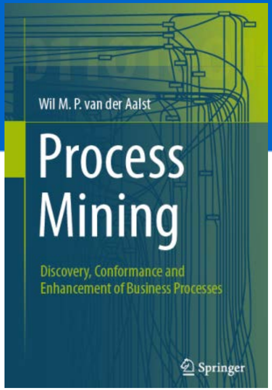
Process Mining: Data Science in Action

Alpha Algorithm: A Process Discovery Algorithm



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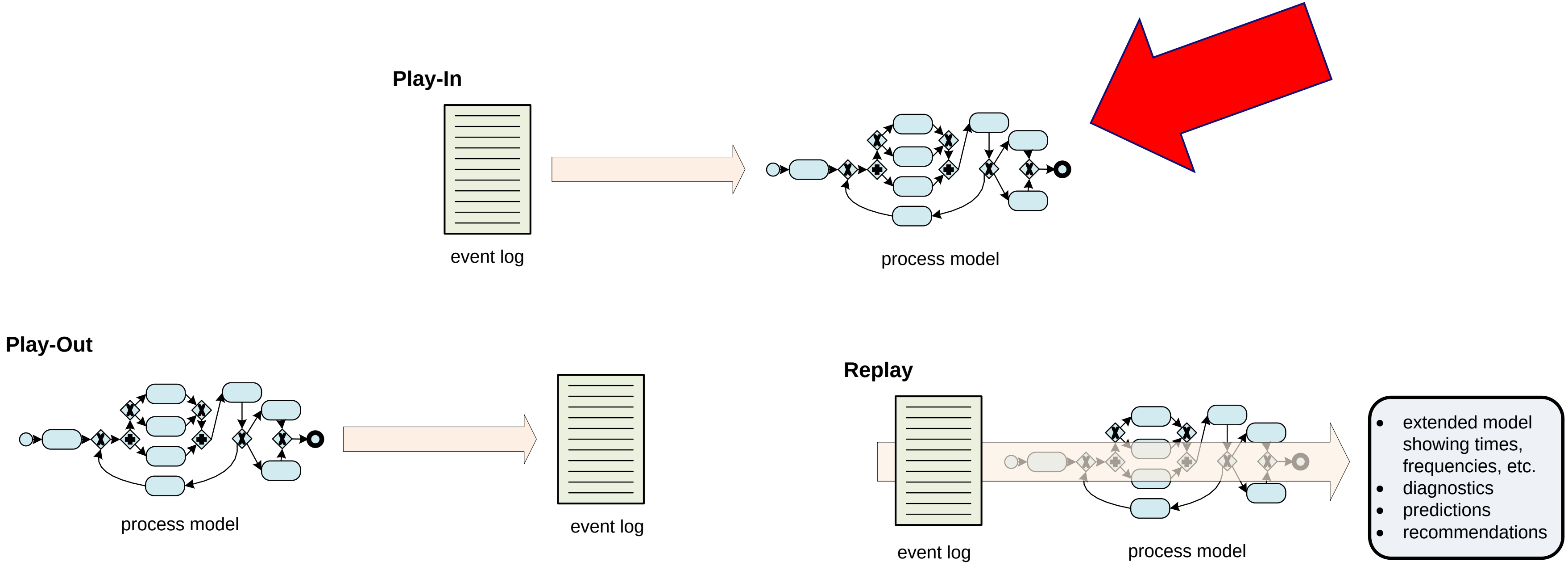
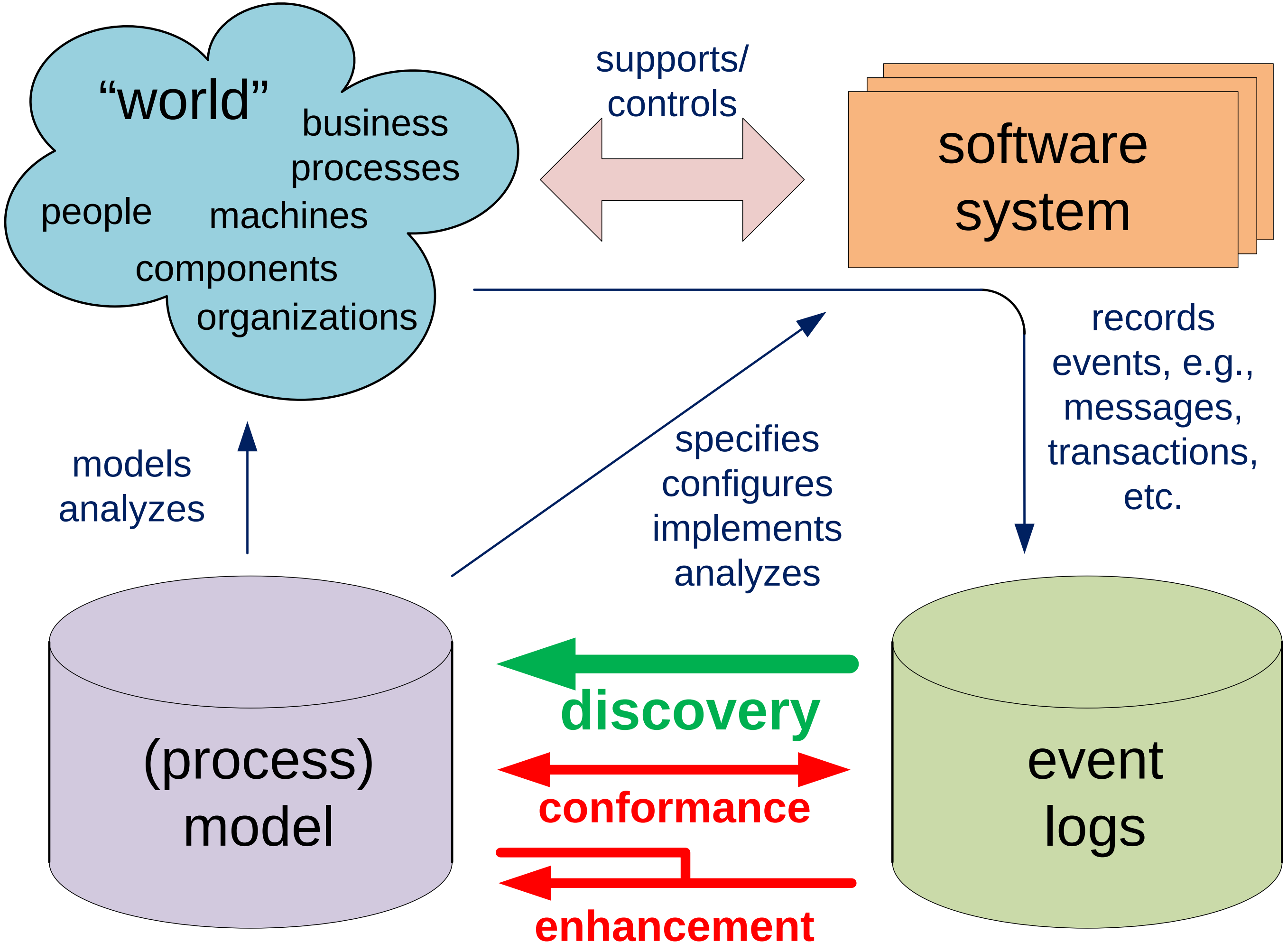
Where innovation starts

Process discovery = Play-In





"world"
business processes
people
machines
components
organizations
supports/ controls
software system
records events, e.g., messages, transactions, etc.
models analyzes
specifies configures implements analyzes
discovery
conformance
enhancement
(process) model
event logs

Simplifying event logs when focusing on control-flow

order number	activity	timestamp	user	product	quantity
9901	register order	22-1-2014@09.15	Sara Jones	iPhone5S	1
9902	register order	22-1-2014@09.18	Sara Jones	iPhone5S	2
9903	register order	22-1-2014@09.27	Sara Jones	iPhone4S	1
9901	check stock	22-1-2014@09.49	Pete Scott	iPhone5S	1
9901	ship order	22-1-2014@10.11	Sue Fox	iPhone5S	1
9903	check stock	22-1-2014@10.34	Pete Scott	iPhone4S	1
9901	handle payment	22-1-2014@10.41	Carol Hope	iPhone5S	1
9902	check stock	22-1-2014@10.57	Pete Scott	iPhone5S	2

[⟨register_order, check_stock,ship_order,handle_payment⟩,
⟨register_order, check_stock,cancel_order⟩,
⟨register_order, check_stock⟩ , ...]

Simple event log

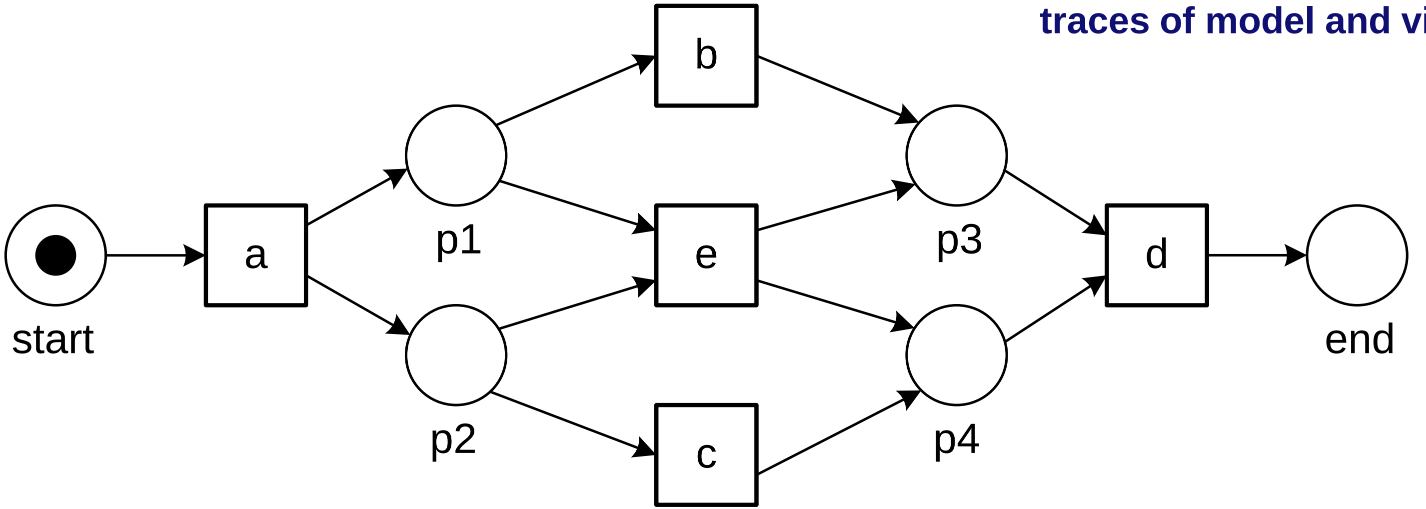
$$L_1 = [\langle a,b,c,d\rangle^3, \langle a,c,b,d\rangle^2, \langle a,e,d\rangle]$$

- **An event log is a multiset of traces (same trace may appear multiple times).**
- **A trace is a sequence of activity names (we abstract from all other attributes, but events are ordered).**

TU/e

Goal of Alpha algorithm

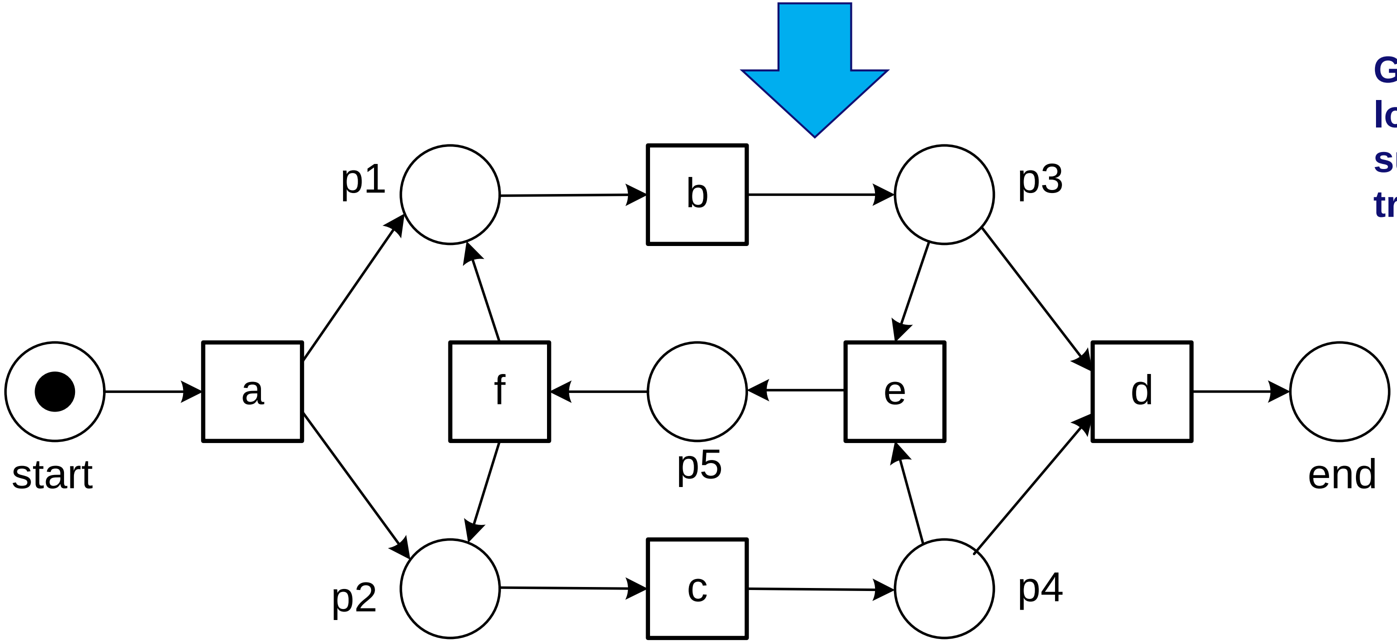
$$L_1 = [\langle a,b,c,d\rangle^3, \langle a,c,b,d\rangle^2, \langle a,e,d\rangle]$$



Event log contains all possible traces of model and vice versa.

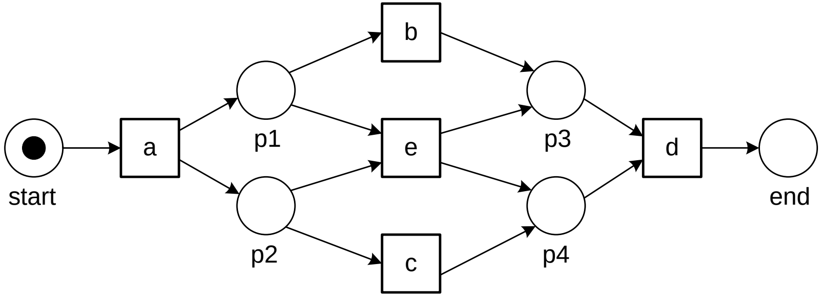
Another example

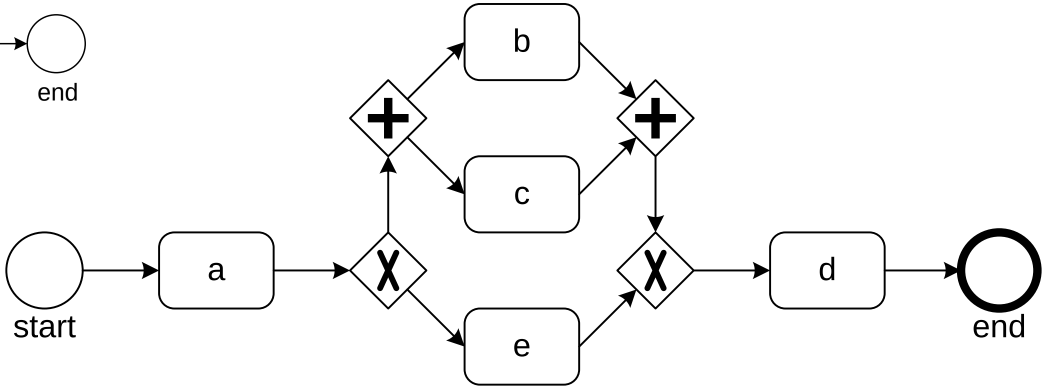
$$L_2 = [\langle a,b,c,d\rangle^3, \langle a,c,b,d\rangle^4, \langle a,b,c,e,f,b,c,d\rangle^2, \langle a,b,c,e,f,c,b,d\rangle, \langle a,c,b,e,f,b,c,d\rangle^2, \langle a,c,b,e,f,b,c,e,f,c,b,d\rangle]$$



Generalization: event log contains only subset of all possible traces of model.

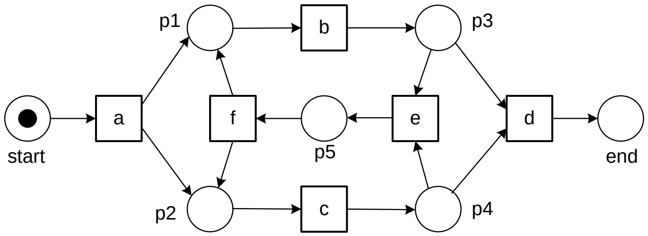
Notation is less relevant (e.g. BPMN)

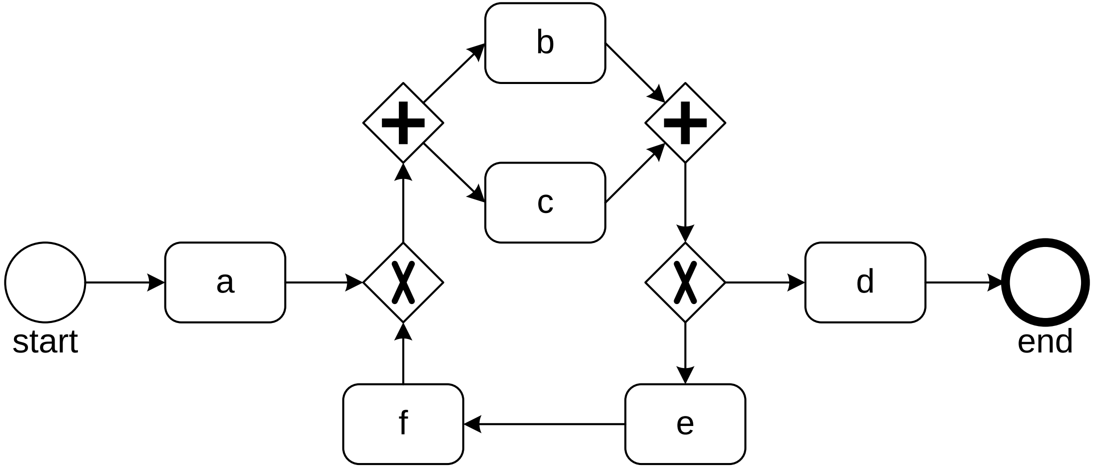




$$L_1 = [\langle a,b,c,d\rangle^3, \langle a,c,b,d\rangle^2, \langle a,e,d\rangle]$$

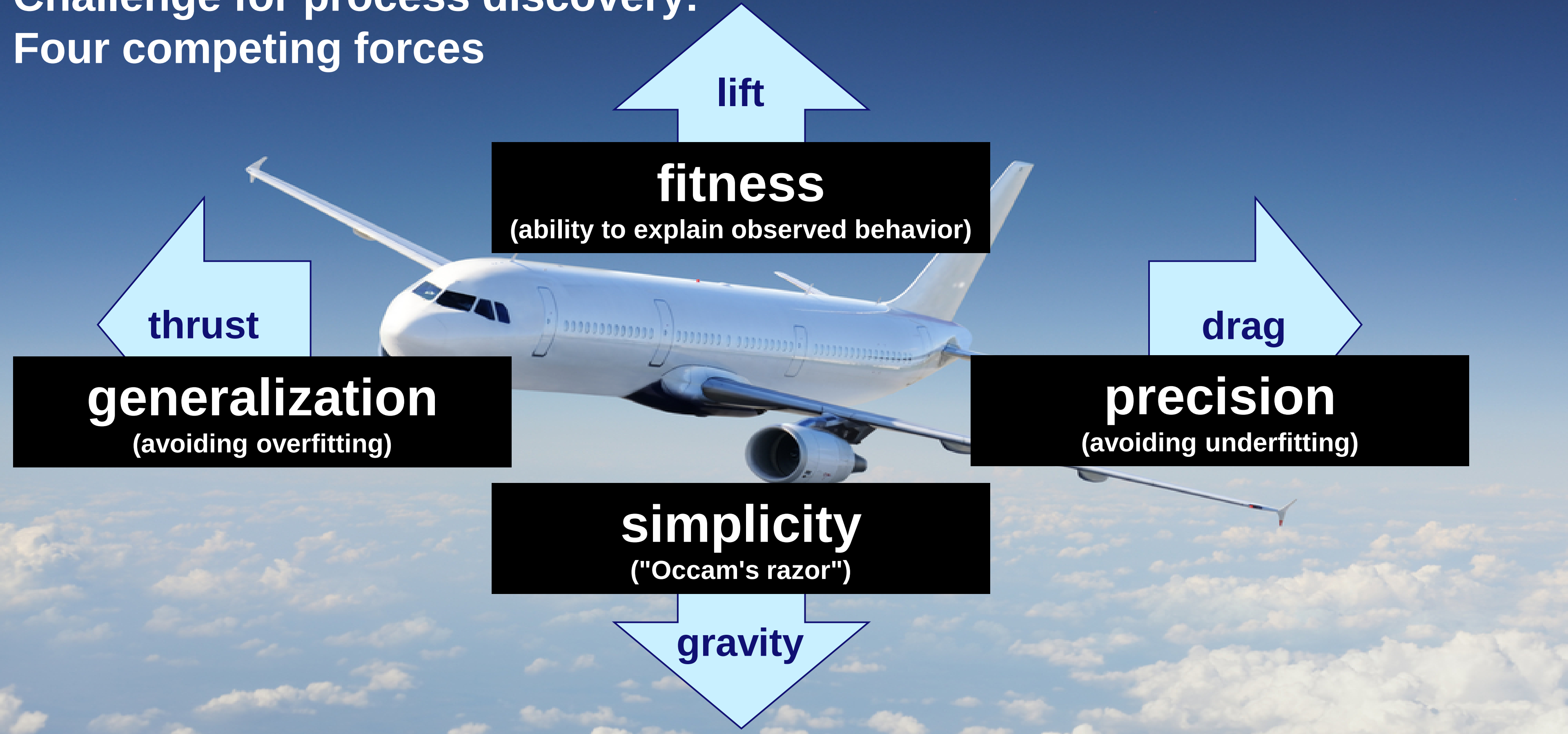
Another BPMN example





$$L_2 = [\langle a,b,c,d\rangle^3, \langle a,c,b,d\rangle^4, \langle a,b,c,e,f,b,c,d\rangle^2, \langle a,b,c,e,f,c,b,d\rangle,$$
$$\langle a,c,b,e,f,b,c,d\rangle^2, \langle a,c,b,e,f,b,c,e,f,c,b,d\rangle]$$

Challenge for process discovery: Four competing forces



Will be discussed later …

>,→,||,# relations

$L_1 = [\langle a,b,c,d \rangle^3, \langle a,c,b,d \rangle^2, \langle a,e,d \rangle]$

- Direct succession: **x>y iff for some case x is directly followed by y.**
- Causality: **x→y iff x>y and not y>x.**
- Parallel: **x||y iff x>y and y>x**
- Choice: **x#y iff not x>y and not y>x.**

abcd
acbd
aed

a>b
a>c
a>e
b>c
b>d
c>b
c>d
e>d

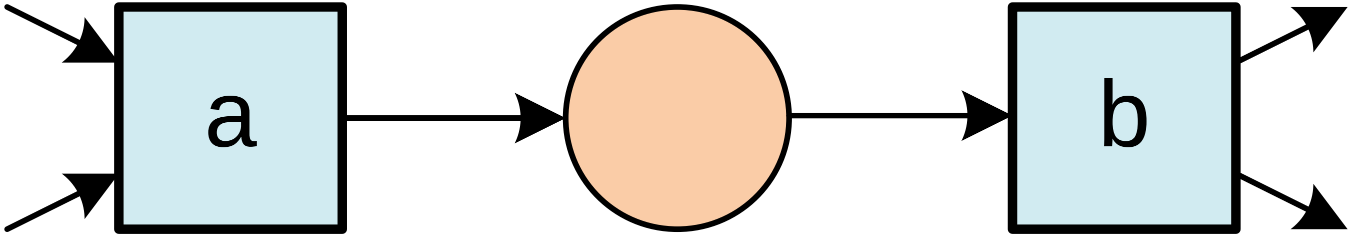
a→b
a→c
a→e
b→d
c→d
e→d

b||c
c||b

b#e
e#b
c#e
a#d
...

TU/e

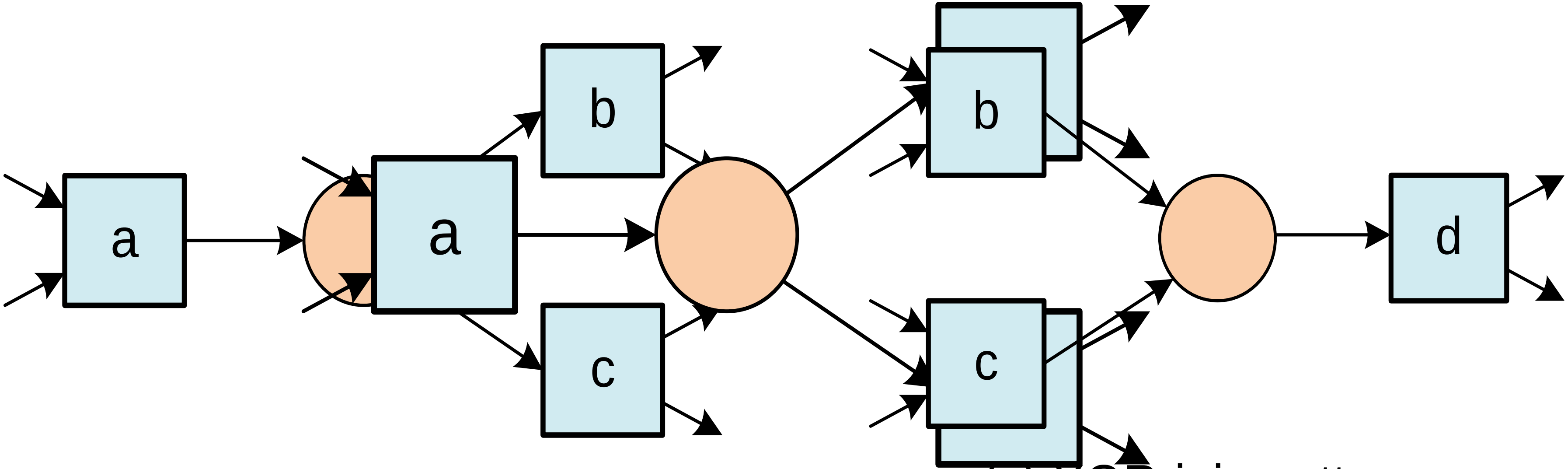
Basic Idea Used by Alpha Algorithm (1)



(a) sequence pattern: a→b

TU/e

Basic Idea Used by Alpha Algorithm (2)

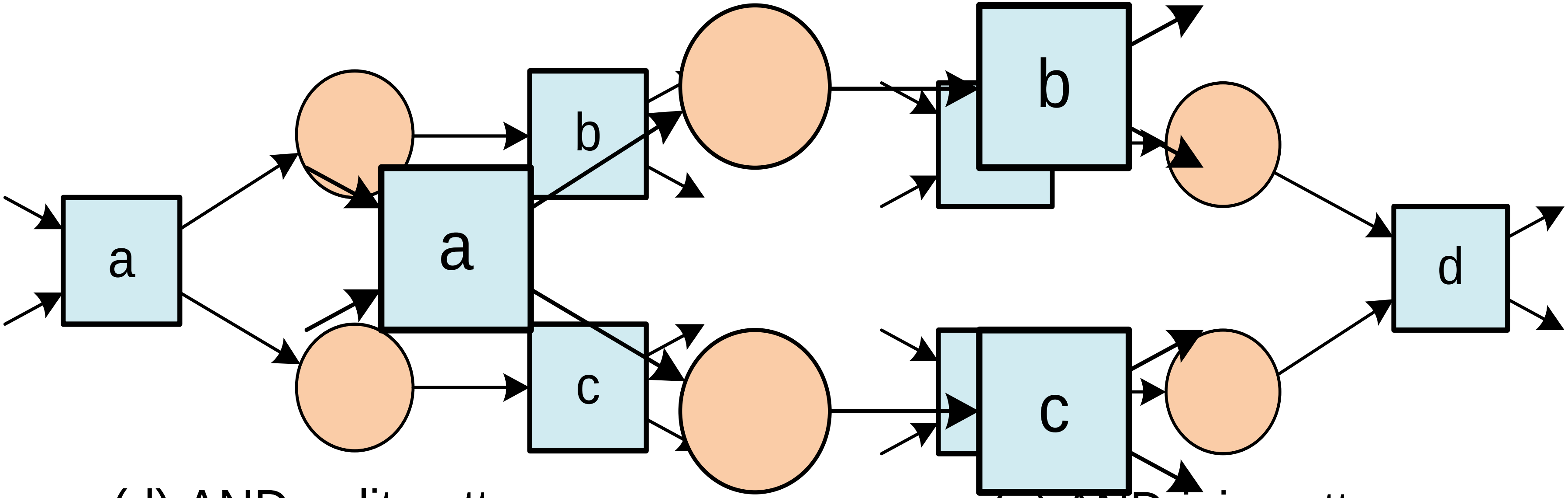


(b) XOR-split pattern:
a→b, a→c, and b#c

(b) XOR-split pattern:
a→b, a→c, and b#c

(c) XOR-join pattern:
b→d, c→d, and b#c

Basic Idea Used by Alpha Algorithm (3)



(d) AND-split pattern:
a→b, a→c, and b||c

(e) AND-join pattern:
b→d, c→d, and b||c

(d) AND-split pattern:
a→b, a→c, and b||c

Example Revisited

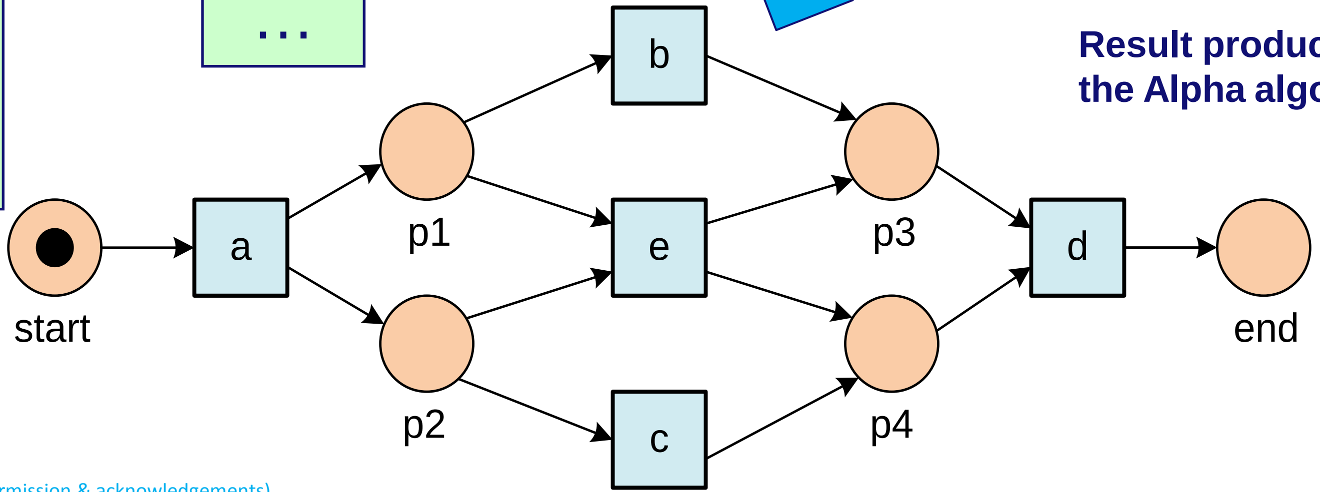
$$L_1 = [\langle a,b,c,d\rangle^3, \langle a,c,b,d\rangle^2, \langle a,e,d\rangle]$$

$a>b$
$a>c$
$a>e$
$b>c$
$b>d$
$c>b$
$c>d$
$e>d$

$a \rightarrow b$
$a \rightarrow c$
$a \rightarrow e$
$b \rightarrow d$
$c \rightarrow d$
$e \rightarrow d$

$b \| c$
$c \| b$

$b \# e$
$e \# b$
$c \# e$
$a \# d$
…



Result produced by the Alpha algorithm

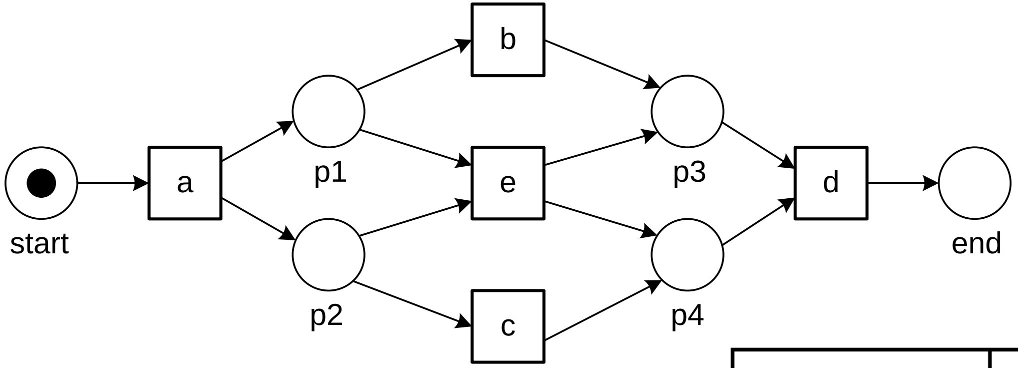
Footprint of L_1

$$L_1 = [\langle a,b,c,d\rangle^3, \langle a,c,b,d\rangle^2, \langle a,e,d\rangle]$$

One of the following:
$\rightarrow$, $\leftarrow$ #, $\|$

	a	b	c	d	e
a	$\#_{L_1}$	$\rightarrow_{L_1}$	$\rightarrow_{L_1}$	$\#_{L_1}$	$\rightarrow_{L_1}$
b	$\leftarrow_{L_1}$	$\#_{L_1}$	$\|_{L_1}$	$\rightarrow_{L_1}$	$\#_{L_1}$
c	$\leftarrow_{L_1}$	$\|_{L_1}$	$\#_{L_1}$	$\rightarrow_{L_1}$	$\#_{L_1}$
d	$\#_{L_1}$	$\leftarrow_{L_1}$	$\leftarrow_{L_1}$	$\#_{L_1}$	$\leftarrow_{L_1}$
e	$\leftarrow_{L_1}$	$\#_{L_1}$	$\#_{L_1}$	$\rightarrow_{L_1}$	$\#_{L_1}$

Discovered model has the same footprint



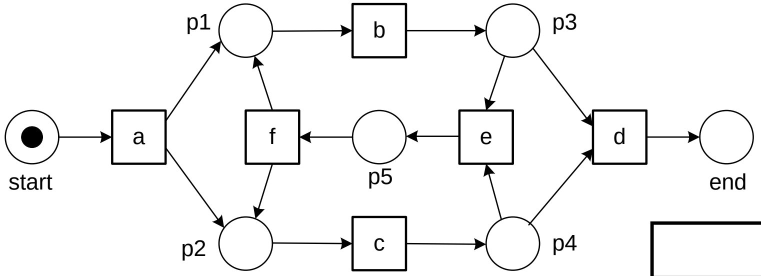
$$L_1 = [\langle a,b,c,d\rangle^3, \langle a,c,b,d\rangle^2, \langle a,e,d\rangle]$$

	a	b	c	d	e
a	$\#_{L_1}$	$\rightarrow_{L_1}$	$\rightarrow_{L_1}$	$\#_{L_1}$	$\rightarrow_{L_1}$
b	$\leftarrow_{L_1}$	$\#_{L_1}$	$\Vert_{L_1}$	$\rightarrow_{L_1}$	$\#_{L_1}$
c	$\leftarrow_{L_1}$	$\Vert_{L_1}$	$\#_{L_1}$	$\rightarrow_{L_1}$	$\#_{L_1}$
d	$\#_{L_1}$	$\leftarrow_{L_1}$	$\leftarrow_{L_1}$	$\#_{L_1}$	$\leftarrow_{L_1}$
e	$\leftarrow_{L_1}$	$\#_{L_1}$	$\#_{L_1}$	$\rightarrow_{L_1}$	$\#_{L_1}$

Log and model agree on footprint

Footprint of L_2

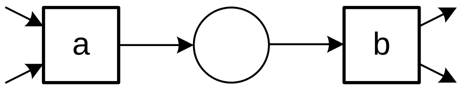
$$L_2 = [\langle a,b,c,d\rangle^3, \langle a,c,b,d\rangle^4, \langle a,b,c,e,f,b,c,d\rangle^2, \langle a,b,c,e,f,c,b,d\rangle, \langle a,c,b,e,f,b,c,d\rangle^2, \langle a,c,b,e,f,b,c,e,f,c,b,d\rangle]$$



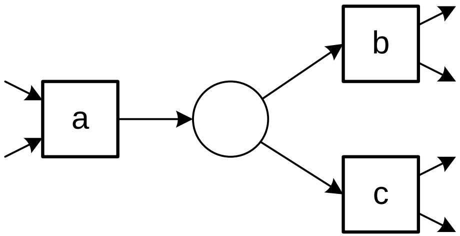
	a	b	c	d	e	f
a	$\#$	$\rightarrow$	$\rightarrow$	$\#$	$\#$	$\#$
b	$\leftarrow$	$\#$	$\parallel$	$\rightarrow$	$\rightarrow$	$\leftarrow$
c	$\leftarrow$	$\parallel$	$\#$	$\rightarrow$	$\rightarrow$	$\leftarrow$
d	$\#$	$\leftarrow$	$\leftarrow$	$\#$	$\#$	$\#$
e	$\#$	$\leftarrow$	$\leftarrow$	$\#$	$\#$	$\rightarrow$
f	$\#$	$\rightarrow$	$\rightarrow$	$\#$	$\leftarrow$	$\#$

Log and model agree on footprint

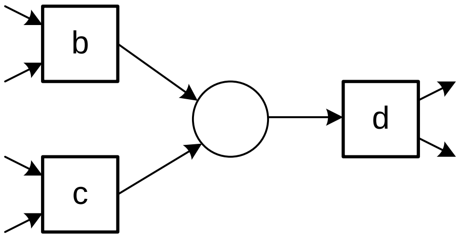
Summary: Simple process patterns can be discovered from event logs



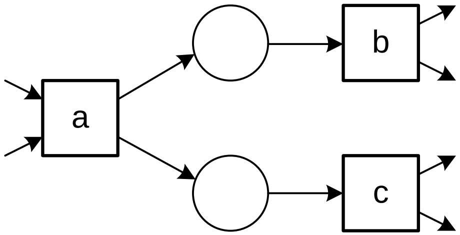
(a) sequence pattern: a→b



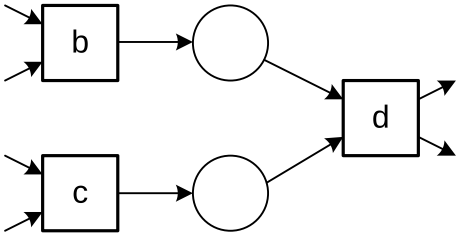
(b) XOR-split pattern:
a→b, a→c, and b#c



(c) XOR-join pattern:
b→d, c→d, and b#c



(d) AND-split pattern:
a→b, a→c, and b||c



(e) AND-join pattern:
b→d, c→d, and b||c

Let L be an event log over T. $\alpha(L)$ is defined as follows.

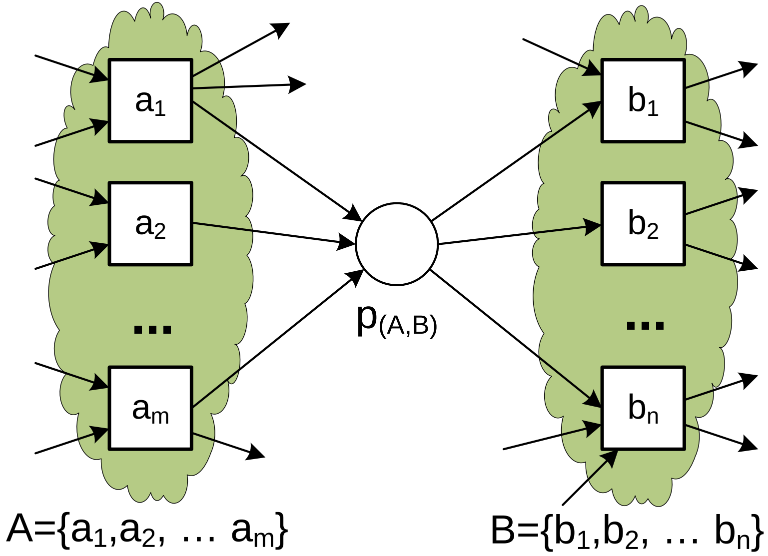
1. $T_L = \{ t \in T \mid \exists_{\sigma \in L}\ t \in \sigma \}$,
2. $T_I = \{ t \in T \mid \exists_{\sigma \in L}\ t = \mathit{first}(\sigma) \}$,
3. $T_O = \{ t \in T \mid \exists_{\sigma \in L}\ t = \mathit{last}(\sigma) \}$,
4. $X_L = \{ (A,B) \mid A \subseteq T_L \wedge A \neq \emptyset \wedge B \subseteq T_L \wedge B \neq \emptyset \wedge \forall_{a \in A} \forall_{b \in B}\ a \rightarrow_L b \wedge \forall_{a1,a2 \in A}\ a_1 \#_L a_2 \wedge \forall_{b1,b2 \in B}\ b_1 \#_L b_2 \}$,
5. $Y_L = \{ (A,B) \in X_L \mid \forall_{(A',B') \in X_L} A \subseteq A' \wedge B \subseteq B' \Rightarrow (A,B) = (A',B') \}$,
6. $P_L = \{ p_{(A,B)} \mid (A,B) \in Y_L \} \cup \{i_L, o_L\}$,
7. $F_L = \{ (a, p_{(A,B)}) \mid (A,B) \in Y_L \wedge a \in A \} \cup \{ (p_{(A,B)}, b) \mid (A,B) \in Y_L \wedge b \in B \} \cup \{ (i_L, t) \mid t \in T_I \} \cup \{ (t, o_L) \mid t \in T_O \}$, and
8. $\alpha(L) = (P_L, T_L, F_L)$.

The α–algorithm

Let L be an event log over T. Then, $\alpha(L)$ is defined as follows:

1. $T_L = \{ t \in T \mid \exists_{\sigma \in L}\ t \in \sigma \}$,
   Each activity in L corresponds to a transition in $\alpha(L)$.
2. $T_I = \{ t \in T \mid \exists_{\sigma \in L}\ t = \mathit{first}(\sigma) \}$
   Fix the set of start activities – that is, the first elements of each trace: $\langle t_1, \ldots, t_n\rangle, \ldots, \langle t'_1, \ldots, t'_m\rangle$
3. $T_O = \{ t \in T \mid \exists_{\sigma \in L}\ t = \mathit{last}(\sigma) \}$
   Fix the set of end activities – that is, elements that appear last in a trace : $\langle t_1, \ldots, t_n\rangle, \ldots, \langle t'_1, \ldots, t'_m\rangle$

Next steps aim at finding places



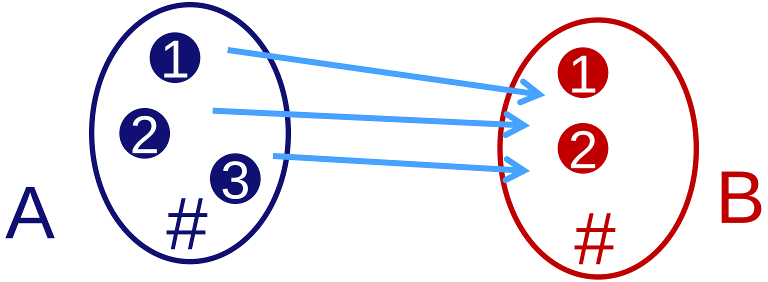
Step 4: Calculate pairs (A, B)

Step 5: Delete non-maximal pairs (A, B)

Step 6: Determine places $p_{(A, B)}$ from pairs (A, B)

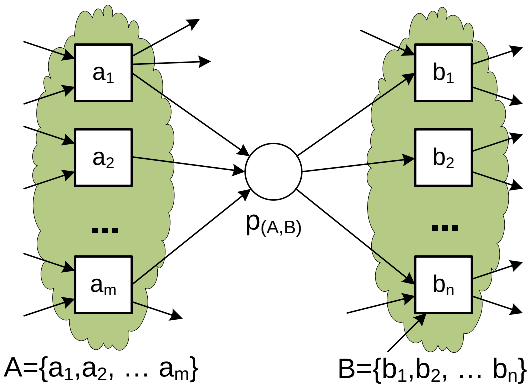
The α–algorithm (cont.)

4. $X_L = \{ (A,B) \mid A \subseteq T_L \wedge A \neq \emptyset \wedge B \subseteq T_L \wedge B \neq \emptyset$
$\wedge \forall_{a \in A} \forall_{b \in B}\ a \rightarrow_L b$
$\wedge \forall_{a1,a2 \in A}\ a_1 \#_L a_2$
$\wedge \forall_{b1,b2 \in B}\ b_1 \#_L b_2 \}$,



Find pairs (A, B) of sets of activities such that every element $a \in A$ and every element $b \in B$ are causally related (i.e., $a \rightarrow_L b$), all elements in A are independent ($a_1 \#_L a_2$), and all elements in B are independent ($b_1 \#_L b_2$).

Places as footprints

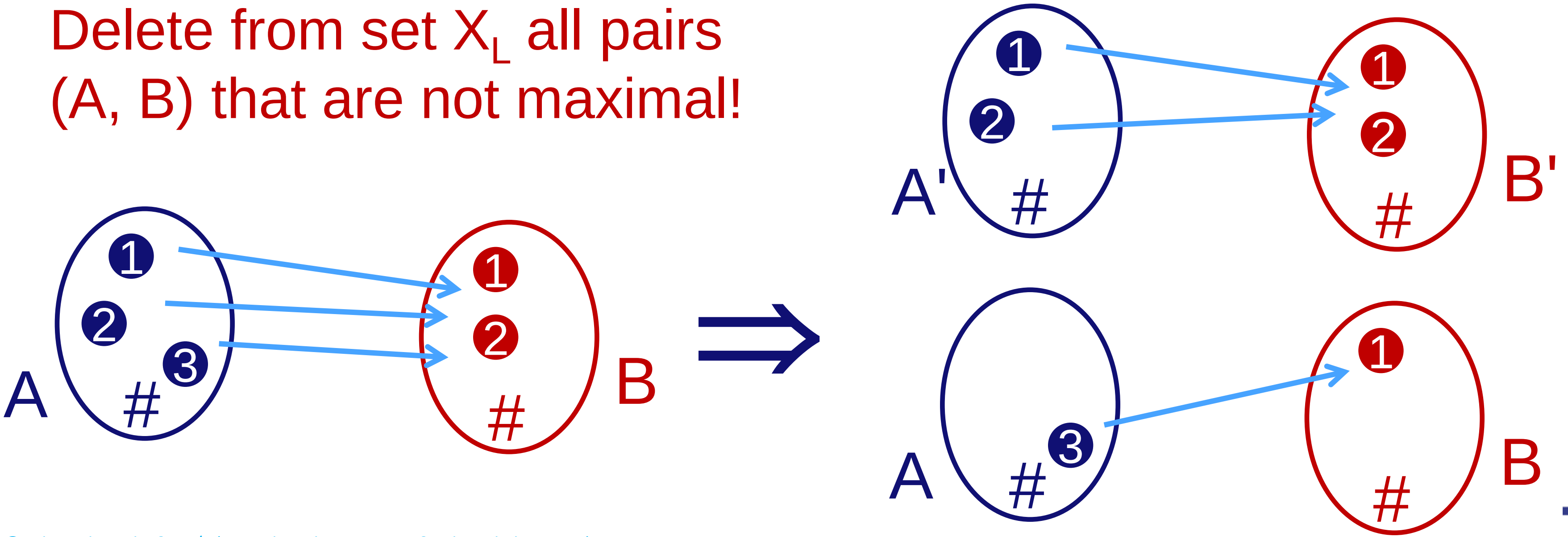


	a_1	a_2	$\dots$	a_m	b_1	b_2	$\dots$	b_n
a_1	#	#	$\dots$	#	$\rightarrow$	$\rightarrow$	$\dots$	$\rightarrow$
a_2	#	#	$\dots$	#	$\rightarrow$	$\rightarrow$	$\dots$	$\rightarrow$
$\dots$	$\dots$	$\dots$	$\dots$	$\dots$	$\dots$	$\dots$	$\dots$	$\dots$
a_m	#	#	$\dots$	#	$\rightarrow$	$\rightarrow$	$\dots$	$\rightarrow$
b_1	$\leftarrow$	$\leftarrow$	$\dots$	$\leftarrow$	#	#	$\dots$	#
b_2	$\leftarrow$	$\leftarrow$	$\dots$	$\leftarrow$	#	#	$\dots$	#
$\dots$	$\dots$	$\dots$	$\dots$	$\dots$	$\dots$	$\dots$	$\dots$	$\dots$
b_n	$\leftarrow$	$\leftarrow$	$\dots$	$\leftarrow$	#	#	$\dots$	#

The α–algorithm (cont.)

5. $Y_L = \{ (A,B) \in X_L \mid \forall_{(A',B') \in X_L} A \subseteq A' \wedge B \subseteq B' \Rightarrow (A,B) = (A',B') \}$

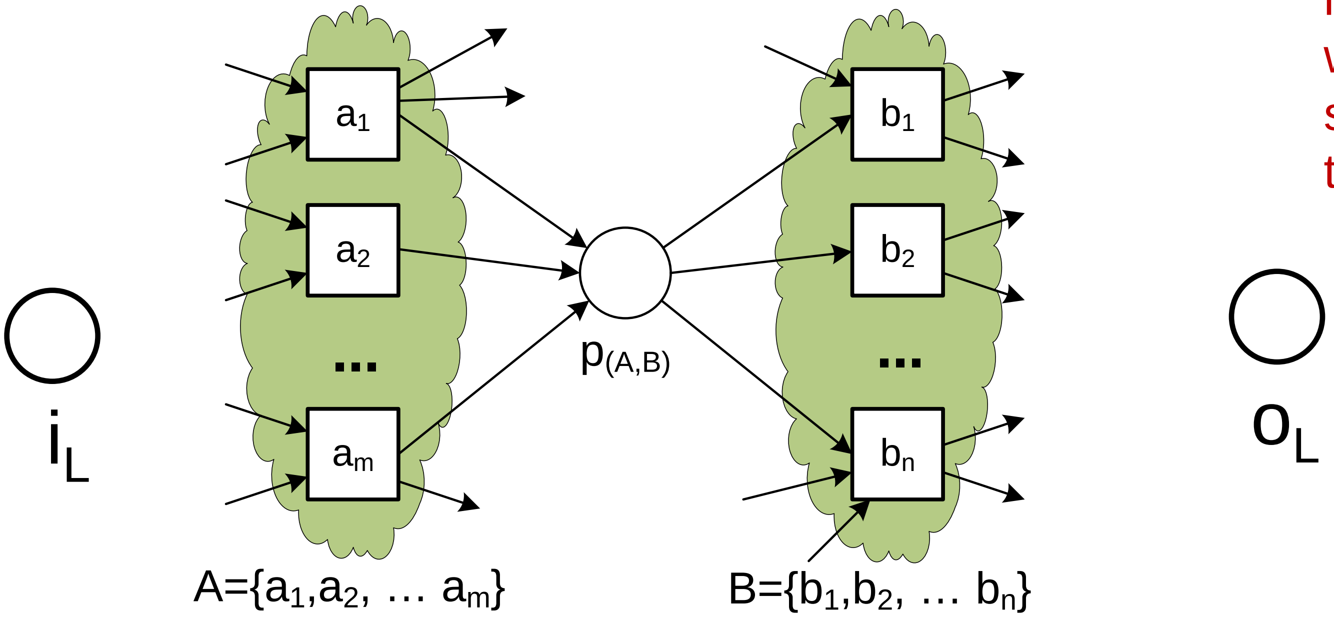
Delete from set X_L all pairs (A, B) that are not maximal!



The α–algorithm (cont.)

6. $P_L = \{ p_{(A,B)} \mid (A,B) \in Y_L \} \cup \{i_L, o_L\}$,

Determine the place set: Each element (A, B) of Y_L is a place. To ensure the workflow structure, add a source place i_L and a target place o_L



The α–algorithm (cont.)

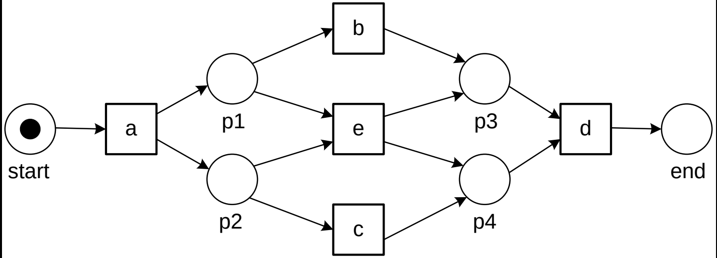
7. $F_L = \{ (a,p_{(A,B)}) \mid (A,B) \in Y_L \wedge a \in A \}$
$\cup \{ (p_{(A,B)},b) \mid (A,B) \in Y_L \wedge b \in B \}$
$\cup \{ (i_L,t) \mid t \in T_I\} \cup \{ (t,o_L) \mid t \in T_O \}$

   Determine the flow relation: Connect each place $p_{(A,B)}$ with each element a of its set A of source transitions and with each element of its set B of target transitions. In addition, draw an arc from the source place i_L to each start transition $t \in T_I$ and an arc from each end transition $t \in T_O$ to the sink place o_L.

8. $\alpha(L) = (P_L, T_L, F_L)$

$$L_1 = [\langle a,b,c,d\rangle^3, \langle a,c,b,d\rangle^2, \langle a,e,d\rangle]$$

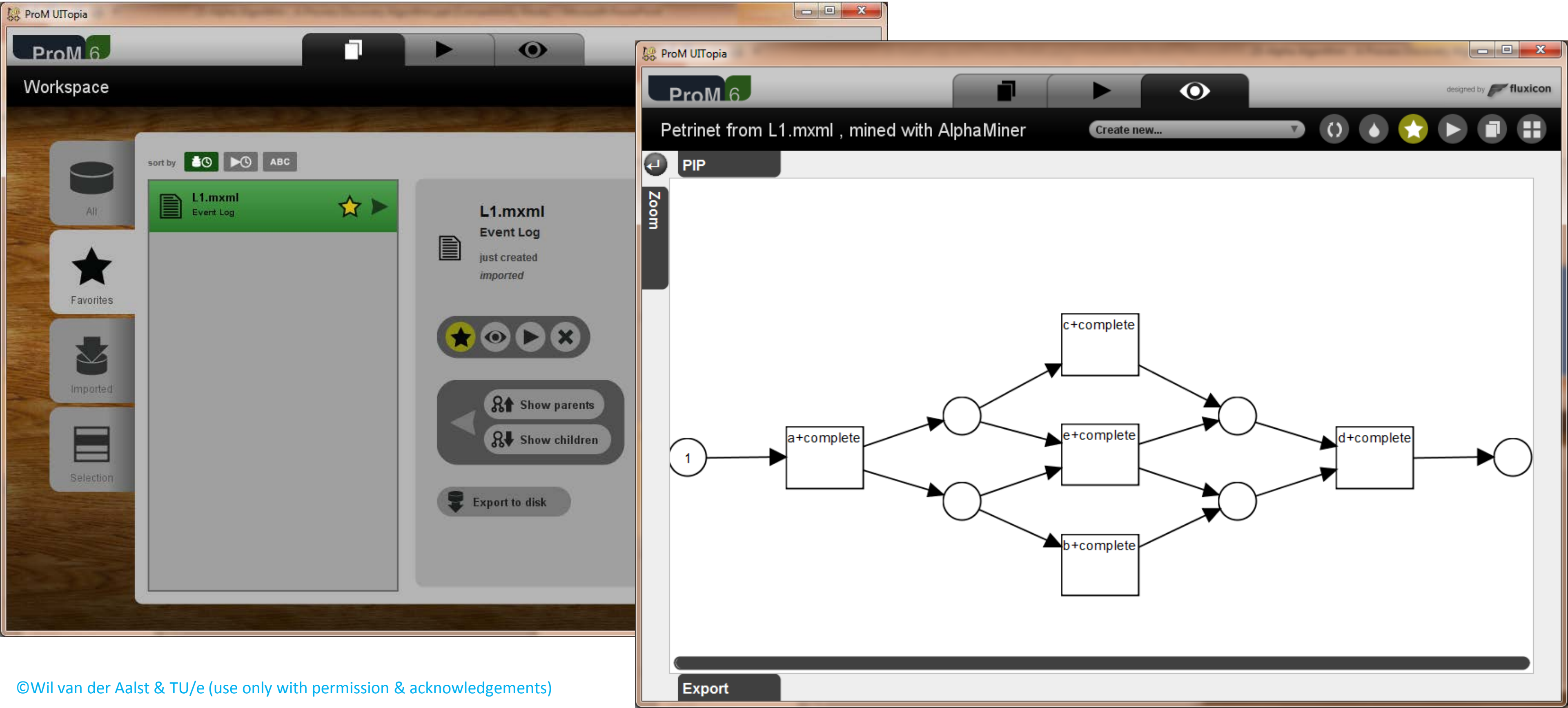
	a	b	c	d	e
a	$\#_{L_1}$	$\rightarrow_{L_1}$	$\rightarrow_{L_1}$	$\#_{L_1}$	$\rightarrow_{L_1}$
b	$\leftarrow_{L_1}$	$\#_{L_1}$	$\Vert_{L_1}$	$\rightarrow_{L_1}$	$\#_{L_1}$
c	$\leftarrow_{L_1}$	$\Vert_{L_1}$	$\#_{L_1}$	$\rightarrow_{L_1}$	$\#_{L_1}$
d	$\#_{L_1}$	$\leftarrow_{L_1}$	$\leftarrow_{L_1}$	$\#_{L_1}$	$\leftarrow_{L_1}$
e	$\leftarrow_{L_1}$	$\#_{L_1}$	$\#_{L_1}$	$\rightarrow_{L_1}$	$\#_{L_1}$



$$X_{L_1} = \{\cancel{(\{a\},\{b\})}, \cancel{(\{a\},\{c\})}, \cancel{(\{a\},\{e\})}, (\{a\},\{b,e\}), (\{a\},\{c,e\}),$$
$$\cancel{(\{b\},\{d\})}, \cancel{(\{c\},\{d\})}, \cancel{(\{e\},\{d\})}, (\{b,e\},\{d\}), (\{c,e\},\{d\})\}$$

$$Y_{L_1} = \{(\{a\},\{b,e\}), (\{a\},\{c,e\}), (\{b,e\},\{d\}), (\{c,e\},\{d\})\}$$

ProM's output for event log L_1



Question:
Give footprint matrix for event log L_3

$$L_3 = [\langle a,b,c,d,e,f,b,d,c,e,g\rangle,\\
\langle a,b,d,c,e,g\rangle^2,\\
\langle a,b,c,d,e,f,b,c,d,e,f,b,d,c,e,g\rangle]$$

Answer:
Footprint matrix for event log L_3

	a	b	c	d	e	f	g
a	$\#$	$\rightarrow$	$\#$	$\#$	$\#$	$\#$	$\#$
b	$\leftarrow$	$\#$	$\rightarrow$	$\rightarrow$	$\#$	$\leftarrow$	$\#$
c	$\#$	$\leftarrow$	$\#$	$\|$	$\rightarrow$	$\#$	$\#$
d	$\#$	$\leftarrow$	$\|$	$\#$	$\rightarrow$	$\#$	$\#$
e	$\#$	$\#$	$\leftarrow$	$\leftarrow$	$\#$	$\rightarrow$	$\rightarrow$
f	$\#$	$\rightarrow$	$\#$	$\#$	$\leftarrow$	$\#$	$\#$
g	$\#$	$\#$	$\#$	$\#$	$\leftarrow$	$\#$	$\#$

$$L_3 = [\langle a,b,c,d,e,f,b,d,c,e,g\rangle, \langle a,b,d,c,e,g\rangle^2, \langle a,b,c,d,e,f,b,c,d,e,f,b,d,c,e,g\rangle]$$

TU/e

Question:
Apply the 8 steps of the Alpha algorithm.

$$L_3 = [\langle a,b,c,d,e,f,b,d,c,e,g\rangle,\ \langle a,b,d,c,e,g\rangle^2,\ \langle a,b,c,d,e,f,b,c,d,e,f,b,d,c,e,g\rangle]$$

Let L be an event log over T. $\alpha(L)$ is defined as follows.

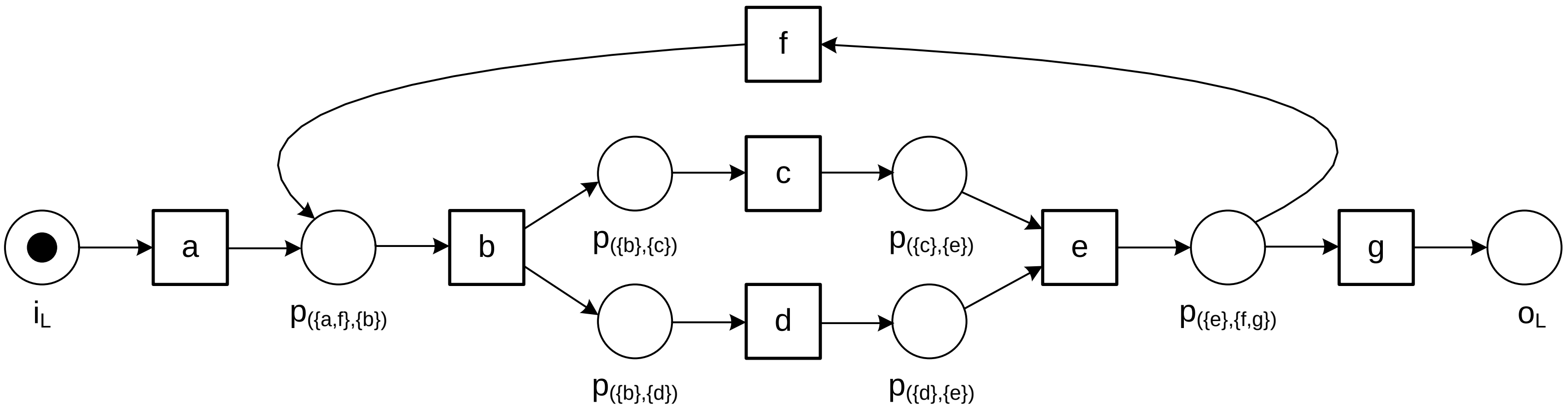
1. $T_L = \{ t \in T \mid \exists_{\sigma \in L}\, t \in \sigma\}$,
2. $T_I = \{ t \in T \mid \exists_{\sigma \in L}\, t = \mathit{first}(\sigma) \}$,
3. $T_O = \{ t \in T \mid \exists_{\sigma \in L}\, t = \mathit{last}(\sigma) \}$,
4. $X_L = \{ (A,B) \mid A \subseteq T_L \wedge A \neq \emptyset \wedge B \subseteq T_L \wedge B \neq \emptyset \wedge \forall_{a \in A}\forall_{b \in B}\, a \rightarrow_L b \wedge \forall_{a1,a2 \in A}\, a_1 \#_L a_2 \wedge \forall_{b1,b2 \in B}\, b_1 \#_L b_2 \}$,
5. $Y_L = \{ (A,B) \in X_L \mid \forall_{(A',B') \in X_L}\, A \subseteq A' \wedge B \subseteq B' \Rightarrow (A,B) = (A',B') \}$,
6. $P_L = \{ p_{(A,B)} \mid (A,B) \in Y_L \} \cup \{i_L, o_L\}$,
7. $F_L = \{ (a, p_{(A,B)}) \mid (A,B) \in Y_L \wedge a \in A \} \cup \{ (p_{(A,B)}, b) \mid (A,B) \in Y_L \wedge b \in B \} \cup \{ (i_L, t) \mid t \in T_I\} \cup \{ (t, o_L) \mid t \in T_O\}$, and
8. $\alpha(L) = (P_L, T_L, F_L)$.

	a	b	c	d	e	f	g
a	$\#$	$\rightarrow$	$\#$	$\#$	$\#$	$\#$	$\#$
b	$\leftarrow$	$\#$	$\rightarrow$	$\rightarrow$	$\#$	$\leftarrow$	$\#$
c	$\#$	$\leftarrow$	$\#$	$\parallel$	$\rightarrow$	$\#$	$\#$
d	$\#$	$\leftarrow$	$\parallel$	$\#$	$\rightarrow$	$\#$	$\#$
e	$\#$	$\#$	$\leftarrow$	$\leftarrow$	$\#$	$\rightarrow$	$\rightarrow$
f	$\#$	$\rightarrow$	$\#$	$\#$	$\leftarrow$	$\#$	$\#$
g	$\#$	$\#$	$\#$	$\#$	$\leftarrow$	$\#$	$\#$

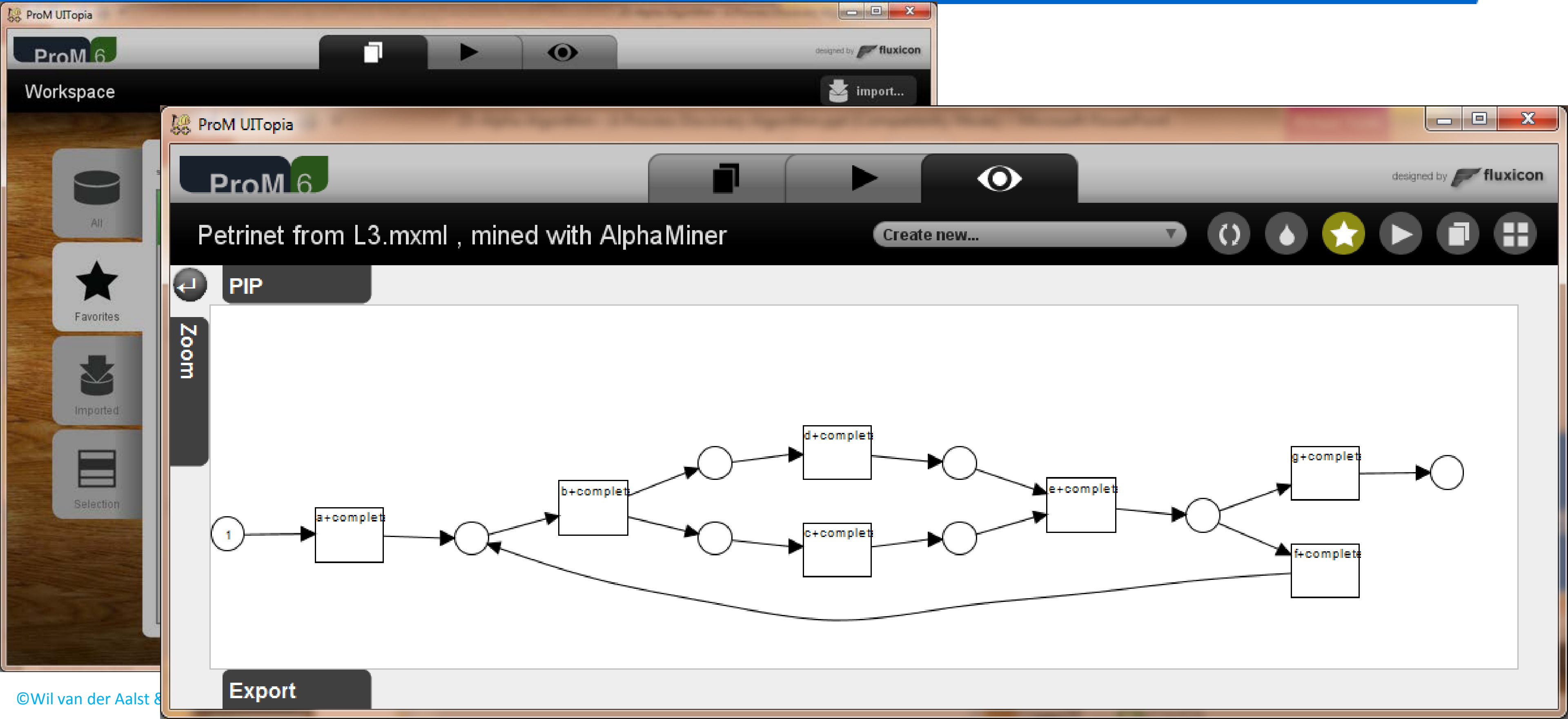
Model for L_3 discovered by the Alpha algorithm

$$L_3 = [\langle a,b,c,d,e,f,b,d,c,e,g\rangle,\\ \langle a,b,d,c,e,g\rangle^2,\\ \langle a,b,c,d,e,f,b,c,d,e,f,b,d,c,e,g\rangle]$$

	a	b	c	d	e	f	g
a	#	$\rightarrow$	#	#	#	#	#
b	$\leftarrow$	#	$\rightarrow$	$\rightarrow$	#	$\leftarrow$	#
c	#	$\leftarrow$	#	$\|$	$\rightarrow$	#	#
d	#	$\leftarrow$	$\|$	#	$\rightarrow$	#	#
e	#	#	$\leftarrow$	$\leftarrow$	#	$\rightarrow$	$\rightarrow$
f	#	$\rightarrow$	#	#	$\leftarrow$	#	#
g	#	#	#	#	$\leftarrow$	#	#

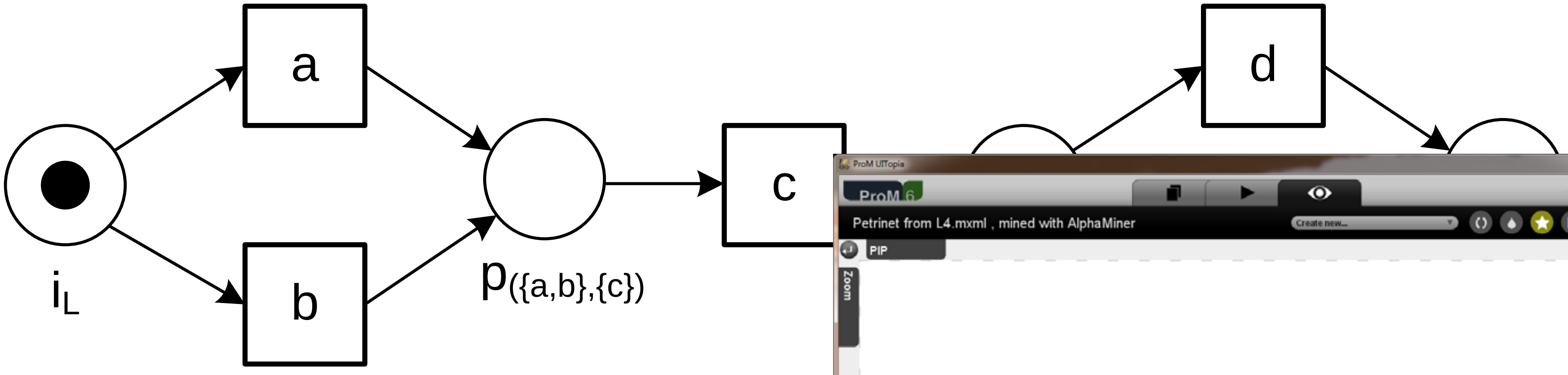


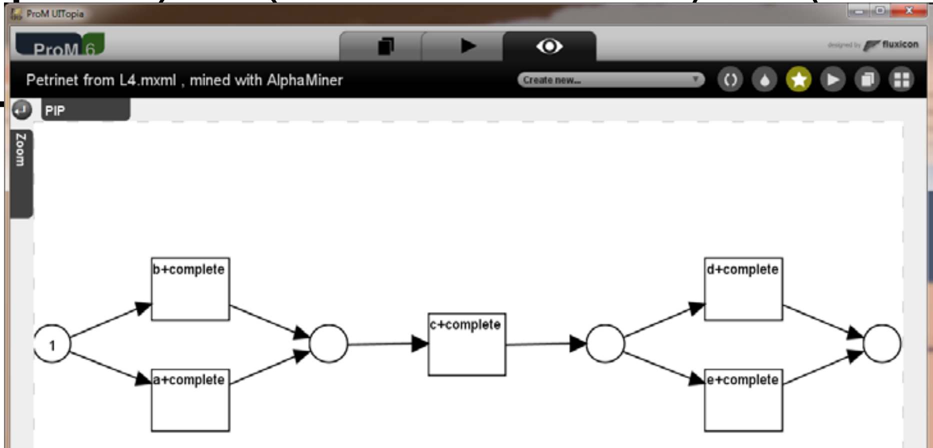
ProM's output for event log L_3



Another event log L_4

$$L_4 = [\langle a,c,d\rangle^{45}, \langle b,c,d\rangle^{42}, \langle a,c,e\rangle^{38}, \langle b,c,e\rangle^{22}]$$





Event log L_5

$$L_5 = [\langle a,b,e,f\rangle^2, \langle a,b,e,c,d,b,f\rangle^3, \langle a,b,c,e,d,b,f\rangle^2, \langle a,b,c,d,e,b,f\rangle^4, \langle a,e,b,c,d,b,f\rangle^3]$$

	a	b	c	d	e	f
a	$\#$	$\rightarrow$	$\#$	$\#$	$\rightarrow$	$\#$
b	$\leftarrow$	$\#$	$\rightarrow$	$\leftarrow$	$\parallel$	$\rightarrow$
c	$\#$	$\leftarrow$	$\#$	$\rightarrow$	$\parallel$	$\#$
d	$\#$	$\rightarrow$	$\leftarrow$	$\#$	$\parallel$	$\#$
e	$\leftarrow$	$\parallel$	$\parallel$	$\parallel$	$\#$	$\rightarrow$
f	$\#$	$\leftarrow$	$\#$	$\#$	$\leftarrow$	$\#$

$$T_L = \{a,b,c,d,e,f\}$$

$$T_I = \{a\}$$

$$T_I = \{f\}$$

$$X_L = \{(\{a\},\{b\}),(\{a\},\{e\}),(\{b\},\{c\}),(\{b\},\{f\}),(\{c\},\{d\}),
(\{d\},\{b\}),(\{e\},\{f\}),(\{a,d\},\{b\}),(\{b\},\{c,f\})\}$$

$$Y_L = \{(\{a\},\{e\}),(\{c\},\{d\}),(\{e\},\{f\}),(\{a,d\},\{b\}),(\{b\},\{c,f\})\}$$

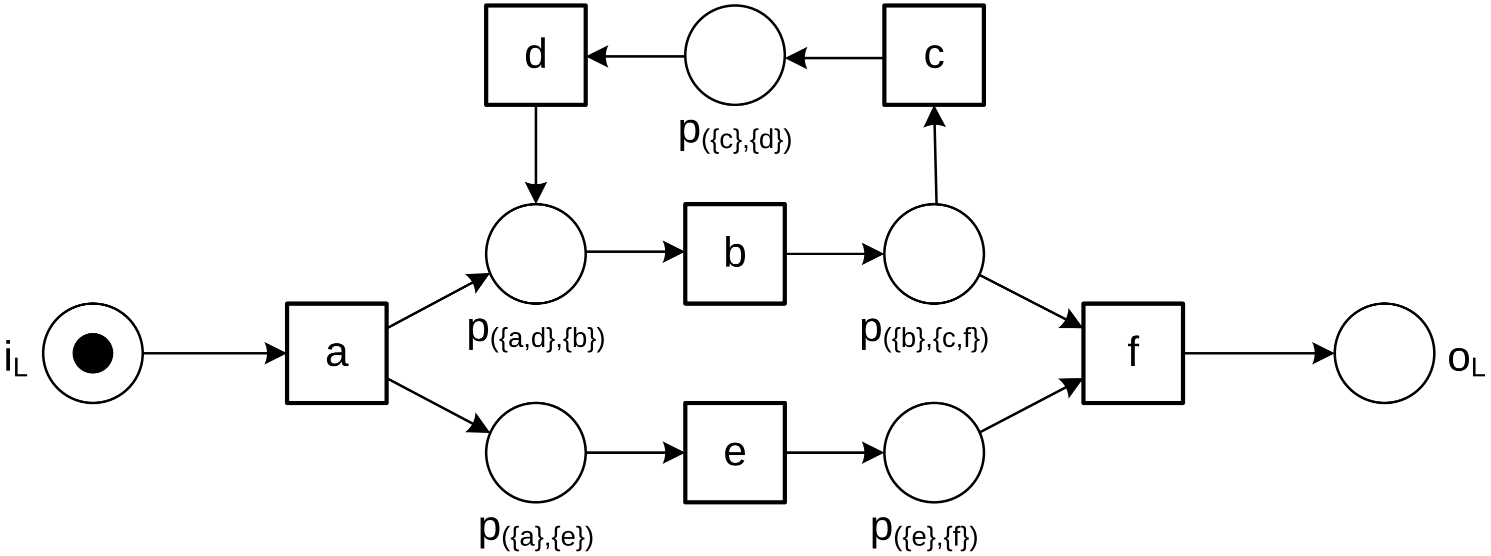
$$P_L = \{p_{(\{a\},\{e\})}, p_{(\{c\},\{d\})}, p_{(\{e\},\{f\})}, p_{(\{a,d\},\{b\})}, p_{(\{b\},\{c,f\})}, i_L, o_L\}$$

$$F_L = \{(a, p_{(\{a\},\{e\})}), (p_{(\{a\},\{e\})}, e), (c, p_{(\{c\},\{d\})}), (p_{(\{c\},\{d\})}, d),
(e, p_{(\{e\},\{f\})}), (p_{(\{e\},\{f\})}, f), (a, p_{(\{a,d\},\{b\})}), (d, p_{(\{a,d\},\{b\})}),
(p_{(\{a,d\},\{b\})}, b), (b, p_{(\{b\},\{c,f\})}), (p_{(\{b\},\{c,f\})}, c), (p_{(\{b\},\{c,f\})}, f),
(i_L, a), (f, o_L)\}$$

$$\alpha(L) = (P_L, T_L, F_L)$$

Discovered model

$$L_5 = [\langle a,b,e,f\rangle^2, \langle a,b,e,c,d,b,f\rangle^3, \langle a,b,c,e,d,b,f\rangle^2, \langle a,b,c,d,e,b,f\rangle^4, \langle a,e,b,c,d,b,f\rangle^3]$$



$$X_L = \{(\{a\},\{b\}),(\{a\},\{e\}),(\{b\},\{c\}),(\{b\},\{f\}),(\{c\},\{d\}),$$
$$(\{d\},\{b\}),(\{e\},\{f\}),(\{a,d\},\{b\}),(\{b\},\{c,f\})\}$$

$$Y_L = \{(\{a\},\{e\}),(\{c\},\{d\}),(\{e\},\{f\}),(\{a,d\},\{b\}),(\{b\},\{c,f\})\}$$

Summary

- The Alpha algorithm provides a basic process discovery approach.
- It has many limitations. These will be discussed later.
- However, it nicely illustrates the key ingredients of process discovery.
- Hence, it is important to understand the algorithm and practice using concrete examples.

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