



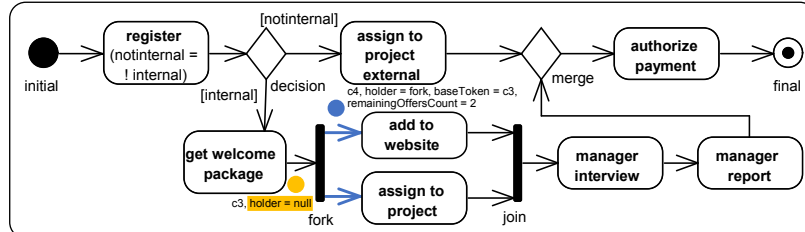
3. The decision node *decision* offers the control token *c2* to the opaque action *get welcome package*, because the variable *internal* defined as guard condition has the current value *true*.



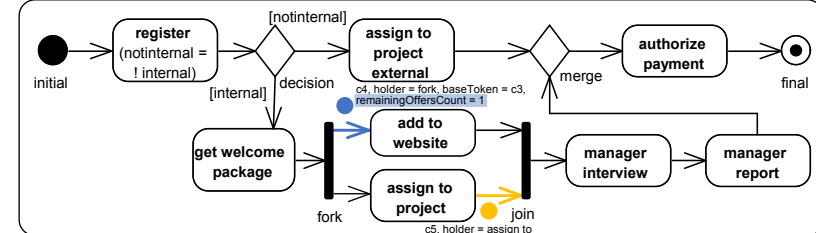
4. The action *get welcome package* consumes the control token *c2*, produces the control token *c3*, and offers it to the fork node.



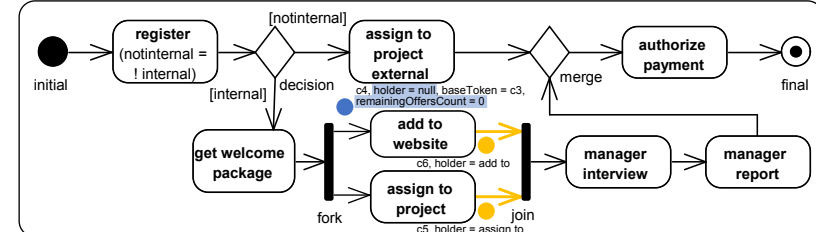
5. The fork node *fork* produces the forked token *c4* for the incoming control token *c3* (i.e., the forked token's base token). The remaining offers count is set to 2, because the fork node has two outgoing control flow edges. The forked token *c4* is offered to the successor actions via two distinct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



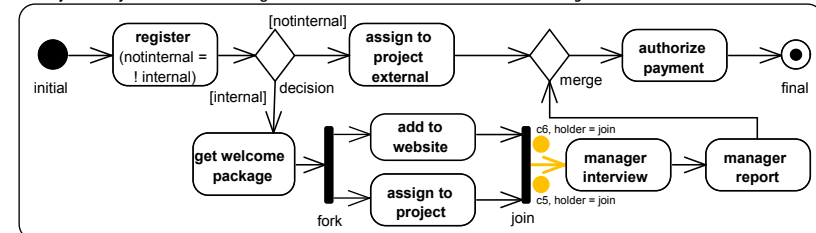
6. The action *assign to project* consumes its token offer for *c4* leading to an update of *c4*'s remaining offers count to 1, produces the control token *c5*, and offers it to the join node *join*.



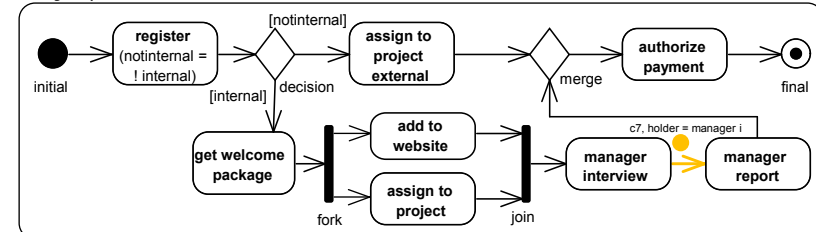
7. The action *add to website* consumes its token offer for *c4* leading to an update of *c4*'s remaining offers count to 0, which in turn leads to the withdrawal of *c4* (*holder* is set to *null*). Furthermore, it produces the control token *c6*, and offers it to the join node.



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)
 - 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
 - >> incremental

} mutual control

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)

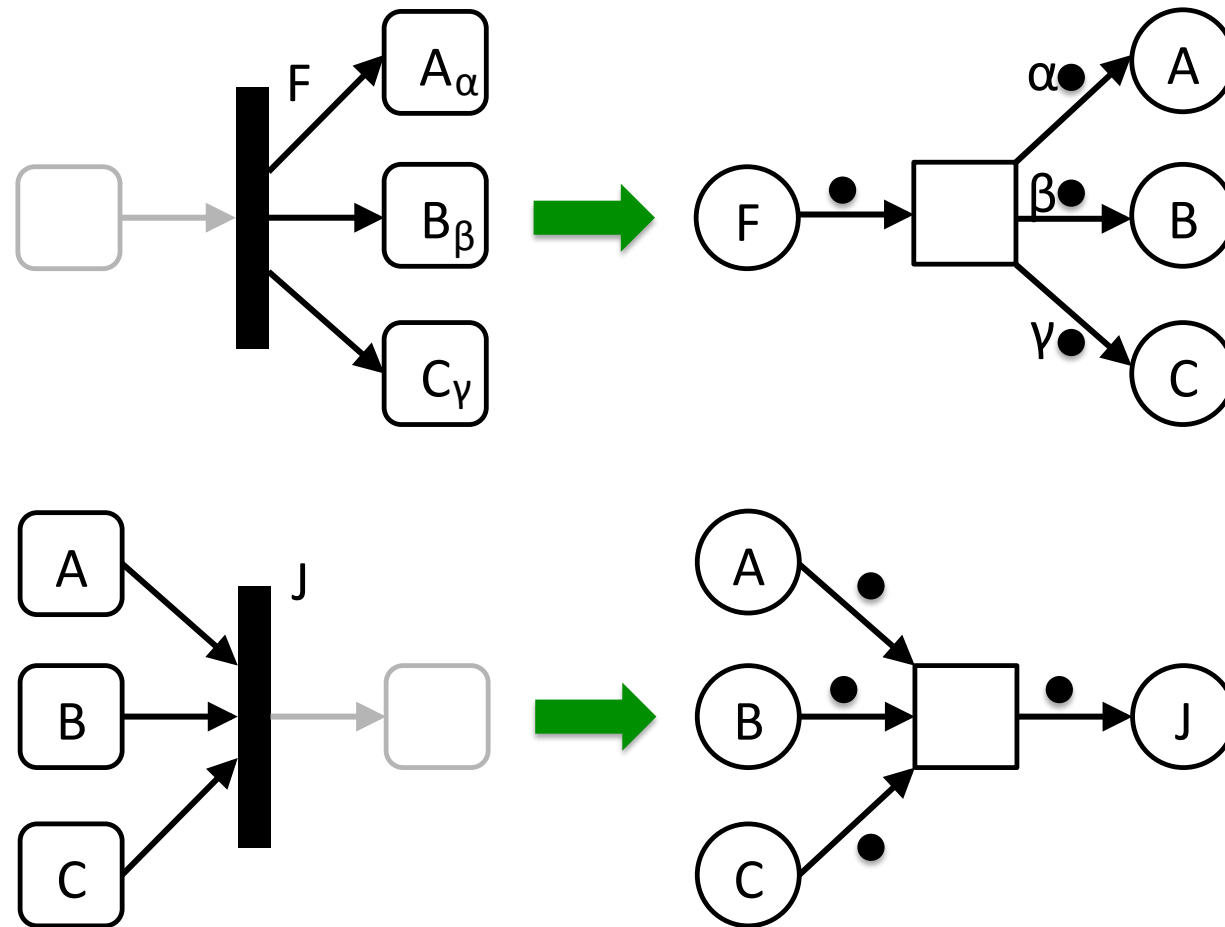
<https://github.com/christoff-buerger/racr>

Solution

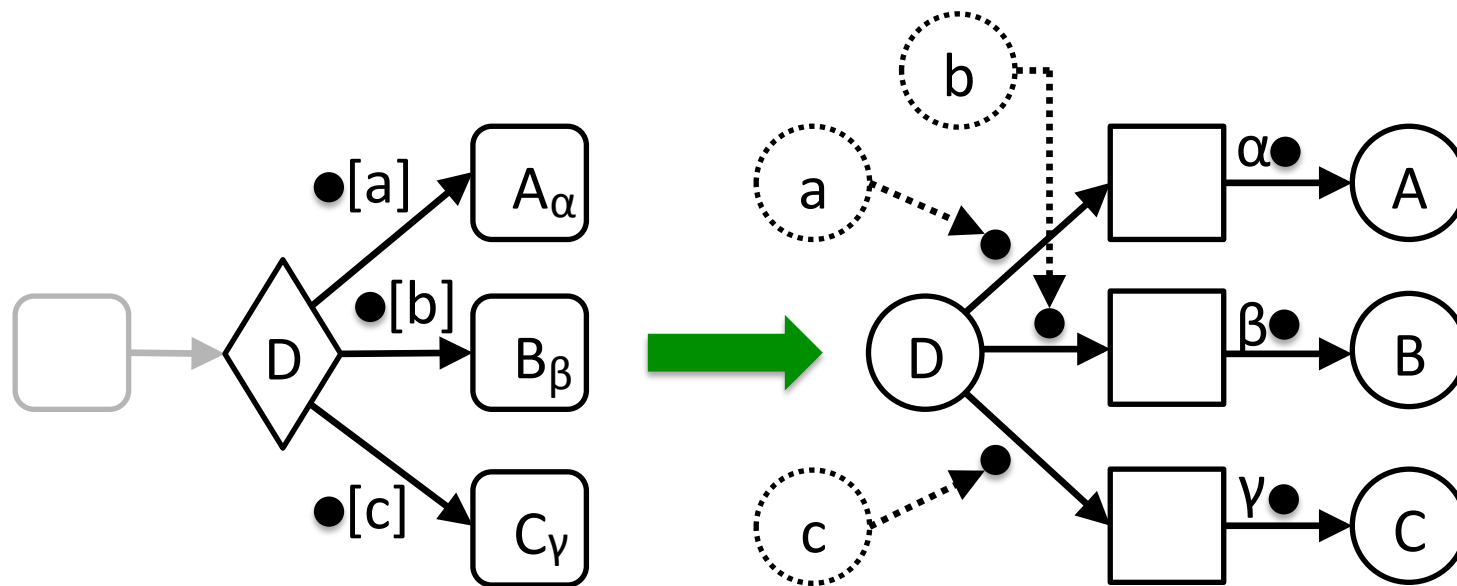
fUML Activity Diagram compiler

- 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 \rightarrow Petri net

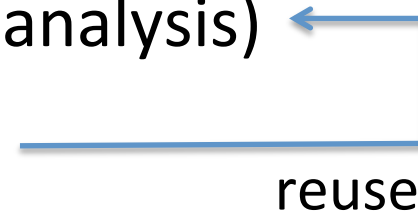


fUML Activity Diagram \rightarrow Petri net

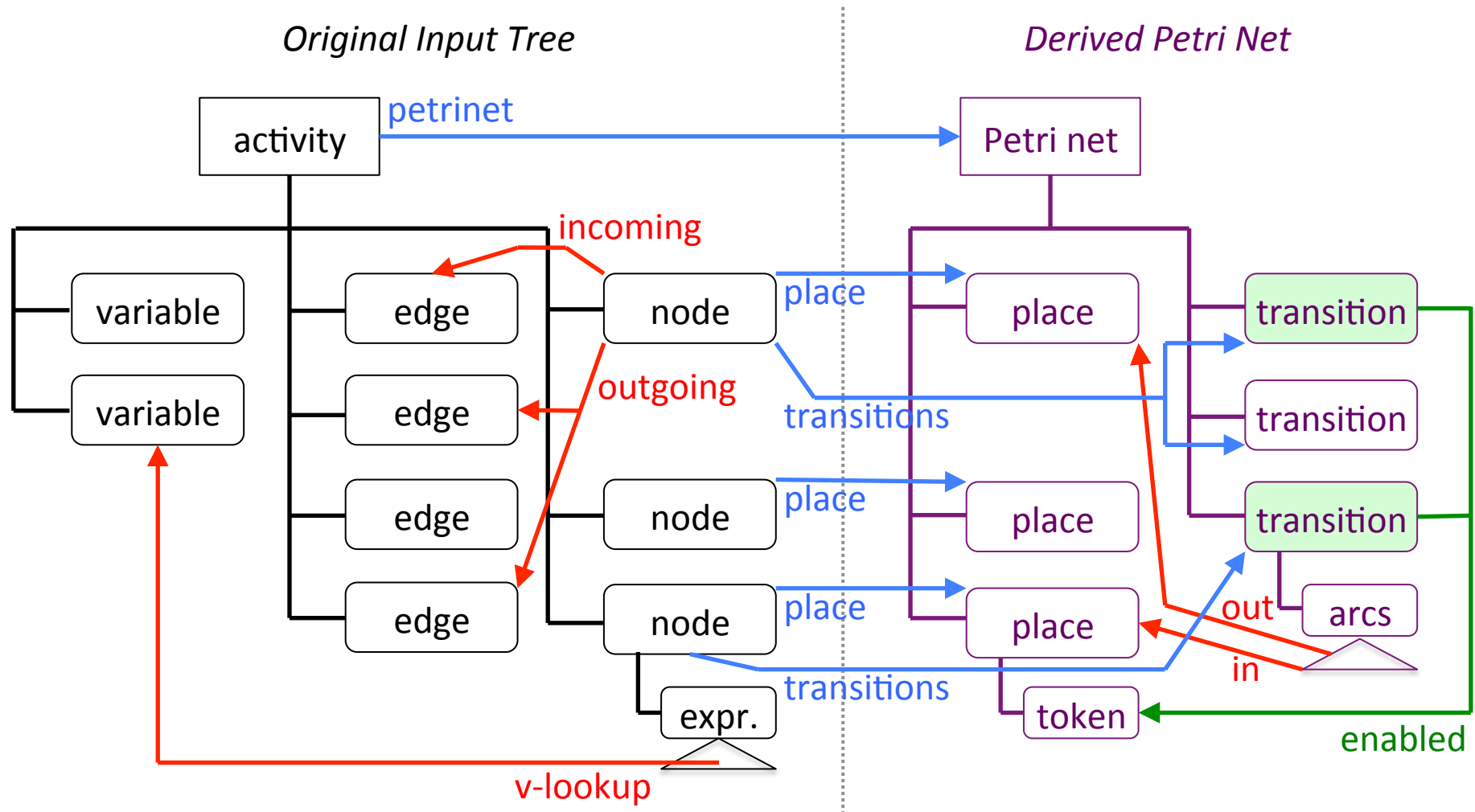


Petri net interpreter

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

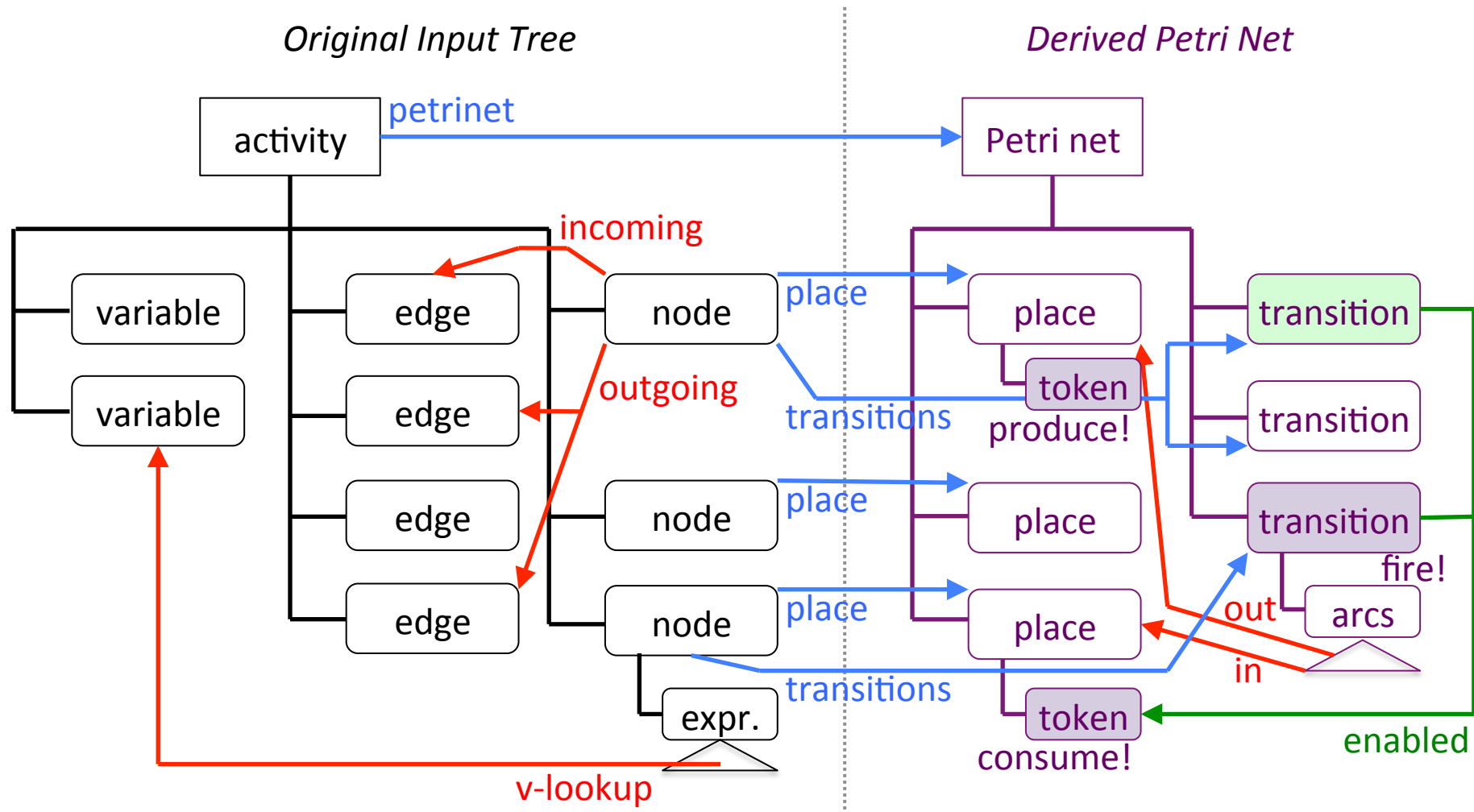


ASG



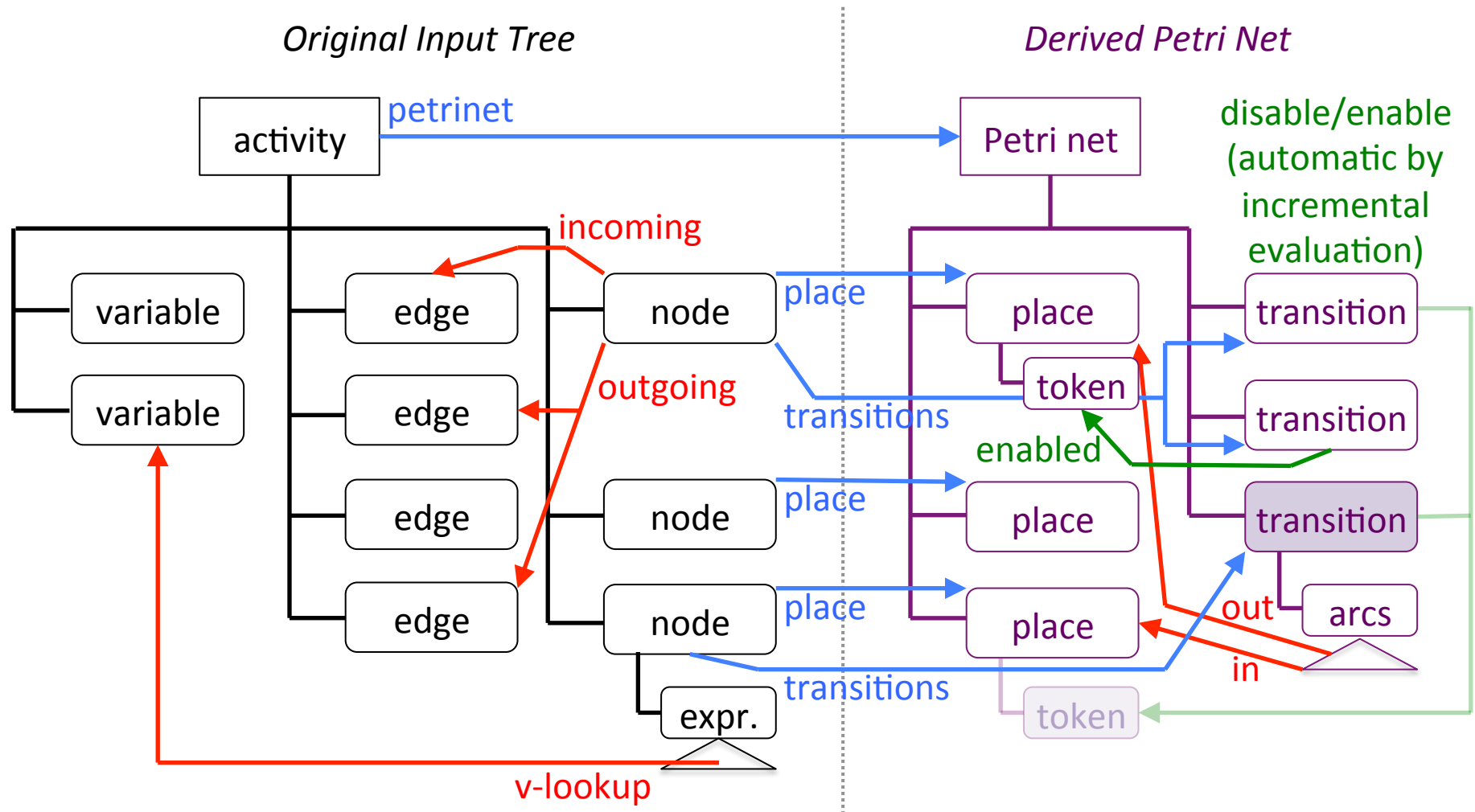
semantic overlay graph (excerpt): ■ name analysis ■ code generation ■ enabled analysis

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

Performance

Tasks Performed <i>(later tasks include previous ones)</i>	Test Cases (testperformance_variant)				Time Spend <i>(lowest / highest / average)</i>
	1	2	3_1	3_2	
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%

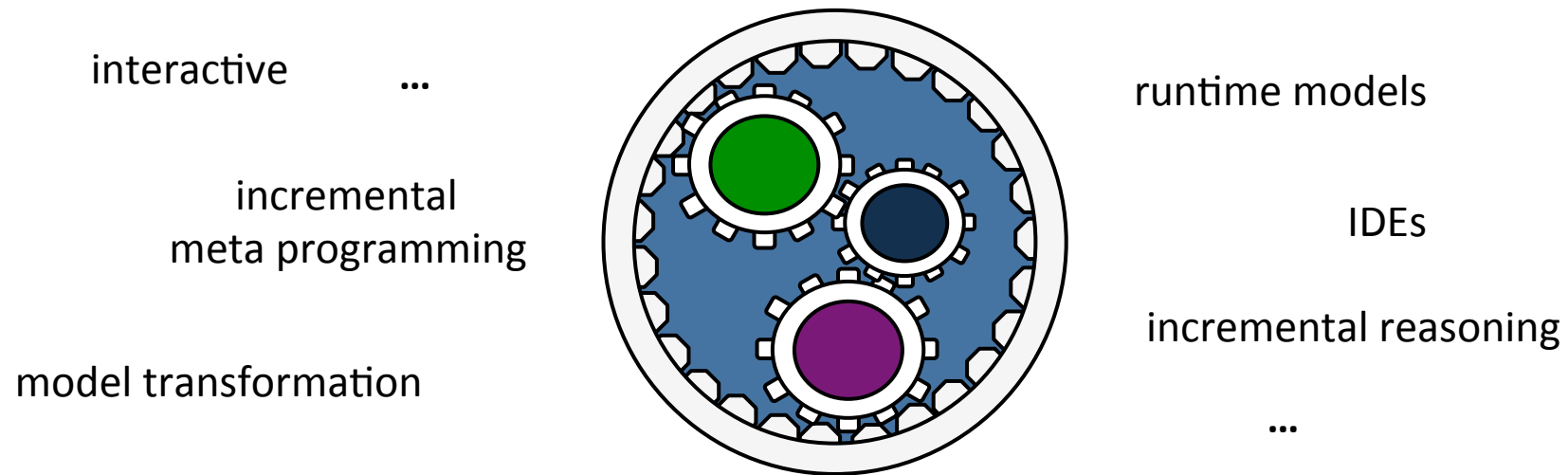
execution times in ms
(cf. solution description)

Lines of code

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

no further software artefacts

Benefits of RAG-controlled rewriting



Efficient Analyses

Efficient Rewriting

Programmed /
RAG Controlled Rewriting

RACR