On the Performance Overhead of BPMN Modeling Practices

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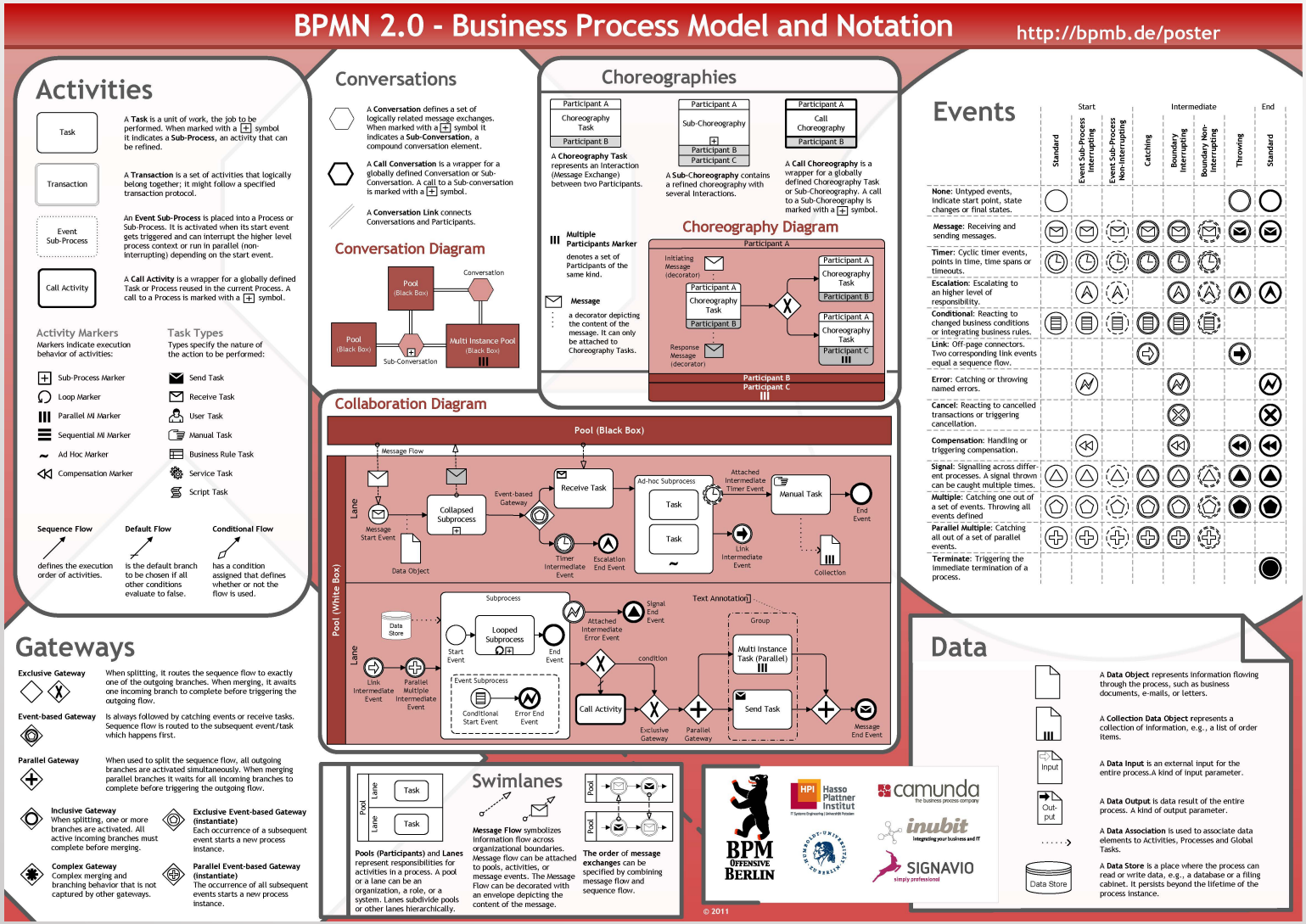
BPMN Expressiveness



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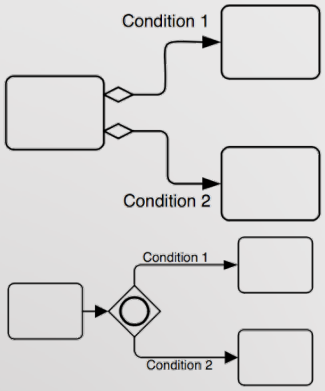
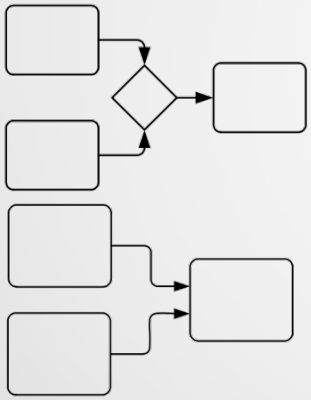
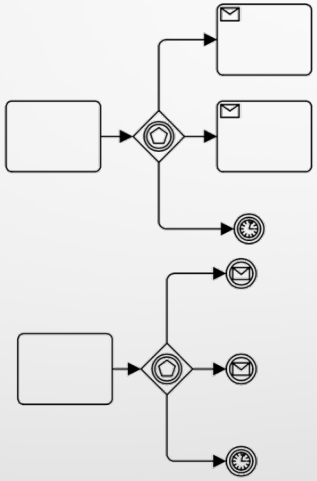
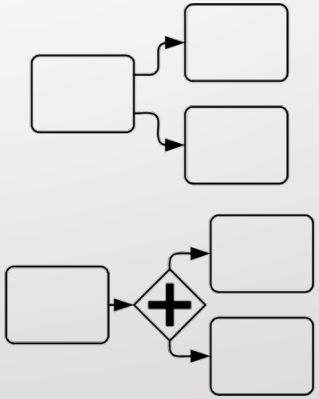


BPMN Standard







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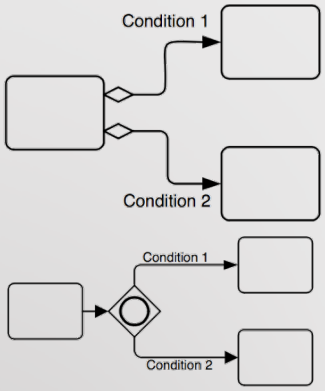

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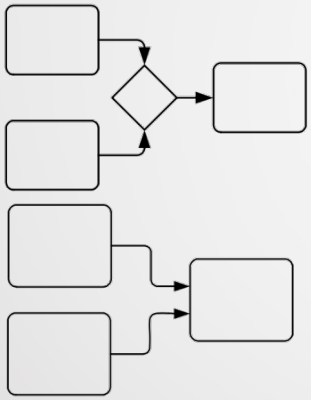
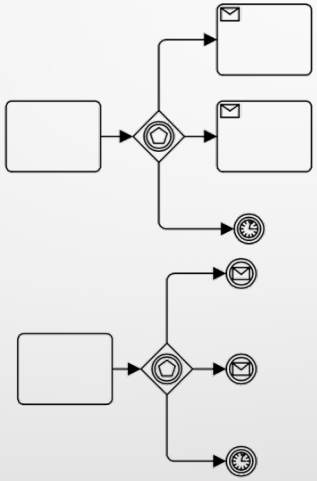
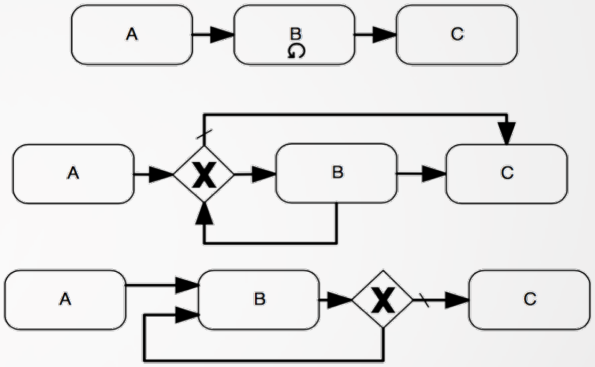
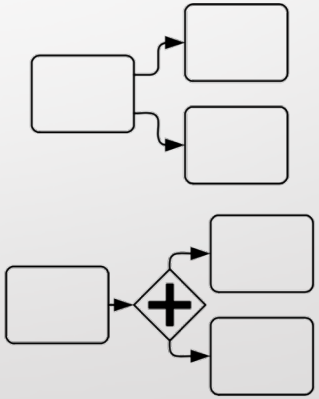






Model's Semantics



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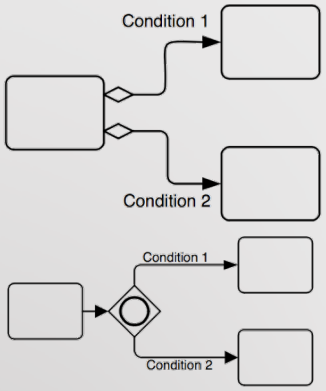

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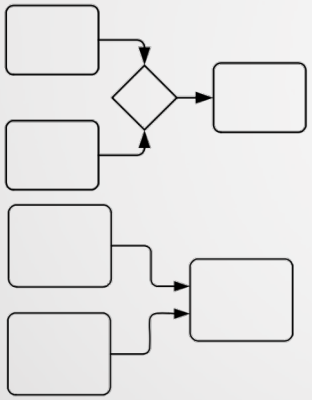

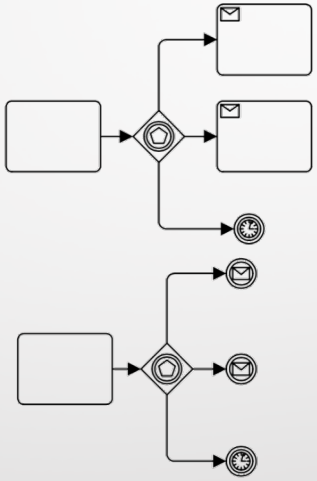

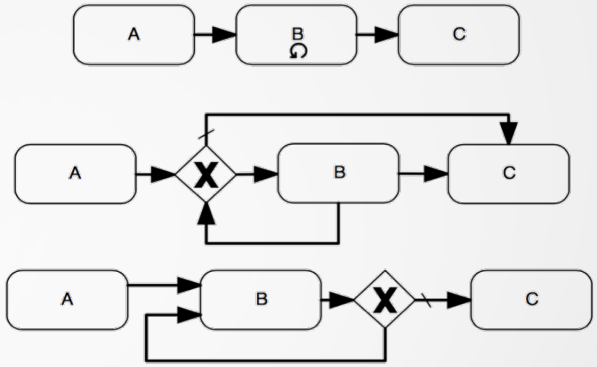

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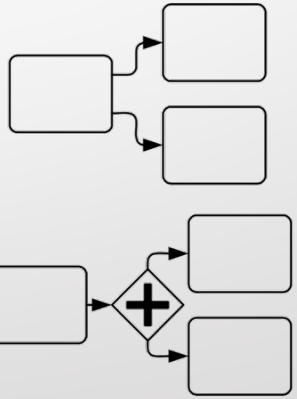
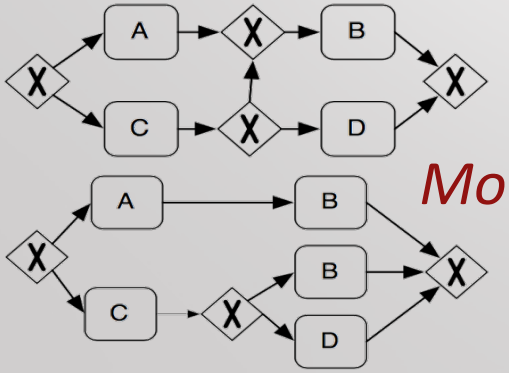
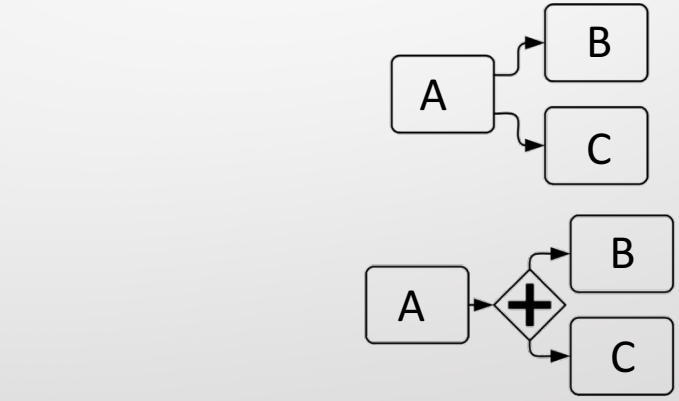




Model's Understandability


A
B
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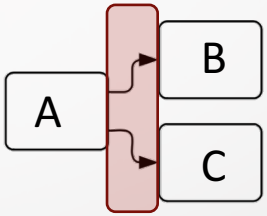
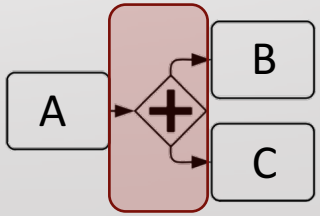
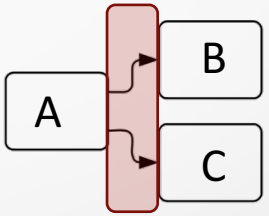


Structural Differences



Semantical Equivalence



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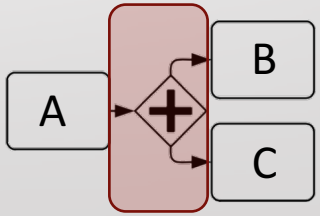
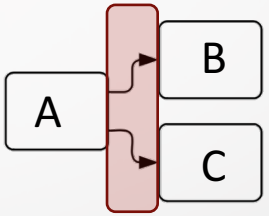


Semantical Equivalence

case id	trace
1	ABC
2	ACB
3	ABC
….	….



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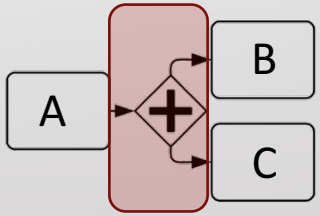
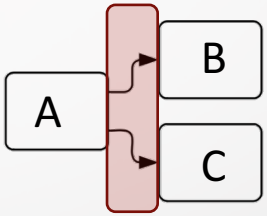


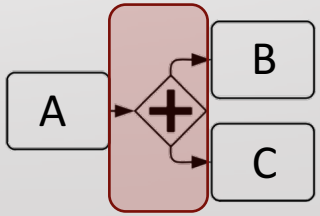
Semantical Equivalence

Performance Equivalence

case id	trace
1	ABC
2	ACB
3	ABC
….	….



Structural Differences



Semantical Equivalence

case id	trace
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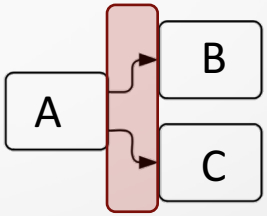
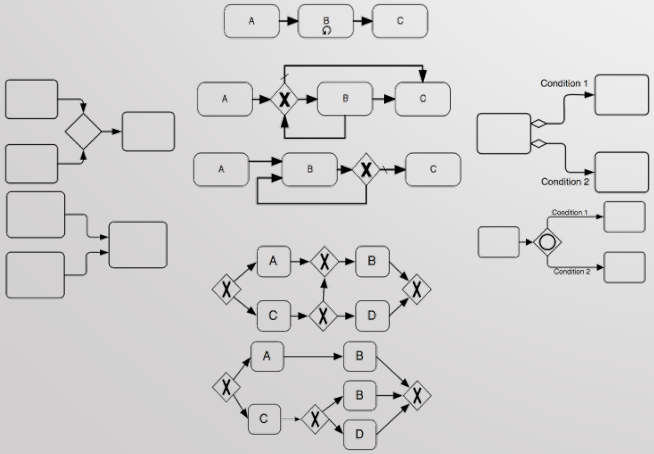
Performance Equivalence

?





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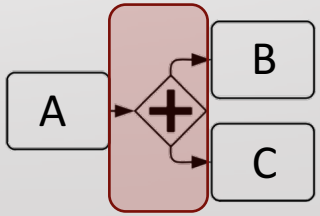

Research Questions

RQ1: Does the application of different modeling practices have a significant impact on the duration of a BP instance execution?

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RQ2: Is there a ***total order*** between semantically equivalent but structurally different models, when ranked according to their performance?

Methodology

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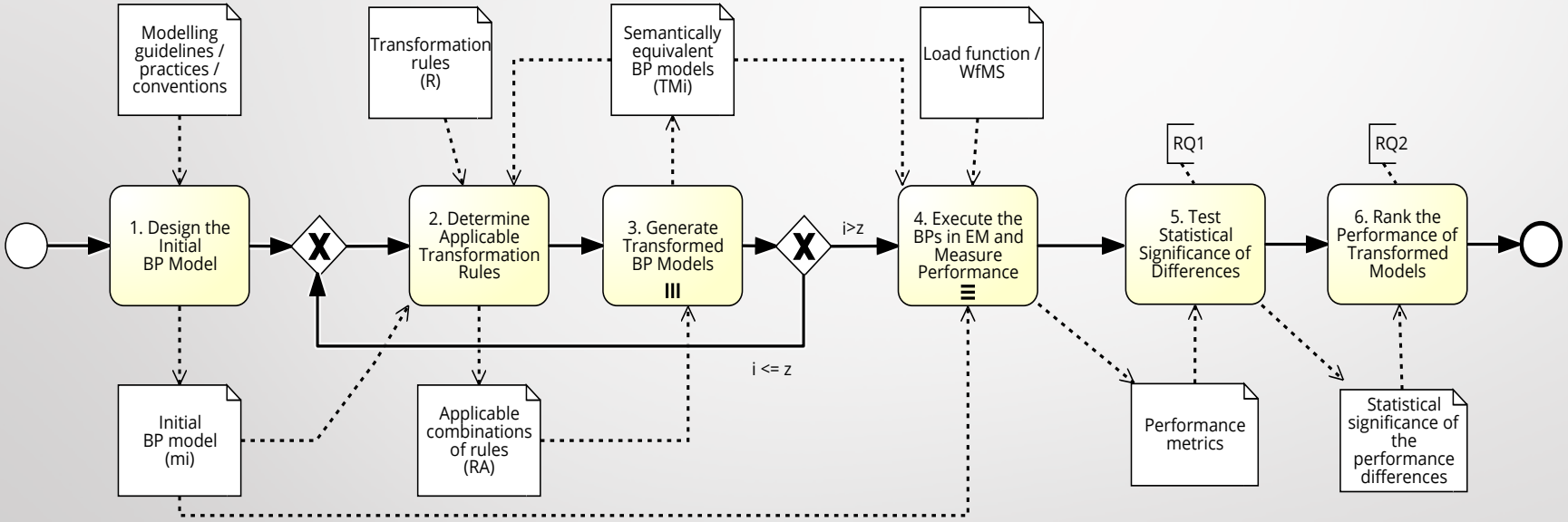

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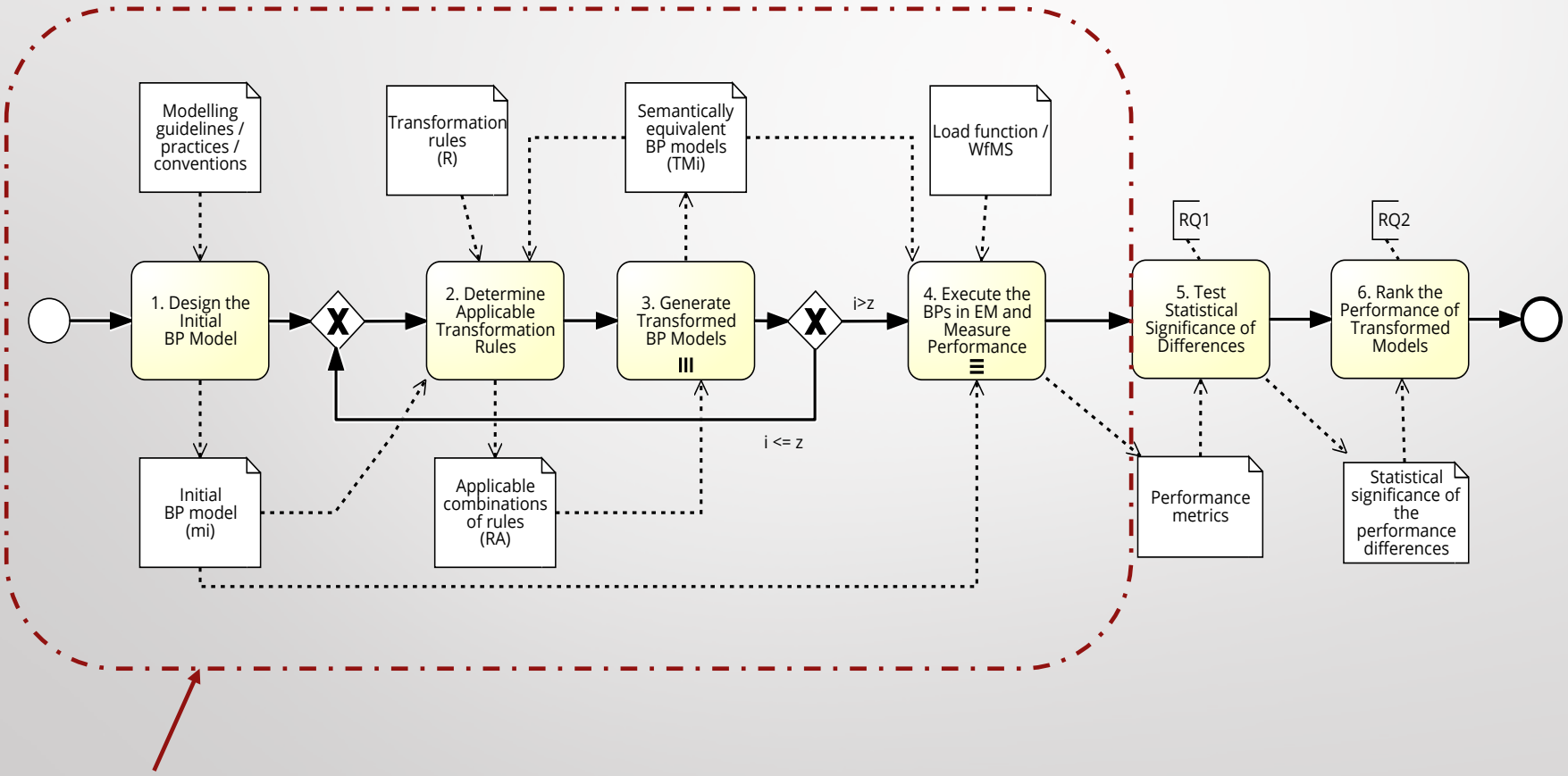

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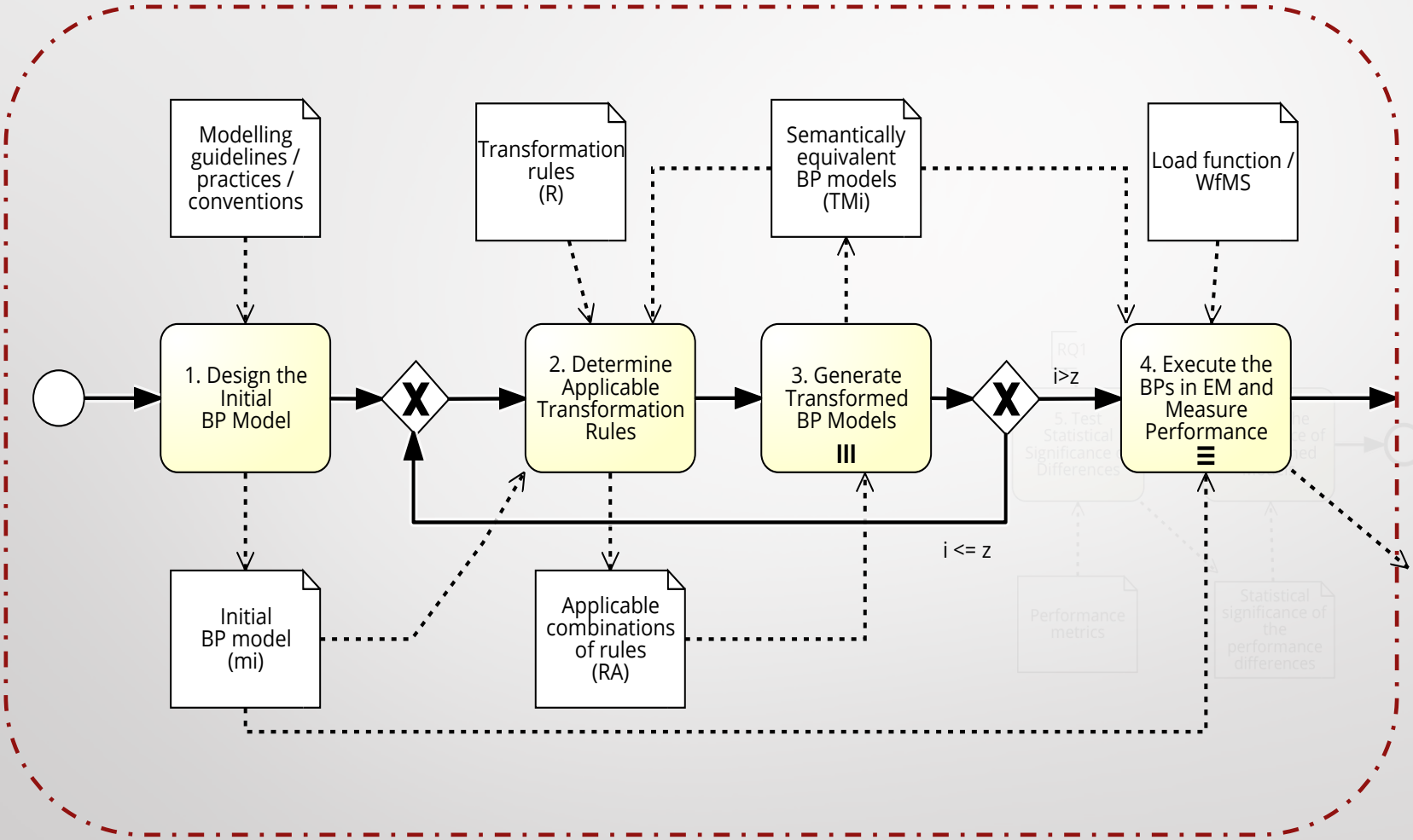
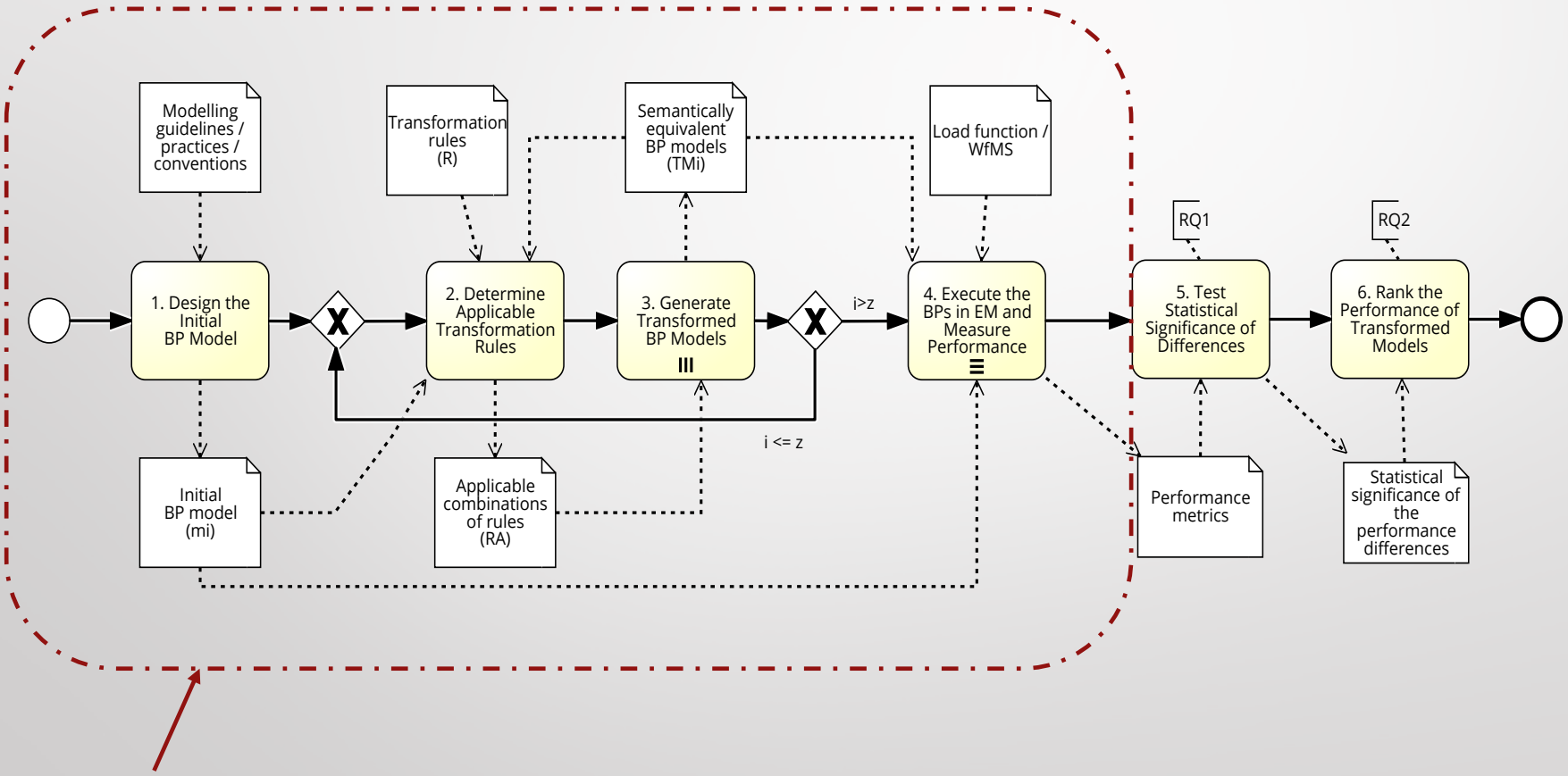


Experiment definition and execution

Methodology



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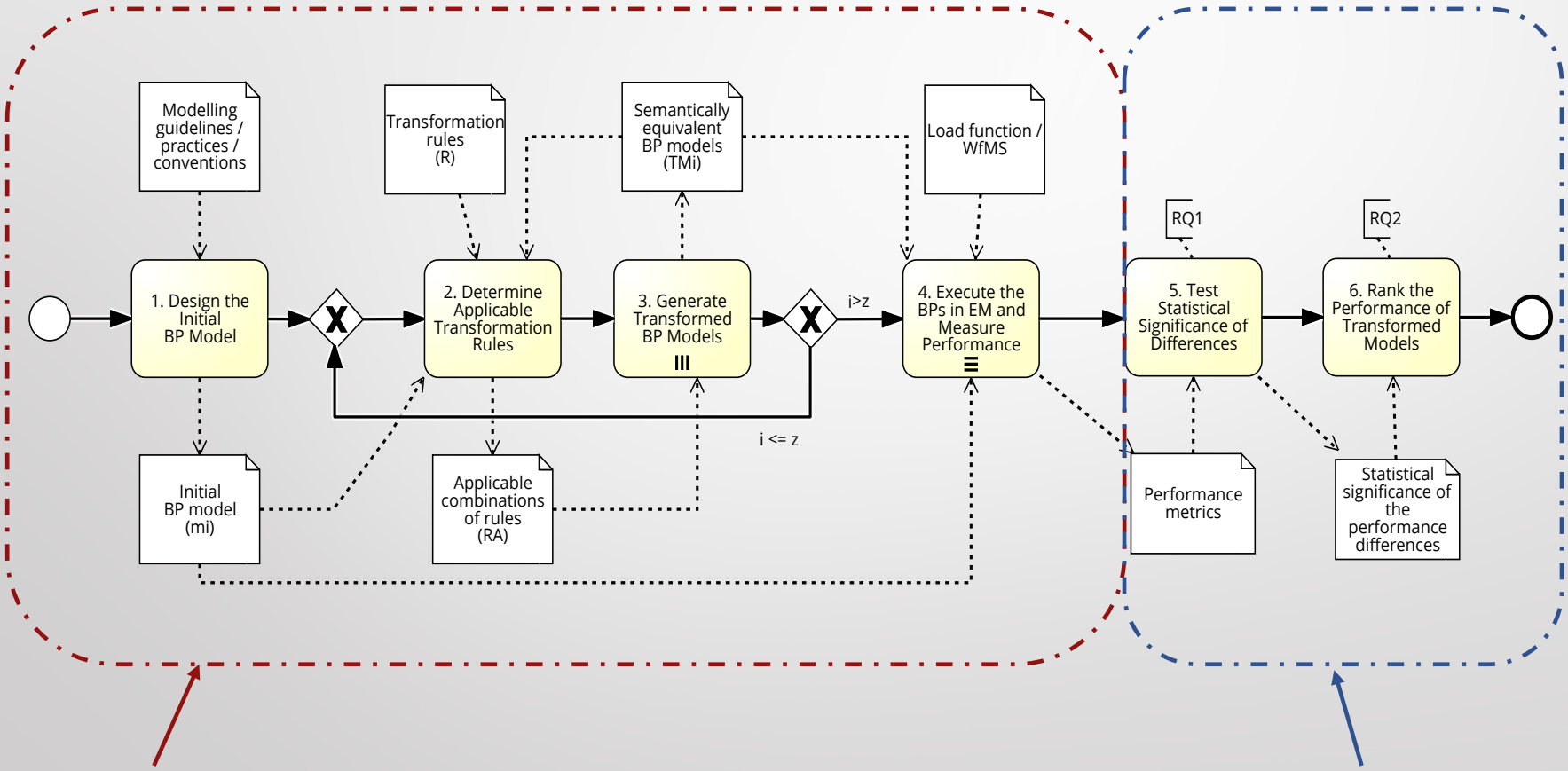

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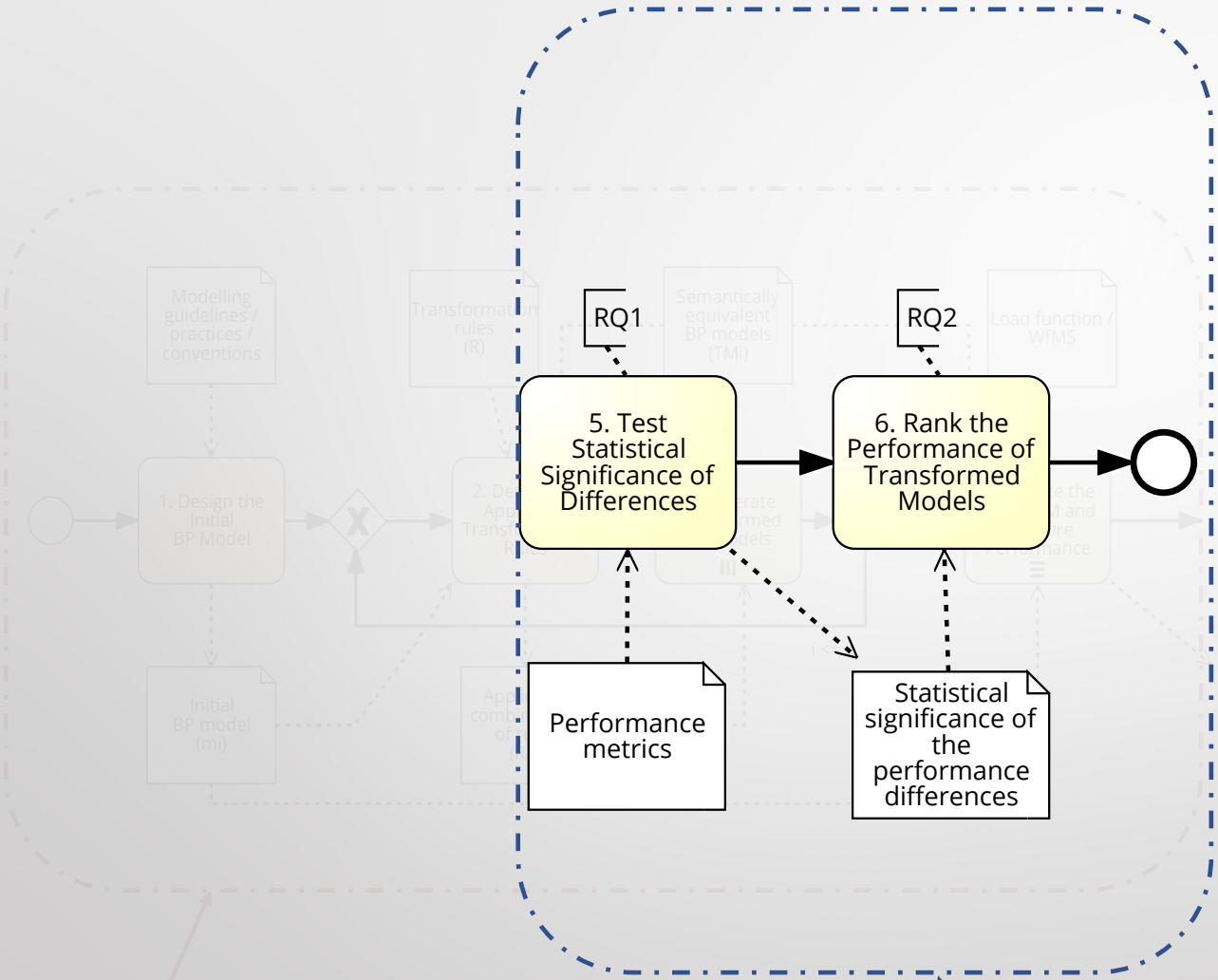

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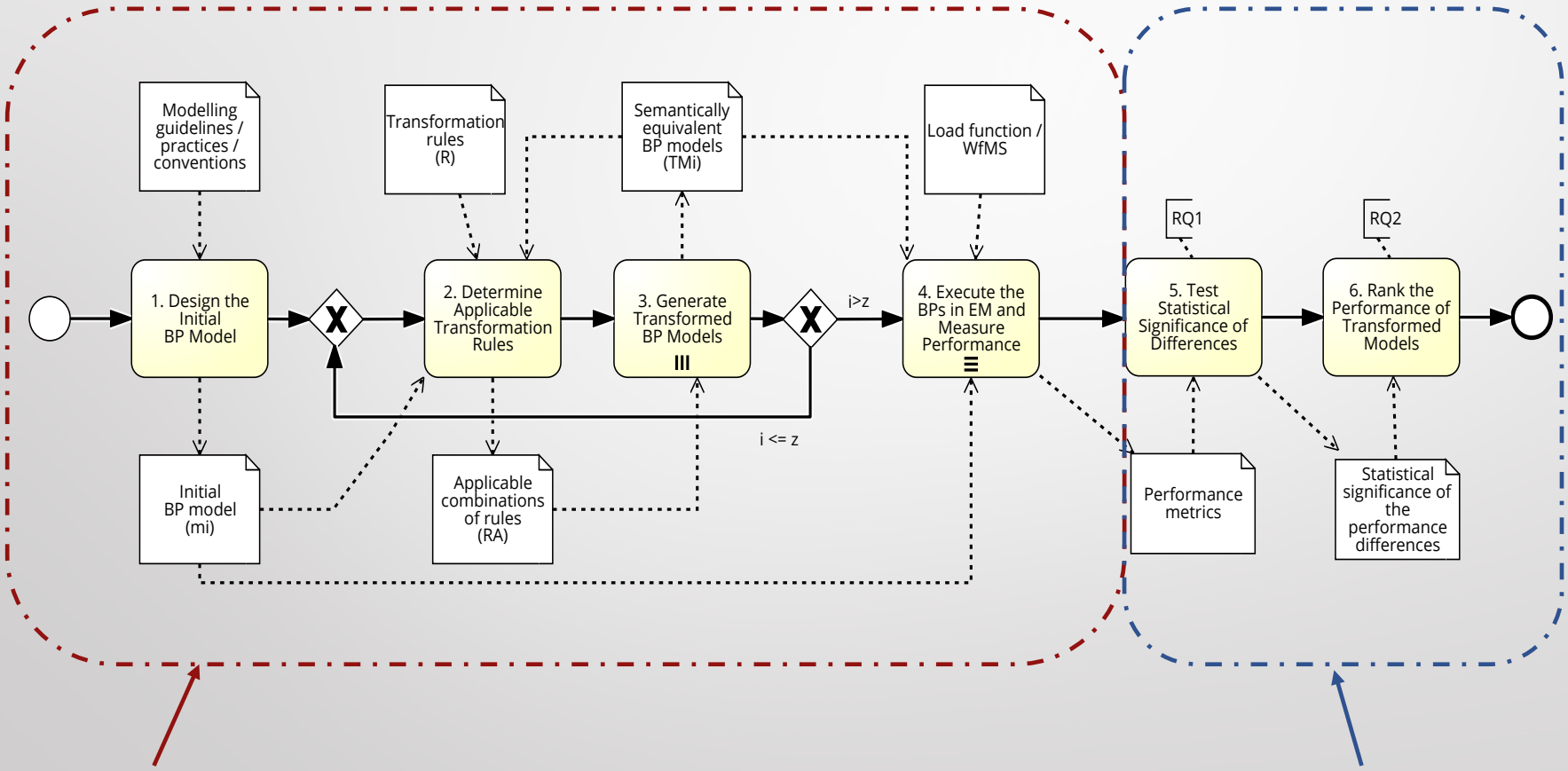
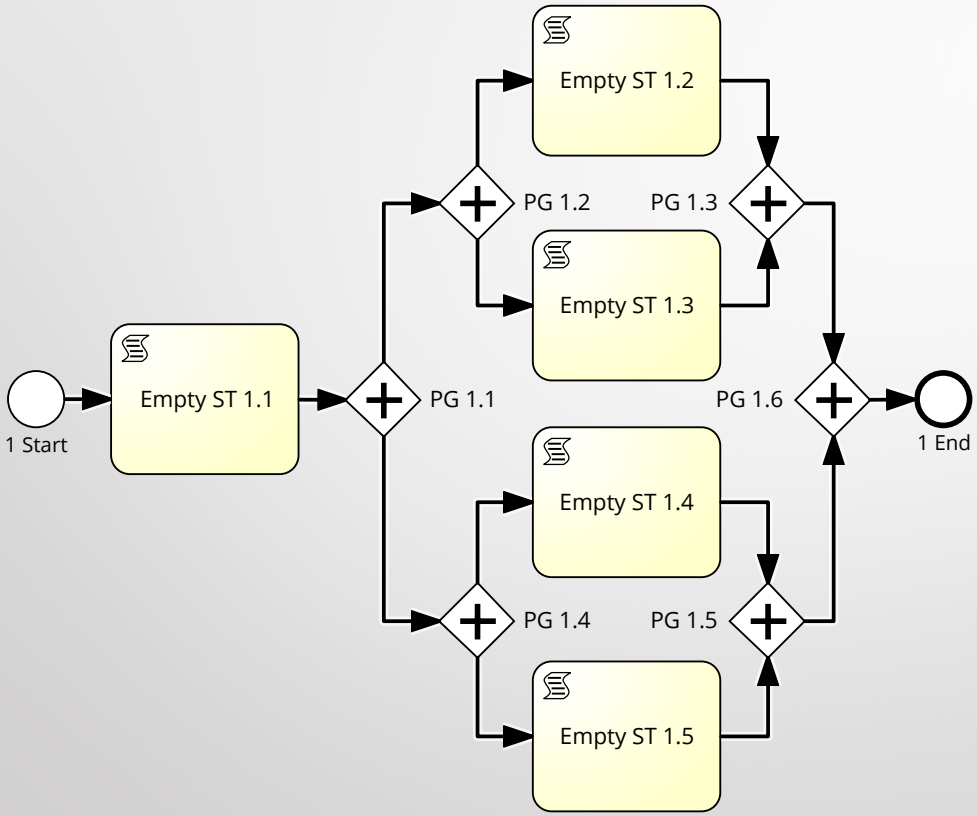
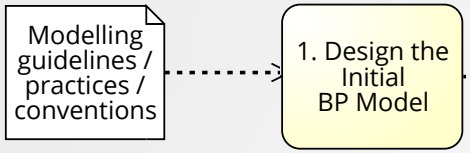


1. Design the Initial BP Model




Modelling guidelines / practices / conventions
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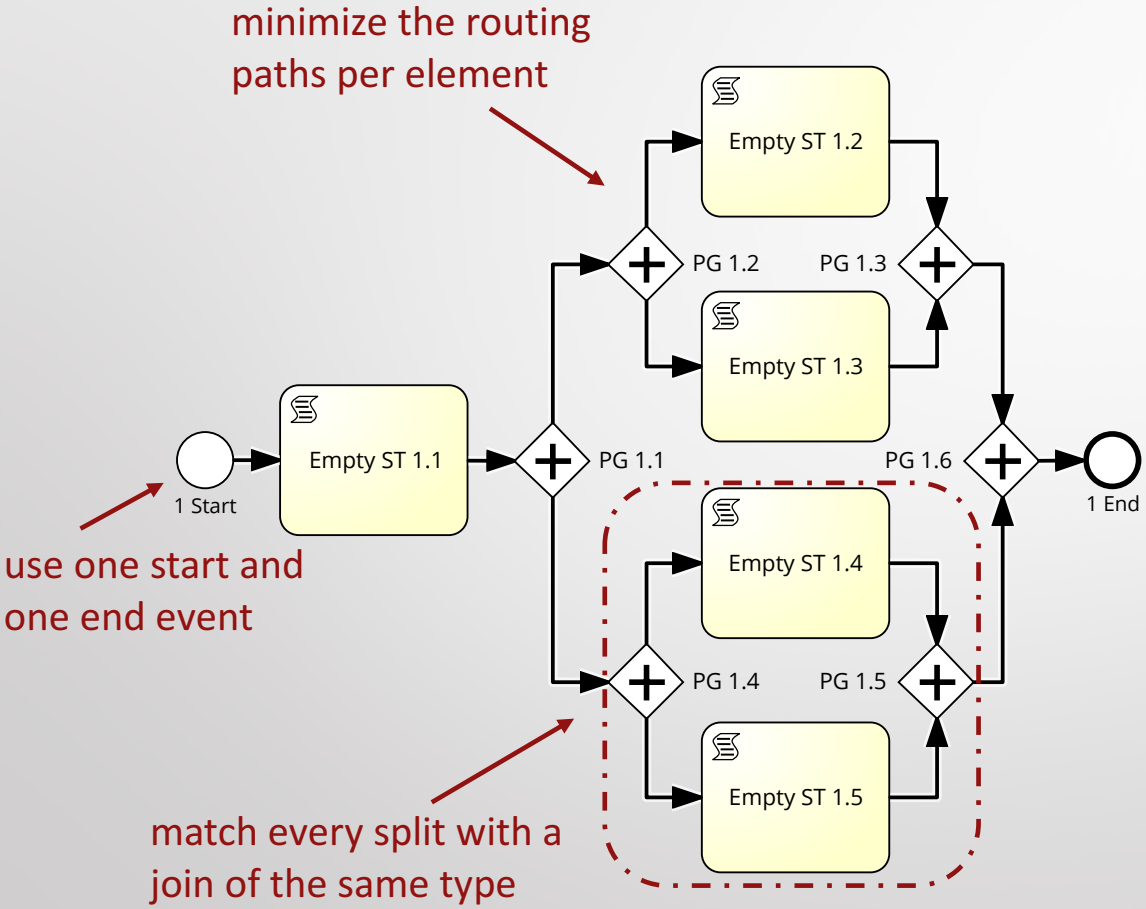
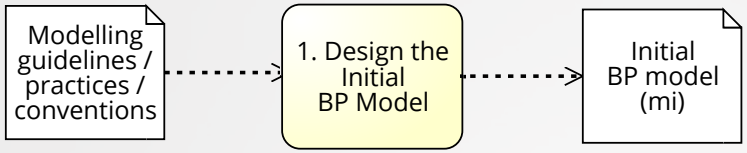

minimize the routing paths per element
Empty ST 1.2
PG 1.2
PG 1.3
Empty ST 1.3
Empty ST 1.1
PG 1.1
PG 1.6
1 Start
1 End
use one start and one end event
Empty ST 1.4
PG 1.4
PG 1.5
Empty ST 1.5
match every split with a join of the same type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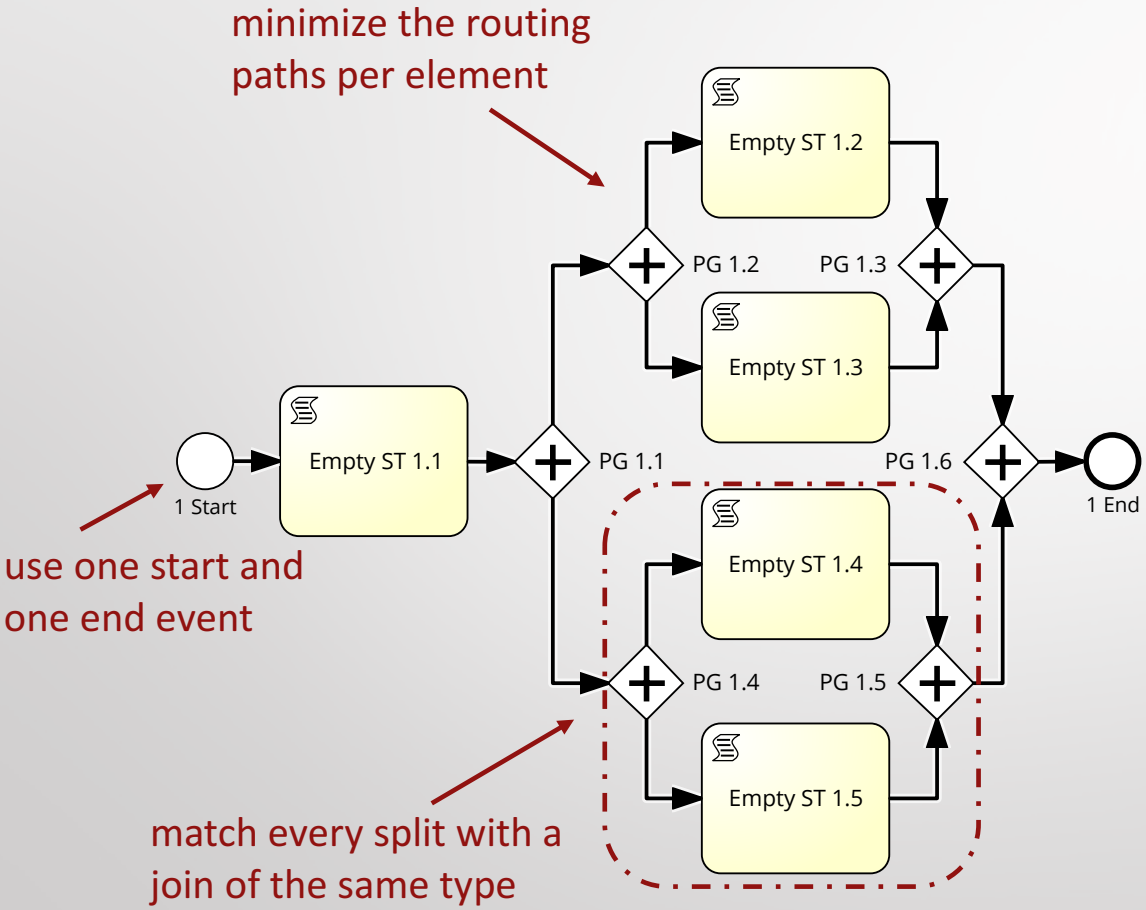
Initial BP model (mi)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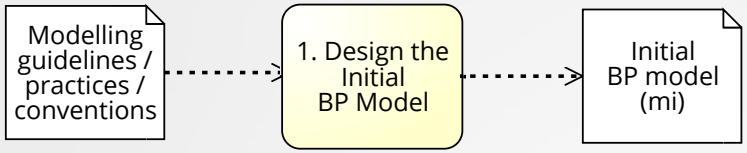
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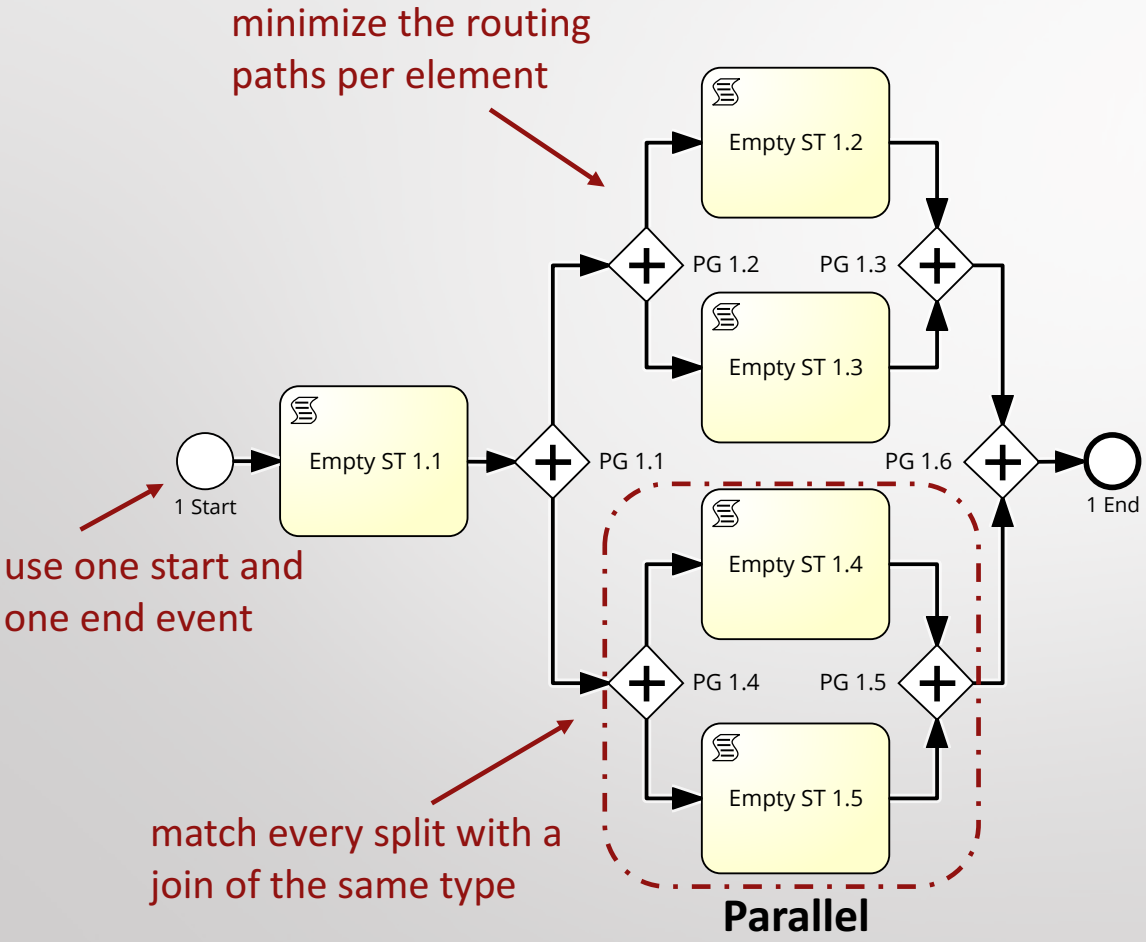
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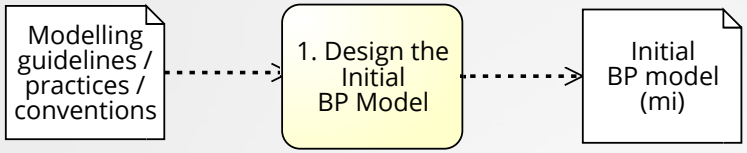
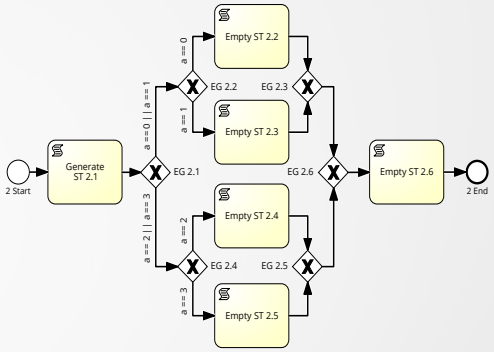
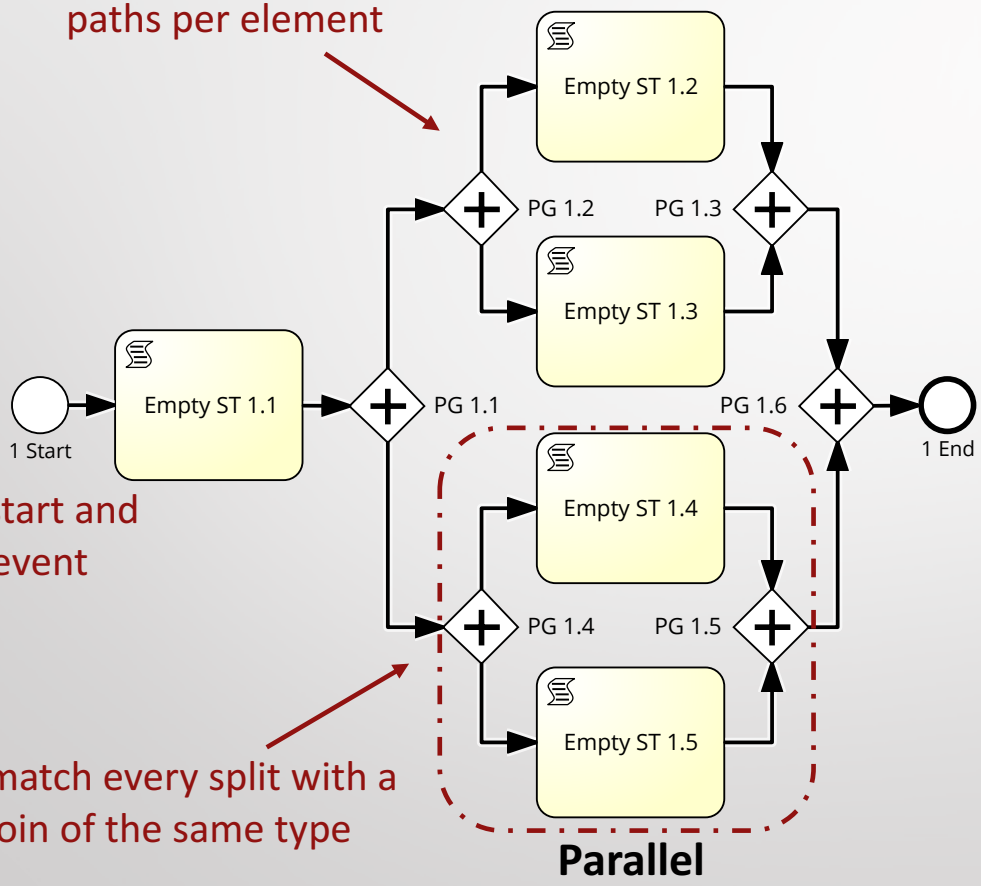
Parallel



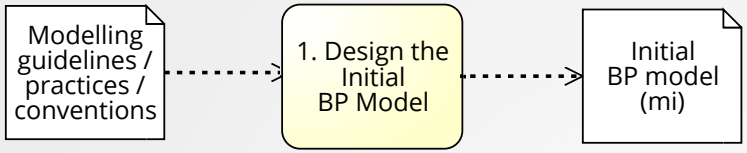


minimize the routing paths per element



use one start and one end event

match every split with a join of the same type



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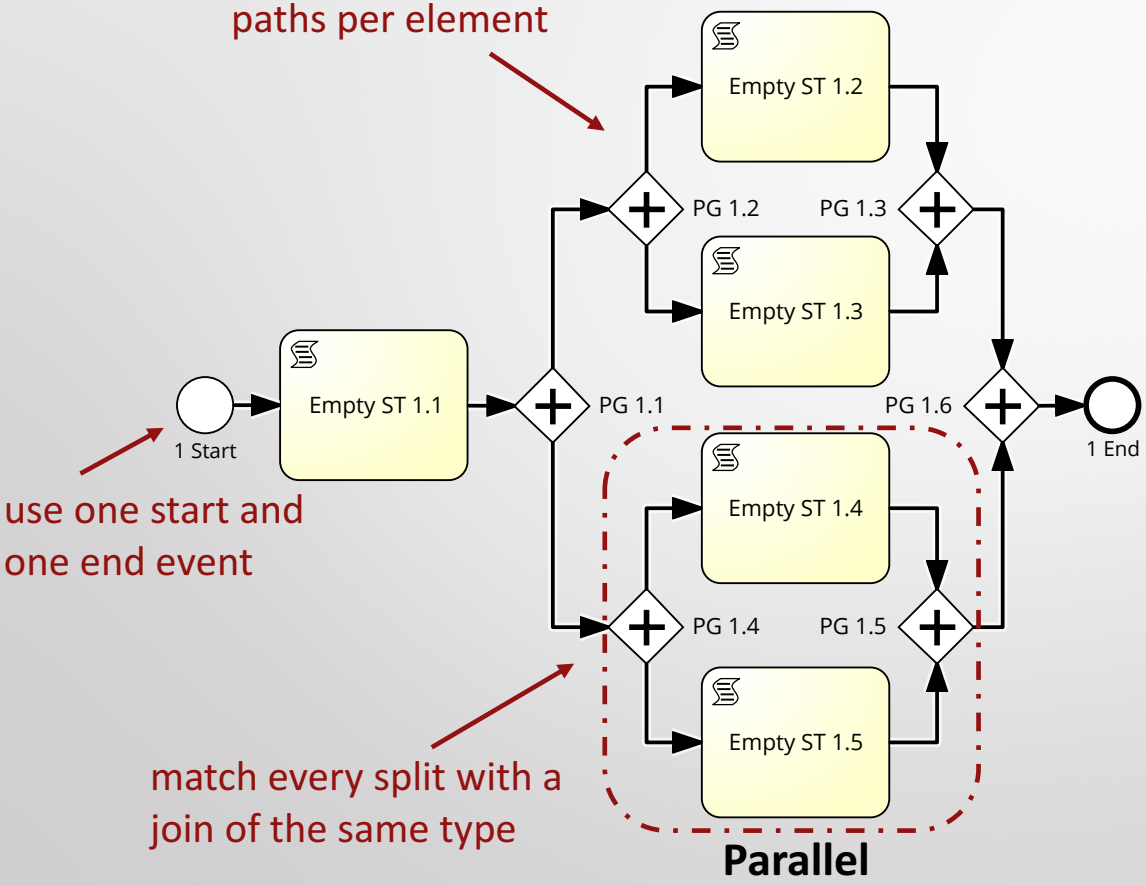

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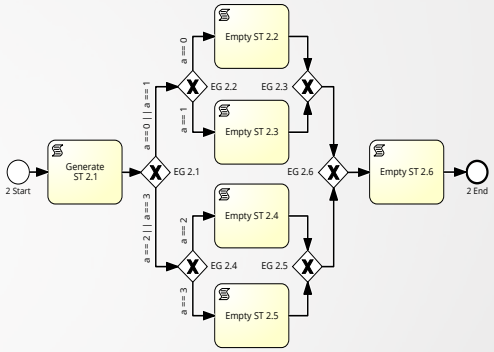
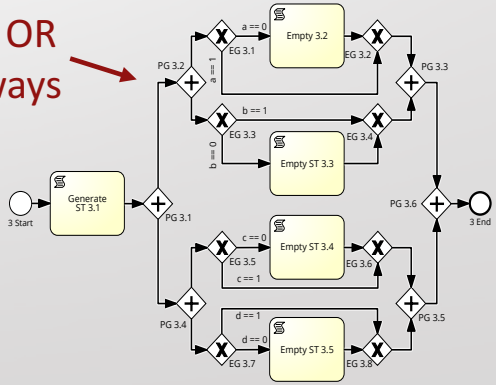


Exclusive

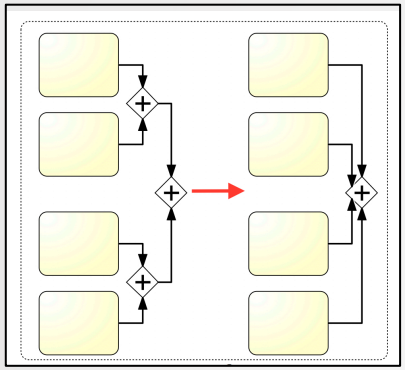
avoid OR gateways



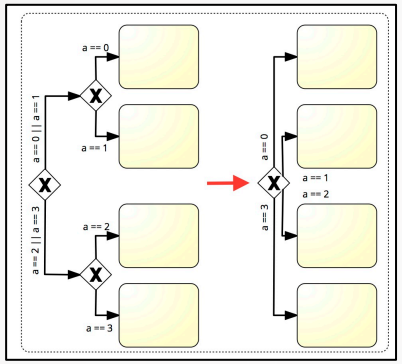
Inclusive

Transformation rules (R)

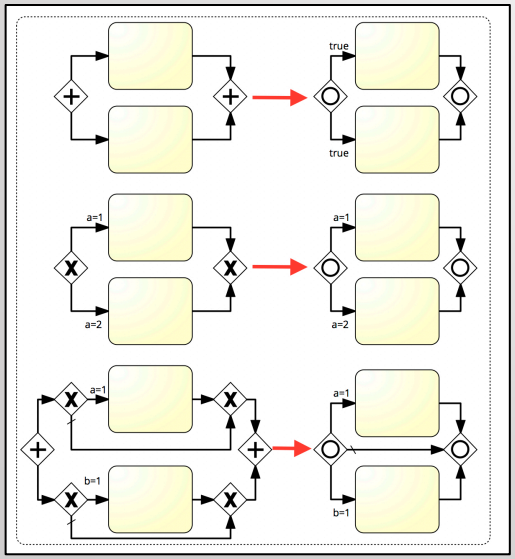
r_1 Coalesce Joins



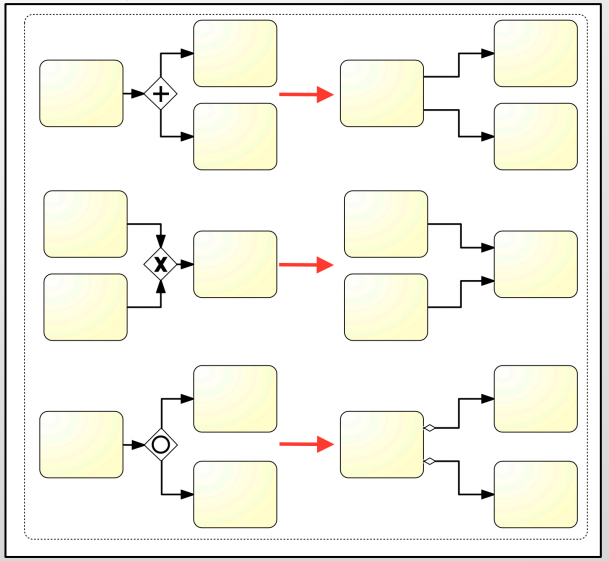
r_2 Coalesce Splits



r_3 Use Inclusive Gateway



r_4 Use Implicit Gateway



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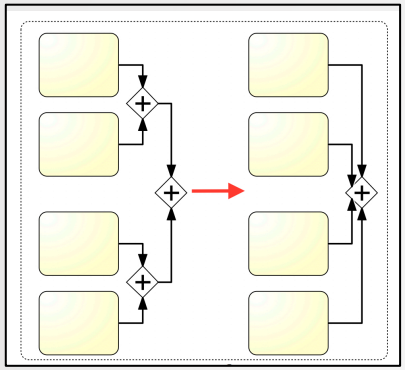
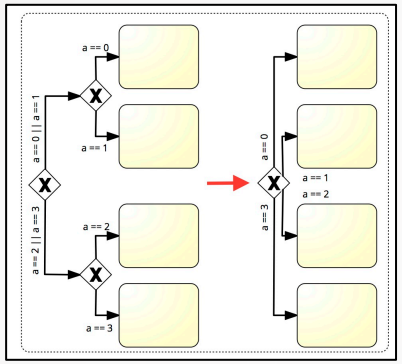
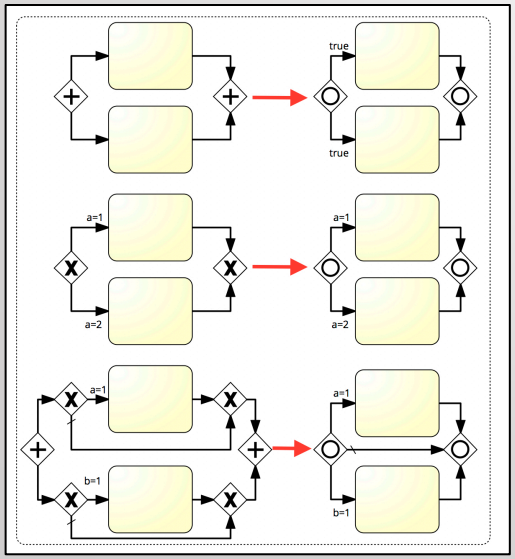


r_2 Coalesce Splits

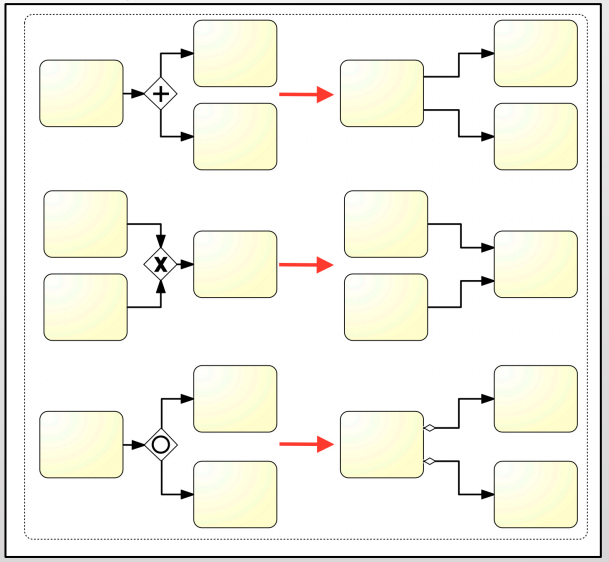


r_3 Use Inclusive Gateway



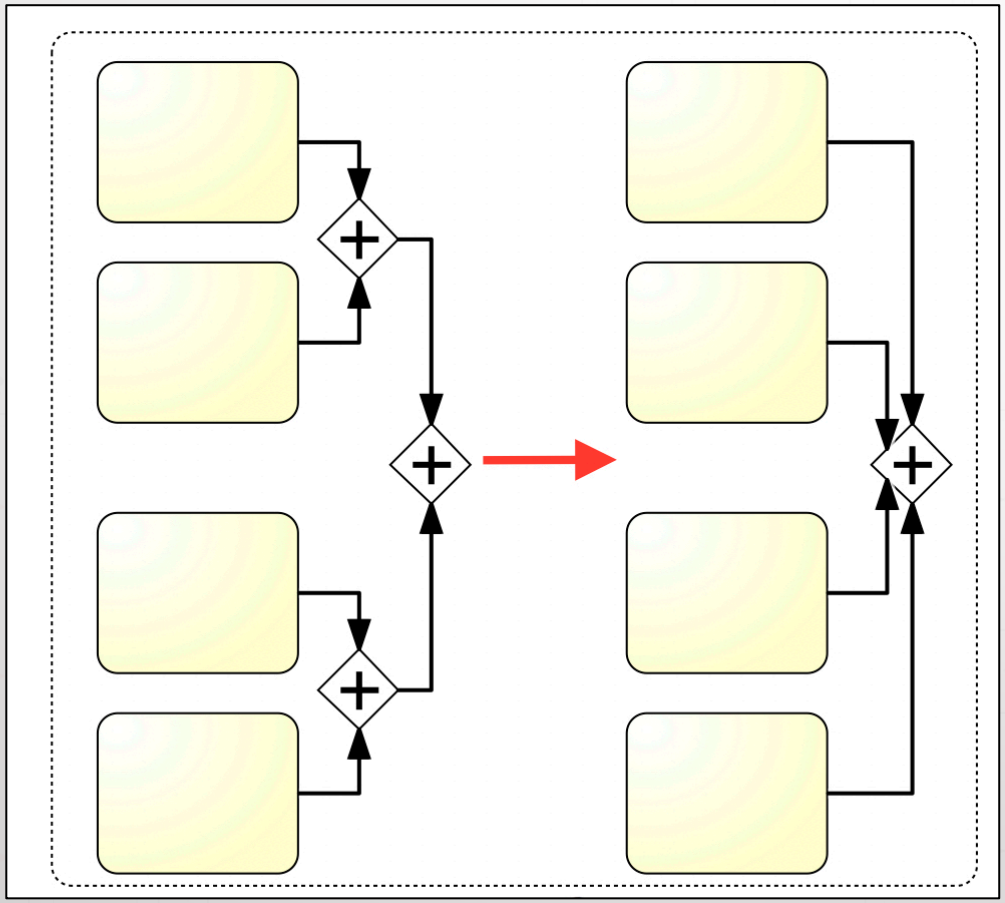
Semantics Preserving Transformation Rules!

r_4 Use Implicit Gateway



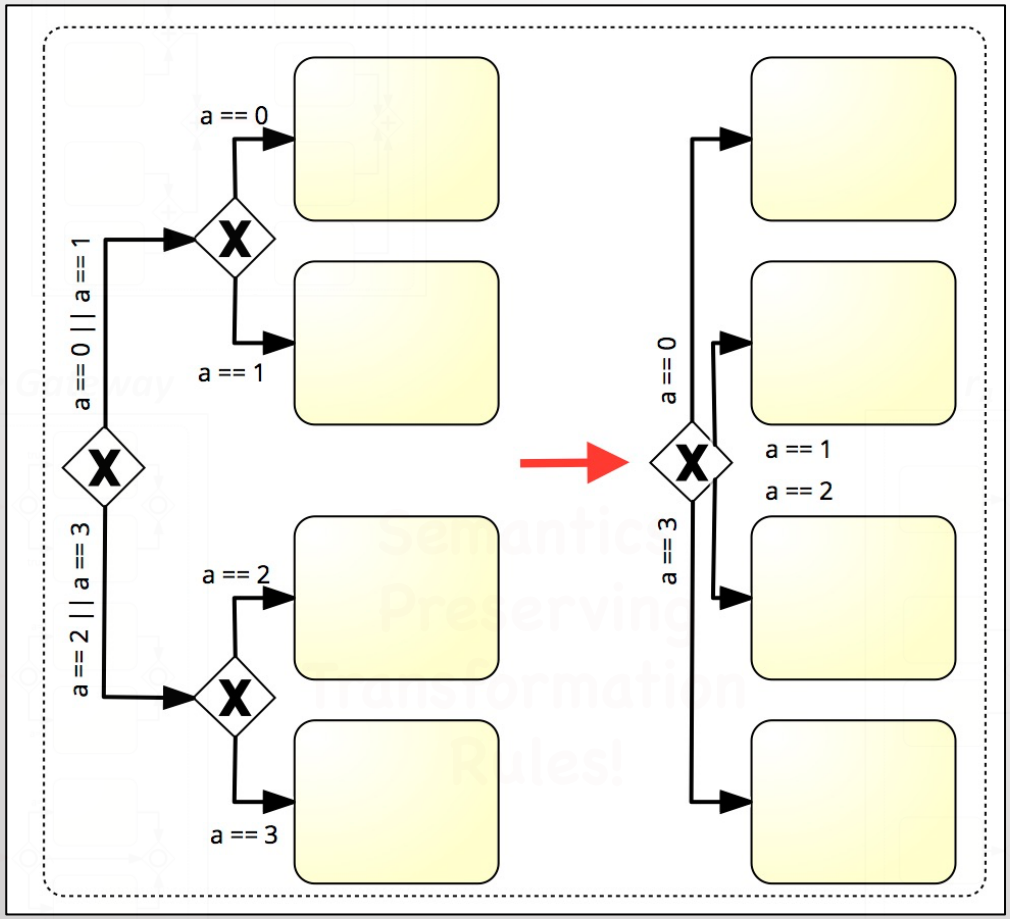
Transformation rules (R)

r_1 Coalesce Joins



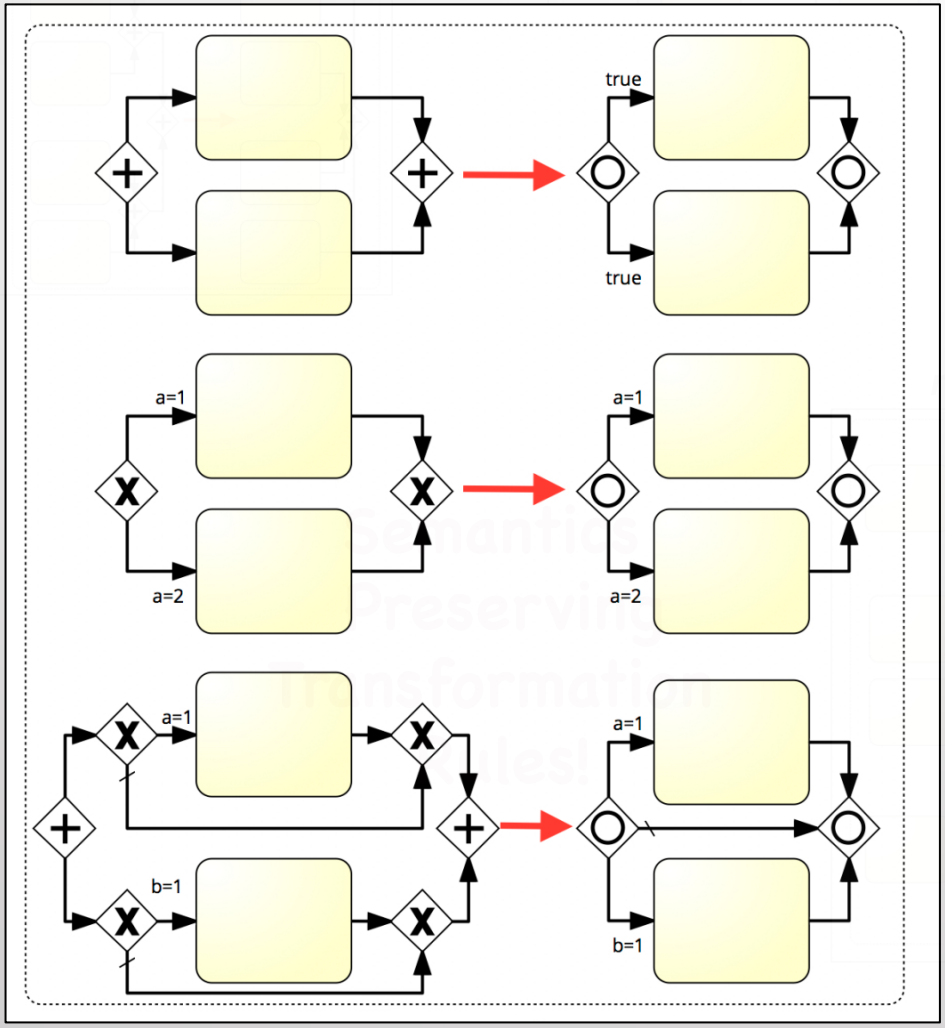
Transformation rules (R)

r_2 Coalesce Splits



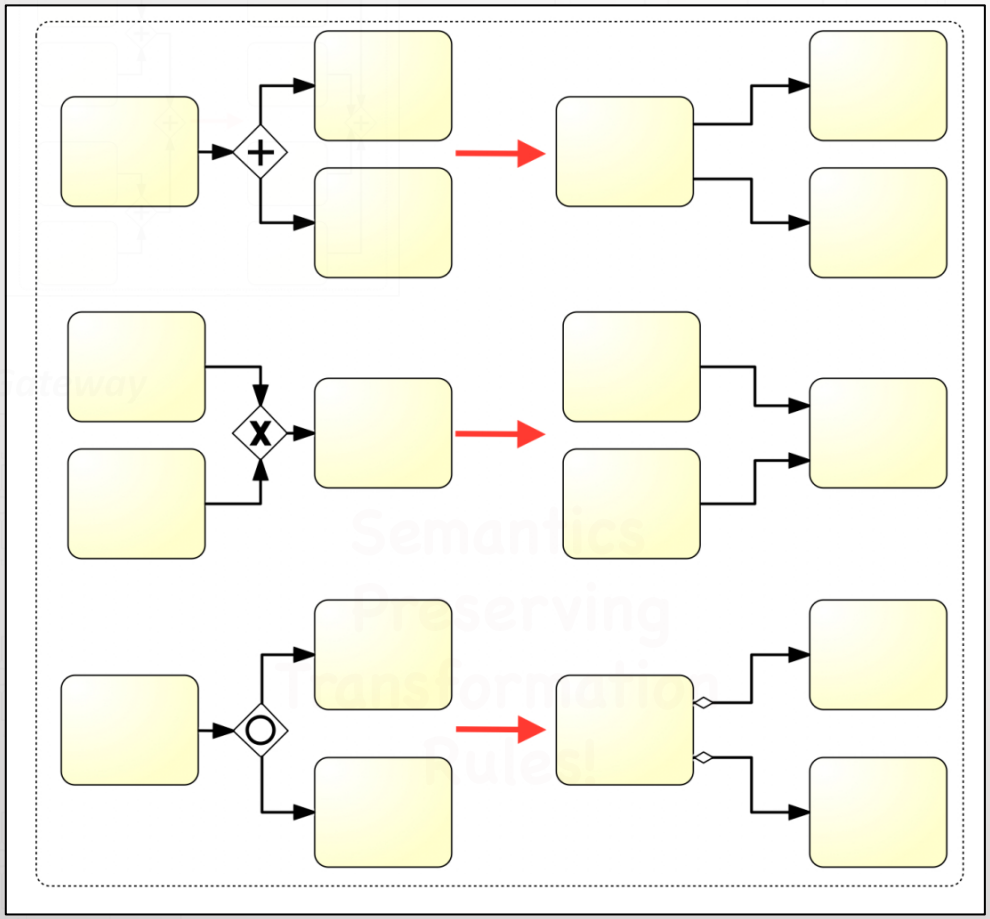
Transformation rules (R)

r_3 Use Inclusive Gateway



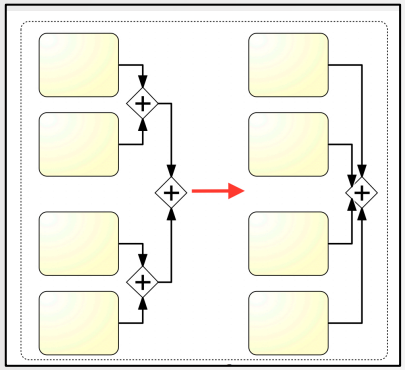
Transformation rules (R)

r_4 Use Implicit Gateway

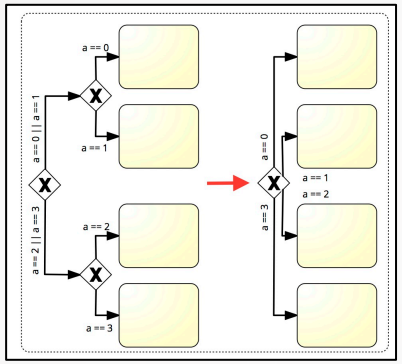


Transformation rules (R)

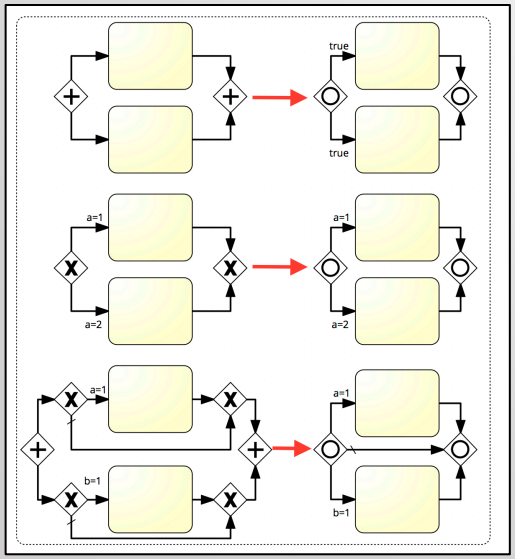
r_1 Coalesce Joins



r_2 Coalesce Splits

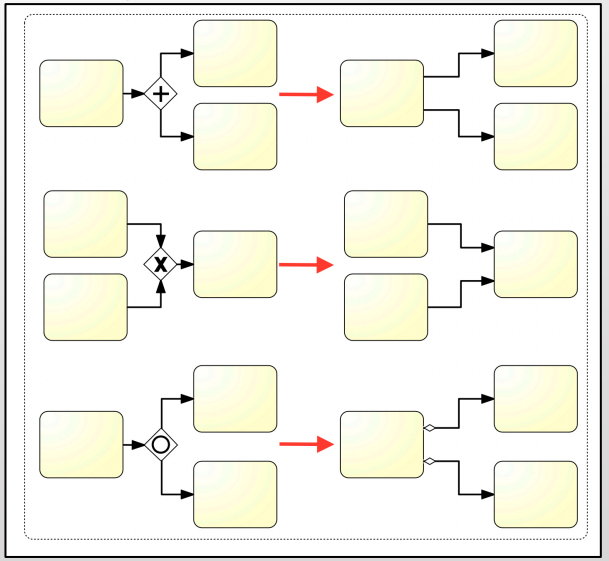


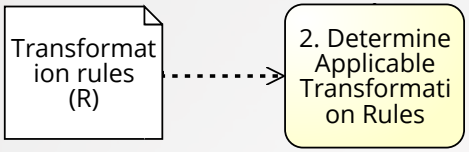
r_3 Use Inclusive Gateway



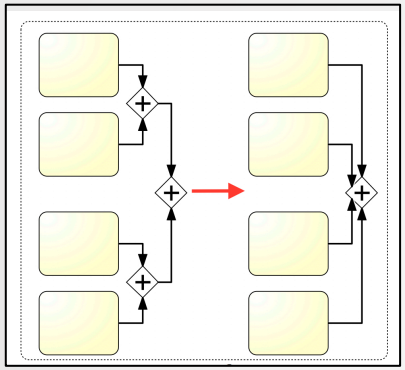
Semantics Preserving Transformation Rules!

r_4 Use Implicit Gateway

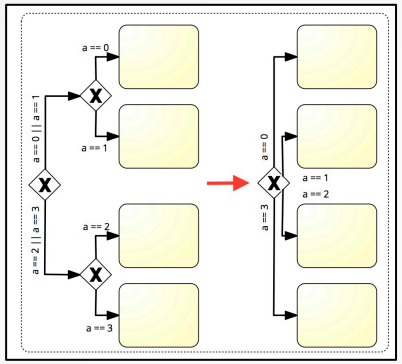




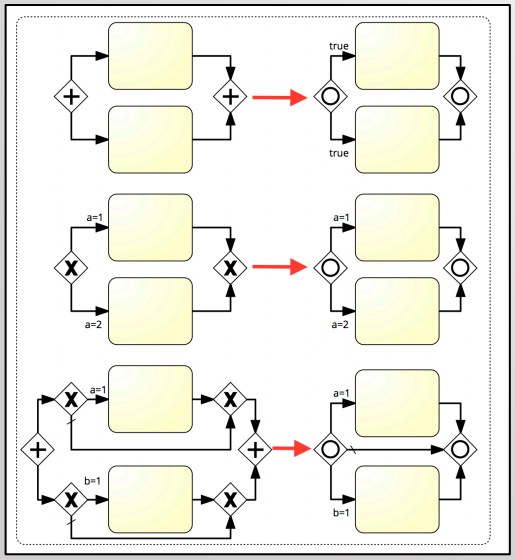
r_1 Coalesce Joins



r_2 Coalesce Splits

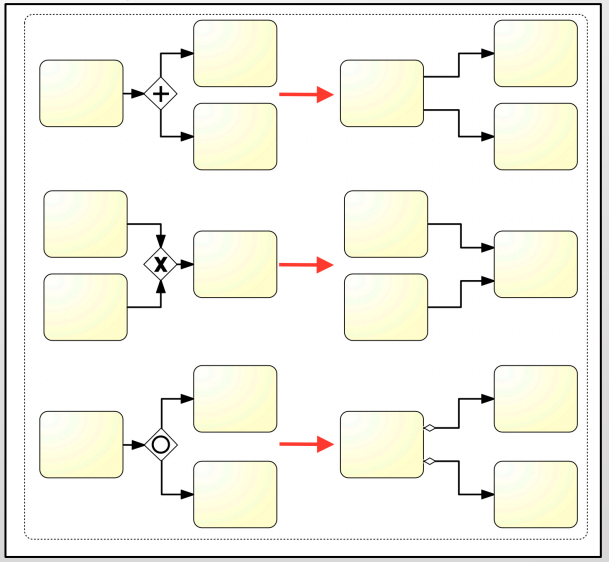


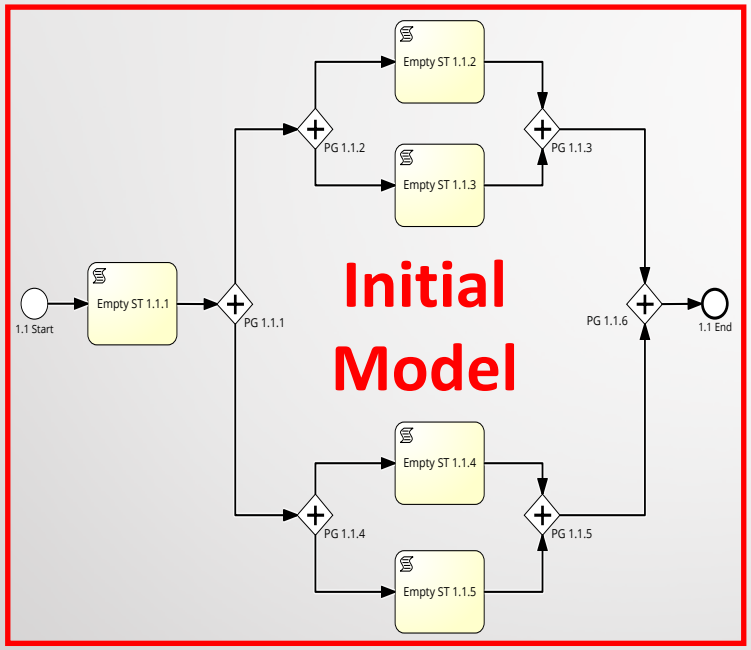
r_3 Use Inclusive Gateway



Semantics Preserving Transformation Rules!

r_4 Use Implicit Gateway




Empty ST 1.1.2
PG 1.1.2
PG 1.1.3
Empty ST 1.1.3
Empty ST 1.1.1
1.1 Start
PG 1.1.1
Initial
Model
PG 1.1.6
1.1 End
Empty ST 1.1.4
PG 1.1.4
PG 1.1.5
Empty ST 1.1.5

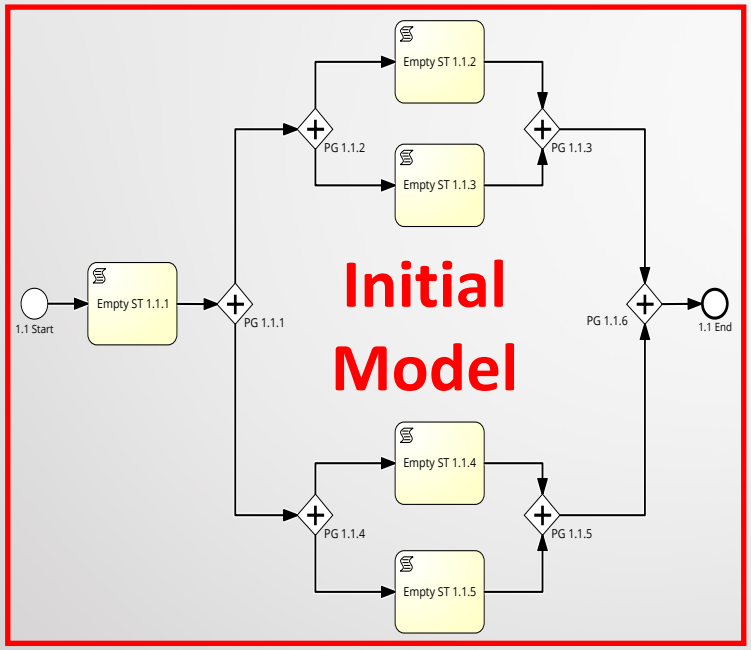
Transformation rules (R)

t1

coalesce joins

t4

use implicit gateway

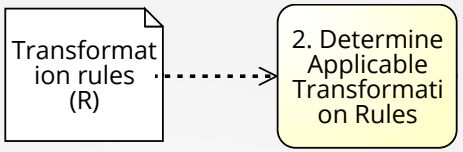


t2

coalesce splits

t3

use inclusive gateway

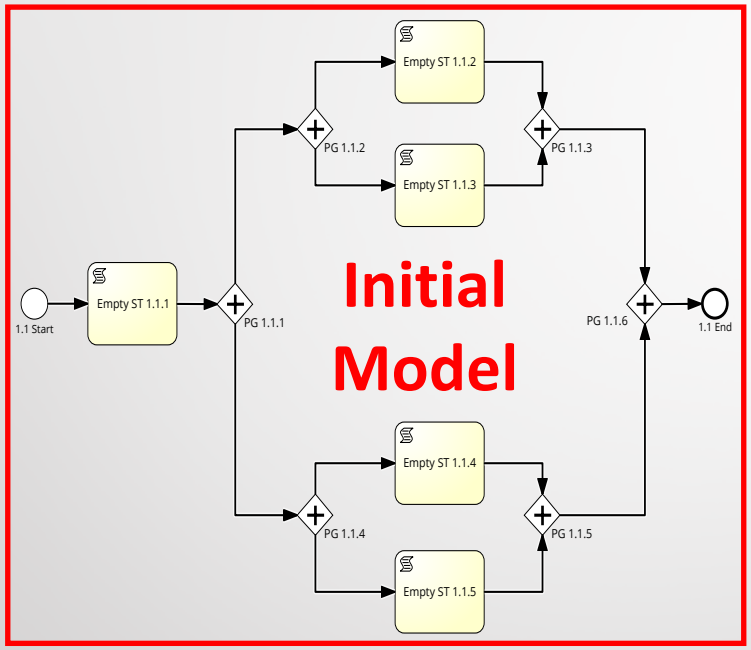


t1

coalesce joins

t4

use implicit gateway

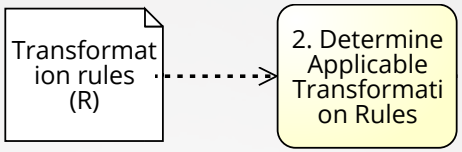


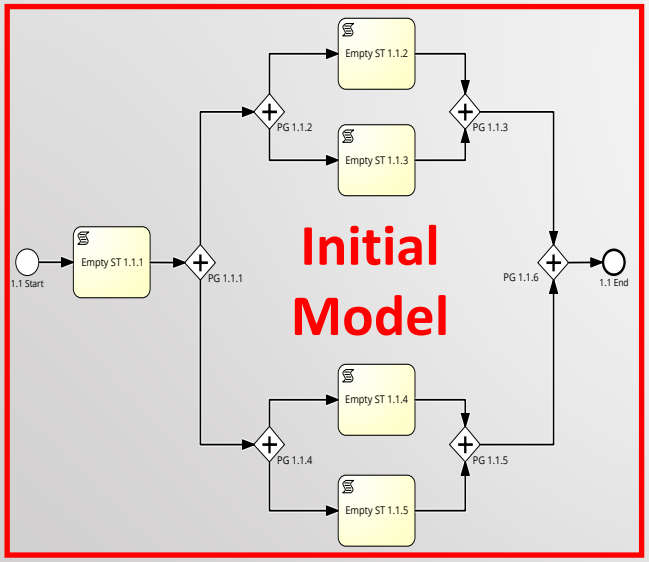
t2

coalesce splits

t3

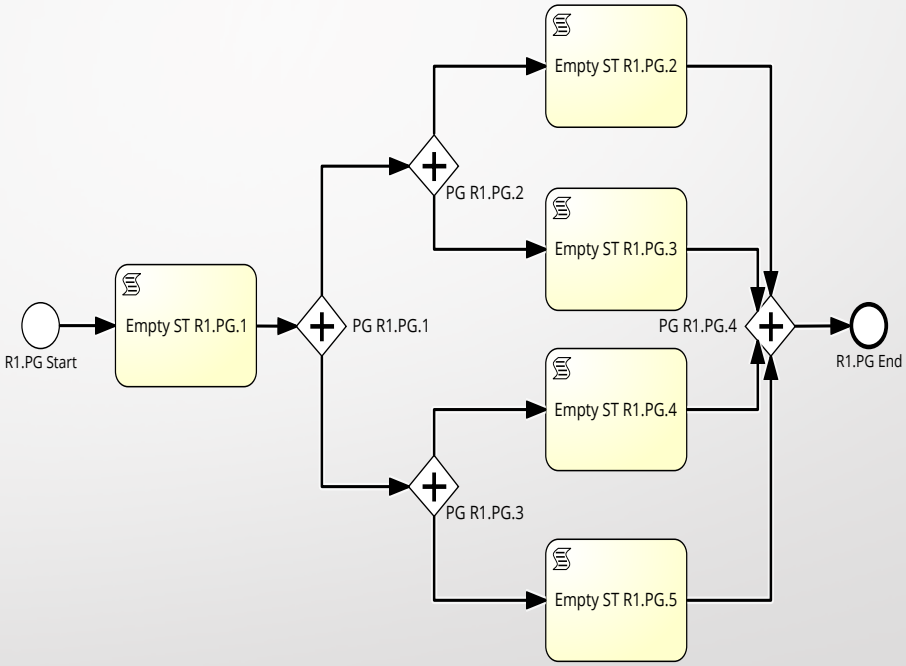
use inclusive gateway

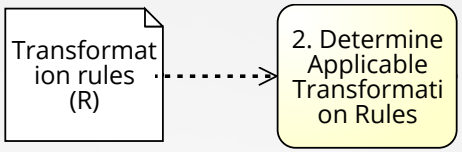


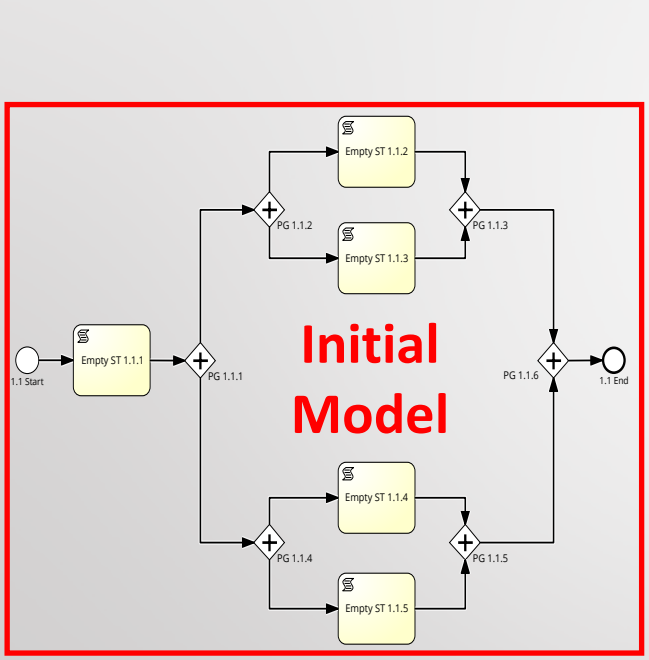


t1

coalesce joins

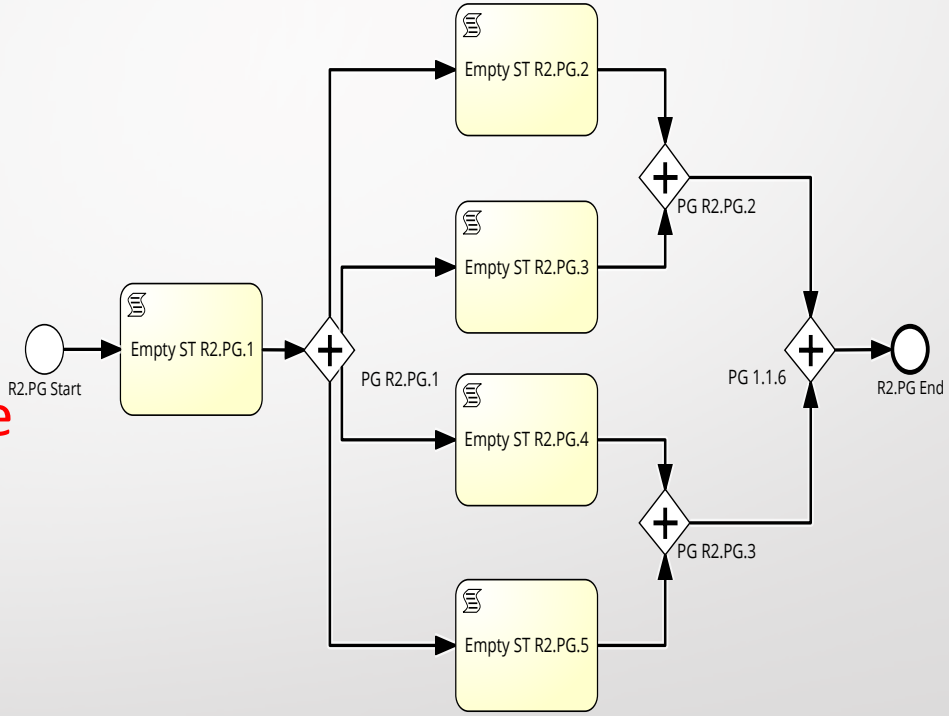


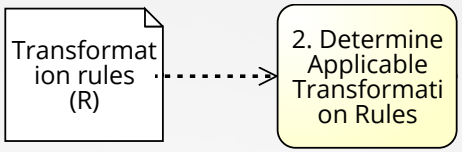


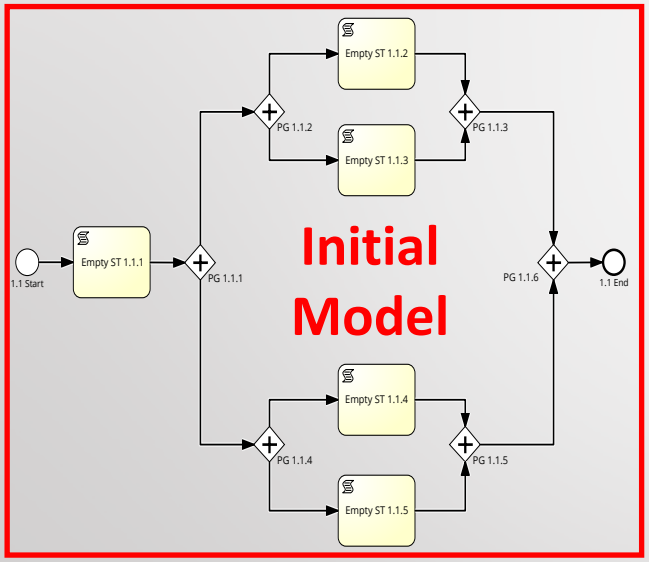


t2

coalesce splits

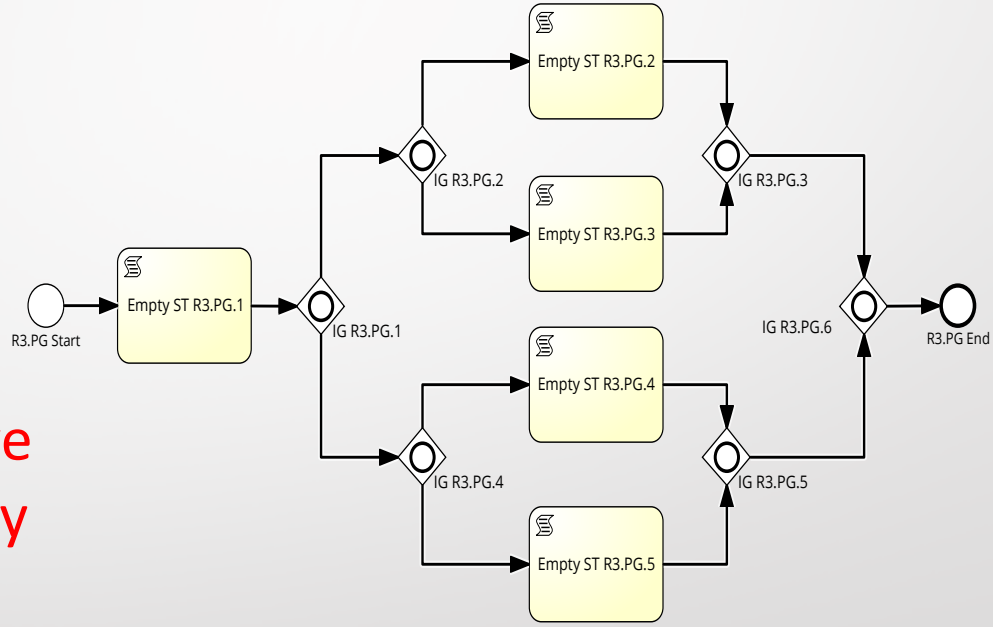


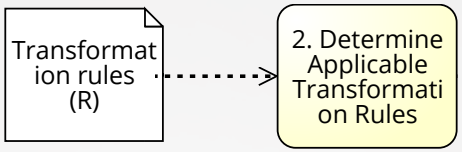


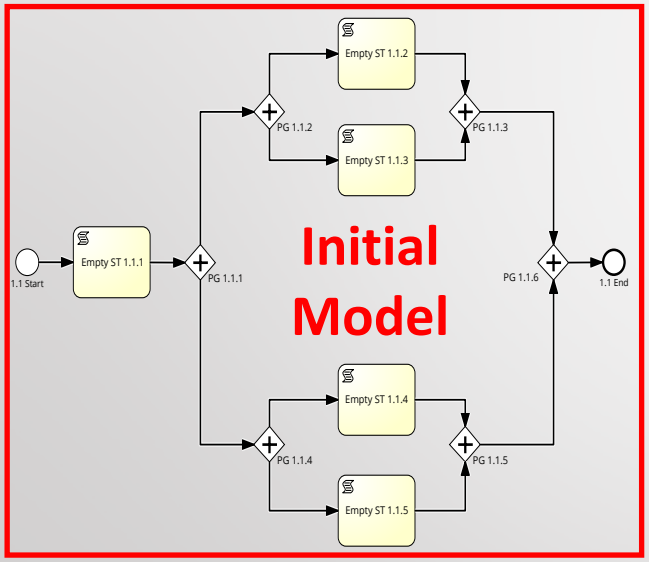


t3

use inclusive gateway

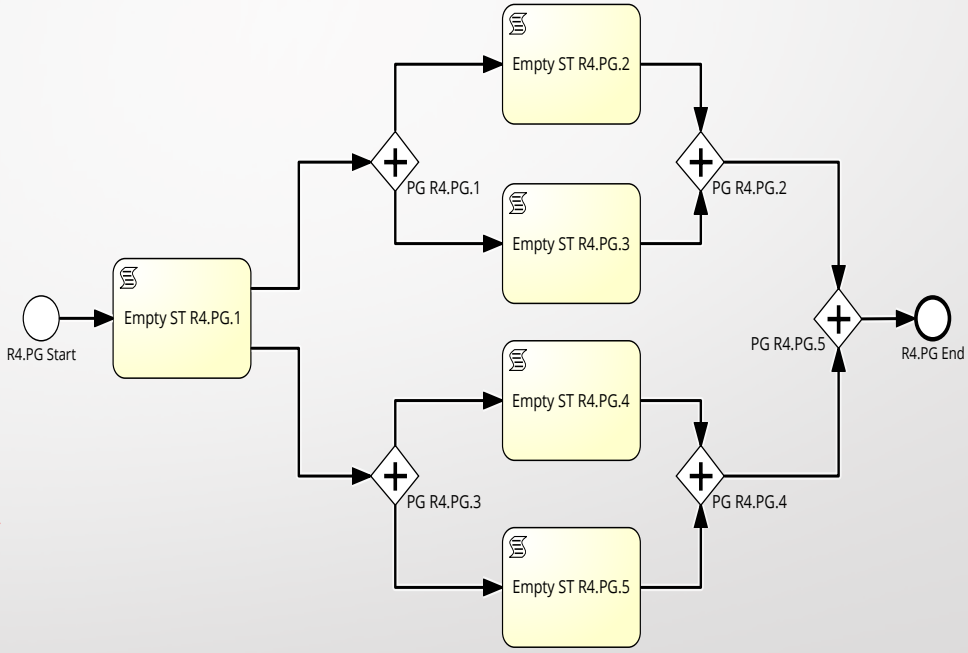


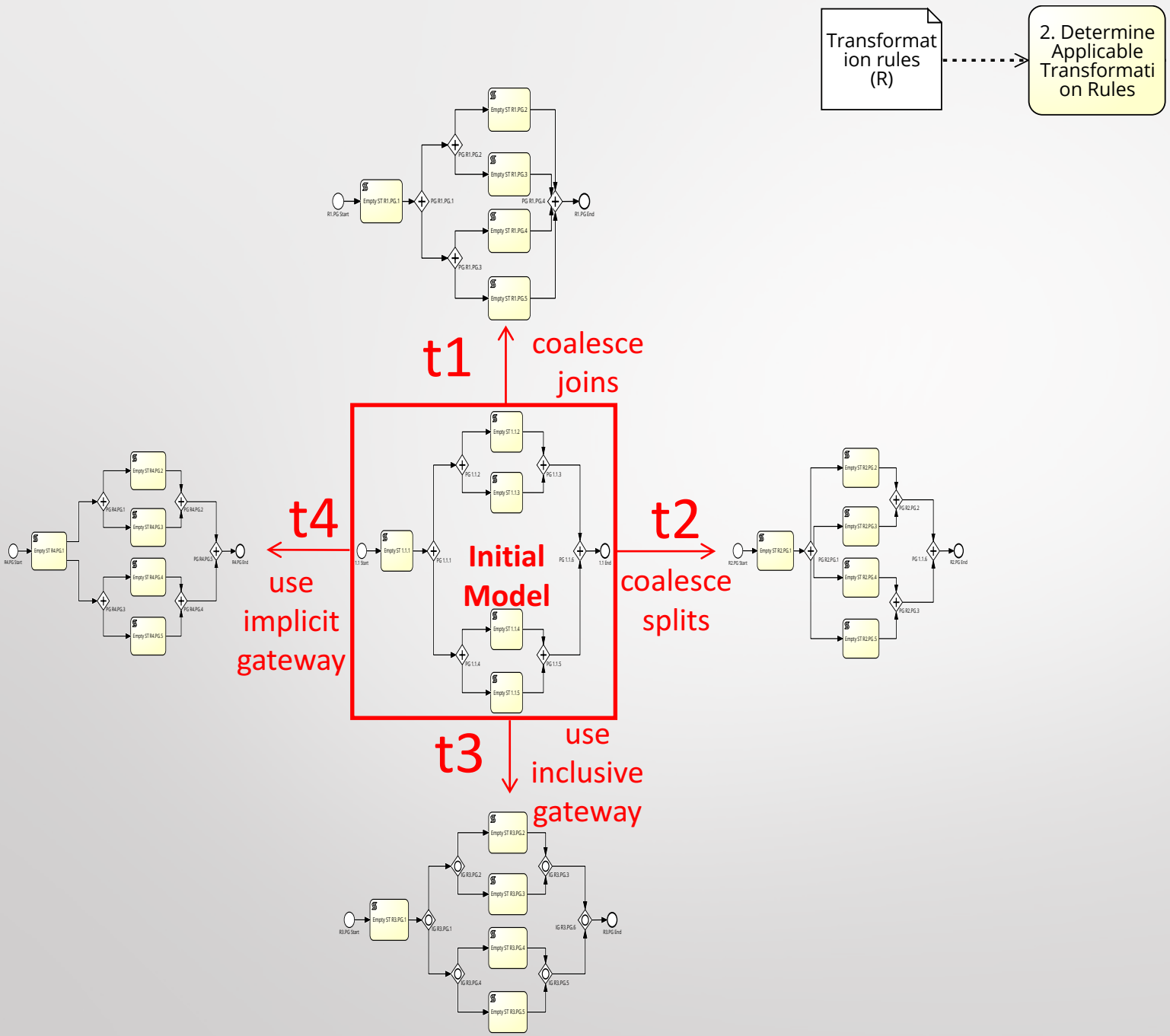


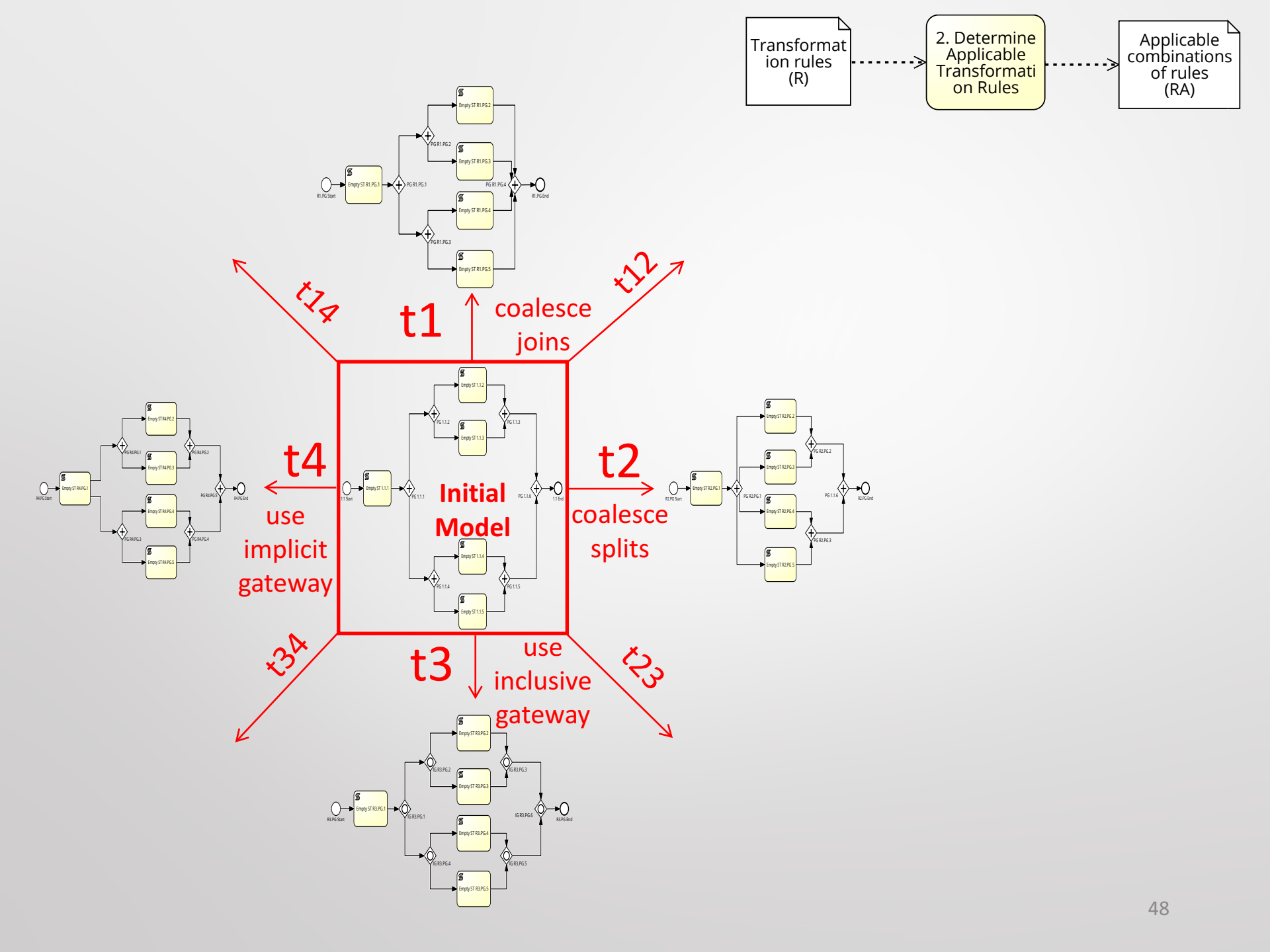


t4

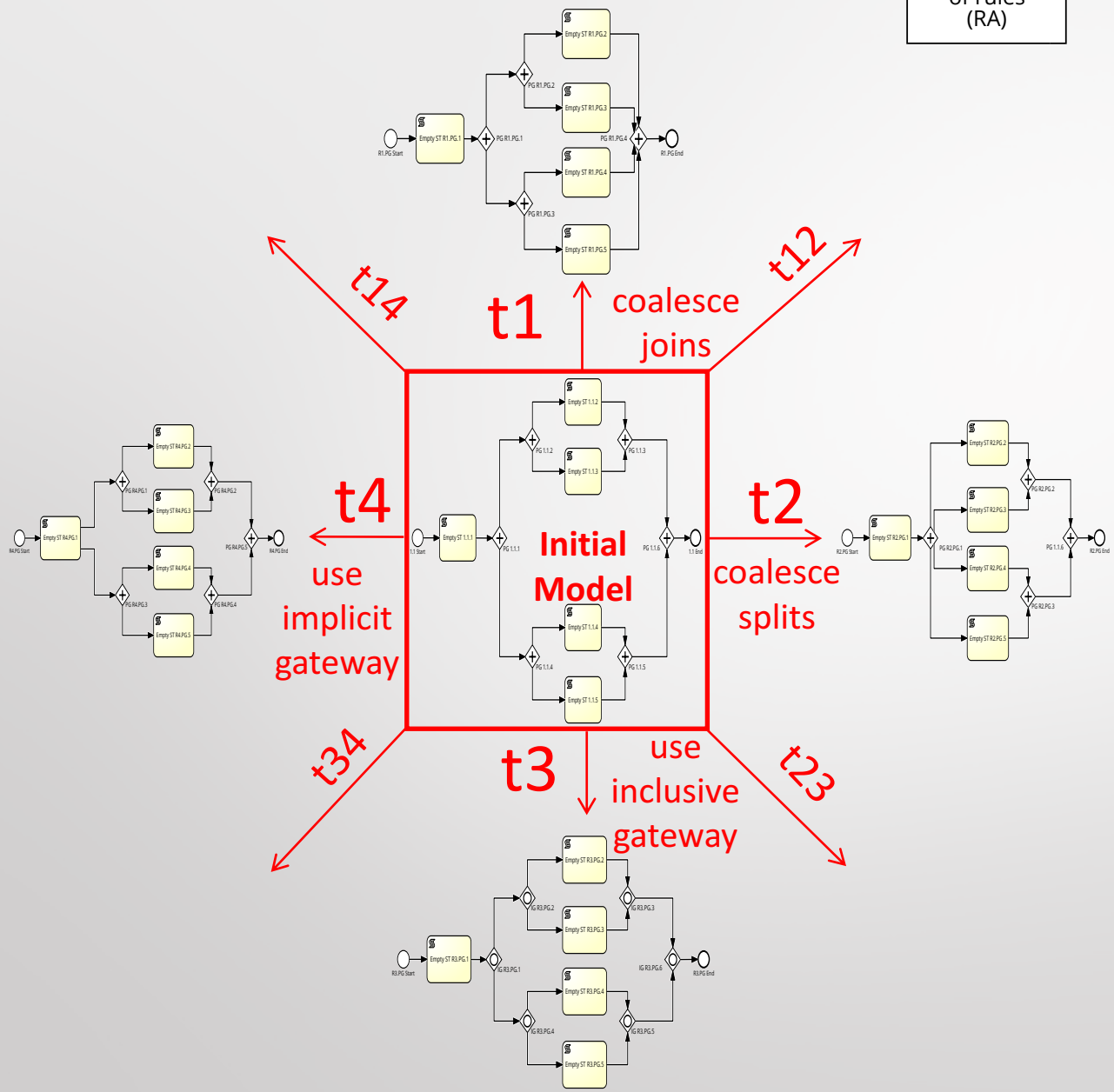
use implicit gateway

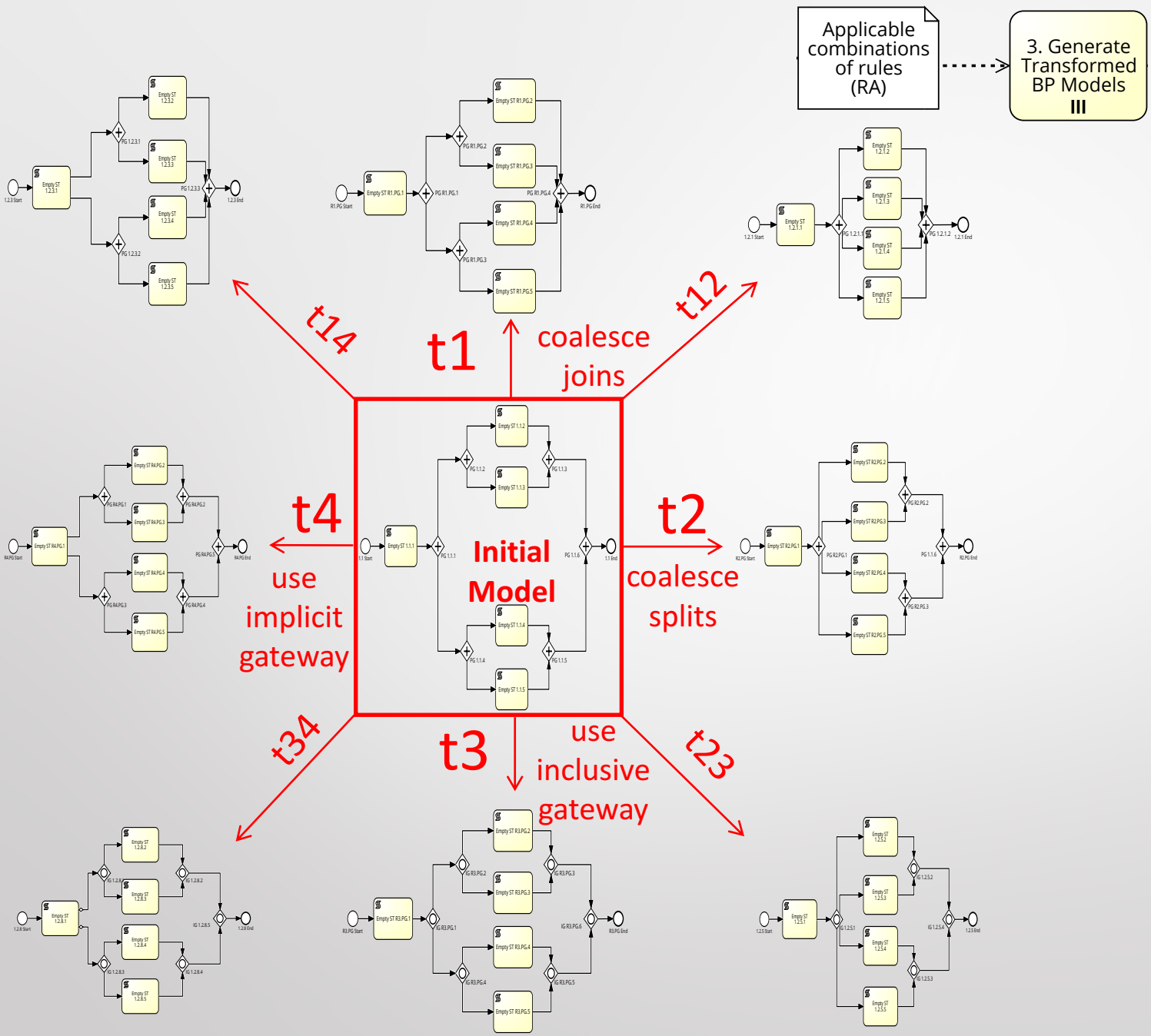


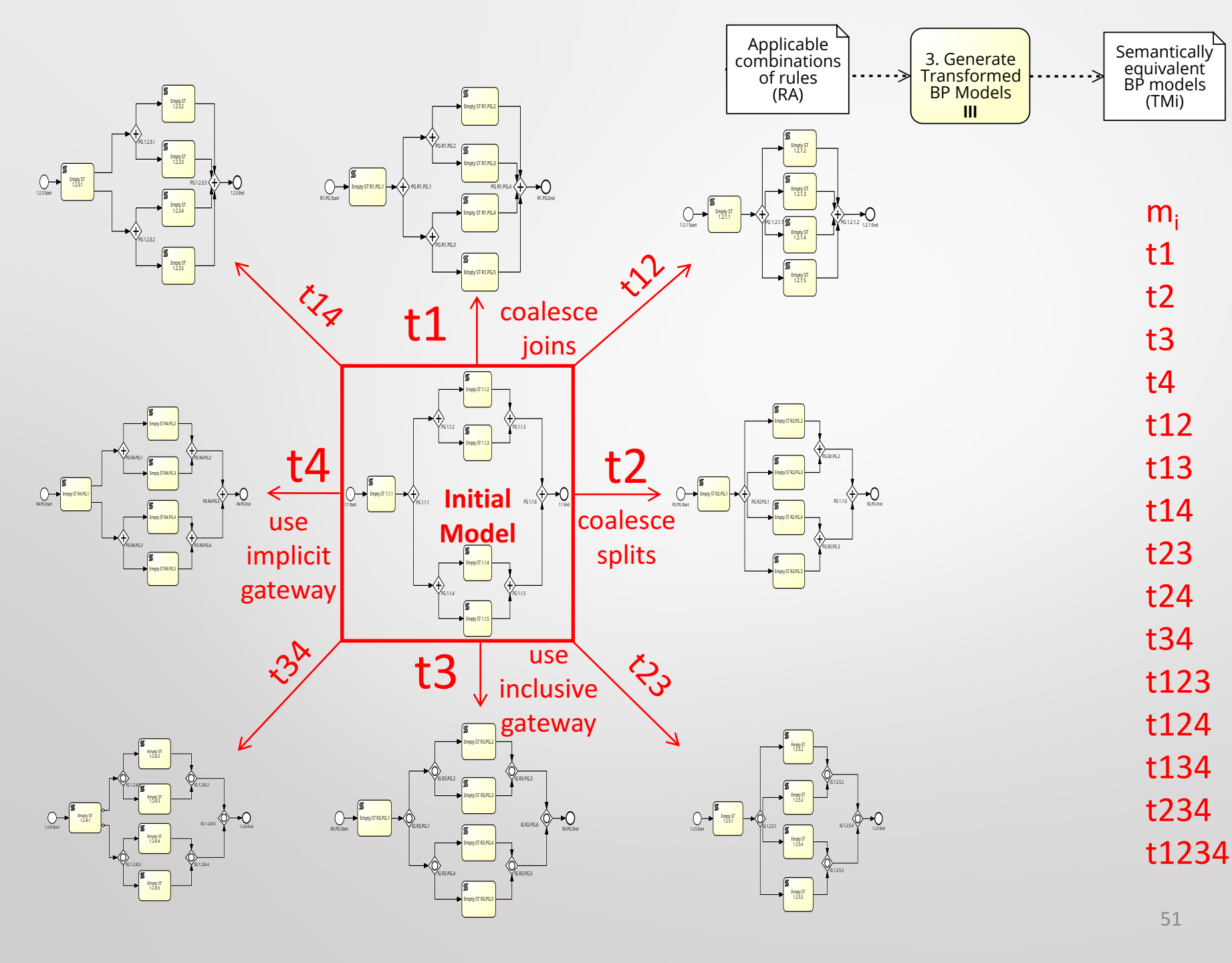

Transformation rules (R)
2. Determine Applicable Transformation Rules
t1
coalesce joins
t4
use implicit gateway
Initial Model
t2
coalesce splits
t3
use inclusive gateway

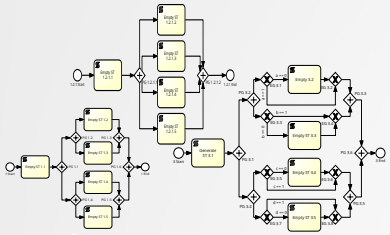

Transformation rules (R)
2. Determine Applicable Transformation Rules
Applicable combinations of rules (RA)
t1
coalesce joins
t12
t2
coalesce splits
t23
t3
use inclusive gateway
t34
t4
use implicit gateway
t14
Initial Model

Applicable combinations of rules (RA)



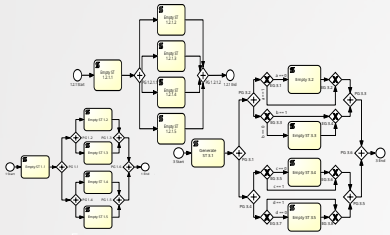

Applicable combinations of rules (RA)
3. Generate Transformed BP Models
III
t14
t1
coalesce joins
t12
t4
use implicit gateway
Initial Model
t2
coalesce splits
t34
t3
use inclusive gateway
t23


Applicable combinations of rules (RA)
3. Generate Transformed BP Models III
Semantically equivalent BP models (TMi)
t1
coalesce joins
t12
t2
coalesce splits
t23
t3
use inclusive gateway
t34
t4
use implicit gateway
t14
Initial Model
mi
t1
t2
t3
t4
t12
t13
t14
t23
t24
t34
t123
t124
t134
t234
t1234

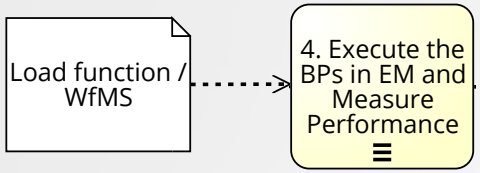


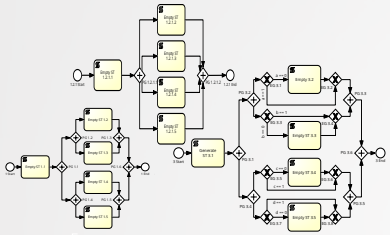
Workload

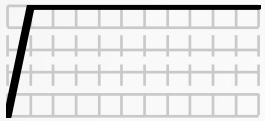
4. Execute the BPs in EM and Measure Performance



Workload



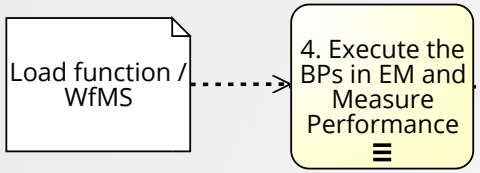


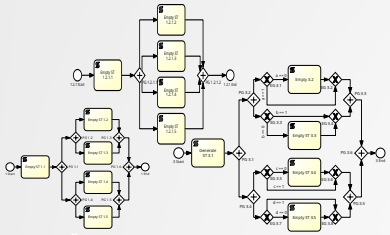


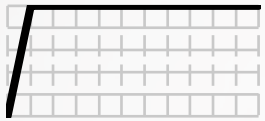
Workload

Load function

WfMS







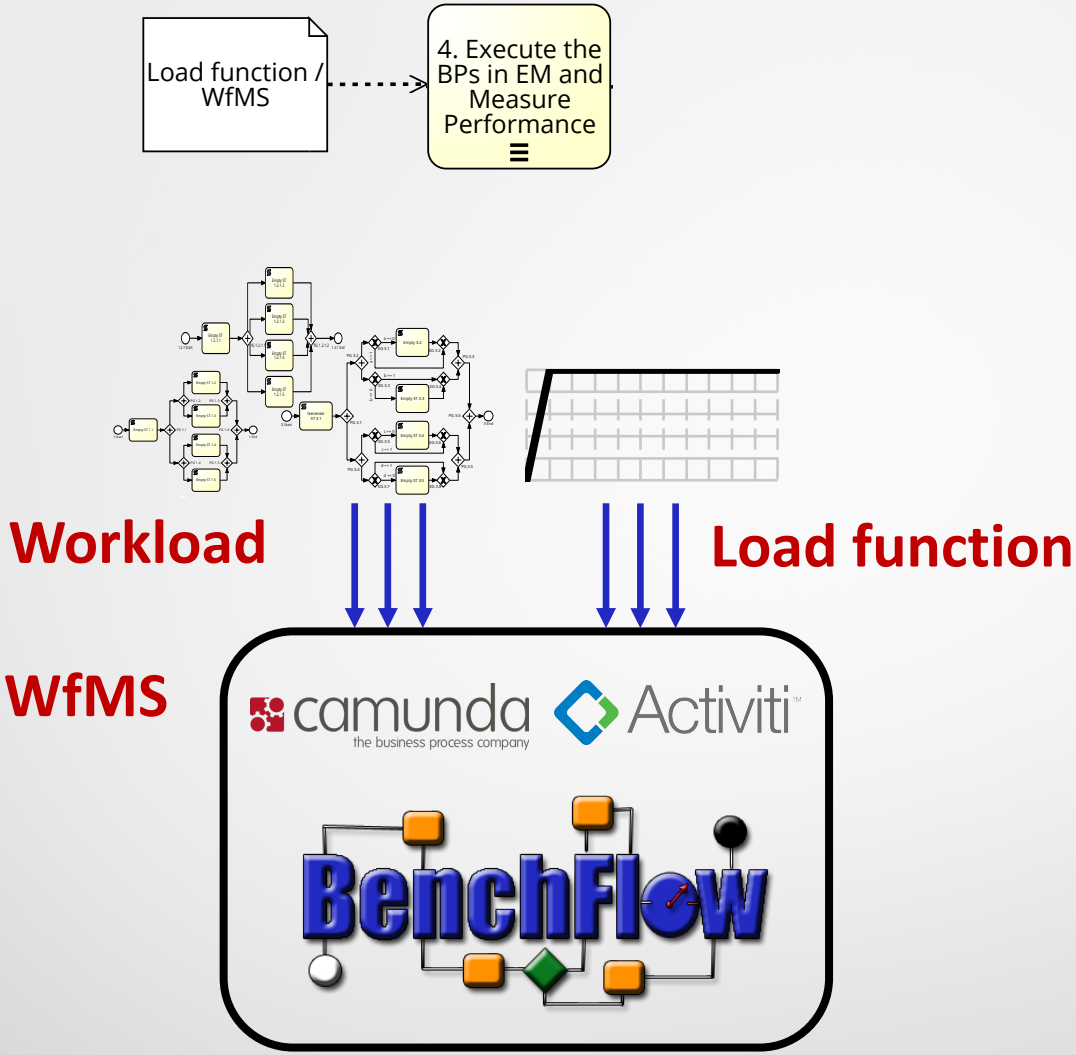
Workload

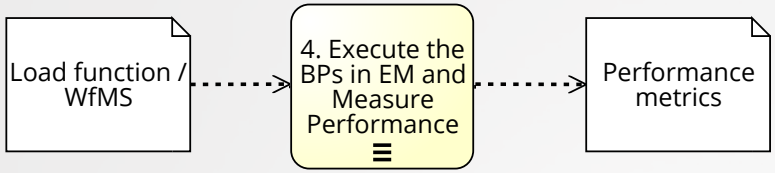
Load function

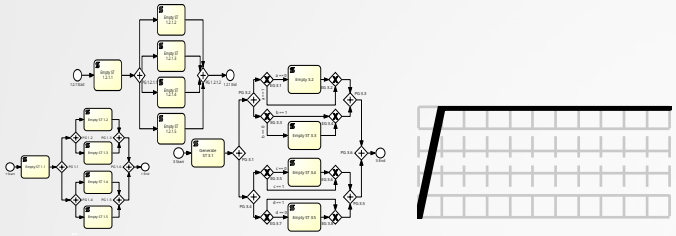
WfMS

camunda the business process company

Activiti


Load function / WfMS
4. Execute the BPs in EM and Measure Performance
Workload
Load function
WfMS
camunda
the business process company
Activiti
BenchFlow





Workload

Load function

WfMS

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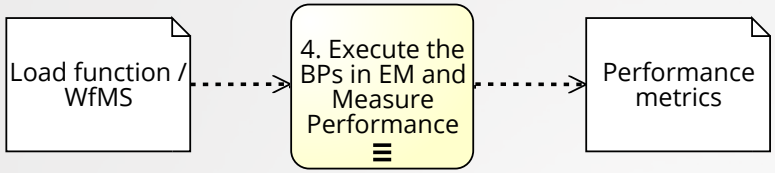
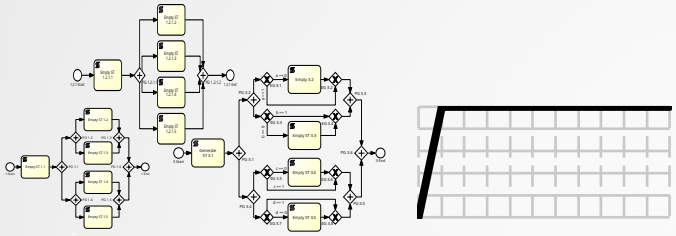
the business process company

Activiti

BenchFlow

Metrics





Workload

Load function

WfMS

camunda the business process company

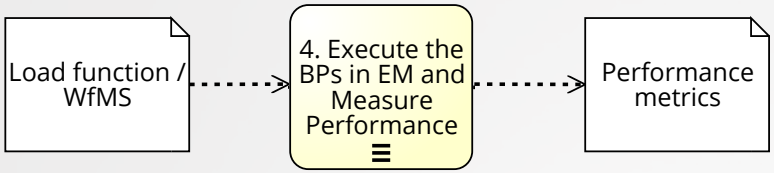
Activiti

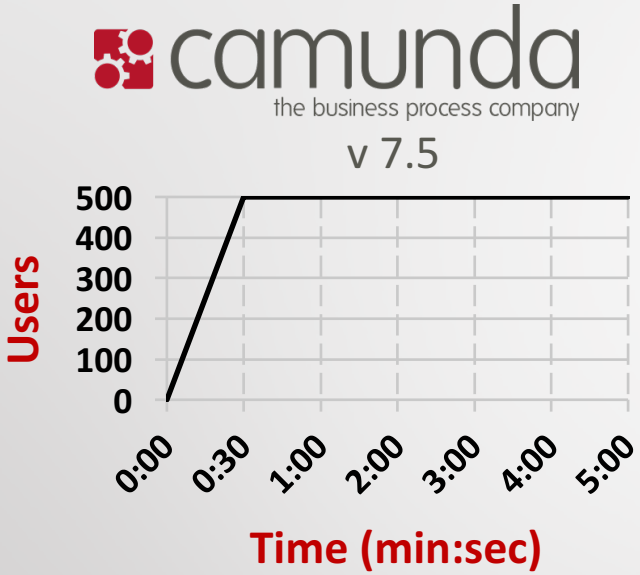
BenchFlow

Metrics

instance duration in milliseconds (ms)

benchflow [BPM ’15][ICPE ’16]


Load function / WfMS
4. Execute the BPs in EM and Measure Performance
Performance metrics


camunda
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v 7.5
Users
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400
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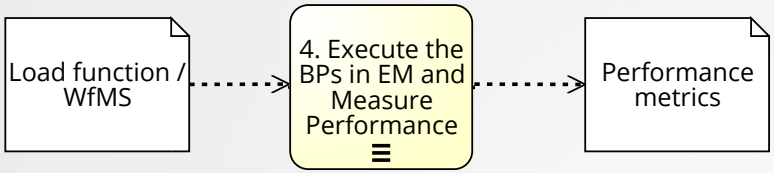
100
0
0:00
0:30
1:00
2:00
3:00
4:00
5:00
Time (min:sec)



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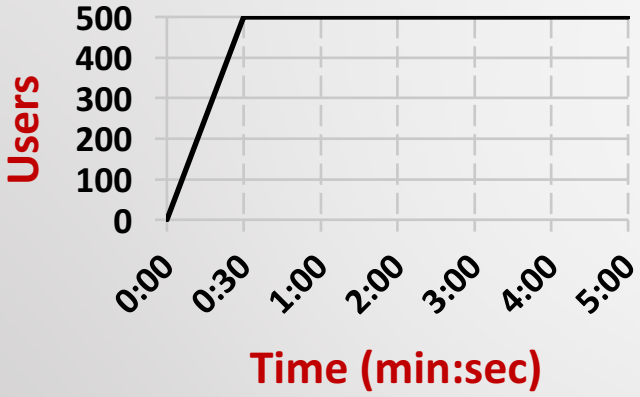

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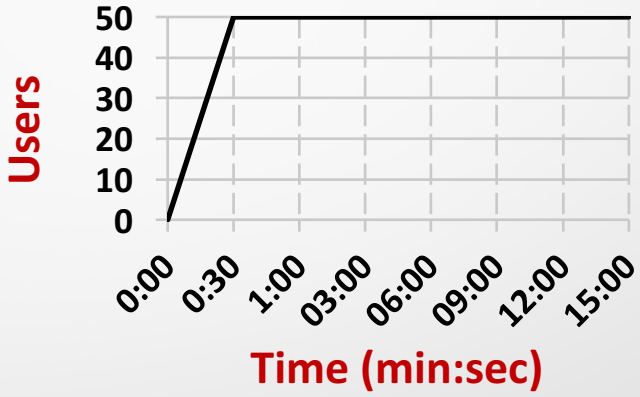
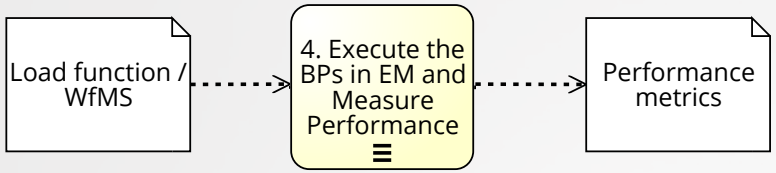
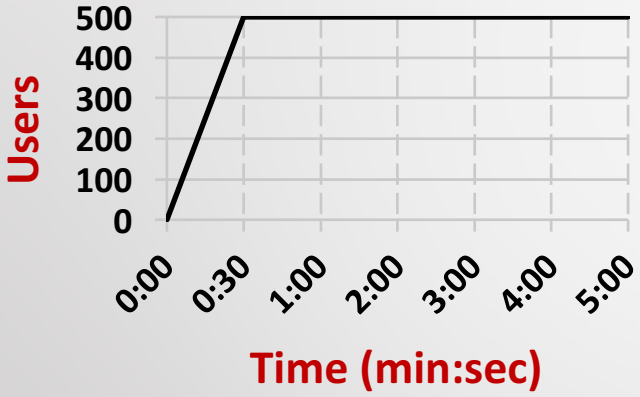
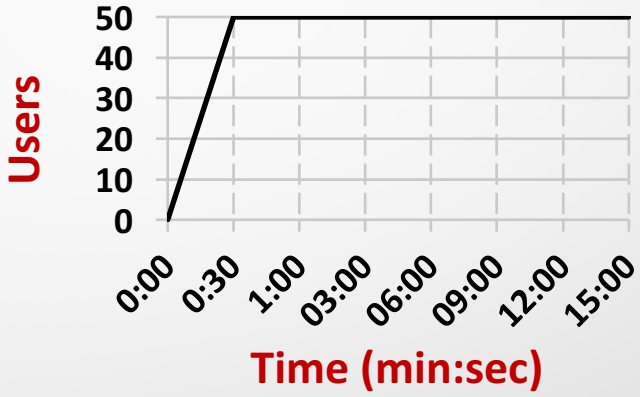




camunda
the business process company
v 7.5



Activiti™
v 5.21



1 second think time

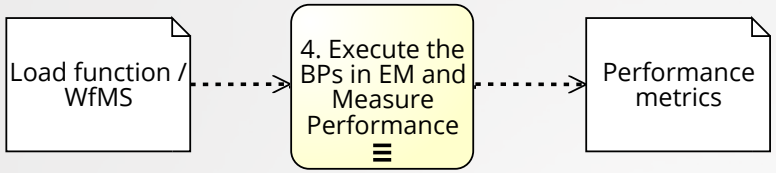
Results discussion

Table 1. Camunda: 95% confidence intervals of the BP instance duration (ms)

	Parallel			Exclusive			Inclusive		
	Trial 1	**Trial 2**	**Trial 3**	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 1**	**Trial 2**	**Trial 3**
m_i	2.59±0.05	2.55±0.05	2.51±0.05	1.53±0.02	1.54±0.02	1.55±0.02	2.55±0.03	2.76±0.08	2.73±0.06
$t1$	2.36±0.06	2.44±0.05	2.42±0.04	1.49±0.02	1.46±0.02	1.42±0.02	2.63±0.06	2.43±0.03	2.44±0.03
$t2$	2.39±0.05	2.45±0.05	2.39±0.04	1.46±0.02	1.49±0.02	1.46±0.02	2.67±0.08	2.53±0.04	2.64±0.07
$t3$	2.57±0.05	2.51±0.05	2.58±0.05	1.57±0.02	1.53±0.02	1.53±0.02	2.02±0.03	2.03±0.03	2.09±0.04
$t4$	2.49±0.06	2.45±0.04	2.42±0.04	1.46±0.02	1.49±0.02	1.47±0.02	2.57±0.04	2.66±0.05	2.68±0.08
$t12$	2.21±0.04	2.24±0.04	2.25±0.04	1.42±0.02	1.41±0.02	1.40±0.02	2.43±0.04	2.51±0.05	2.45±0.07
$t13$	2.49±0.06	2.44±0.03	2.45±0.04	1.47±0.02	1.48±0.02	1.42±0.02	1.90±0.03	1.98±0.03	2.03±0.05
$t14$	2.31±0.05	2.28±0.04	2.28±0.03	1.44±0.02	1.41±0.02	1.36±0.02	2.43±0.03	2.50±0.05	2.68±0.08
$t23$	2.37±0.04	2.48±0.05	2.41±0.05	1.48±0.02	1.47±0.02	1.46±0.02	1.89±0.03	1.97±0.03	2.05±0.04
$t24$	2.29±0.04	2.35±0.05	2.30±0.04	1.43±0.02	1.39±0.02	1.40±0.02	2.38±0.03	2.57±0.04	2.44±0.03
$t34$	2.48±0.06	2.49±0.04	2.58±0.06	1.47±0.02	1.43±0.02	1.46±0.02	1.99±0.03	2.05±0.03	2.03±0.03
$t123$	2.23±0.04	2.29±0.05	2.28±0.05	1.41±0.02	1.41±0.02	1.39±0.02	1.90±0.03	1.87±0.03	1.83±0.02
$t124$	2.16±0.03	2.21±0.04	2.23±0.04	1.38±0.02	1.33±0.02	1.32±0.02	2.25±0.03	2.34±0.03	2.48±0.06
$t134$	2.35±0.04	2.38±0.05	2.34±0.05	1.45±0.02	1.40±0.02	1.41±0.02	1.92±0.03	1.90±0.03	1.91±0.03
$t234$	2.33±0.03	2.39±0.04	2.34±0.04	1.40±0.02	1.43±0.02	1.42±0.02	1.92±0.03	1.90±0.03	1.98±0.04
$t1234$	2.20±0.03	2.21±0.04	2.28±0.04	1.36±0.02	1.35±0.02	1.37±0.02	1.78±0.02	1.81±0.02	1.87±0.03

Table 2. Activiti: 95% confidence intervals of the BP instance duration (ms)

	Parallel			Exclusive			Inclusive		
	Trial 1	**Trial 2**	**Trial 3**	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 1**	**Trial 2**	**Trial 3**
m_i	26.04±0.21	25.33±0.21	25.22±0.21	2.12±0.07	2.01±0.06	2.14±0.07	29.87±0.30	27.93±0.24	29.57±0.27
$t1$	21.62±0.18	21.47±0.16	20.90±0.17	2.09±0.07	1.93±0.05	1.91±0.06	24.04±0.21	27.14±0.26	24.75±0.22
$t2$	21.34±0.17	20.38±0.14	20.55±0.15	2.02±0.06	1.98±0.06	1.95±0.05	25.43±0.24	27.29±0.26	26.75±0.26
$t3$	19.57±0.18	20.02±0.19	20.00±0.19	2.10±0.06	2.06±0.06	2.02±0.06	11.82±0.16	11.66±0.16	11.74±0.17
$t4$	25.32±0.21	24.55±0.20	24.66±0.20	2.06±0.06	1.92±0.05	1.99±0.06	28.92±0.26	28.24±0.26	29.64±0.27
$t12$	18.83±0.14	18.38±0.14	18.79±0.15	1.84±0.05	1.91±0.06	1.89±0.06	23.68±0.22	23.00±0.21	24.53±0.23
$t13$	18.26±0.15	17.39±0.14	17.42±0.15	1.92±0.06	1.93±0.06	2.02±0.06	11.38±0.18	11.19±0.18	11.11±0.15
$t14$	21.25±0.16	21.39±0.17	20.88±0.18	1.91±0.06	1.85±0.05	1.77±0.05	24.78±0.23	23.07±0.19	23.61±0.20
$t23$	16.52±0.14	16.37±0.14	15.62±0.12	2.11±0.06	1.93±0.05	2.12±0.07	10.56±0.14	10.90±0.16	11.06±0.16
$t24$	21.67±0.17	21.80±0.17	21.72±0.18	1.91±0.05	1.86±0.06	1.86±0.05	23.66±0.21	25.08±0.24	23.45±0.21
$t34$	19.06±0.17	18.06±0.15	19.13±0.17	2.11±0.07	1.89±0.05	1.93±0.05	11.14±0.15	11.02±0.15	11.06±0.15
$t123$	17.35±0.16	17.39±0.21	16.47±0.13	1.92±0.06	2.01±0.07	2.05±0.07	10.19±0.14	10.27±0.14	10.01±0.15
$t124$	19.09±0.14	17.86±0.12	18.64±0.14	1.39±0.02	1.45±0.03	1.59±0.04	22.46±0.21	22.42±0.21	23.31±0.24
$t134$	18.03±0.16	18.61±0.17	18.53±0.16	1.92±0.06	2.03±0.09	1.92±0.05	10.51±0.14	11.46±0.20	10.83±0.15
$t234$	18.04±0.16	17.36±0.16	17.08±0.15	1.89±0.05	1.98±0.07	2.01±0.07	10.53±0.15	10.51±0.15	10.71±0.16
$t1234$	15.83±0.12	15.75±0.13	15.86±0.13	1.72±0.04	1.67±0.04	1.62±0.04	10.03±0.13	9.93±0.14	9.99±0.13



Instance duration (ms)

camunda
the business process company

Activiti™

Parallel

m_i	t124
2.59 ms ± 0.05 ms	2.16 ms ± 0.03 ms

Exclusive

t3	t124
1.57 ms ± 0.02 ms	1.32 ms ± 0.02 ms

Inclusive

m_i	t1234
2.76 ms ± 0.08 ms	1.78 ms ± 0.02 ms

Parallel

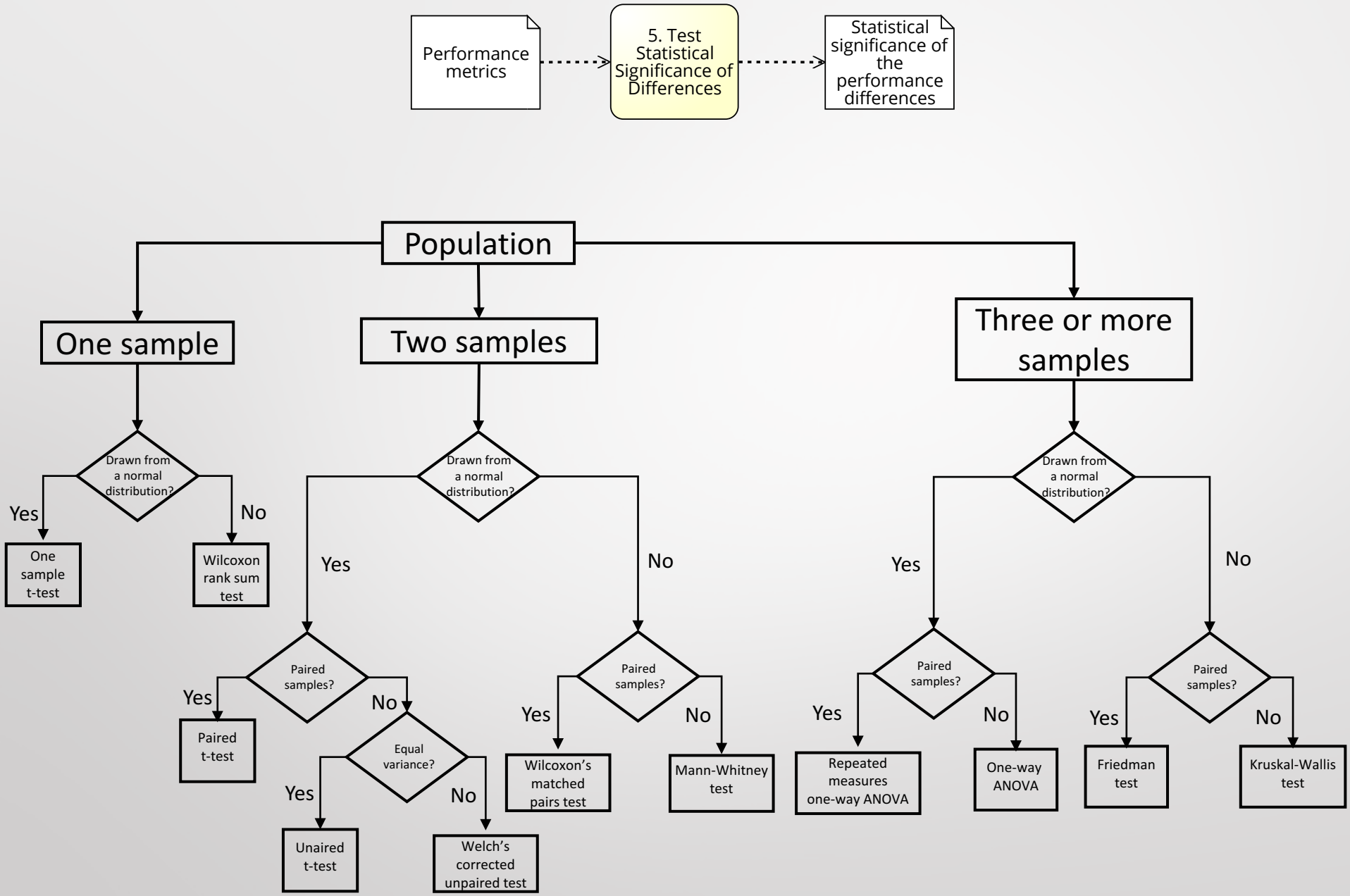
m_i	t23
26.04 ms ± 0.01 ms	15.62 ms ± 0.12 ms

Exclusive

m_i	t124
2.14 ms ± 0.07 ms	1.39 ms ± 0.02 ms

Inclusive

m_i	t1234
29.87 ms ± 0.30 ms	9.93 ms ± 0.14 ms



*http://www.biochemia-medica.com/content/comparing-groups-statistical-differences-how-choose-right-statistical-test

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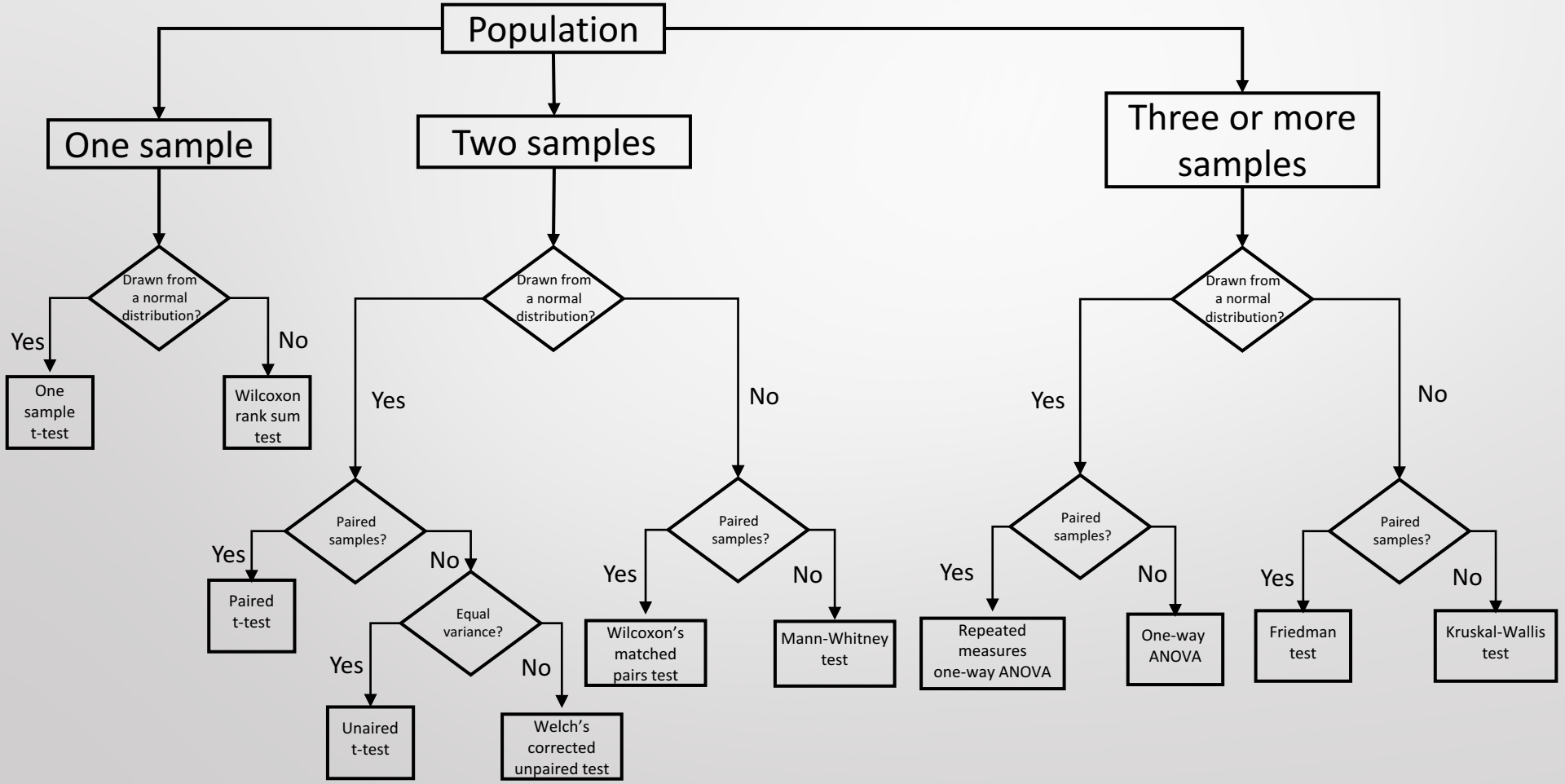

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mi t1 t2 t3 t4 t12 t13 t14 t23 t24 t34 t123 t124 t134 t234 t1234

Population

- **One sample**
  - Drawn from a normal distribution?
    - Yes → One sample t-test
    - No → Wilcoxon rank sum test
- **Two samples**
  - Drawn from a normal distribution?
    - Yes
      - Paired samples?
        - Yes → Paired t-test
        - No
          - Equal variance?
            - Yes → Unaired t-test
            - No → Welch's corrected unpaired test
    - No
      - Paired samples?
        - Yes → Wilcoxon's matched pairs test
        - No → Mann-Whitney test
- **Three or more samples**
  - Drawn from a normal distribution?
    - Yes
      - Paired samples?
        - Yes → Repeated measures one-way ANOVA
        - No → One-way ANOVA
    - No
      - Paired samples?
        - Yes → Friedman test
        - No → Kruskal-Wallis test

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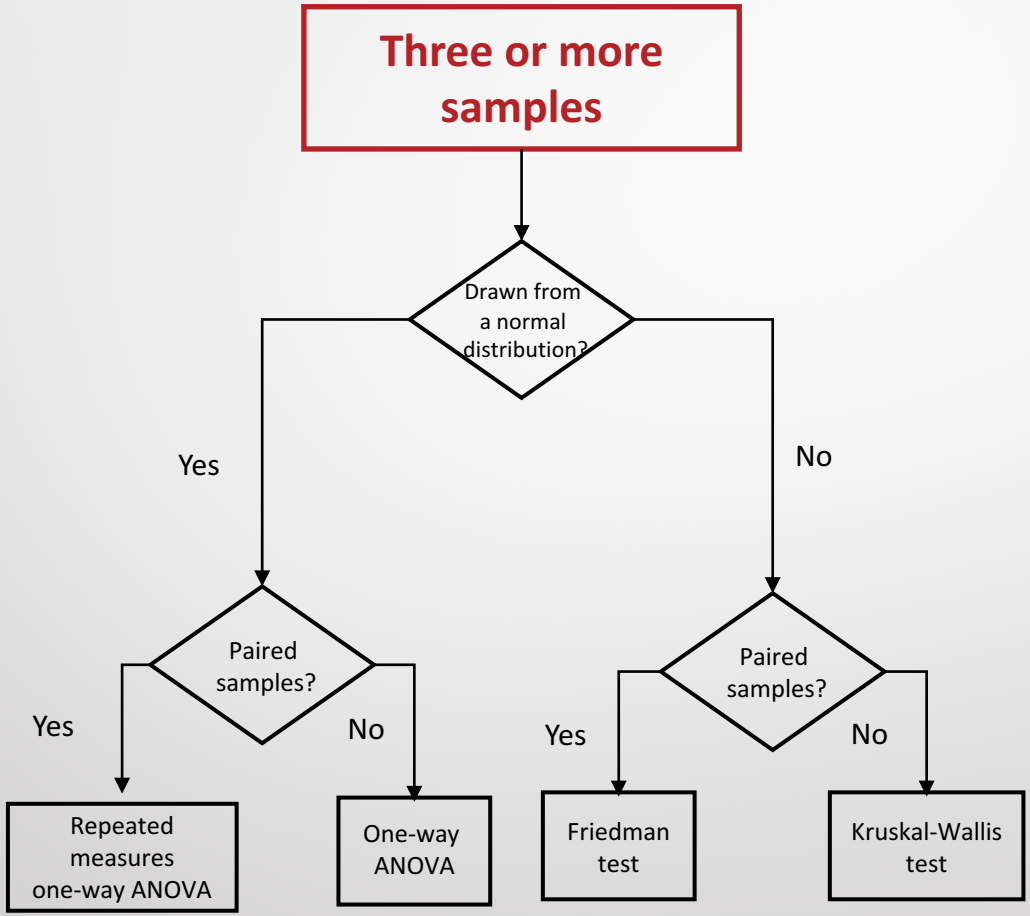

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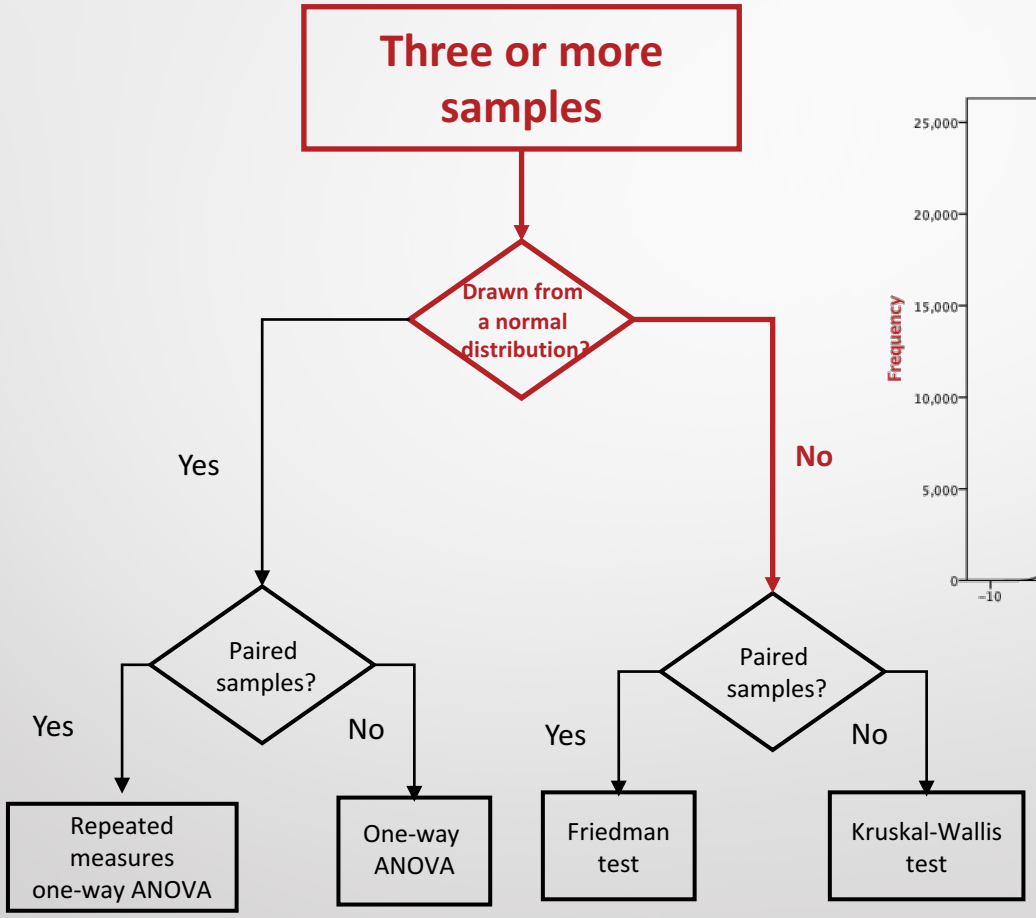

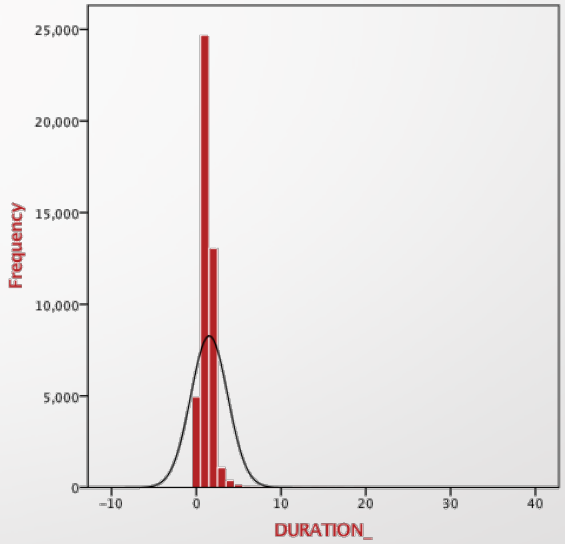

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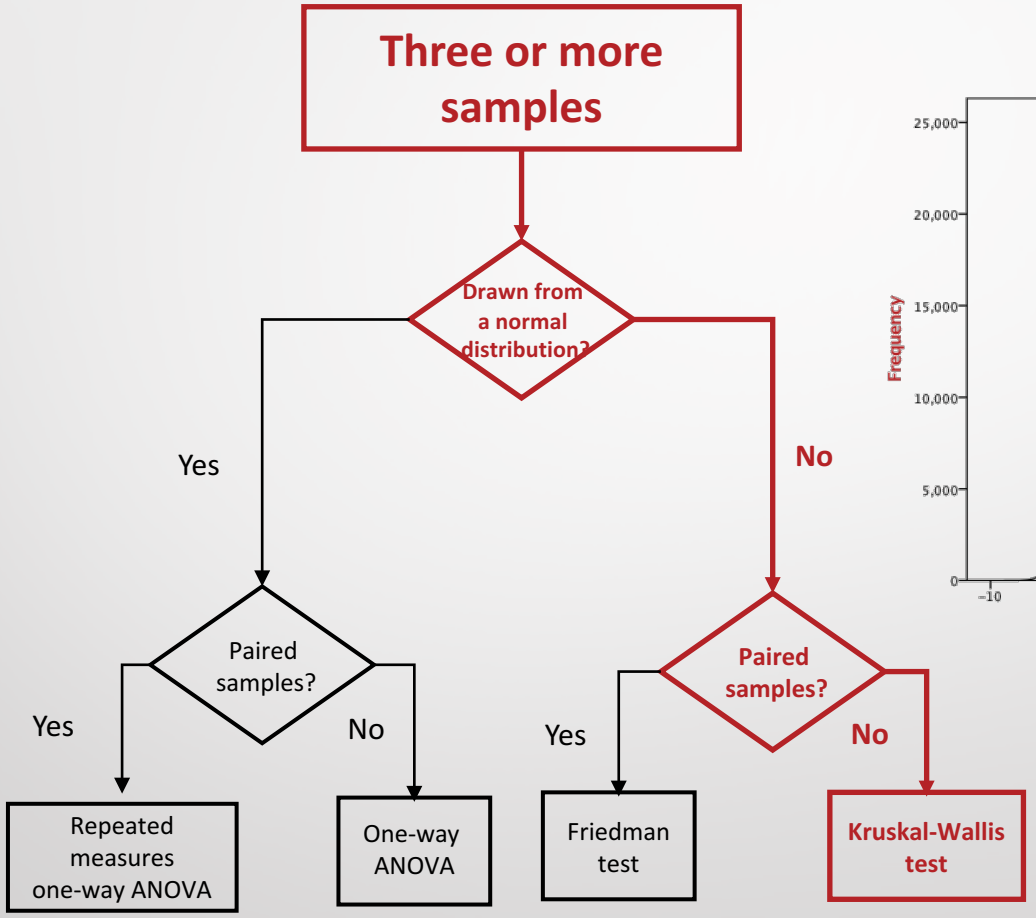

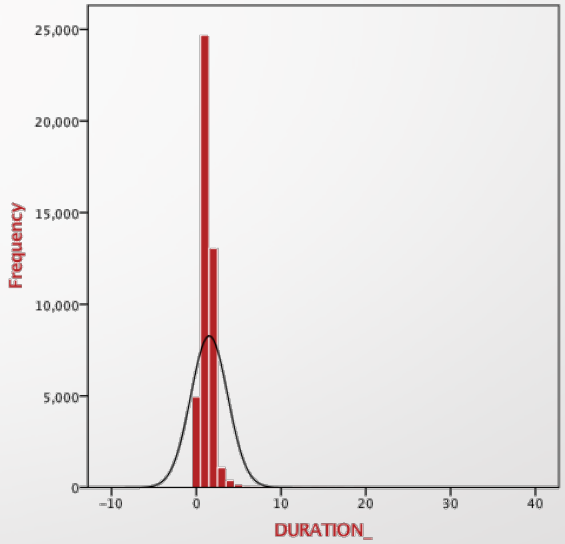

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RQ1: Does the application of different modeling practices have **significant impact** on the duration of a BP instance execution?

Table 3. Kruskal-Wallis Test Summary Results

		Parallel			Exclusive			Inclusive		
		Trial 1	**Trial 2**	**Trial 3**	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 1**	**Trial 2**	**Trial 3**
Camunda	Total # instances	739'845	721'265	775'940	765'393	817'415	850'040	487'213	494'020	544'059
	Test Statistic	6'036	5'686	3'989	2'852	3'290	3'695	27'512	29'646	29'530
	Asymptotic Sig.	0	0	0	0	0	0	0	0	0
Activiti	Total # instances	697'492	698'976	699'478	708'138	710'987	710'467	687'930	687'011	687'746
	Test Statistic	135'513	141'611	139'567	1'268	1'268	1'882	351'816	354'735	354'047
	Asymptotic Sig.	0	0	0	0	0	0	0	0	0

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Activiti	Total # instances	697'492	698'976	699'478	708'138	710'987	710'467	687'930	687'011	687'746
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	Asymptotic Sig.	0	0	0	0	0	0	0	0	0

RQ1: Does the application of different modeling practices have **significant impact** on the duration of a BP instance execution?

YES!

Table 3. Kruskal-Wallis Test Summary Results

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		Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
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	Asymptotic Sig.	0	0	0	0	0	0	0	0	0
Activiti	Total # instances	697'492	698'976	699'478	708'138	710'987	710'467	687'930	687'011	687'746
	Test Statistic	135'513	141'611	139'567	1'268	1'268	1'882	351'816	354'735	354'047
	Asymptotic Sig.	0	0	0	0	0	0	0	0	0

RQ1: Does the application of different modeling practices have **significant impact** on the duration of a BP instance execution?

YES!

improvement possibilities to BPMS vendors

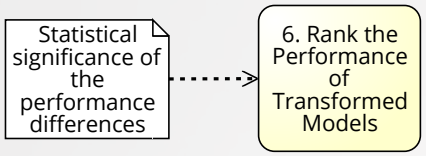

Table 4. Models ranked over their performance in three trials using Dunns' test

Camunda						Activiti					
Parallel		**Exclusive**		**Inclusive**		**Parallel**		**Exclusive**		**Inclusive**	
Model	Rank	Model	Rank	Model	Rank	Model	Rank	Model	Rank	Model	Rank
$t124$	***1***	$t124$	***1***	$t1234$	***1***	$t1234$	***1***	$t124$	***1***	$t1234$	***1***
$t1234$	2	$t1234$	***1***	$t123$	2	$t23$	2	$t1234$	2	$t123$	***1***
$t12$	3	$t12$	2	$t134$	3	$t123$	3	$t24$	2	$t234$	2
$t123$	3	$t123$	2	$t234$	3	$t234$	4	$t12$	3	$t23$	2
$t14$	4	$t24$	2	$t13$	4	$t13$	5	$t14$	3	$t13$	3
$t24$	5	$t234$	2	$t23$	4	$t134$	6	$t123$	4	$t134$	3
$t234$	6	$t14$	3	$t34$	5	$t34$	7	$t134$	4	$t34$	3
$t134$	6	$t134$	3	$t3$	6	$t3$	8	$t234$	4	$t3$	4
$t2$	7	$t1$	4	$t124$	7	$t12$	9	$t1$	5	$t124$	5
$t1$	7	$t13$	4	$t12$	8	$t124$	9	$t2$	5	$t12$	6
$t23$	8	$t2$	5	$t1$	9	$t14$	10	$t4$	5	$t14$	7
$t4$	8	$t23$	5	$t24$	9	$t1$	11	$t13$	5	$t24$	8
$t13$	9	$t34$	5	$t14$	9	$t2$	12	$t23$	5	$t1$	9
$t34$	10	$t4$	6	$t2$	10	$t24$	12	$t34$	5	$t2$	10
m_i	11	$t3$	7	$t4$	11	$t4$	13	m_i	6	m_i	11
$t3$	12	m_i	7	m_i	12	m_i	14	$t3$	6	$t4$	11

RQ2: Is there a **total order** between semantically equivalent but structurally different models, when ranked according to their performance?

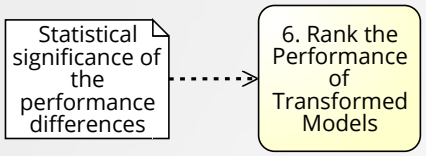

Table 4. Models ranked over their performance in three trials using Dunns' test

Camunda						Activiti					
Parallel		Exclusive		Inclusive		Parallel		Exclusive		Inclusive	
Model	Rank	Model	Rank	Model	Rank	Model	Rank	Model	Rank	Model	Rank
$t124$	***1***	$t124$	***1***	$t1234$	***1***	$t1234$	***1***	$t124$	***1***	$t1234$	***1***
$t1234$	2	$t1234$	***1***	$t123$	2	$t23$	2	$t1234$	2	$t123$	***1***
$t12$	3	$t12$	2	$t134$	3	$t123$	3	$t24$	2	$t234$	2
$t123$	3	$t123$	2	$t234$	3	$t234$	4	$t12$	3	$t23$	2
$t14$	4	$t24$	2	$t13$	4	$t13$	5	$t14$	3	$t13$	3
$t24$	5	$t234$	2	$t23$	4	$t134$	6	$t123$	4	$t134$	3
$t234$	6	$t14$	3	$t34$	5	$t34$	7	$t134$	4	$t34$	3
$t134$	6	$t134$	3	$t3$	6	$t3$	8	$t234$	4	$t3$	4
$t2$	7	$t1$	4	$t124$	7	$t12$	9	$t1$	5	$t124$	5
$t1$	7	$t13$	4	$t12$	8	$t124$	9	$t2$	5	$t12$	6
$t23$	8	$t2$	5	$t1$	9	$t14$	10	$t4$	5	$t14$	7
$t4$	8	$t23$	5	$t24$	9	$t1$	11	$t13$	5	$t24$	8
$t13$	9	$t34$	5	$t14$	9	$t2$	12	$t23$	5	$t1$	9
$t34$	10	$t4$	6	$t2$	10	$t24$	12	$t34$	5	$t2$	10
m_i	11	$t3$	7	$t4$	11	$t4$	13	m_i	6	m_i	11
$t3$	12	m_i	7	m_i	12	m_i	14	$t3$	6	$t4$	11

RQ2: Is there a **total order** between semantically equivalent but structurally different models, when ranked according to their performance?

NO!

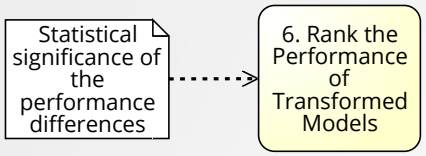

Table 4. Models ranked over their performance in three trials using Dunns' test

Camunda						Activiti					
Parallel		Exclusive		Inclusive		Parallel		Exclusive		Inclusive	
Model	Rank	Model	Rank	Model	Rank	Model	Rank	Model	Rank	Model	Rank
$t124$	***1***	$t124$	***1***	$t1234$	***1***	$t1234$	***1***	$t124$	***1***	$t1234$	***1***
$t1234$	2	$t1234$	***1***	$t123$	2	$t23$	2	$t1234$	2	$t123$	***1***
$t12$	3	$t12$	2	$t134$	3	$t123$	3	$t24$	2	$t234$	2
$t123$	3	$t123$	2	$t234$	3	$t234$	4	$t12$	3	$t23$	2
$t14$	4	$t24$	2	$t13$	4	$t13$	5	$t14$	3	$t13$	3
$t24$	5	$t234$	2	$t23$	4	$t134$	6	$t123$	4	$t134$	3
$t234$	6	$t14$	3	$t34$	5	$t34$	7	$t134$	4	$t34$	3
$t134$	6	$t134$	3	$t3$	6	$t3$	8	$t234$	4	$t3$	4
$t2$	7	$t1$	4	$t124$	7	$t12$	9	$t1$	5	$t124$	5
$t1$	7	$t13$	4	$t12$	8	$t124$	9	$t2$	5	$t12$	6
$t23$	8	$t2$	5	$t1$	9	$t14$	10	$t4$	5	$t14$	7
$t4$	8	$t23$	5	$t24$	9	$t1$	11	$t13$	5	$t24$	8
$t13$	9	$t34$	5	$t14$	9	$t2$	12	$t23$	5	$t1$	9
$t34$	10	$t4$	6	$t2$	10	$t24$	12	$t34$	5	$t2$	10
m_i	11	$t3$	7	$t4$	11	$t4$	13	m_i	6	m_i	11
$t3$	12	m_i	7	m_i	12	m_i	14	$t3$	6	$t4$	11

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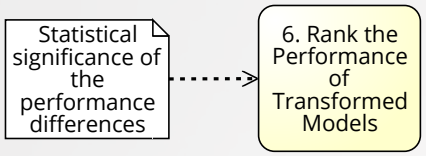

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$t124$	***1***	$t124$	***1***	$t1234$	***1***	$t1234$	***1***	$t124$	***1***	$t1234$	***1***
$t1234$	2	$t1234$	***1***	$t123$	2	$t23$	2	$t1234$	2	$t123$	***1***
$t12$	3	$t12$	2	$t134$	3	$t123$	3	$t24$	2	$t234$	2
$t123$	3	$t123$	2	$t234$	3	$t234$	4	$t12$	3	$t23$	2
$t14$	4	$t24$	2	$t13$	4	$t13$	5	$t14$	3	$t13$	3
$t24$	5	$t234$	2	$t23$	4	$t134$	6	$t123$	4	$t134$	3
$t234$	6	$t14$	3	$t34$	5	$t34$	7	$t134$	4	$t34$	3
$t134$	6	$t134$	3	$t3$	6	$t3$	8	$t234$	4	$t3$	4
$t2$	7	$t1$	4	$t124$	7	$t12$	9	$t1$	5	$t124$	5
$t1$	7	$t13$	4	$t12$	8	$t124$	9	$t2$	5	$t12$	6
$t23$	8	$t2$	5	$t1$	9	$t14$	10	$t4$	5	$t14$	7
$t4$	8	$t23$	5	$t24$	9	$t1$	11	$t13$	5	$t24$	8
$t13$	9	$t34$	5	$t14$	9	$t2$	12	$t23$	5	$t1$	9
$t34$	10	$t4$	6	$t2$	10	$t24$	12	$t34$	5	$t2$	10
m_i	11	$t3$	7	$t4$	11	$t4$	13	m_i	6	m_i	11
$t3$	12	m_i	7	m_i	12	m_i	14	$t3$	6	$t4$	11

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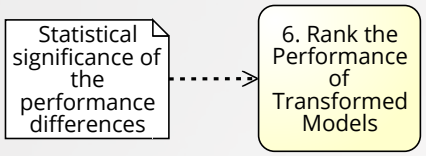

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$t1234$	2	$t1234$	***1***	$t123$	2	$t23$	2	$t1234$	2	$t123$	***1***
$t12$	3	$t12$	2	$t134$	3	$t123$	3	$t24$	2	$t234$	2
$t123$	3	$t123$	2	$t234$	3	$t234$	4	$t12$	3	$t23$	2
$t14$	4	$t24$	2	$t13$	4	$t13$	5	$t14$	3	$t13$	3
$t24$	5	$t234$	2	$t23$	4	$t134$	6	$t123$	4	$t134$	3
$t234$	6	$t14$	3	$t34$	5	$t34$	7	$t134$	4	$t34$	3
$t134$	6	$t134$	3	$t3$	6	$t3$	8	$t234$	4	$t3$	4
$t2$	7	$t1$	4	$t124$	7	$t12$	9	$t1$	5	$t124$	5
$t1$	7	$t13$	4	$t12$	8	$t124$	9	$t2$	5	$t12$	6
$t23$	8	$t2$	5	$t1$	9	$t14$	10	$t4$	5	$t14$	7
$t4$	8	$t23$	5	$t24$	9	$t1$	11	$t13$	5	$t24$	8
$t13$	9	$t34$	5	$t14$	9	$t2$	12	$t23$	5	$t1$	9
$t34$	10	$t4$	6	$t2$	10	$t24$	12	$t34$	5	$t2$	10
m_i	11	$t3$	7	$t4$	11	$t4$	13	m_i	6	m_i	11
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Performance Variability

Acceptability index

$$\boldsymbol{AI(A,B) = \frac{m(B) - m(A)}{w(B) + w(A)}}$$

A initial model (m_i)

B transformed model (t)

$A = [al, ar]$ 95% confidence interval

$B = [bl, br]$ of the duration

$m(A)$ average duration of

$m(B)$ model's instances

$w(A)$ half-width of the

$w(B)$ confidence interval

*Sengupta, A., Pal, T.K.: On comparing interval numbers. European Journal of Operational Research 127(1), 28–43 (2000)

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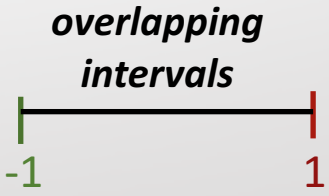
AI



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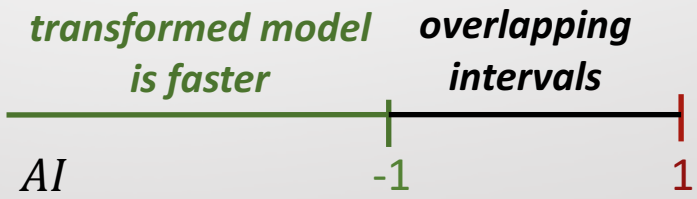

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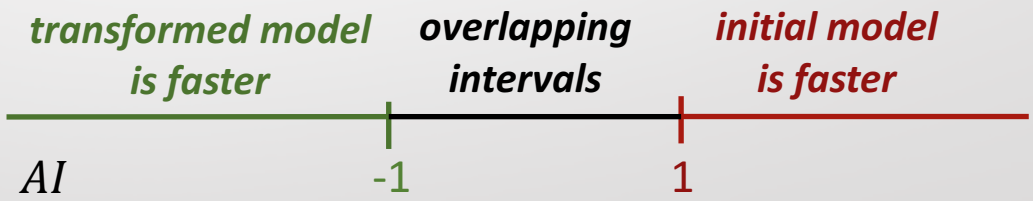

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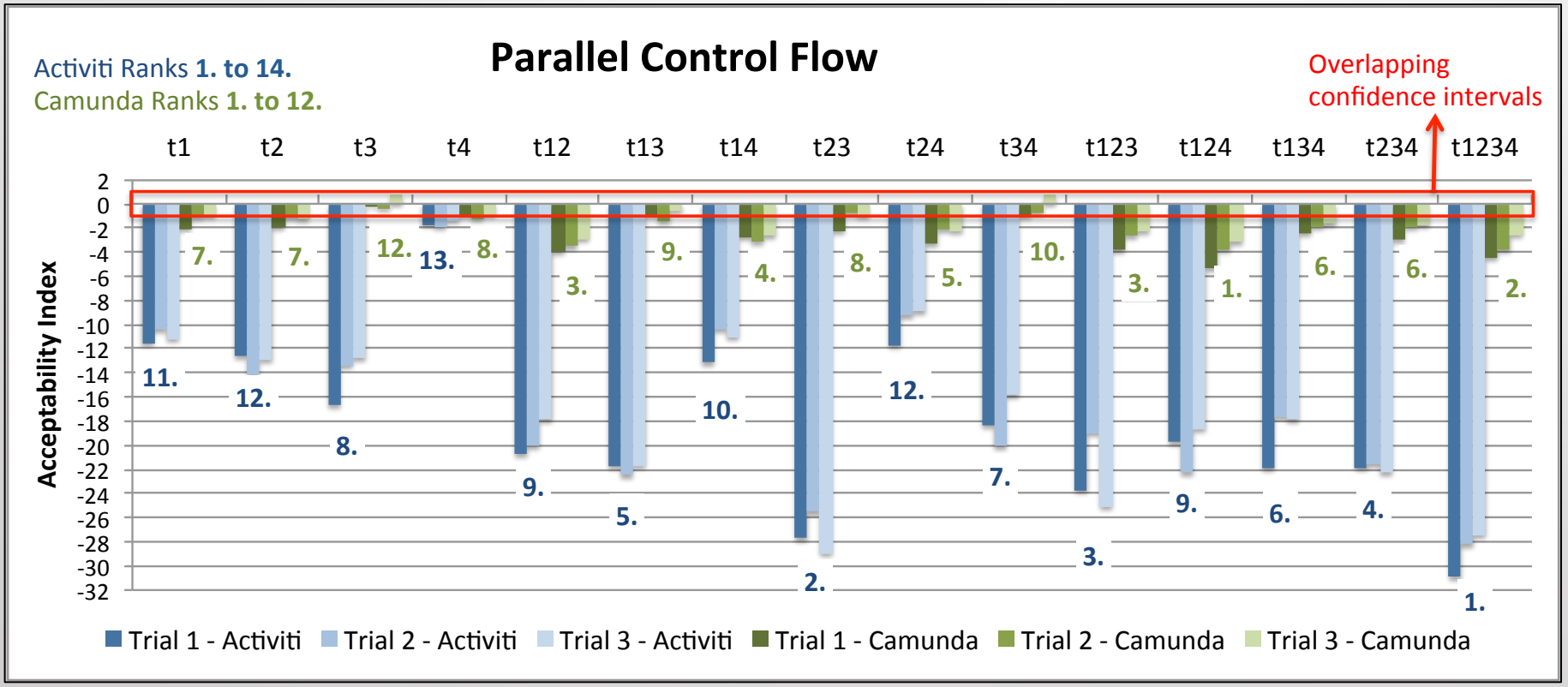

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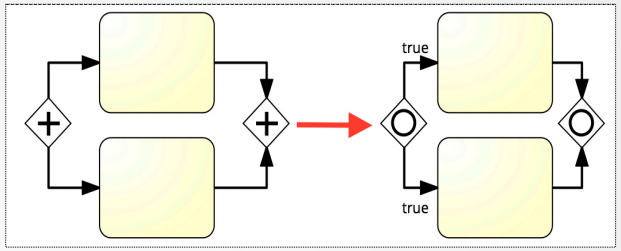

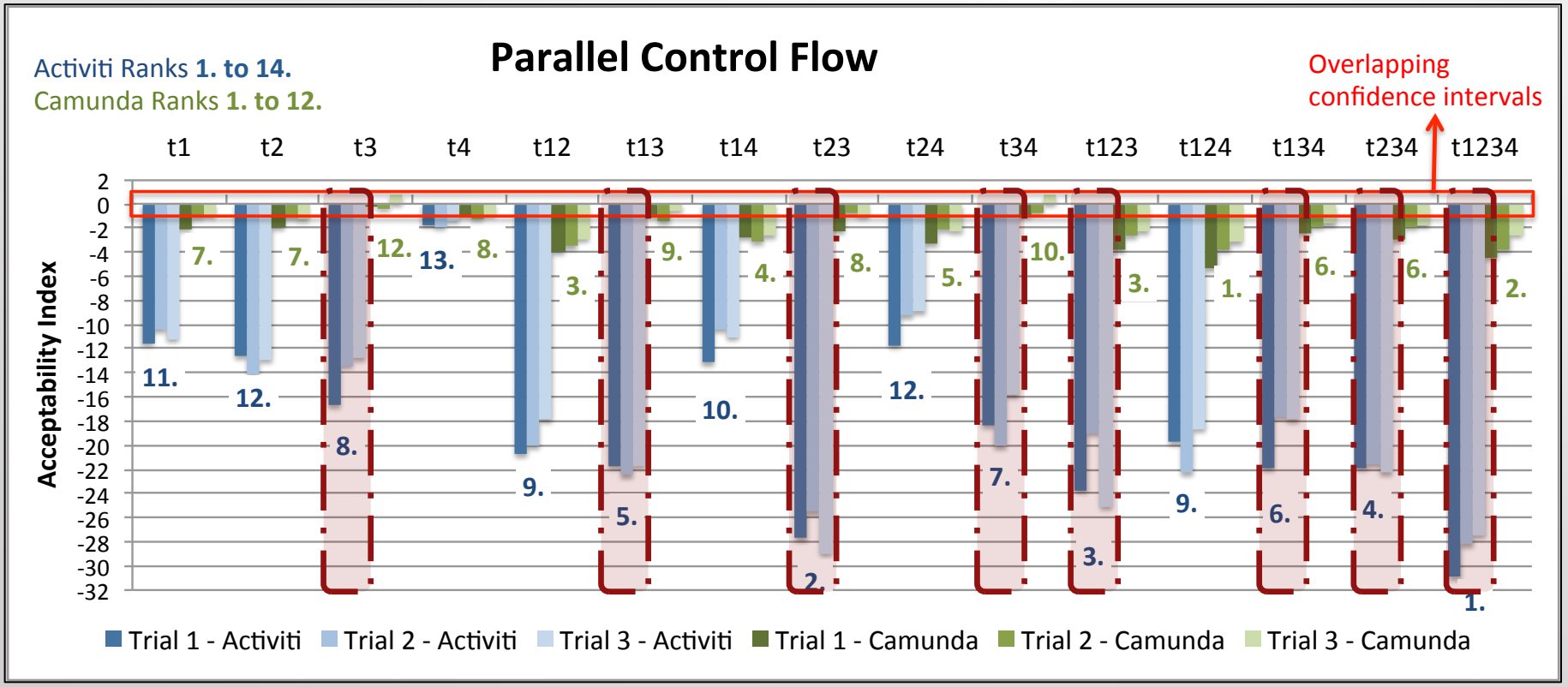

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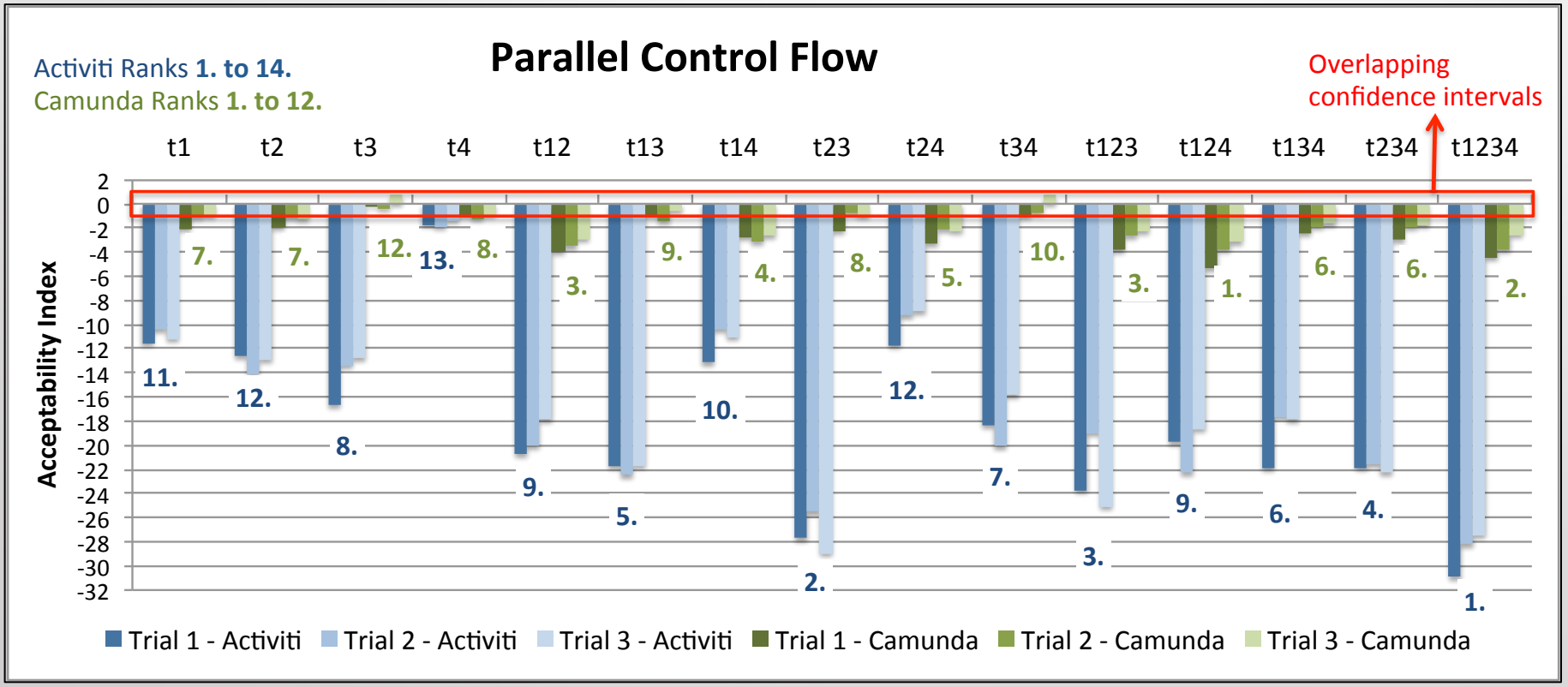

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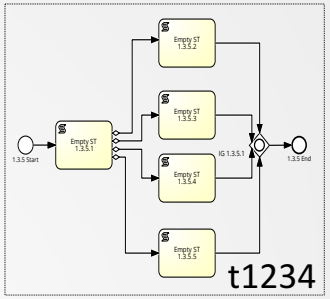

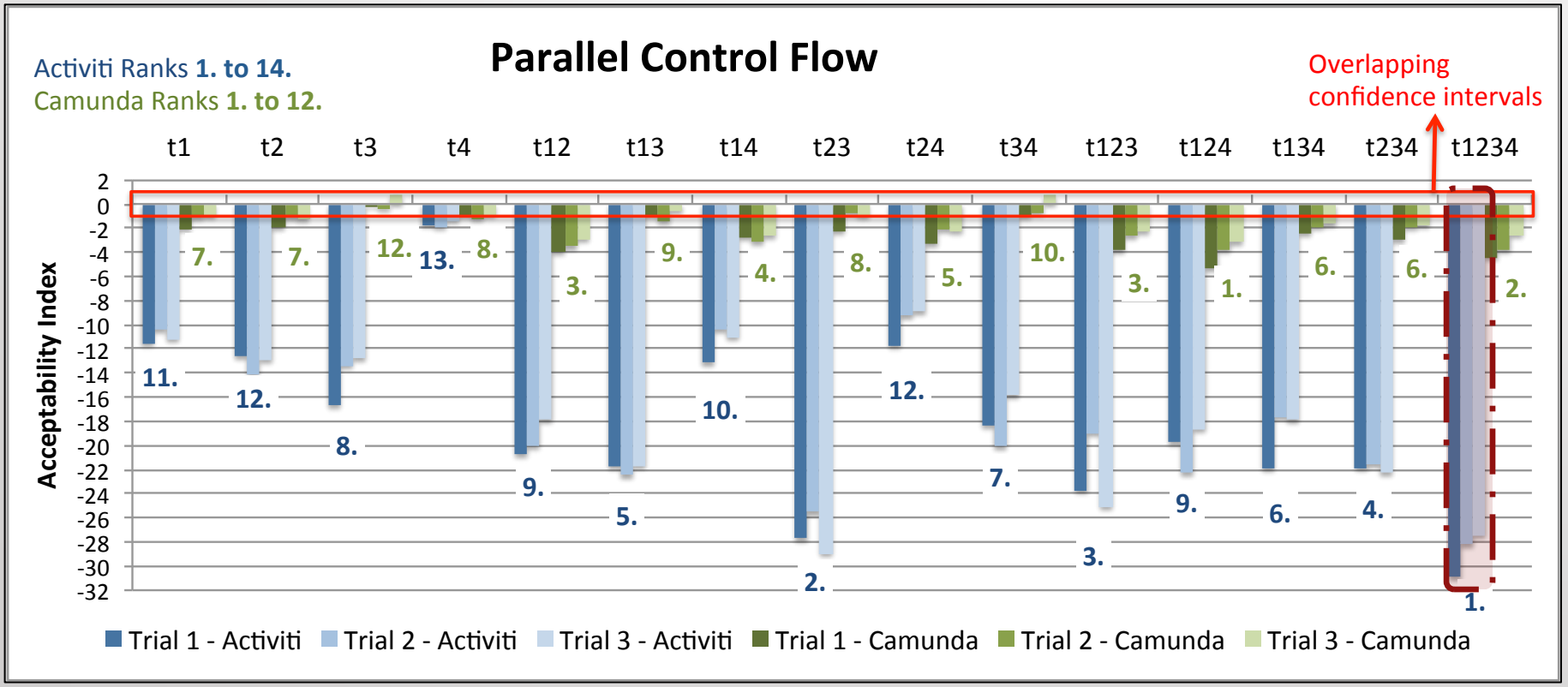

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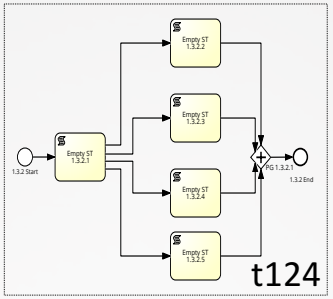

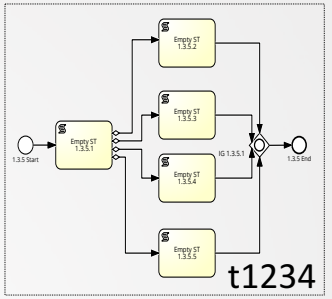

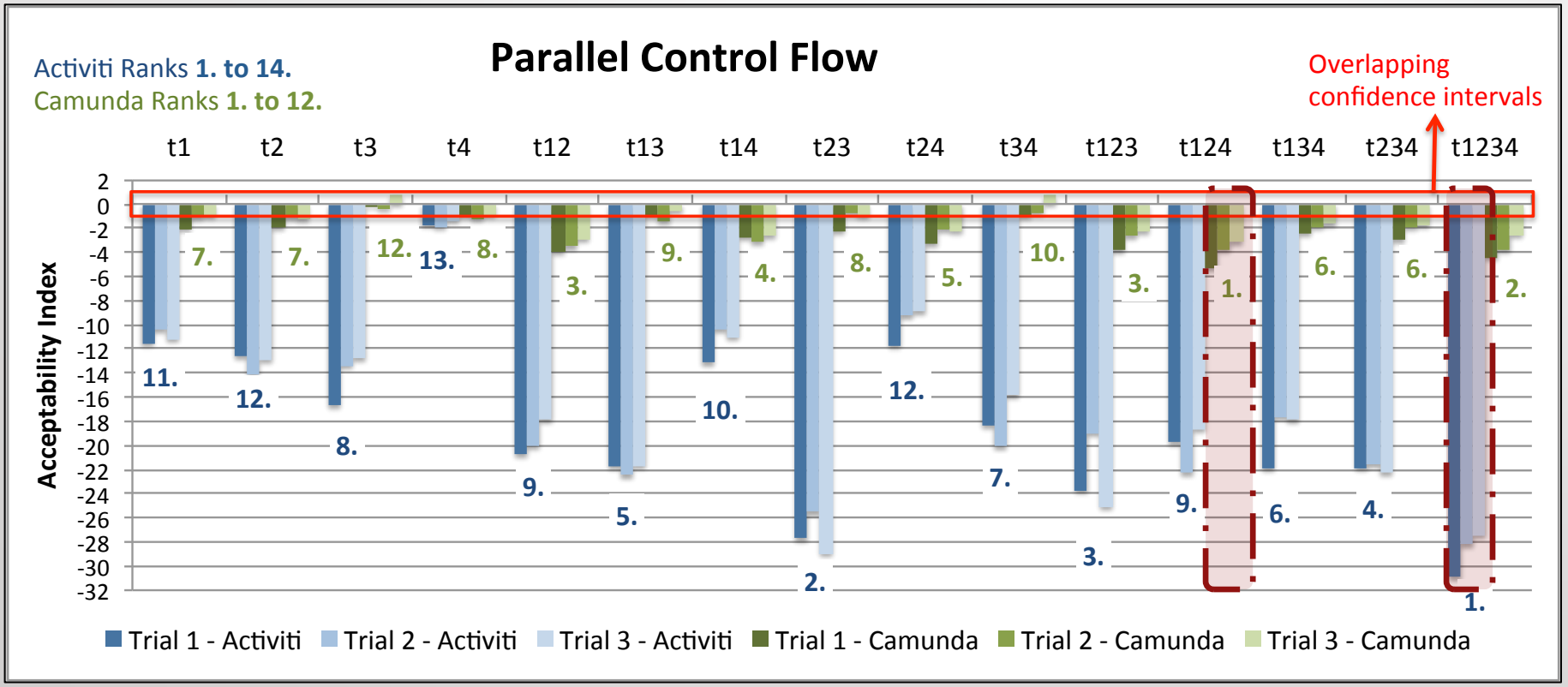

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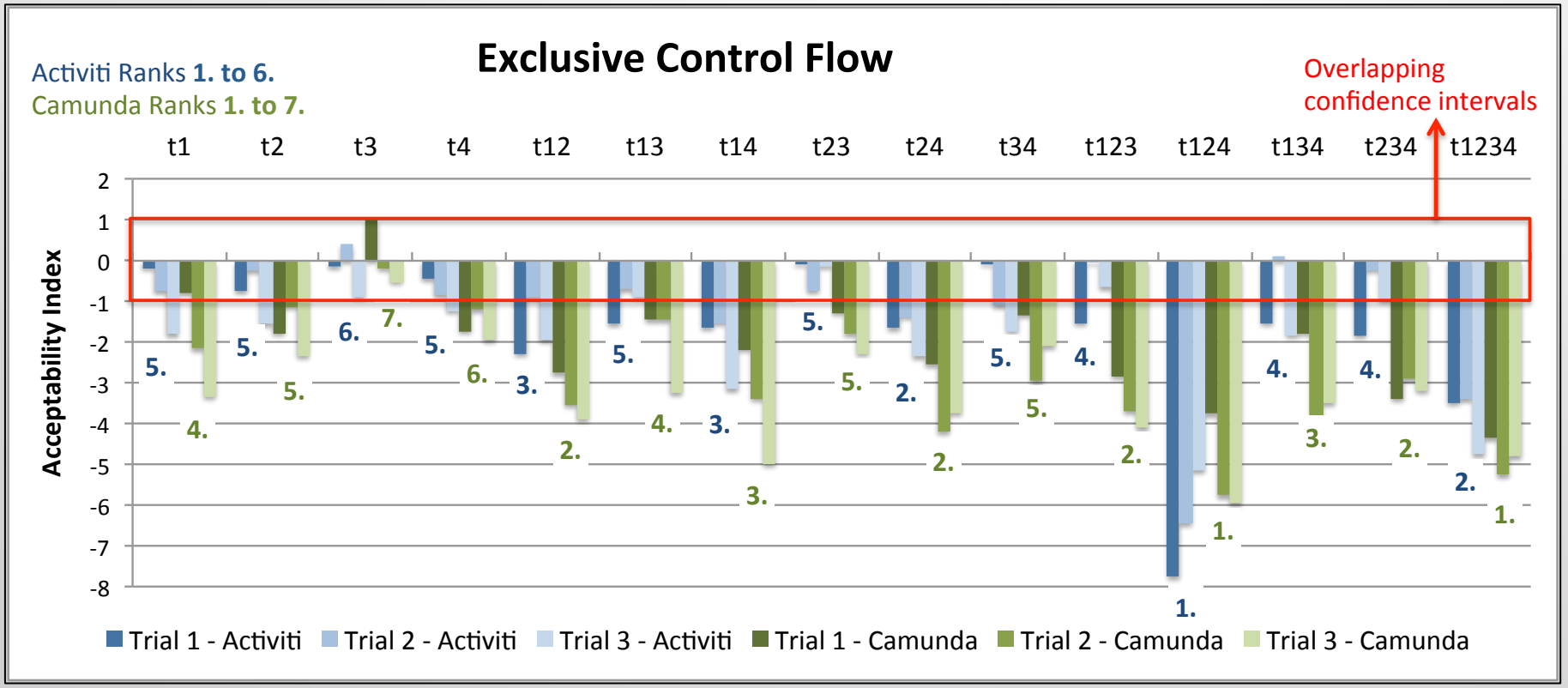

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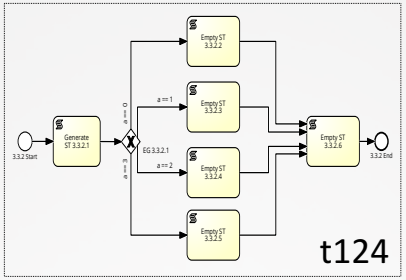

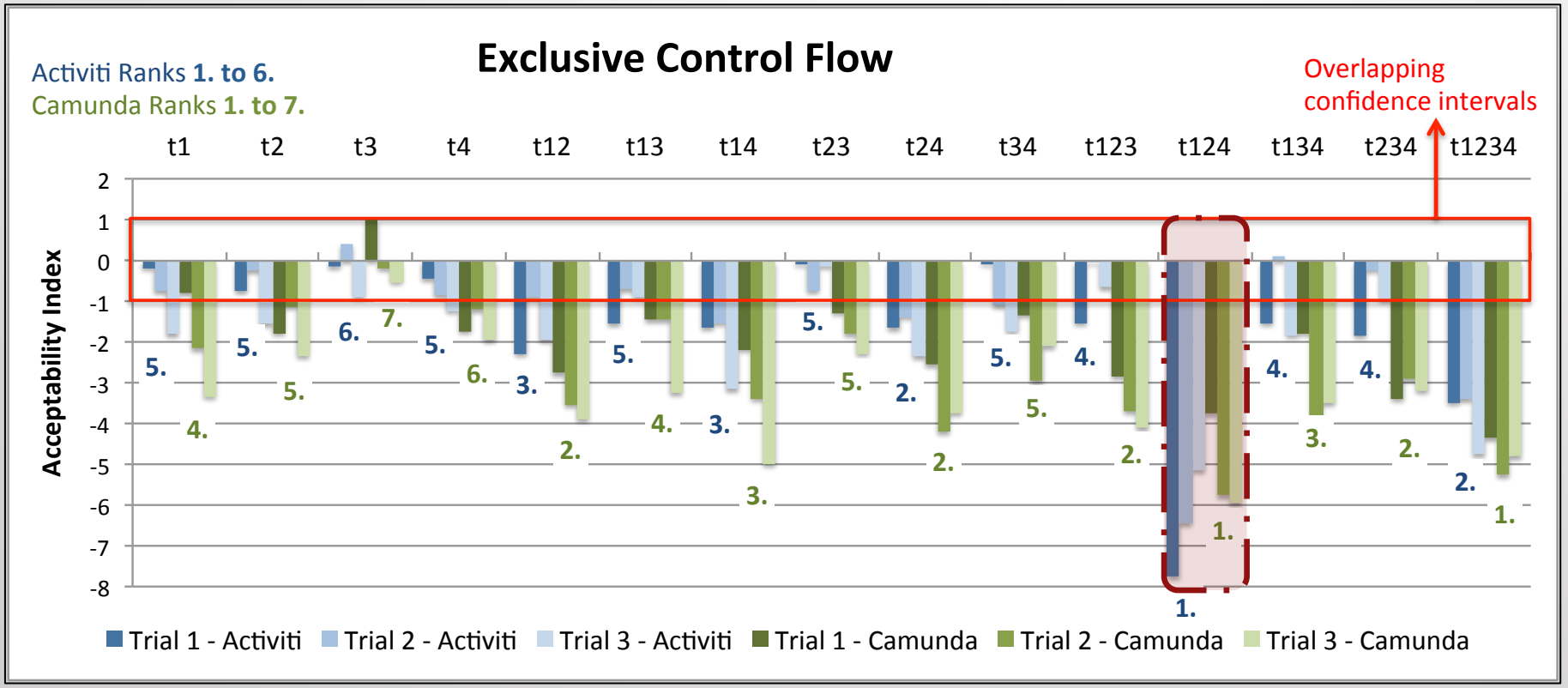

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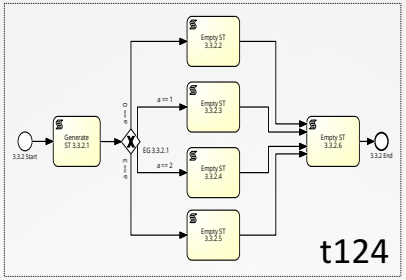

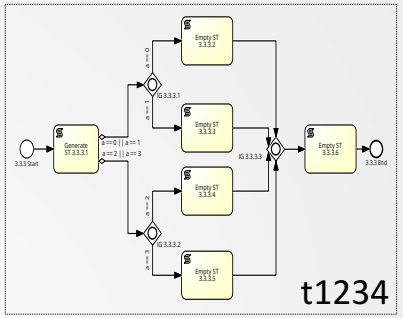

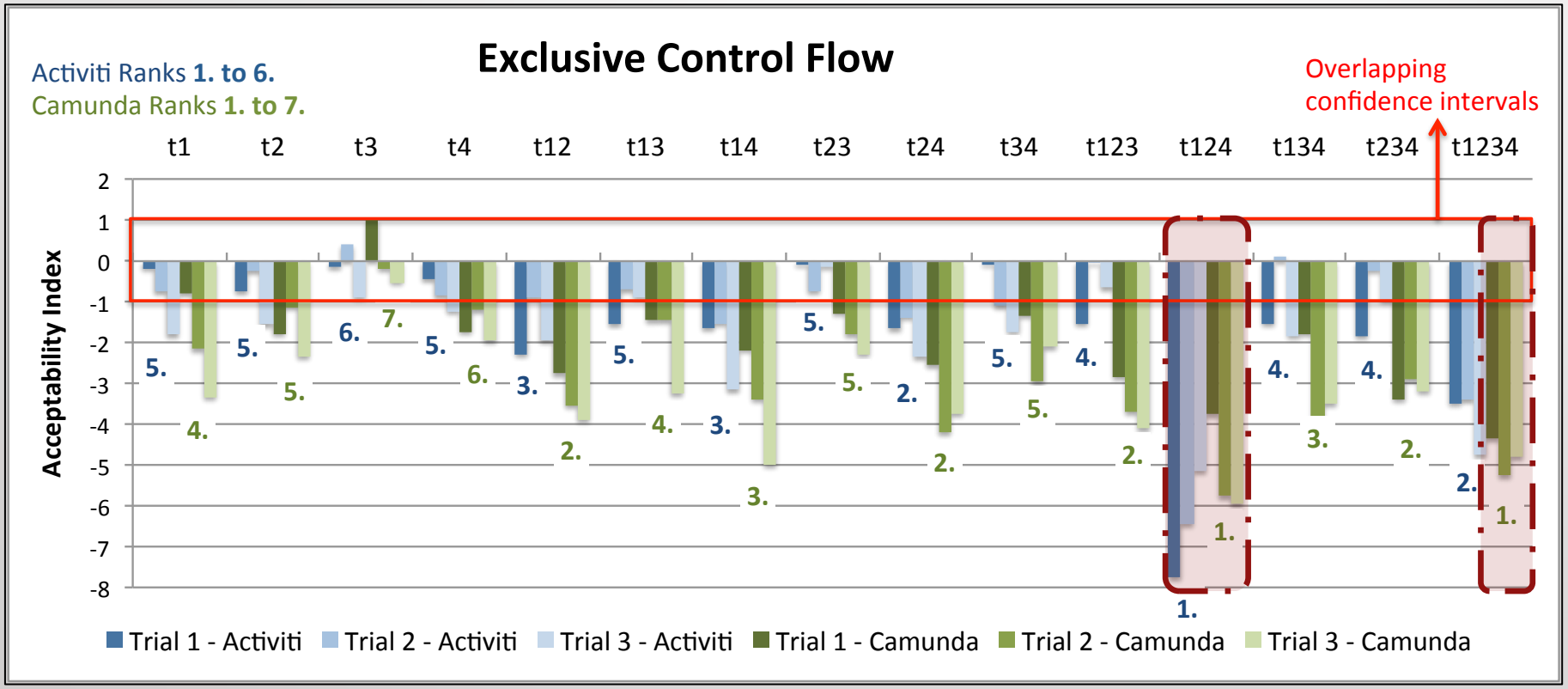

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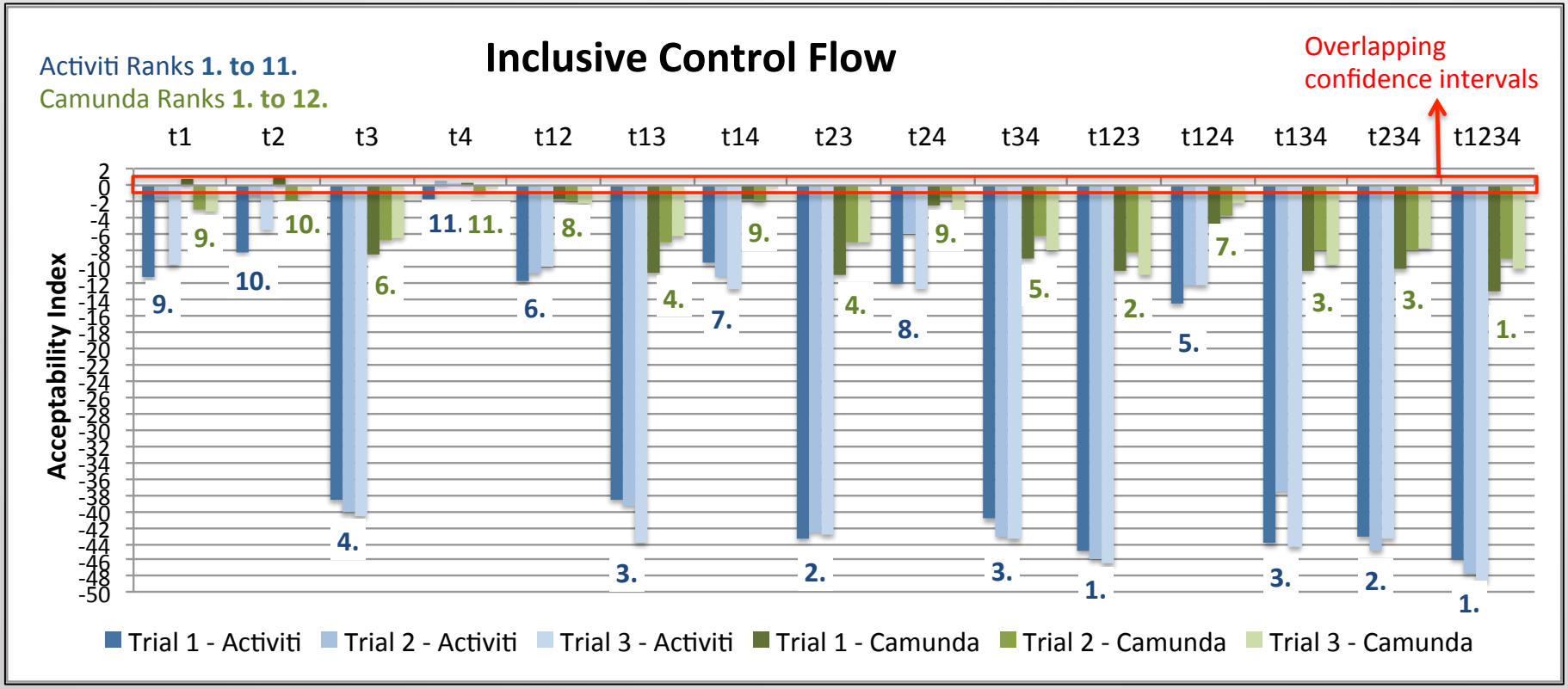

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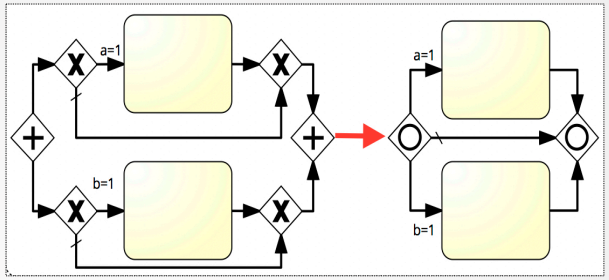

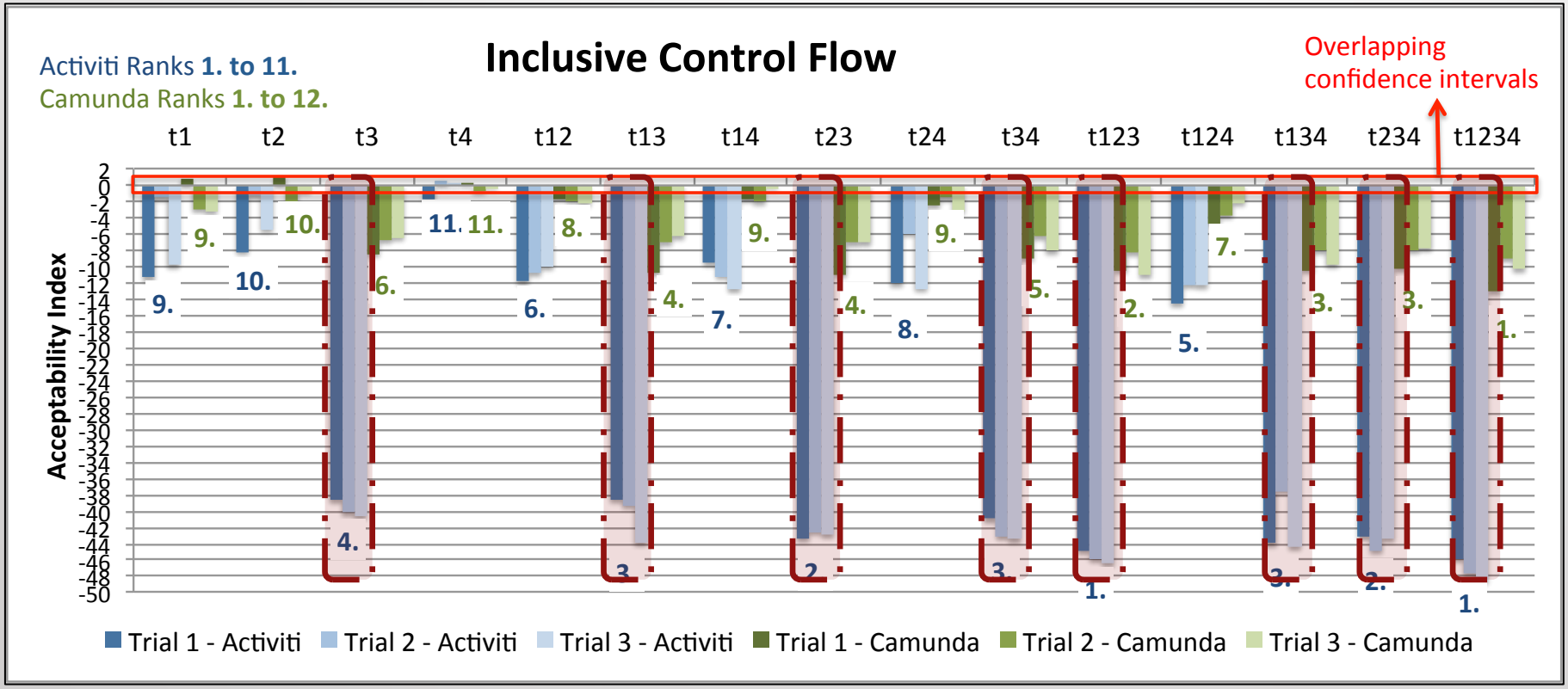

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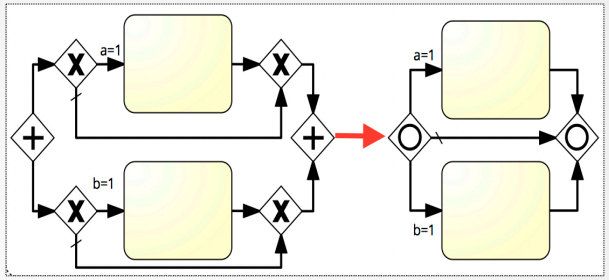

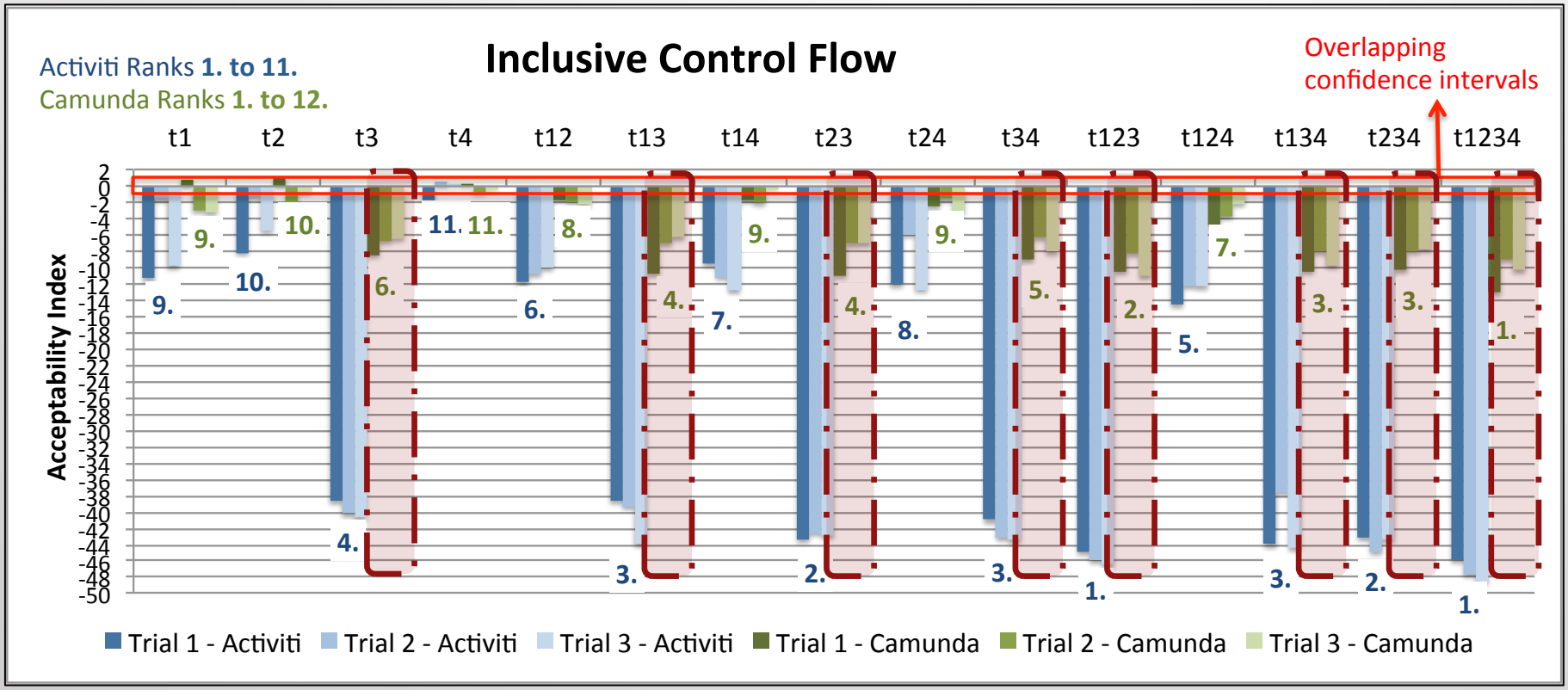

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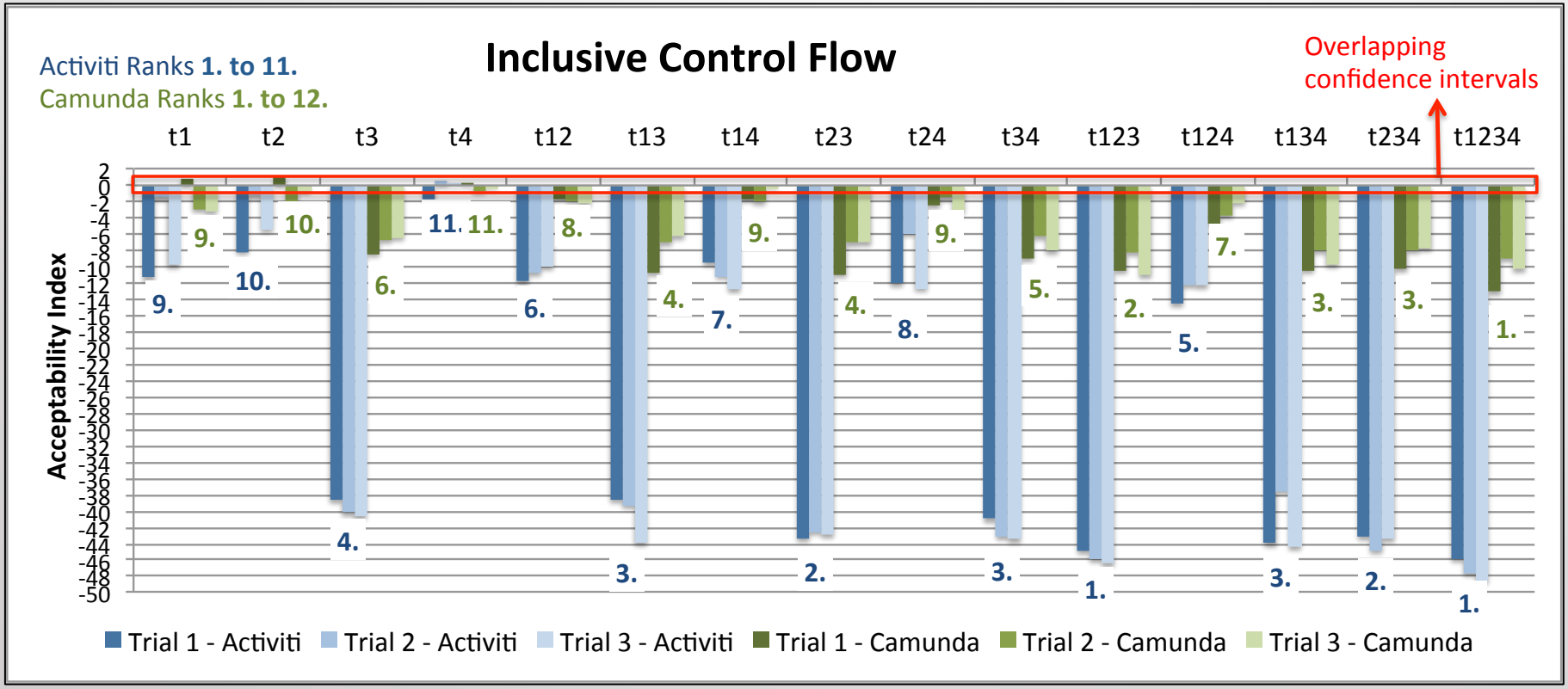

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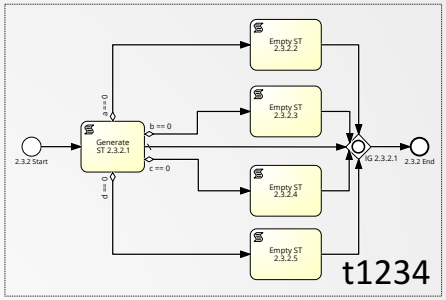

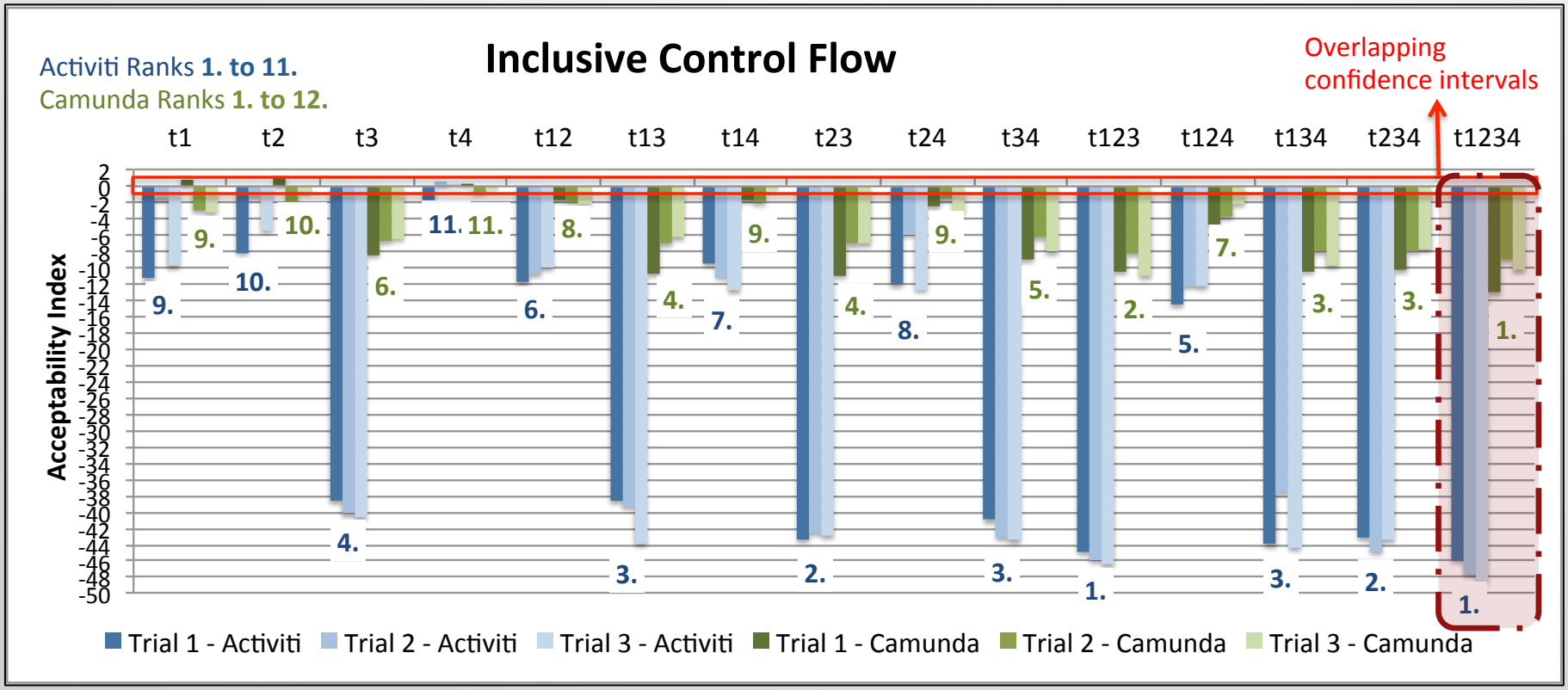

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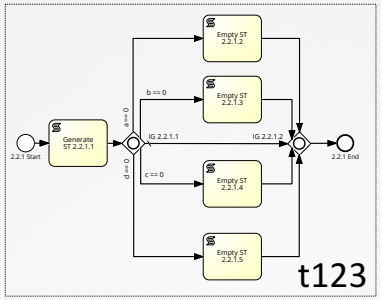

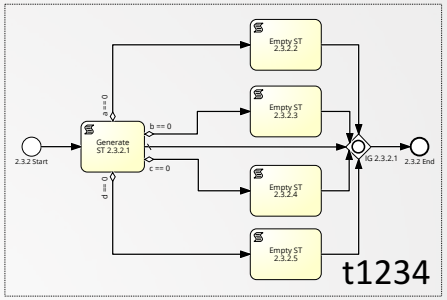

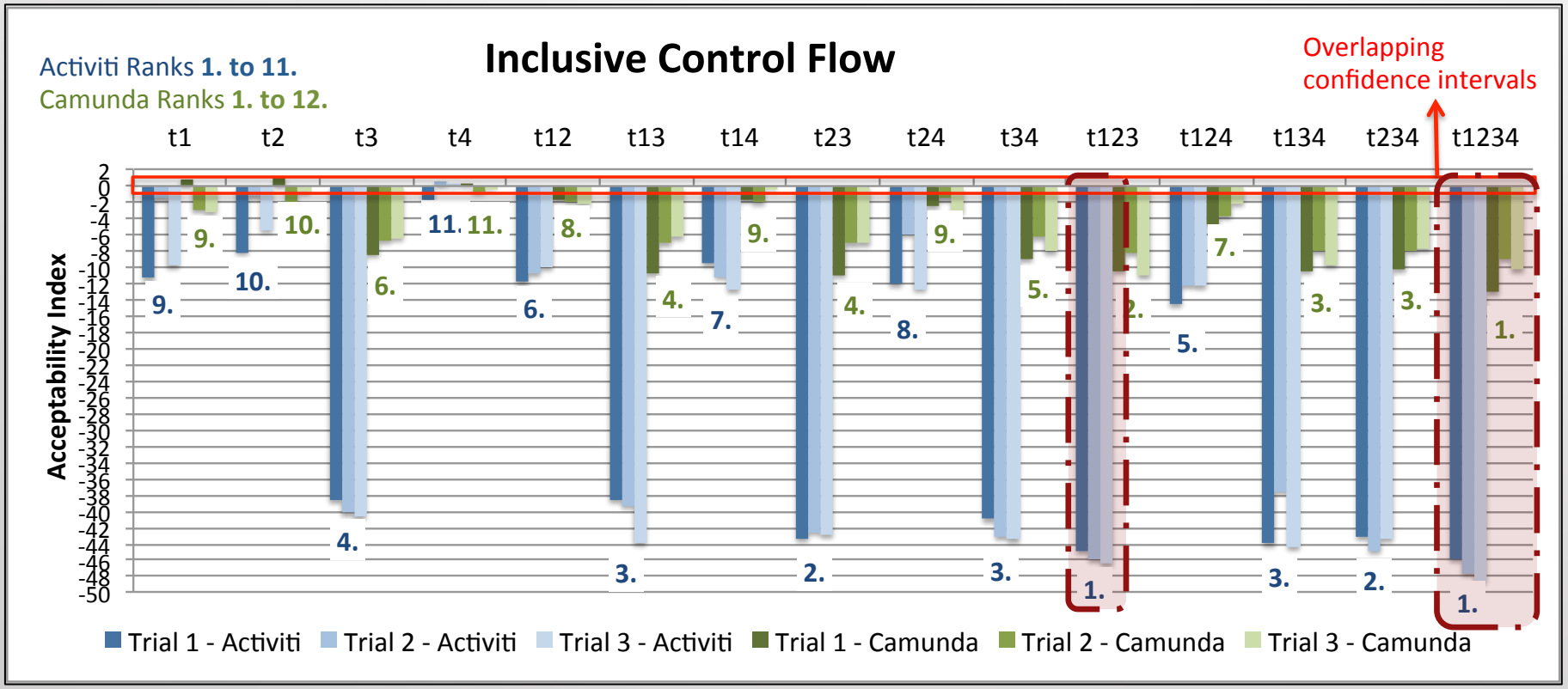

Avoid Inclusive Gateways

Modeling practices and performance

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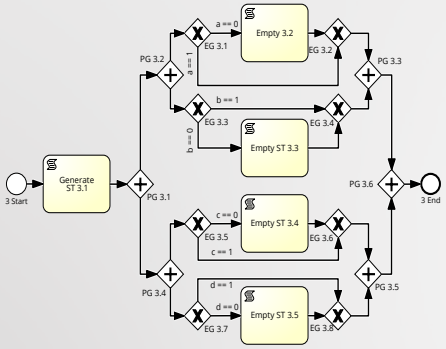

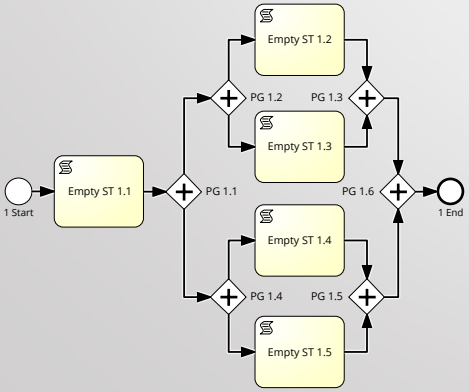

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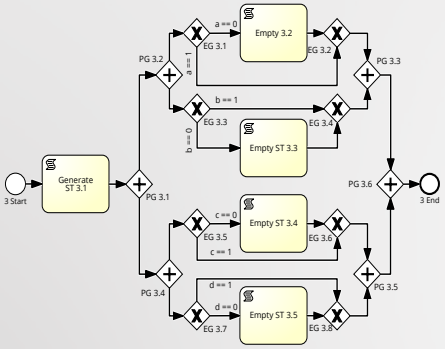
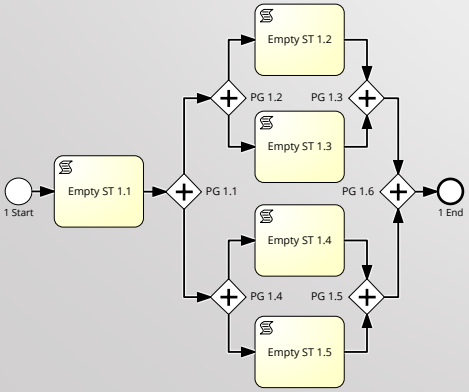
Modeling practices and performance

Use inclusive gateways





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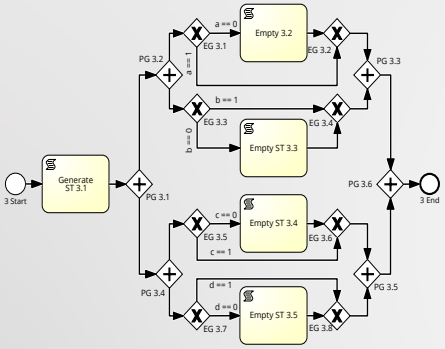
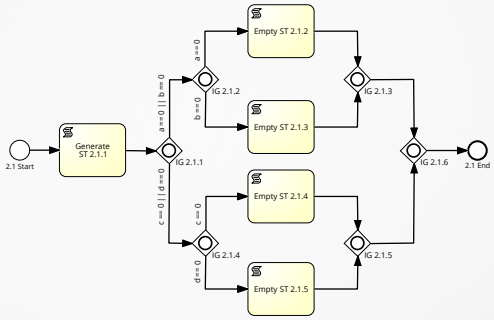
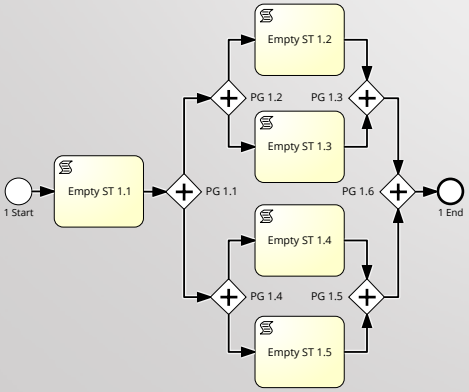


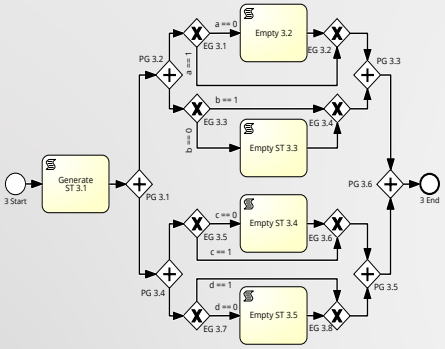
Use inclusive gateways





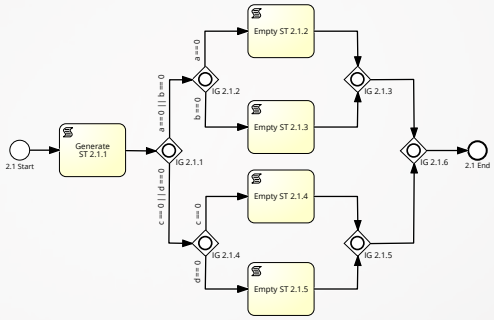
Avoid Inclusive Gateways

Modeling practices and performance

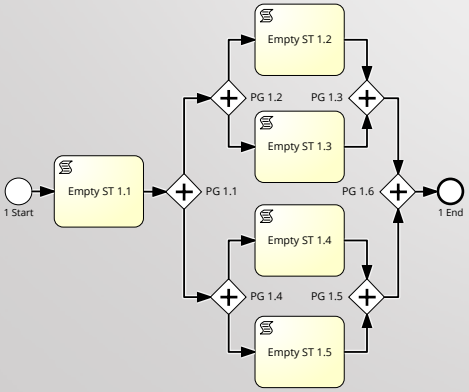


Camunda 2.76 ms ± 0.08 ms

Use inclusive gateways

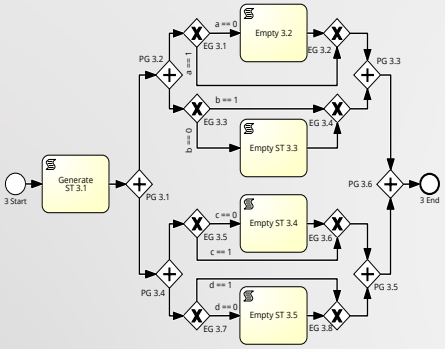


Camunda 2.02 ms ± 0.03 ms



Avoid Inclusive Gateways

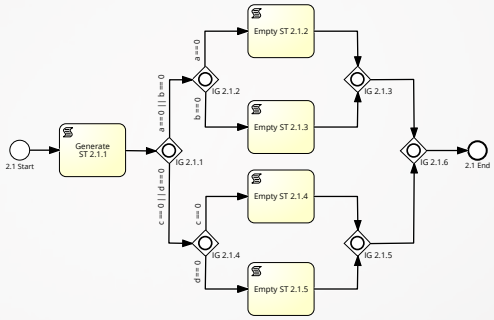
Modeling practices and performance



Camunda 2.76 ms ± 0.08 ms

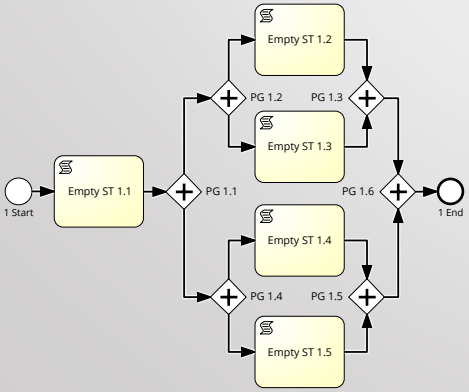
Activiti 29.87ms ± 0.30 ms

Use inclusive gateways



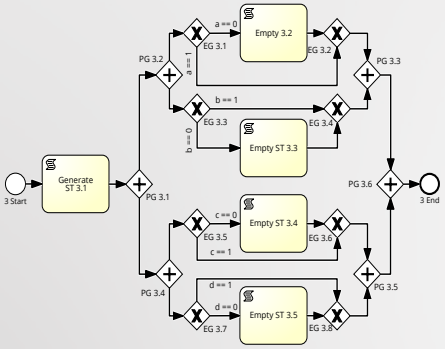
Camunda 2.02 ms ± 0.03 ms

Activiti 11.66 ms ± 0.16 ms



Avoid Inclusive Gateways

Modeling practices and performance



Camunda 2.76 ms ± 0.08 ms

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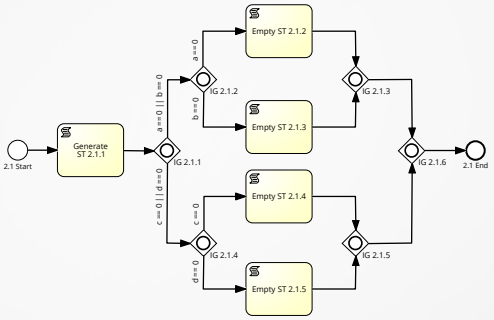
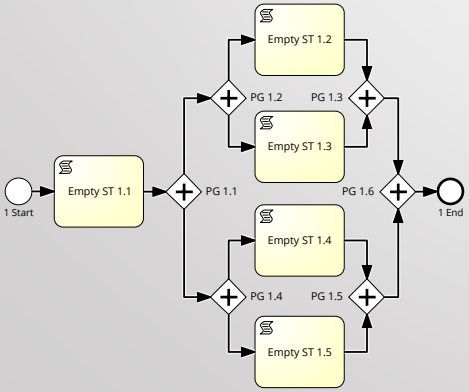
Use inclusive gateways

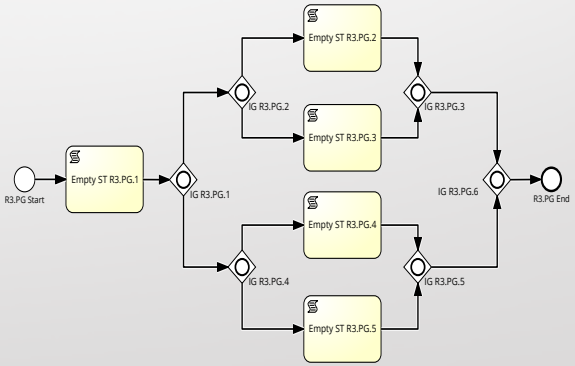


Camunda 2.02 ms ± 0.03 ms

Activiti 11.66 ms ± 0.16 ms



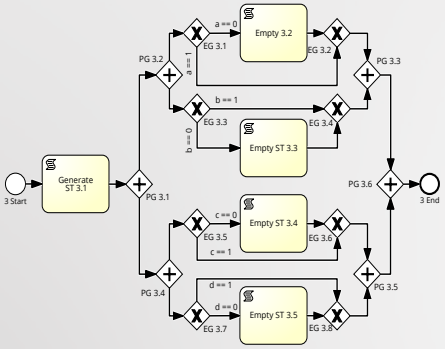
Activiti 26.04 ms ± 0.21 ms



Activiti 19.57 ms ± 0.18 ms

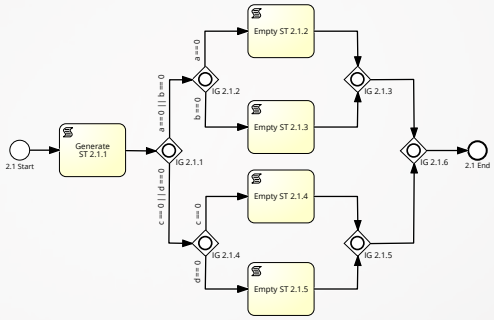
Avoid Inclusive Gateways

Modeling practices and performance

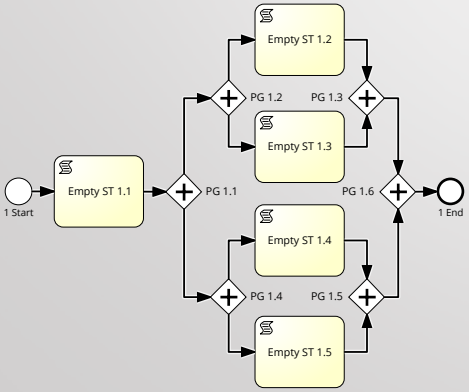


Camunda 2.76 ms ± 0.08 ms
Activiti 29.87ms ± 0.30 ms

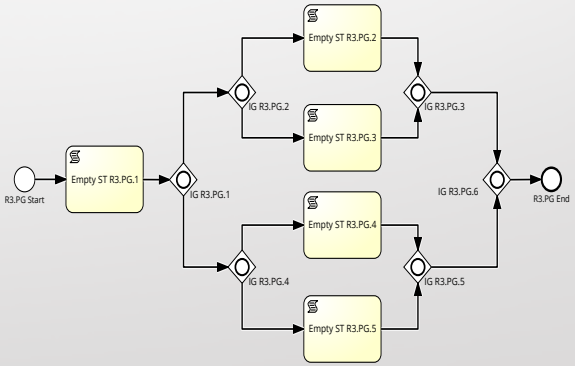
Use inclusive gateways



Camunda 2.02 ms ± 0.03 ms
Activiti 11.66 ms ± 0.16 ms



Camunda 2.51 ms ± 0.05 ms
Activiti 26.04 ms ± 0.21 ms



Camunda 2.58 ms ± 0.05 ms
Activiti 19.57 ms ± 0.18 ms

Use as Few Elements as Possibile

Modeling practices and performance

Camunda									Activiti								
Parallel			Exclusive			Inclusive			Parallel			Exclusive			Inclusive		
Model	Rank	**Size**	Model	Rank	**Size**	Model	Rank	**Size**	Model	Rank	**Size**	Model	Rank	**Size**	Model	Rank	**Size**
t124	1	**18**	t124	1	**20**	t1234	1	**18**	t1234	1	**18**	t124	1	**20**	t1234	1	**18**
t1234	2	**18**	t1234	1	**20**	t123	2	**20**	t23	2	**24**	t24	2	**24**	t123	1	**20**
t12	3	**20**	t123	2	**22**	t134	3	**22**	t123	3	**20**	t1234	2	**20**	t234	2	**22**
t123	3	**20**	t12	2	**22**	t234	3	**22**	t234	4	**22**	t12	3	**22**	t23	2	**24**
t14	4	**22**	t24	2	**24**	t13	4	**24**	t13	5	**24**	t14	3	**24**	t13	3	**24**
t24	5	**22**	t234	2	**24**	t23	4	**24**	t134	6	**22**	t123	4	**22**	t134	3	**22**
t234	6	**22**	t14	3	**24**	t34	5	**26**	t34	7	**26**	t134	4	**24**	t34	3	**26**
t134	6	**22**	t134	3	**24**	t3	6	**28**	t3	8	**28**	t234	4	**24**	t3	4	**28**
t2	7	**24**	t1	4	**26**	t124	7	**38**	t12	9	**20**	t1	5	**26**	t124	5	**38**
t1	7	**24**	t13	4	**26**	t12	8	**40**	t124	9	**18**	t2	5	**26**	t12	6	**40**
t23	8	**24**	t2	5	**26**	t1	9	**44**	t14	10	**22**	t4	5	**28**	t14	7	**42**
t4	8	**26**	t23	5	**26**	t24	9	**42**	t1	11	**24**	t13	5	**26**	t24	8	**42**
t13	9	**24**	t34	5	**28**	t14	9	**42**	t2	12	**24**	t23	5	**26**	t1	9	**44**
t34	10	**26**	t4	6	**28**	t2	10	**44**	t24	12	**22**	t34	5	**28**	t2	10	**44**
im	11	**28**	t3	7	**30**	t4	11	**46**	t4	13	**26**	im	6	**30**	im	11	**48**
t3	12	**28**	im	7	**30**	im	12	**48**	im	14	**28**	t3	6	**30**	t4	11	**46**

Use as Few Elements as Possible

Modeling practices and performance

Camunda									Activiti								
Parallel			Exclusive			Inclusive			Parallel			Exclusive			Inclusive		
Model	Rank	**Size**	Model	Rank	**Size**	Model	Rank	**Size**	Model	Rank	**Size**	Model	Rank	**Size**	Model	Rank	**Size**
t124	1	**18**	t124	1	**20**	t1234	1	**18**	t1234	1	**18**	t124	1	**20**	t1234	1	**18**
t1234	2	**18**	t1234	1	**20**	t123	2	**20**	t23	2	**24**	t24	2	**24**	t123	1	**20**
t12	3	**20**	t123	2	**22**	t134	3	**22**	t123	3	**20**	t1234	2	**20**	t234	2	**22**
t123	3	**20**	t12	2	**22**	t234	3	**22**	t234	4	**22**	t12	3	**22**	t23	2	**24**
t14	4	**22**	t24	2	**24**	t13	4	**24**	t13	5	**24**	t14	3	**24**	t13	3	**24**
t24	5	**22**	t234	2	**24**	t23	4	**24**	t134	6	**22**	t123	4	**22**	t134	3	**22**
t234	6	**22**	t14	3	**24**	t34	5	**26**	t34	7	**26**	t134	4	**24**	t34	3	**26**
t134	6	**22**	t134	3	**24**	t3	6	**28**	t3	8	**28**	t234	4	**24**	t3	4	**28**
t2	7	**24**	t1	4	**26**	t124	7	**38**	t12	9	**20**	t1	5	**26**	t124	5	**38**
t1	7	**24**	t13	4	**26**	t12	8	**40**	t124	9	**18**	t2	5	**26**	t12	6	**40**
t23	8	**24**	t2	5	**26**	t1	9	**44**	t14	10	**22**	t4	5	**28**	t14	7	**42**
t4	8	**26**	t23	5	**26**	t24	9	**42**	t1	11	**24**	t13	5	**26**	t24	8	**42**
t13	9	**24**	t34	5	**28**	t14	9	**42**	t2	12	**24**	t23	5	**26**	t1	9	**44**
t34	10	**26**	t4	6	**28**	t2	10	**44**	t24	12	**22**	t34	5	**28**	t2	10	**44**
im	11	**28**	t3	7	**30**	t4	11	**46**	t4	13	**26**	im	6	**30**	im	11	**48**
t3	12	**28**	im	7	**30**	im	12	**48**	im	14	**28**	t3	6	**30**	t4	11	**46**

Use as Few Elements as Possible

Modeling practices and performance

Camunda									Activiti								
Parallel			Exclusive			Inclusive			Parallel			Exclusive			Inclusive		
Model	Rank	**Size**	Model	Rank	**Size**	Model	Rank	**Size**	Model	Rank	**Size**	Model	Rank	**Size**	Model	Rank	**Size**
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t1234	2	**18**	t1234	1	**20**	t123	2	**20**	t23	2	**24**	t24	2	**24**	t123	1	**20**
t12	3	**20**	t123	2	**22**	t134	3	**22**	t123	3	**20**	t1234	2	**20**	t234	2	**22**
t123	3	**20**	t12	2	**22**	t234	3	**22**	t234	4	**22**	t12	3	**22**	t23	2	**24**
t14	4	**22**	t24	2	**24**	t13	4	**24**	t13	5	**24**	t14	3	**24**	t13	3	**24**
t24	5	**22**	t234	2	**24**	t23	4	**24**	t134	6	**22**	t123	4	**22**	t134	3	**22**
t234	6	**22**	t14	3	**24**	t34	5	**26**	t34	7	**26**	t134	4	**24**	t34	3	**26**
t134	6	**22**	t134	3	**24**	t3	6	**28**	t3	8	**28**	t234	4	**24**	t3	4	**28**
t2	7	**24**	t1	4	**26**	t124	7	**38**	t12	9	**20**	t1	5	**26**	t124	5	**38**
t1	7	**24**	t13	4	**26**	t12	8	**40**	t124	9	**18**	t2	5	**26**	t12	6	**40**
t23	8	**24**	t2	5	**26**	t1	9	**44**	t14	10	**22**	t4	5	**28**	t14	7	**42**
t4	8	**26**	t23	5	**26**	t24	9	**42**	t1	11	**24**	t13	5	**26**	t24	8	**42**
t13	9	**24**	t34	5	**28**	t14	9	**42**	t2	12	**24**	t23	5	**26**	t1	9	**44**
t34	10	**26**	t4	6	**28**	t2	10	**44**	t24	12	**22**	t34	5	**28**	t2	10	**44**
im	11	**28**	t3	7	**30**	t4	11	**46**	t4	13	**26**	im	6	**30**	im	11	**48**
t3	12	**28**	im	7	**30**	im	12	**48**	im	14	**28**	t3	6	**30**	t4	11	**46**

Use as Few Elements as Possible

Modeling practices and performance

Camunda									Activiti								
Parallel			Exclusive			Inclusive			Parallel			Exclusive			Inclusive		
Model	Rank	**Size**	Model	Rank	**Size**	Model	Rank	**Size**	Model	Rank	**Size**	Model	Rank	**Size**	Model	Rank	**Size**
t124	1	**18**	t124	1	**20**	t1234	1	**18**	t1234	1	**18**	t124	1	**20**	t1234	1	**18**
t1234	2	**18**	t1234	1	**20**	t123	2	**20**	t23	2	**24**	t24	2	**24**	t123	1	**20**
t12	3	**20**	t123	2	**22**	t134	3	**22**	t123	3	**20**	t1234	2	**20**	t234	2	**22**
t123	3	**20**	t12	2	**22**	t234	3	**22**	t234	4	**22**	t12	3	**22**	t23	2	**24**
t14	4	**22**	t24	2	**24**	t13	4	**24**	t13	5	**24**	t14	3	**24**	t13	3	**24**
t24	5	**22**	t234	2	**24**	t23	4	**24**	t134	6	**22**	t123	4	**22**	t134	3	**22**
t234	6	**22**	t14	3	**24**	t34	5	**26**	t34	7	**26**	t134	4	**24**	t34	3	**26**
t134	6	**22**	t134	3	**24**	t3	6	**28**	t3	8	**28**	t234	4	**24**	t3	4	**28**
t2	7	**24**	t1	4	**26**	t124	7	**38**	t12	9	**20**	t1	5	**26**	t124	5	**38**
t1	7	**24**	t13	4	**26**	t12	8	**40**	t124	9	**18**	t2	5	**26**	t12	6	**40**
t23	8	**24**	t2	5	**26**	t1	9	**44**	t14	10	**22**	t4	5	**28**	t14	7	**42**
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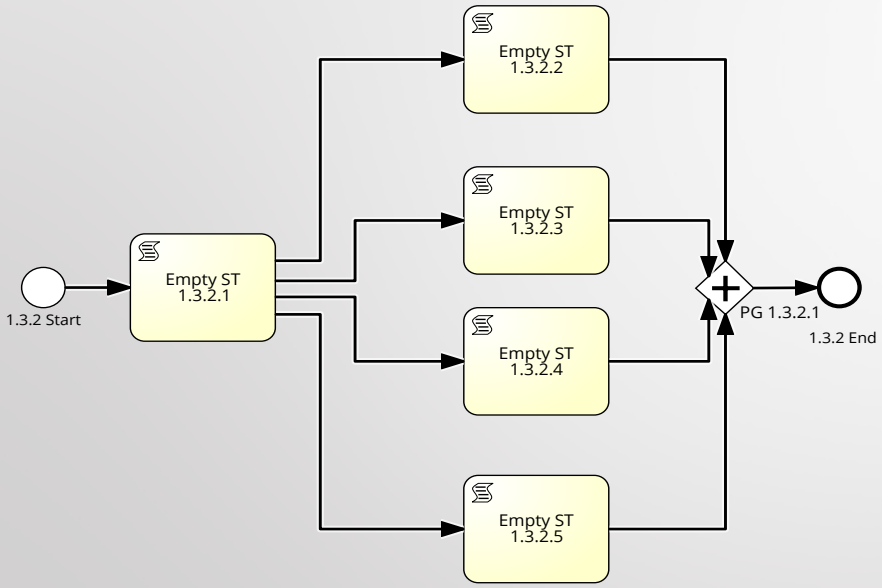
t13	9	**24**	t34	5	**28**	t14	9	**42**	t2	12	**24**	t23	5	**26**	t1	9	**44**
t34	10	**26**	t4	6	**28**	t2	10	**44**	t24	12	**22**	t34	5	**28**	t2	10	**44**
im	11	**28**	t3	7	**30**	t4	11	**46**	t4	13	**26**	im	6	**30**	im	11	**48**
t3	12	**28**	im	7	**30**	im	12	**48**	im	14	**28**	t3	6	**30**	t4	11	**46**

Minimize the routing paths per element
Model as structured as possible

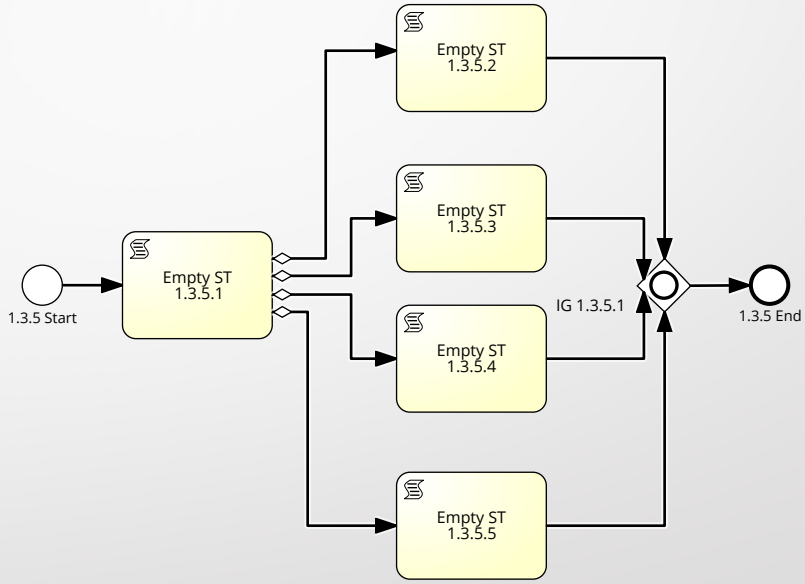
Modeling practices and performance

Minimize the routing paths per element
Model as structured as possible

Modeling practices and performance



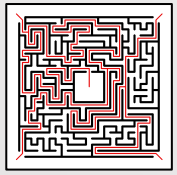
t124



t1234

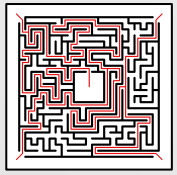
Best performing models

Conclusions



Modeling is a discretional decision of the modeler!!!

Conclusions

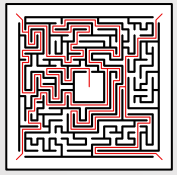


Modeling is a discretional decision of the modeler!!!

Our ultimate goal:

Take the model and transform it to a better performing but semantically equivalent model

Conclusions



Modeling is a discretional decision of the modeler!!!

Our ultimate goal:

Take the model and transform it to a better performing but semantically equivalent model

Our challenge:

Define optimization rules to obtain the better performing model

Conclusions

camunda
the business process company

in milliseconds

Parallel		Exclusive		Inclusive	
Initial model	Best model	Initial model	Best model	Initial model	Best model
2.59±0.05	2.16±0.03	1.55±0.02	1.32±0.02	2.76±0.08	1.78±0.02

Activiti™

in milliseconds

Parallel		Exclusive		Inclusive	
Initial model	Best model	Initial model	Best model	Initial model	Best model
26.04±0.21	15.75±0.13	2.14±0.07	1.39±0.02	29.87±0.30	9.93±0.14

Conclusions

camunda
the business process company

in milliseconds

Parallel		Exclusive		Inclusive	
Initial model	Best model	Initial model	Best model	Initial model	Best model
2.59±0.05	2.16±0.03	1.55±0.02	1.32±0.02	2.76±0.08	1.78±0.02
	~17%		~15%		~36%

Activiti

in milliseconds

Parallel		Exclusive		Inclusive	
Initial model	Best model	Initial model	Best model	Initial model	Best model
26.04±0.21	15.75±0.13	2.14±0.07	1.39±0.02	29.87±0.30	9.93±0.14
	~40%		~35%		~67%

New automatic optimization opportunity?

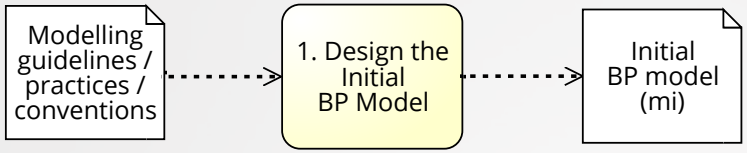
On the Performance Overhead of BPMN Modeling Practices

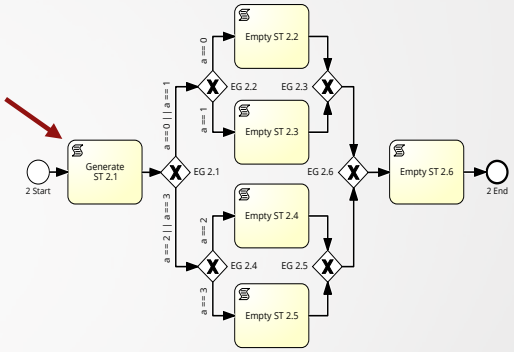
ana.ivanchikj@usi.ch

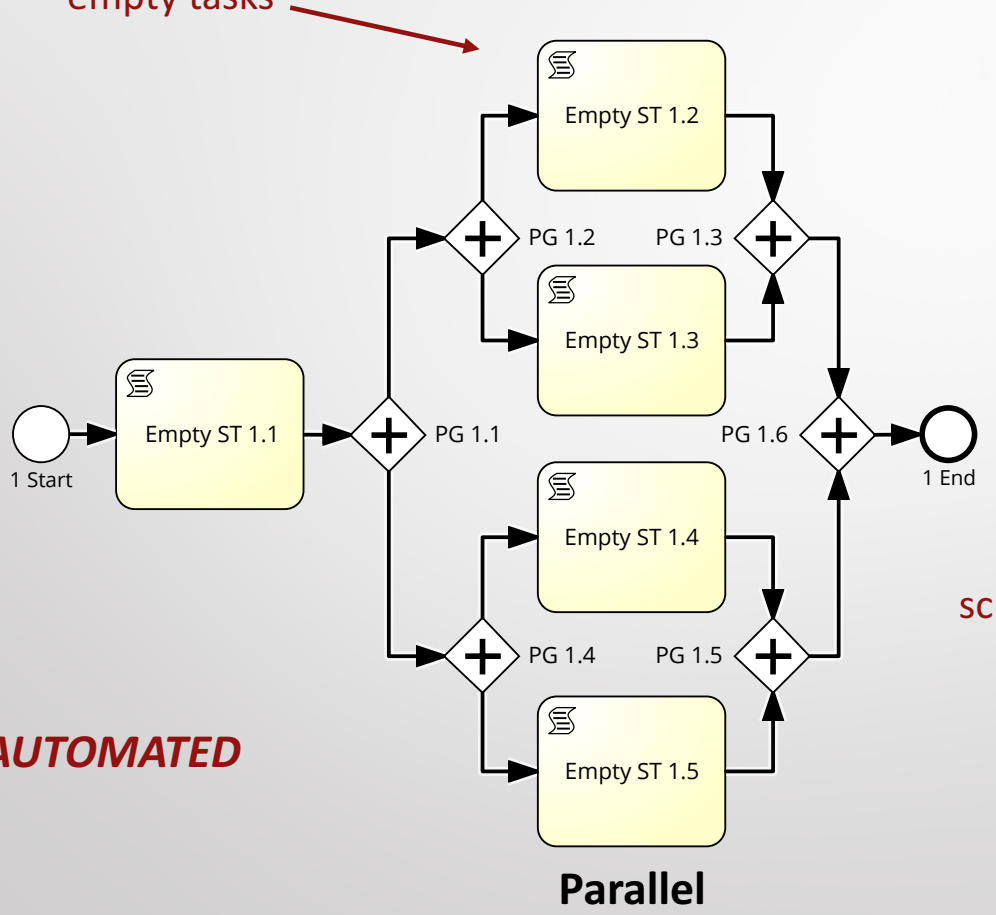
Università della Svizzera italiana

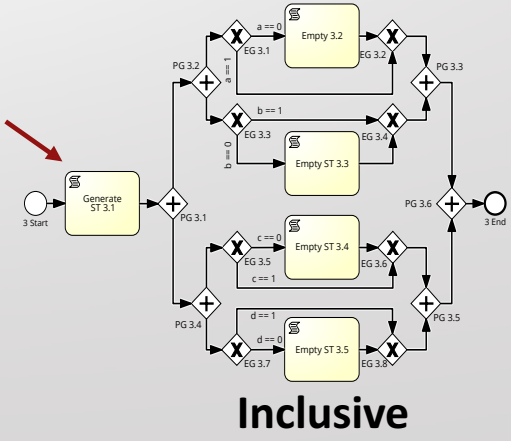
Back-up slides

ana.ivanchikj@usi.ch









FULLY AUTOMATED

Model ranking

Dunn's test - the **H0** is that the probability of observing a randomly selected value from the first sample that is larger than a randomly selected value from the second sample equals one half, i.e., no sample dominates the other => **we assign the same rank.**
Rejecting the H0, implies that the first sample is dominated by the second sample => **we assign different ranks.**

Base-case rank - the **sum** of the assigned ranks in **each** performed **trial** (what we show in the table).

Sensitivity analysis - we test the sensitivity of the order of the performance of the executed models as per the base-case rank on the the ranks from the individual trials. We use a deterministic one-at-a-time, also known as **one-side, sensitivity analysis**.

Benchflow Environment Setup

- the WfMS, the DB and Faban, are all deployed in Docker images on dedicated servers using the **Docker Engine** 1.9.1 and **Ubuntu** 14.04.3 LTS (GNU/Linux 3.13.0-40-generic x86 64) as OS.
- they interact through two **networks** of 10Gbit/s each, one dedicated to the communication between the WfMS and the DB and the other one dedicated to other interactions (e.g., issuing the load).
- The **WfMS** runs on a **server** with 64 Cores (2 threads) and a clock speed of 1'400MHz mounting 128GB of RAM and a magnetic disk with 15'000 rpm.
- The **DB** runs on a **server** with 64 Cores (2 threads) and a clock speed of 2'300MHz mounting 128GB of RAM and a SSD SATA disk.
- **Faban's Load Drivers** are placed on **three servers**: one with 64 Cores (2 threads) and a clock speed of 2'300MHz mounting 128GB of RAM, the second with 48 Cores (2 threads) and a clock speed of 2'000MHz mounting 128GB of RAM, and the third with 12 Cores (1 thread) at 800MHz mounting 64GB of RAM.