Calculation and Applications of Concurrent Rules

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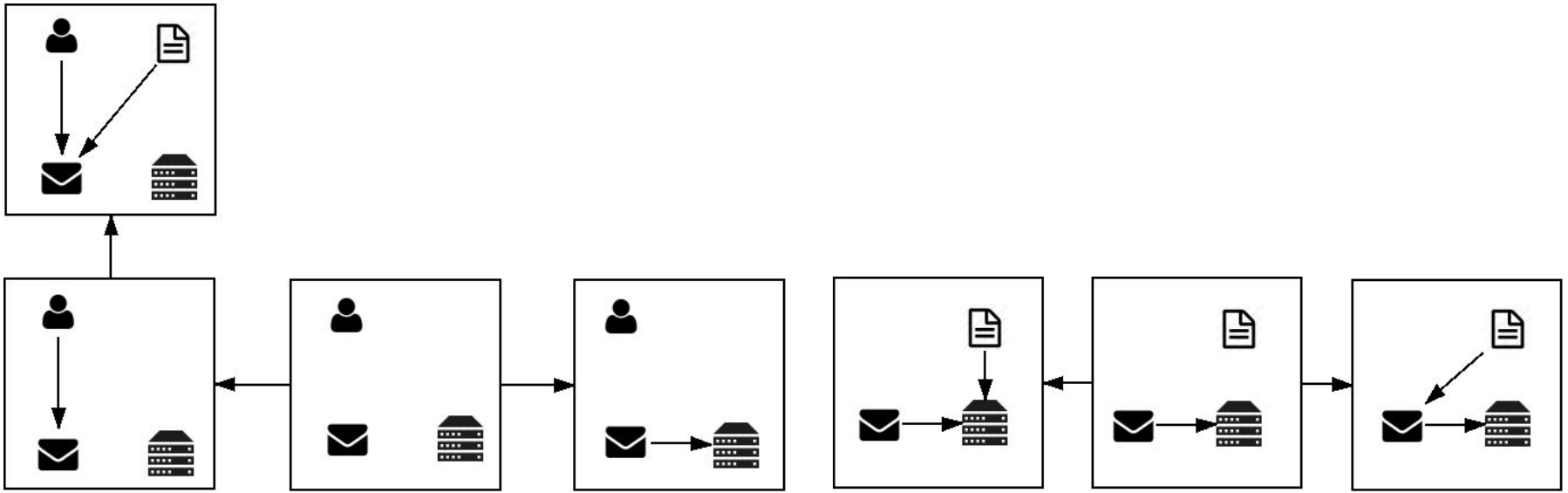
Motivation

- Concurrent Systems (as Graph Transformations)
- Emergent Behaviour

Summarizing Concurrent Behaviour

- Construction of Concurrent Rules
  - Check whether the overall intended behaviour is achieved
  - Show the different behaviours that emerge from the system

Example Grammar

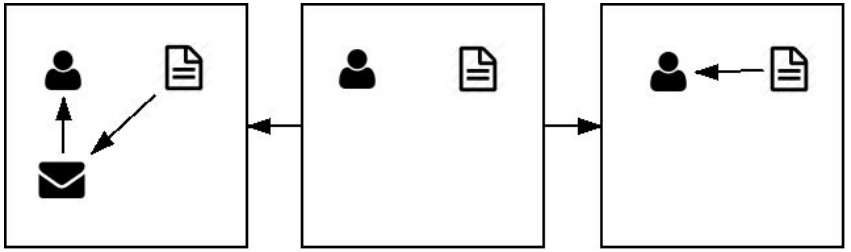


sendMessage

getData

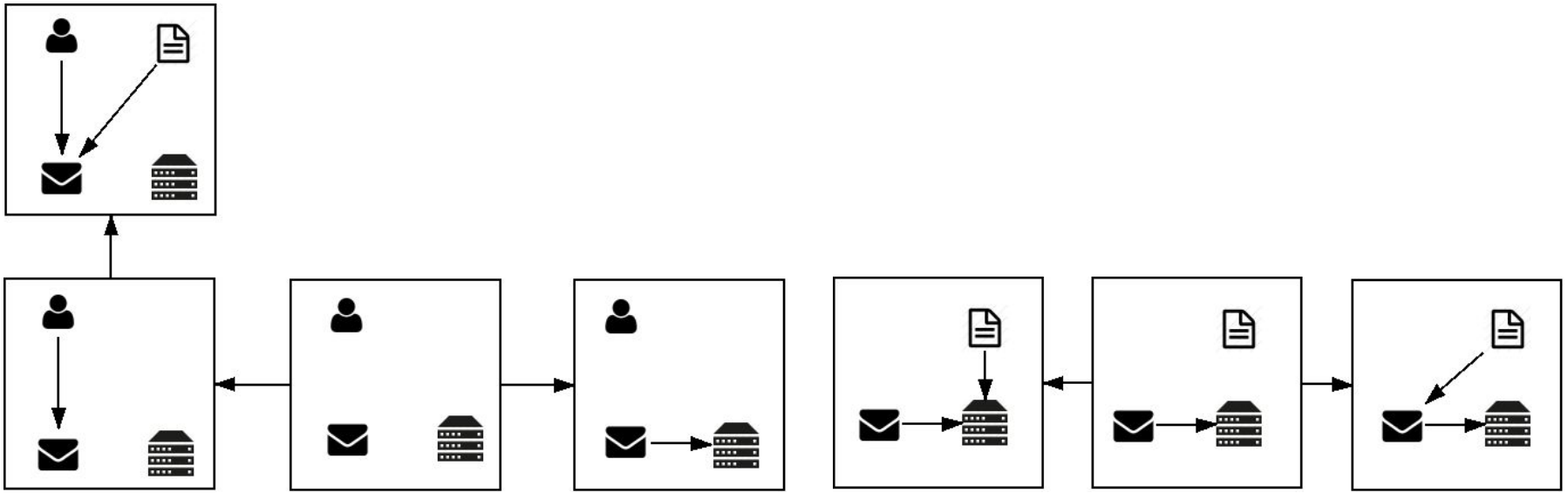
Example Grammar

receiveMessage



deleteMessage

Calculating Concurrent Rules



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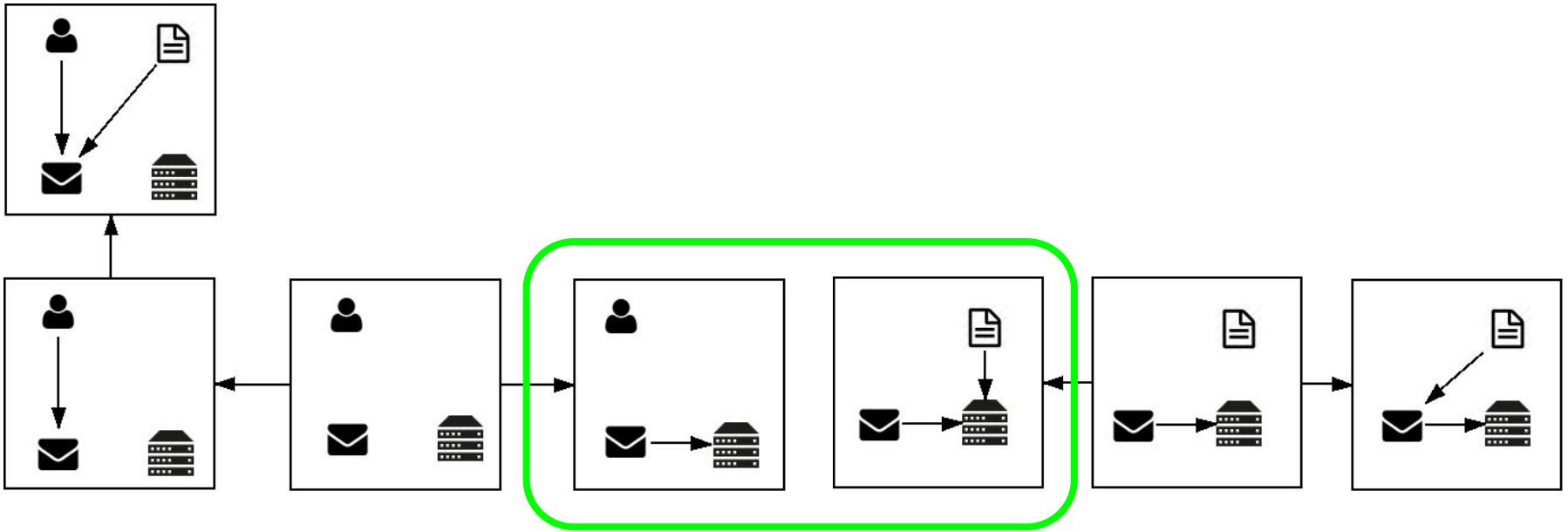
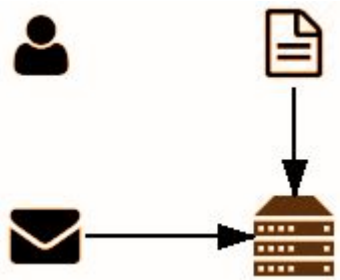


Different Interactions of Rules



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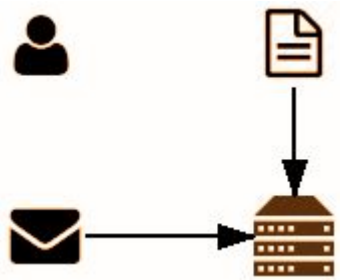

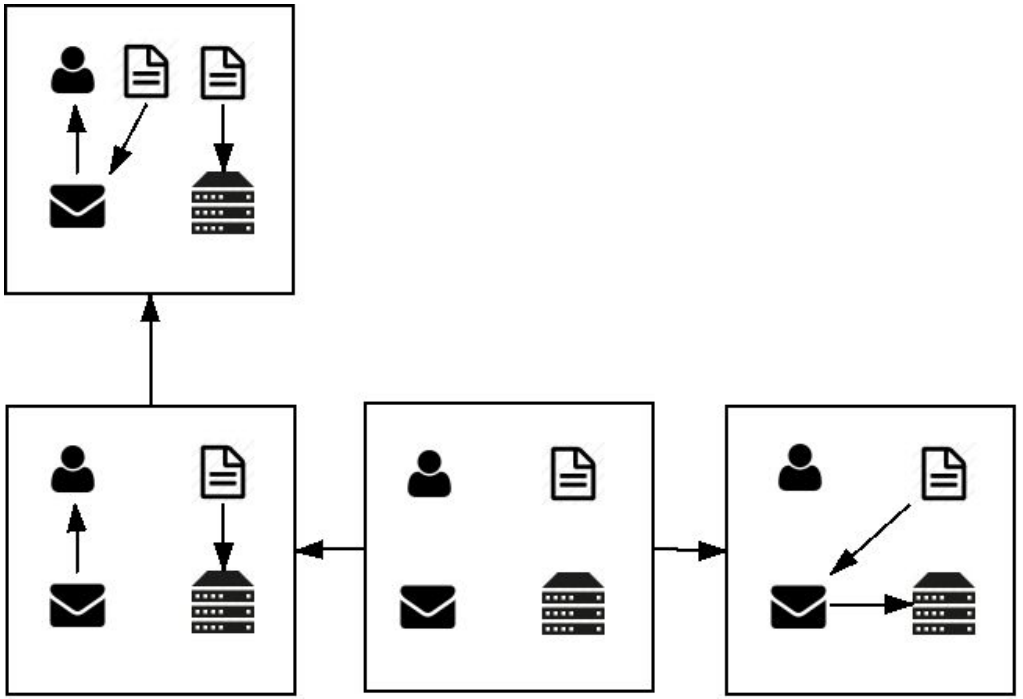

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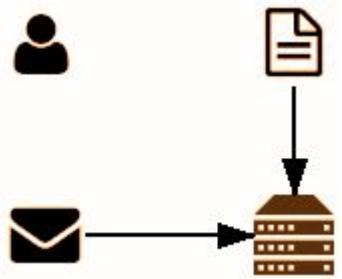

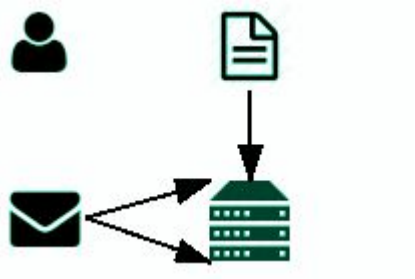

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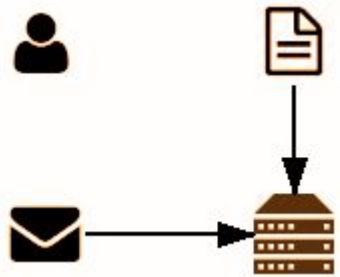

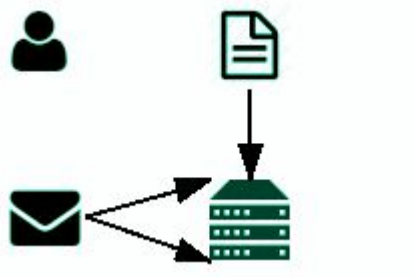

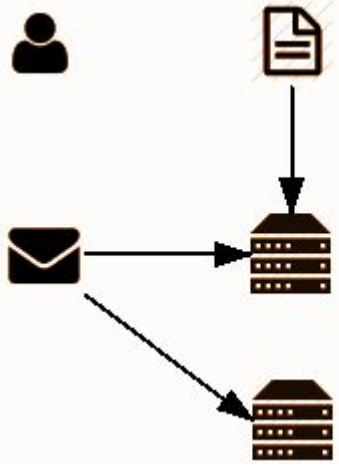

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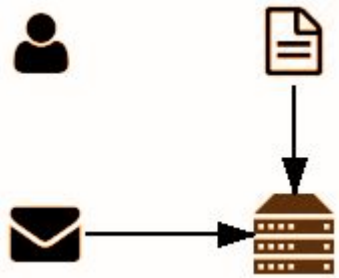

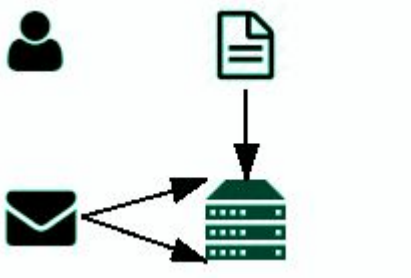

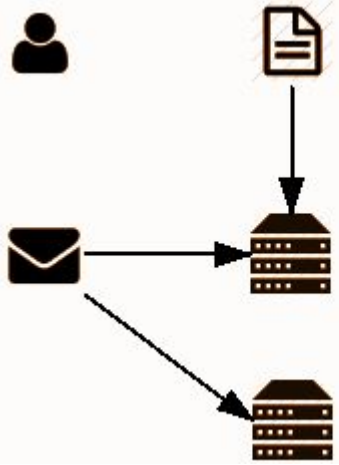

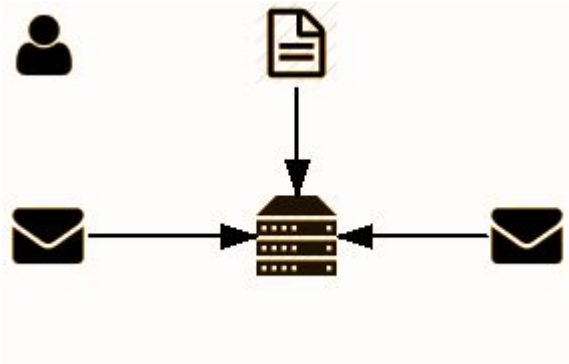

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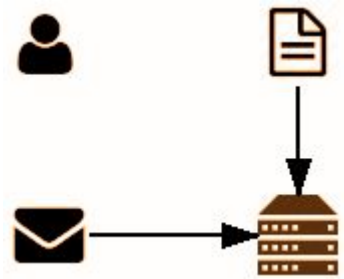

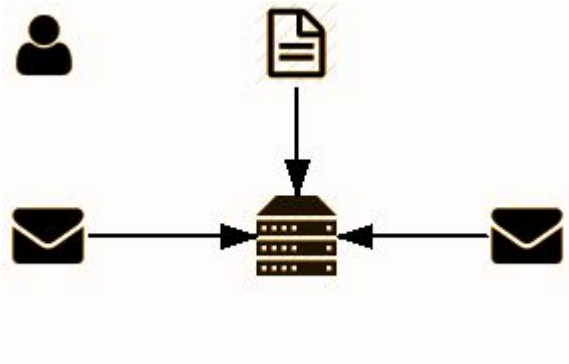

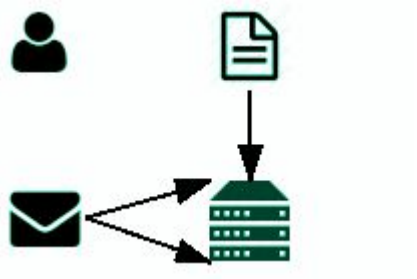

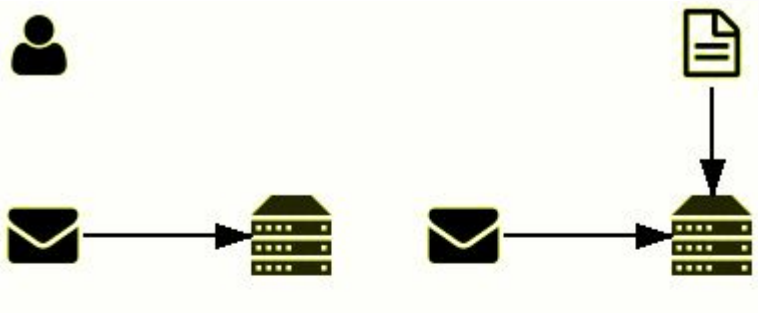

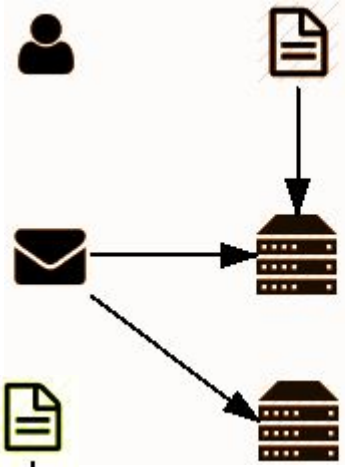

Combinatorial Explosion

- There is one concurrent rule for each possible interaction
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# Rules	2	3	4
# Concurrent Rules	5	189	1021
# NACs	11	533	3961

Combinatorial Explosion

- We can reduce the problem focusing on more “interesting” rules:
  - Constraints
  - Rules by dependencies
  - Maximal Rules

Constraints

- Restrictions on the model domain
  - Forbid certain structures to exist
  - Ensures that certain structures exist

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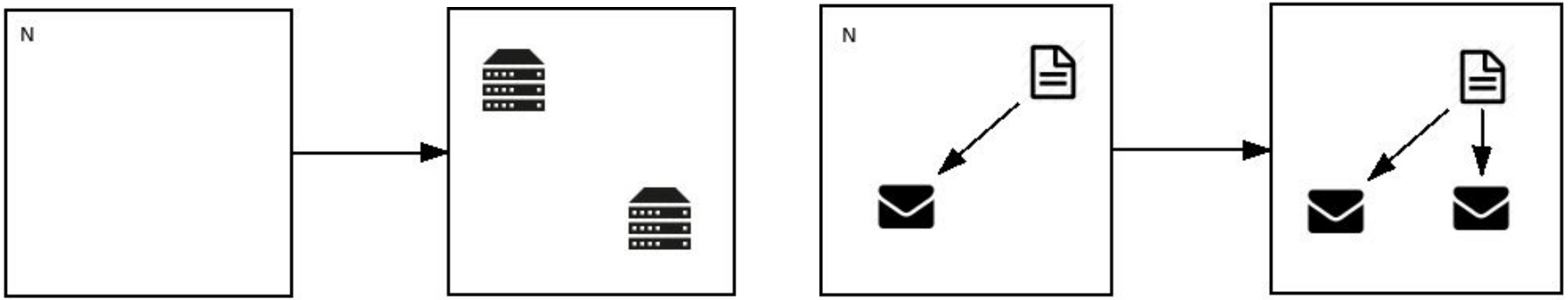
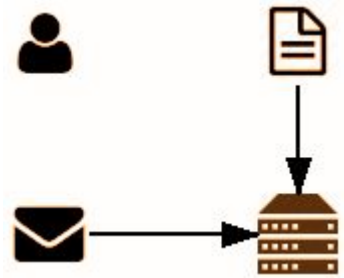
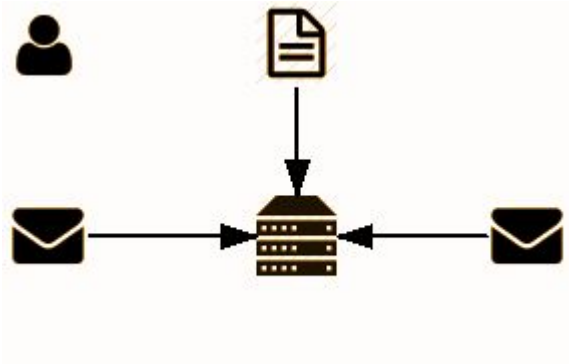
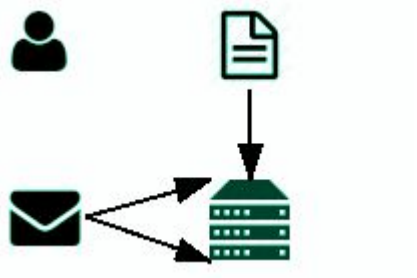
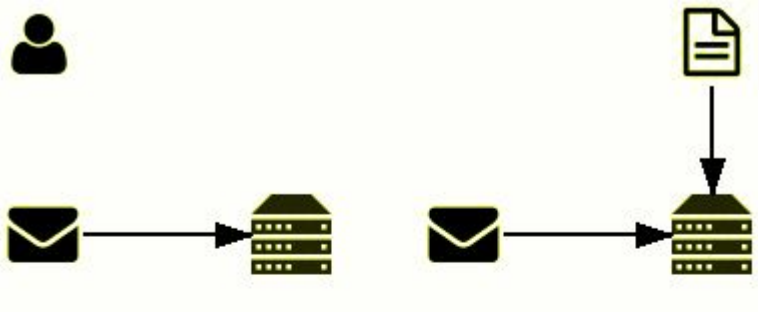


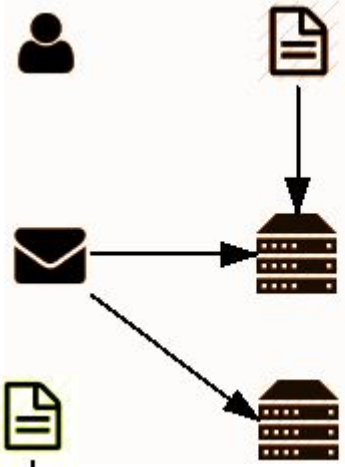
Constraints on Overlappings











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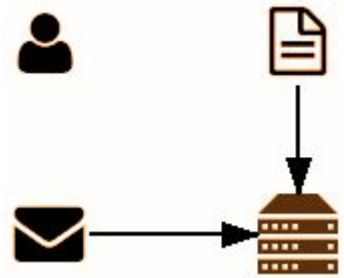
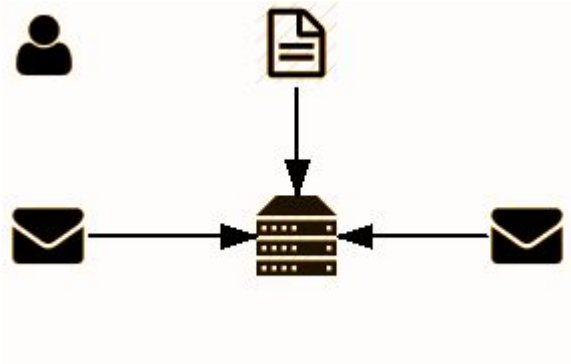
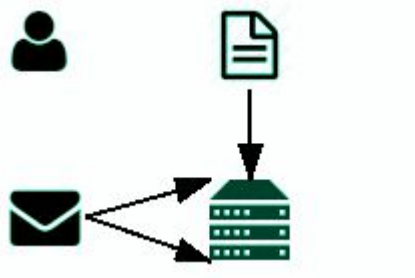
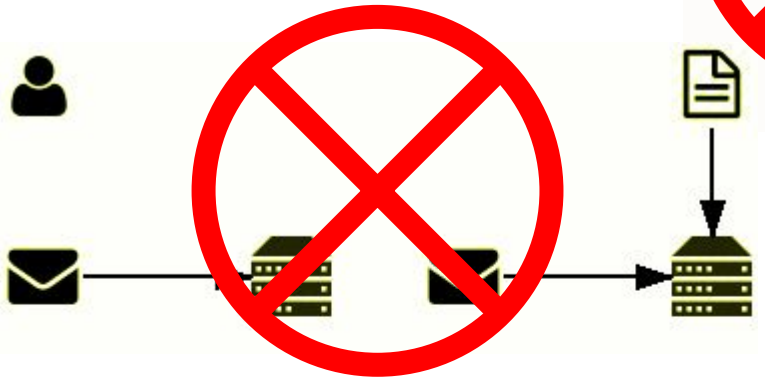








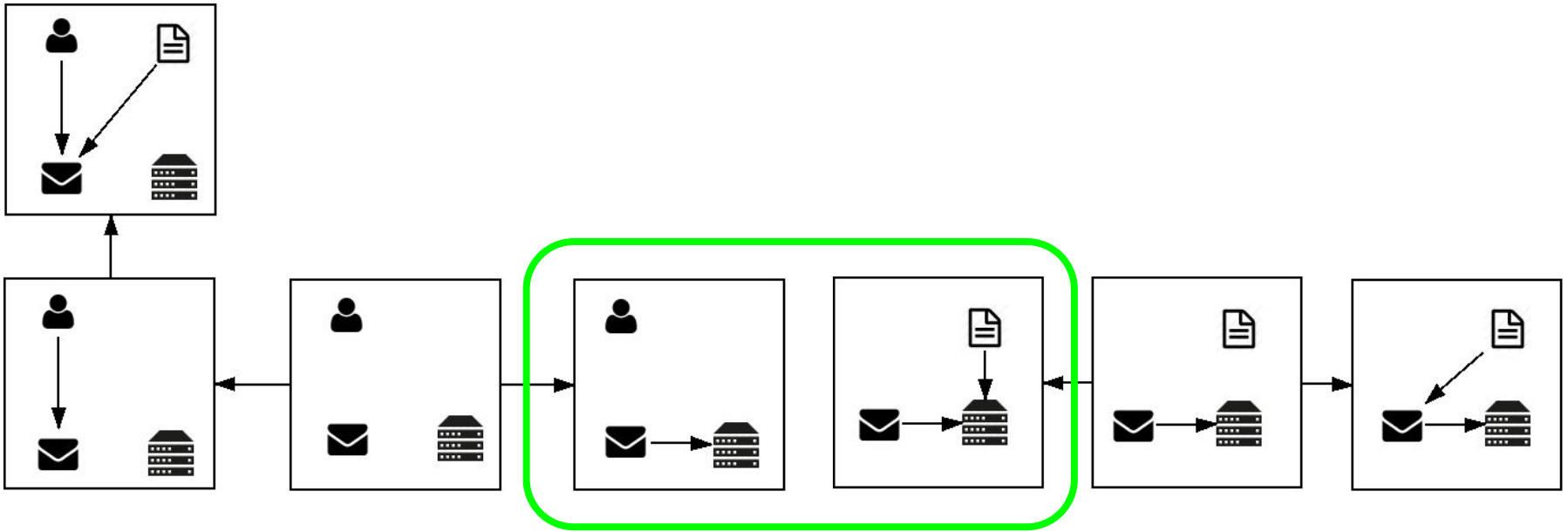
Constraints on Rules and NACs

- Even if the overlapping satisfy the constraints, the LHS and RHS may not
- NACs of the concurrent rules may forbid something already forbidden

Concurrent-Rules induced by dependency

- Restrict the calculation of rules only where the previous rule:
  - Create something needed for the next one
  - Delete something forbidden by a NAC of the next one

Concurrent-Rules induced by dependency



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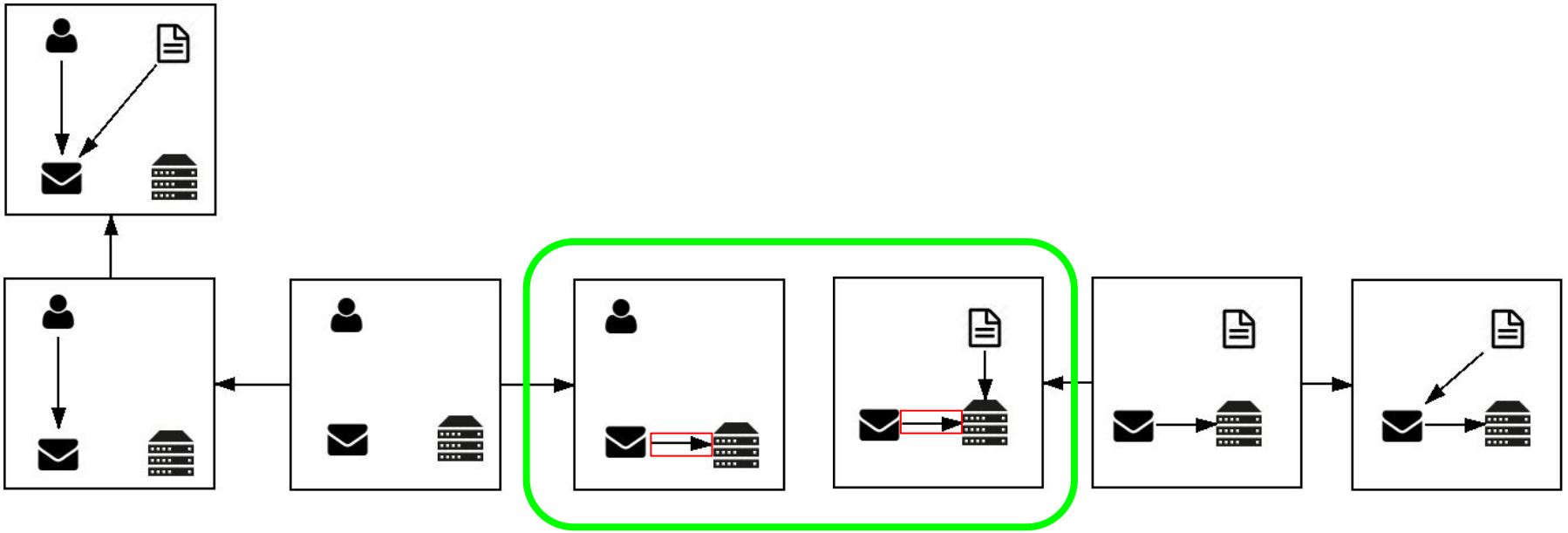
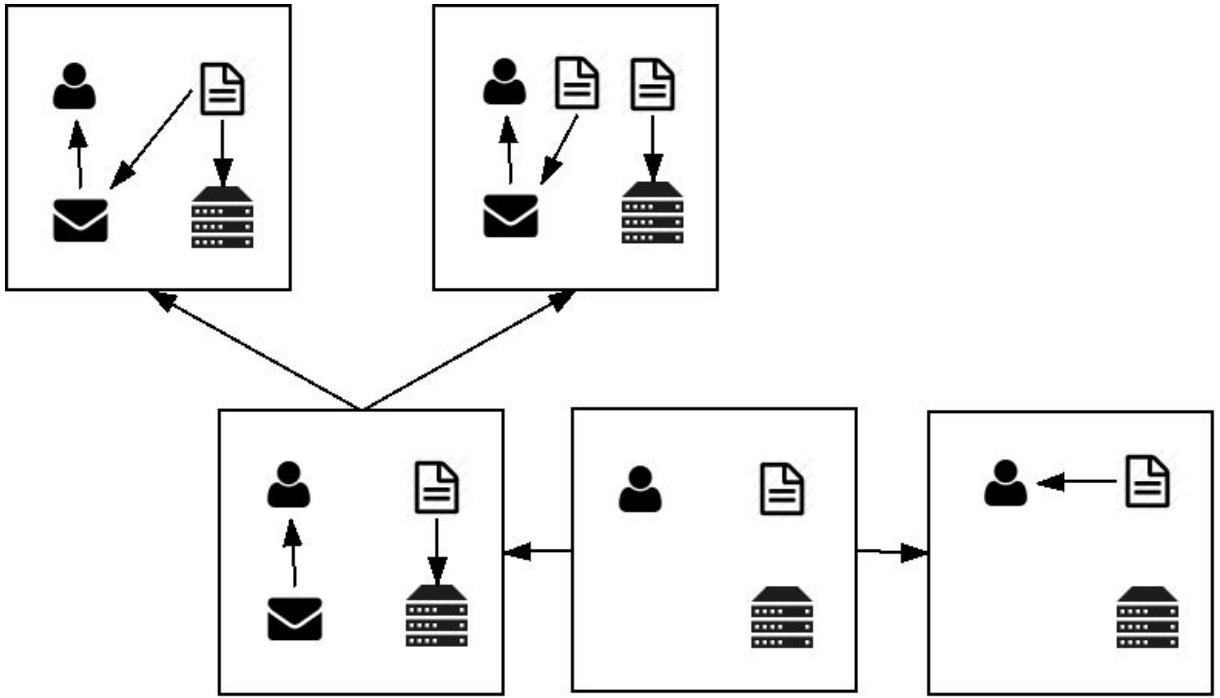


Maximal Concurrent Rules

- Calculate rules for pairs the represent the maximal possible interactions

Maximal Concurrent Rules



Verigraph

- All strategies above were implemented on verigraph
- These strategies can be combined
- The combination of strategies benefits from Haskell laziness

Results

- Concurrent rules for the 4 rules of the example grammar

Strategy	Time	Number of Rules	Number of NACs
None	1m30s	1021 rules	$\approx$ 4 nacs/rule
Constraints on Overlappings	8s	141 rules	$\approx$ 2 nacs/rule
Constraints on LHS and RHS	8s	141 rules	$\approx$ 2 nacs/rule
Dependencies	0.45s	2 rules	2 nacs/rule
Maximal Rule	0.32s	1 rule	2 nacs/rule

Table 1. Concurrent rules for the server grammar

Results

- Concurrent rules for an elevator system grammar with 8 rules

Strategy	Time	Number of Rules	Number of NACs
None	>2d	NA	NA
Constraints on Overlappings	30m	11313 rules	$\approx$ 0.7 nacs/rule
Constraints on LHS and RHS	1m55s	287 rules	$\approx$ 5 nacs/rule
Dependencies	2m15s	9 rules	$\approx$ 4 nacs/rule
Maximal Rule	0.93s	0 rules	0 nacs/rule

Table 2. Concurrent rules for elevator grammar

Conclusion

- Performance improvement
- Focus on meaningful rules
- Available on verigraph: https://github.com/Verites/verigraph

Ongoing/Future Work

- Use of concurrent rules for Use Cases analysis
- Use of concurrent rules for generating test cases
- Use of other static analysis for generating test cases

Acknowledgement

Contact

- Jonas S. Bezerra: jsbezerra@inf.ufrgs.br
- Profª. Drª. Leila Ribeiro: leila@inf.ufrgs.br

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