Business Process Management
#processscience #bpmatqut

Discovering Stochastic Process Models By Reduction and Abstraction

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Petri Nets 2021

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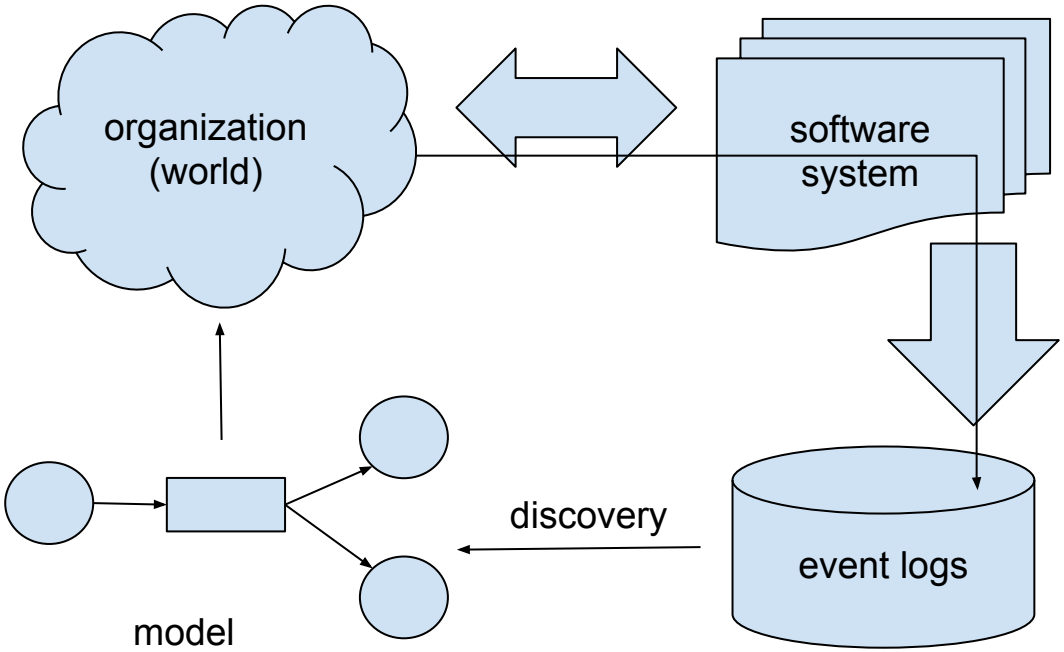
Process Mining

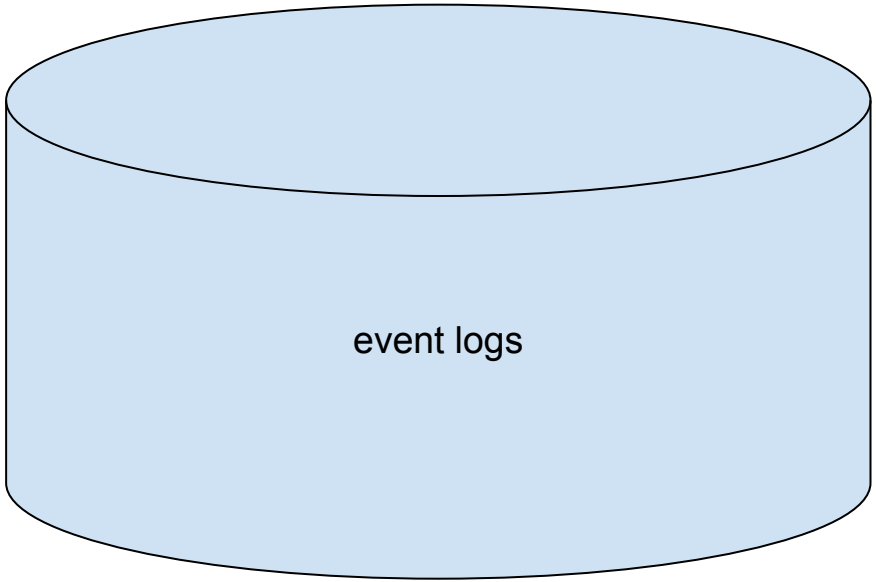


Desire Paths

Complement top-down managerial understanding with bottom-up data-driven understanding

Find out what people and systems are doing in an organization

User TM @ wikicommons



Client: Bob; Order 721; New Order; Buy 300 kg sugar

Client: Jill; Order 431; New Order; Buy 100 iceblocks

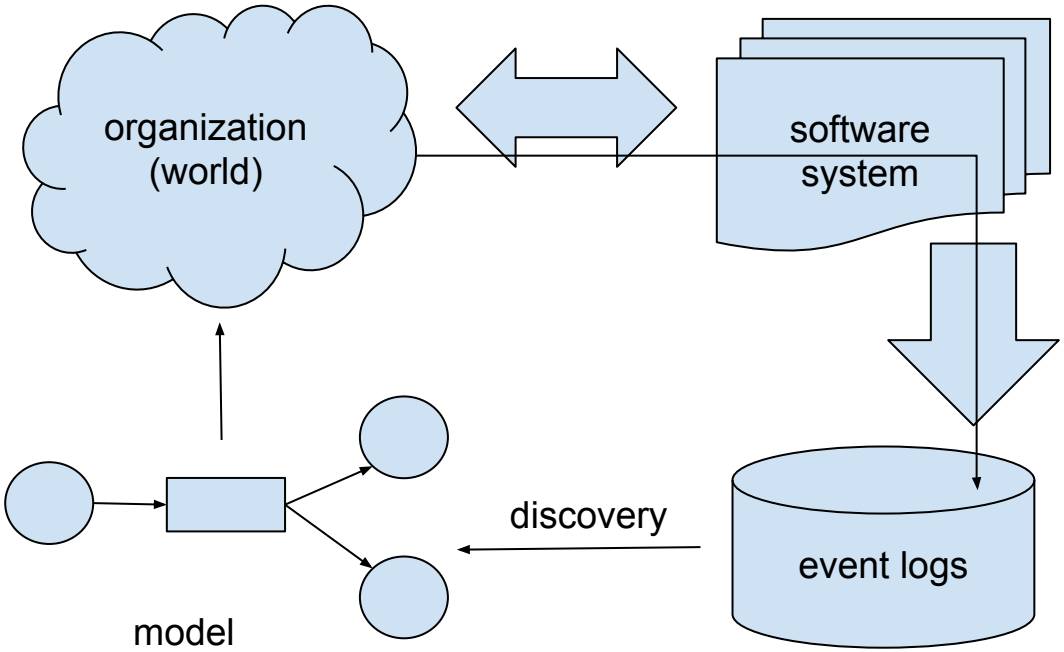
Client: Bob; Order 721; Acknowledge Order

Client: Bob; Order 722; New Order; Buy Toothpaste

Event Logs

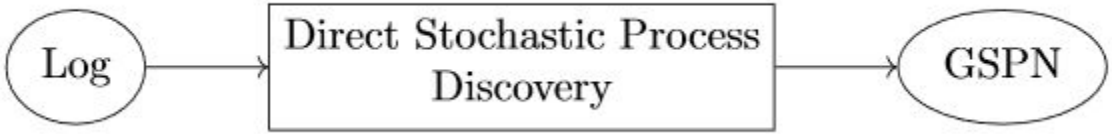
- Timestamp(s) + Case ID + Activity + Other resource information
- The timestamp-ordered activity messages for a Case ID form a ***trace***
- A ***trace*** is then a *sequence* of activities, eg
  - <a,c,e,a>
  - <Assess Claim, Initiate Payment, Advise Claimant, ...>
- A ***log*** is a multiset (bag) of traces, eg [[$\langle a,c,e,a \rangle^{21}$, $\langle c,b,f \rangle^{4}$, $\langle b,b,b,e \rangle^{8}$]]

Process Mining



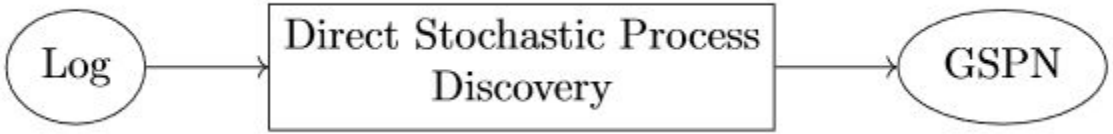
Process Mining Discovery

- Dozens of process mining discovery algorithms including very successful ones
- Explicitly modeling probability much rarer

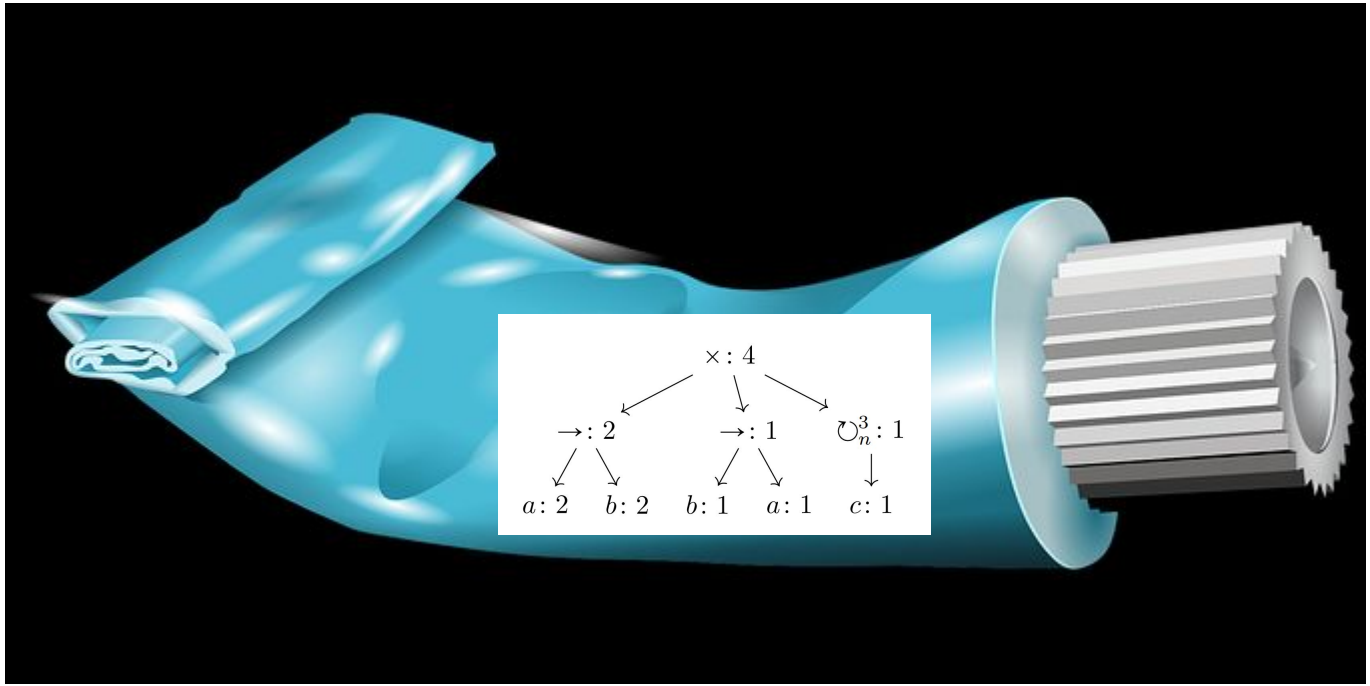


Stochastic Process Mining Discovery

- When stochastic models used, as in performance or simulation, output of post-discovery processing
- Instead, leverage power of Stochastic PNs



Toothpaste miner

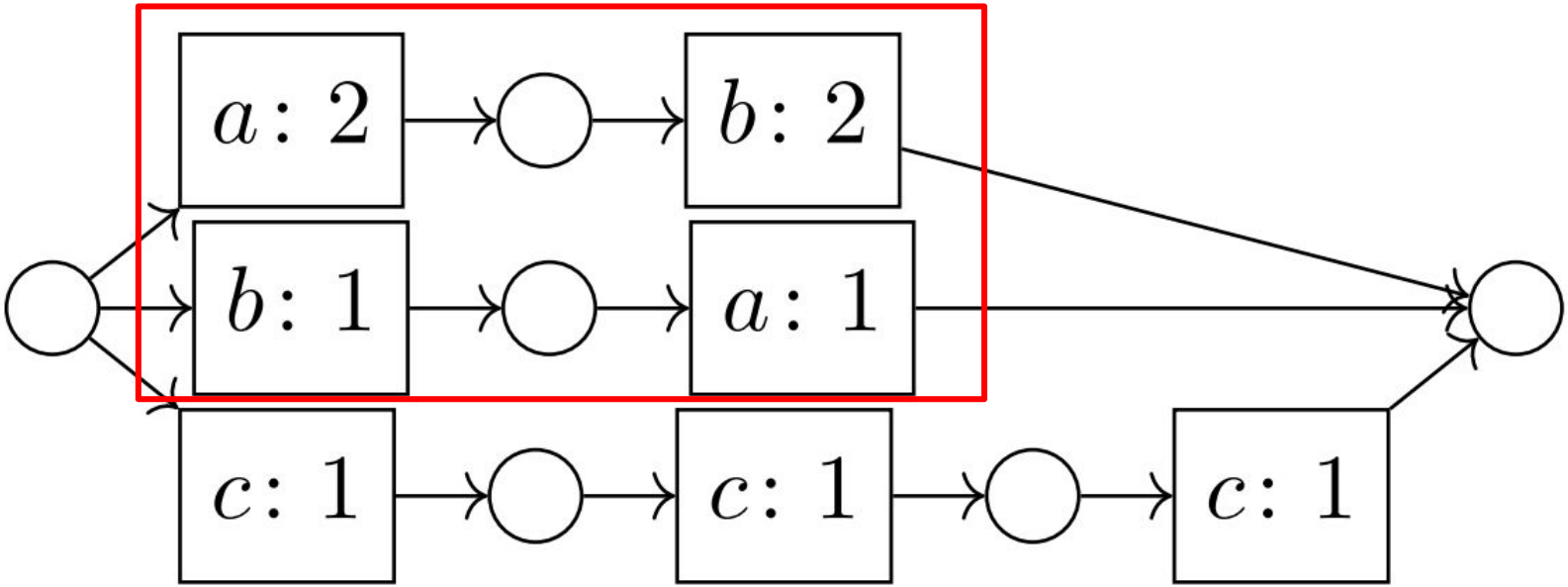


Example - Starting Log

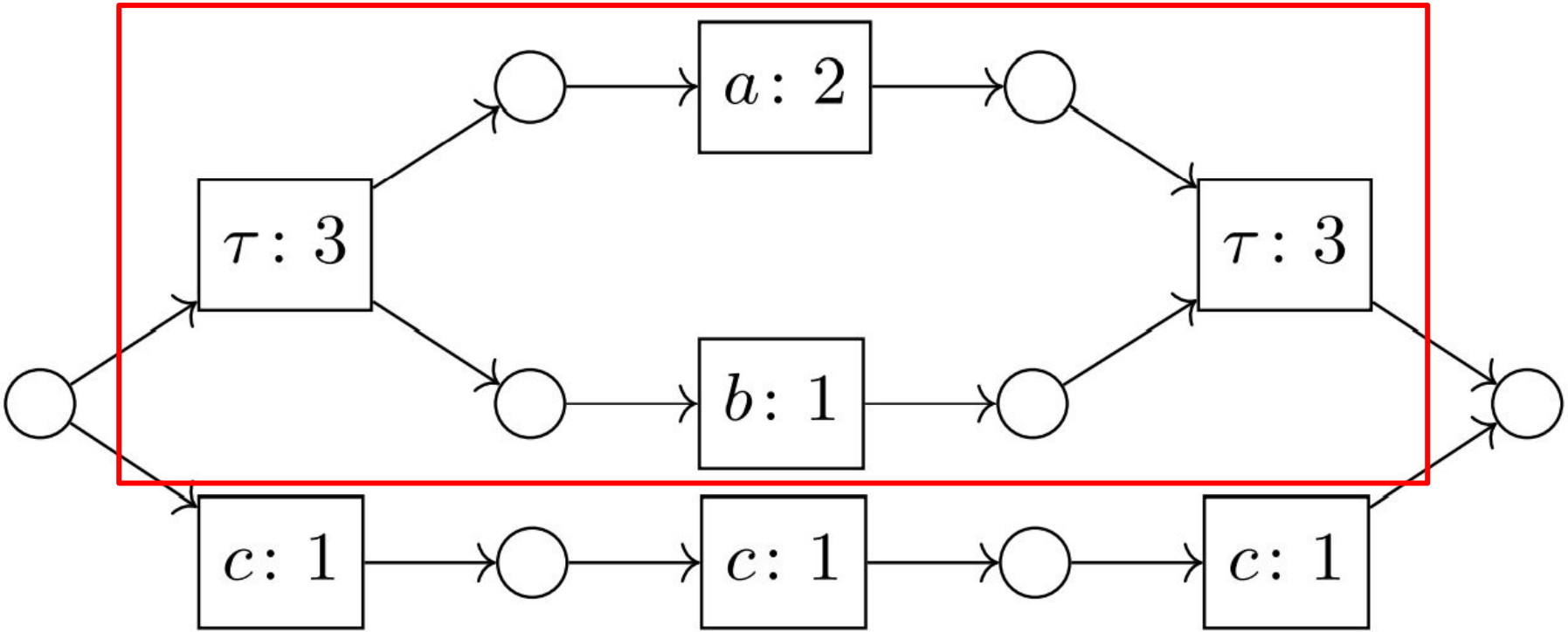
Log [<a,b>,
<a,b>,
<b,a>,
<c,c,c>]

Toothpaste Example - Starting Trace Model

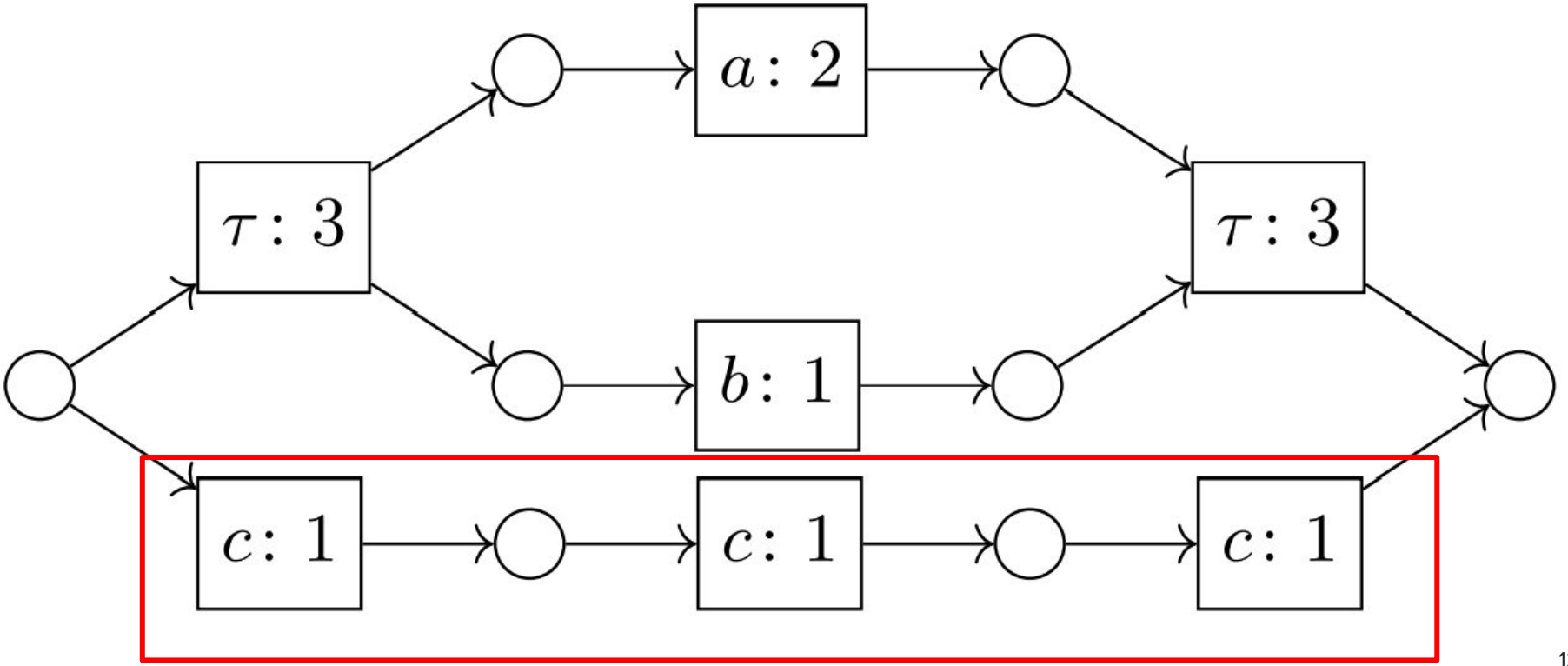
Log [<a,b>,<a,b>,<b,a>,<c,c,c>]



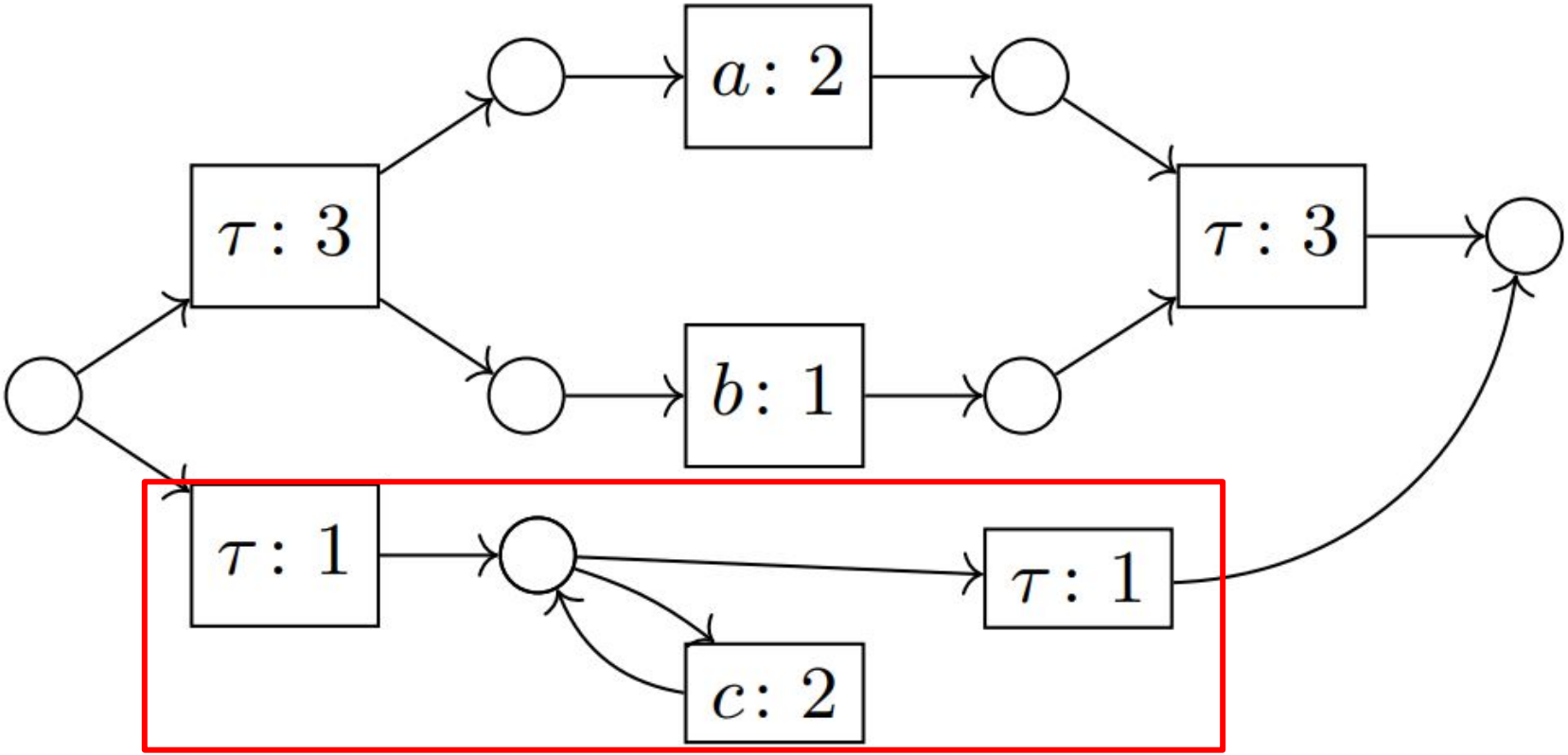
Toothpaste Example - Concurrent reduction

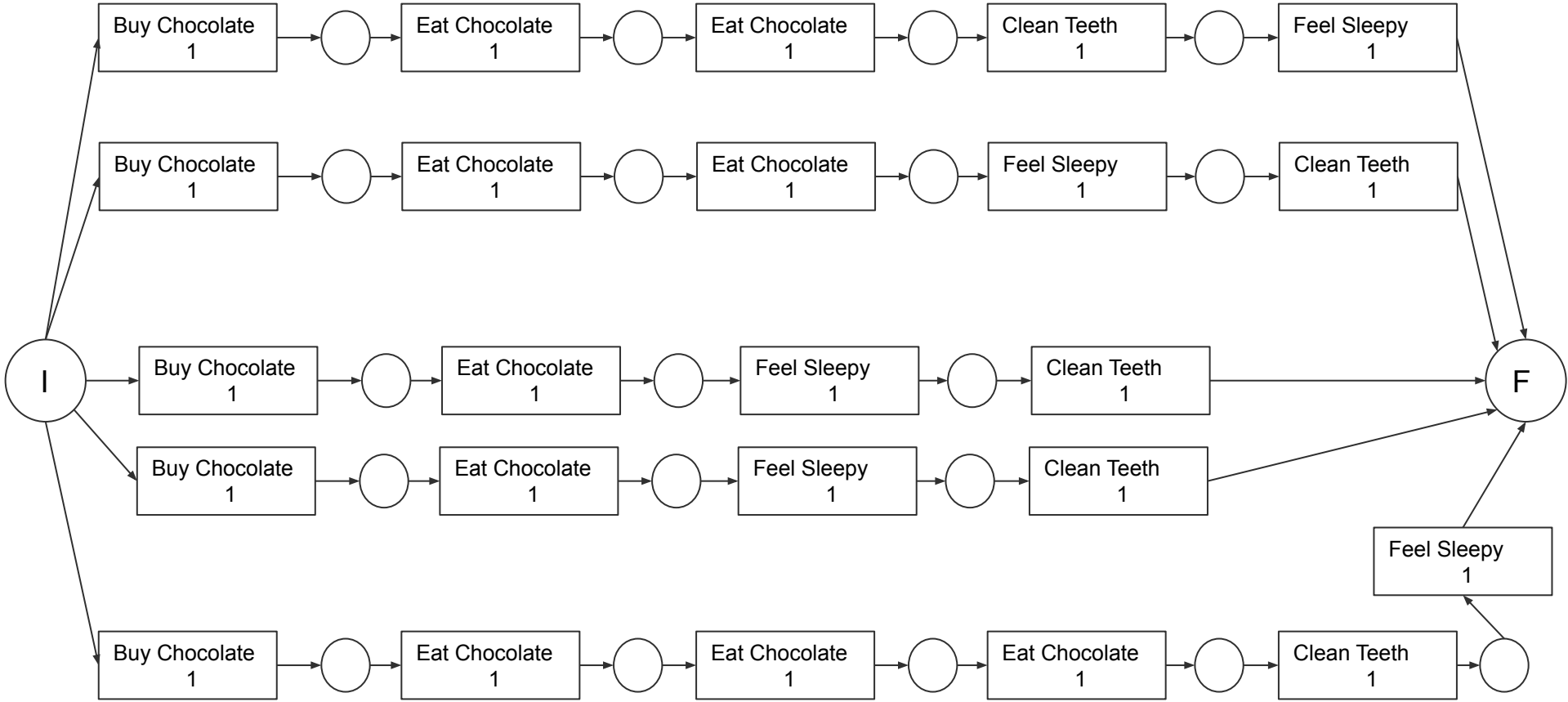


Toothpaste Example - Loop Roll CO.2 / FPL.2

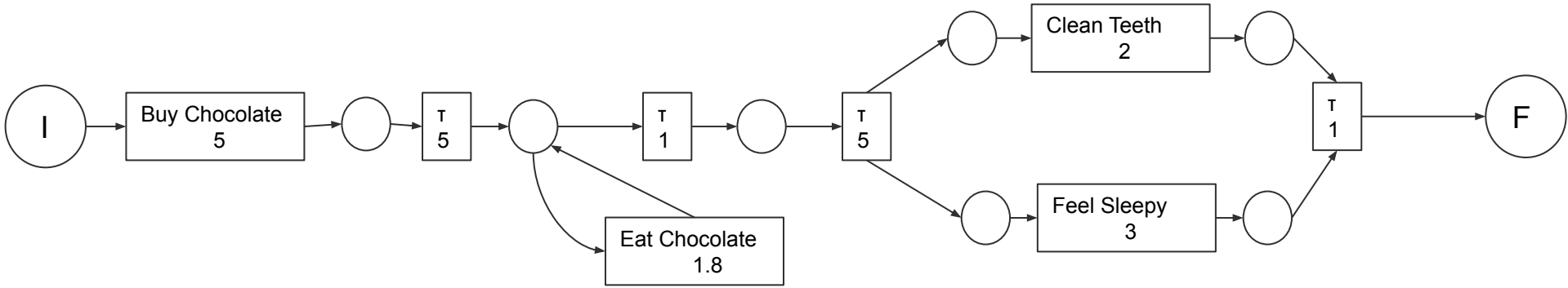


Toothpaste Example - Loop Roll CO.2 / FPL.2



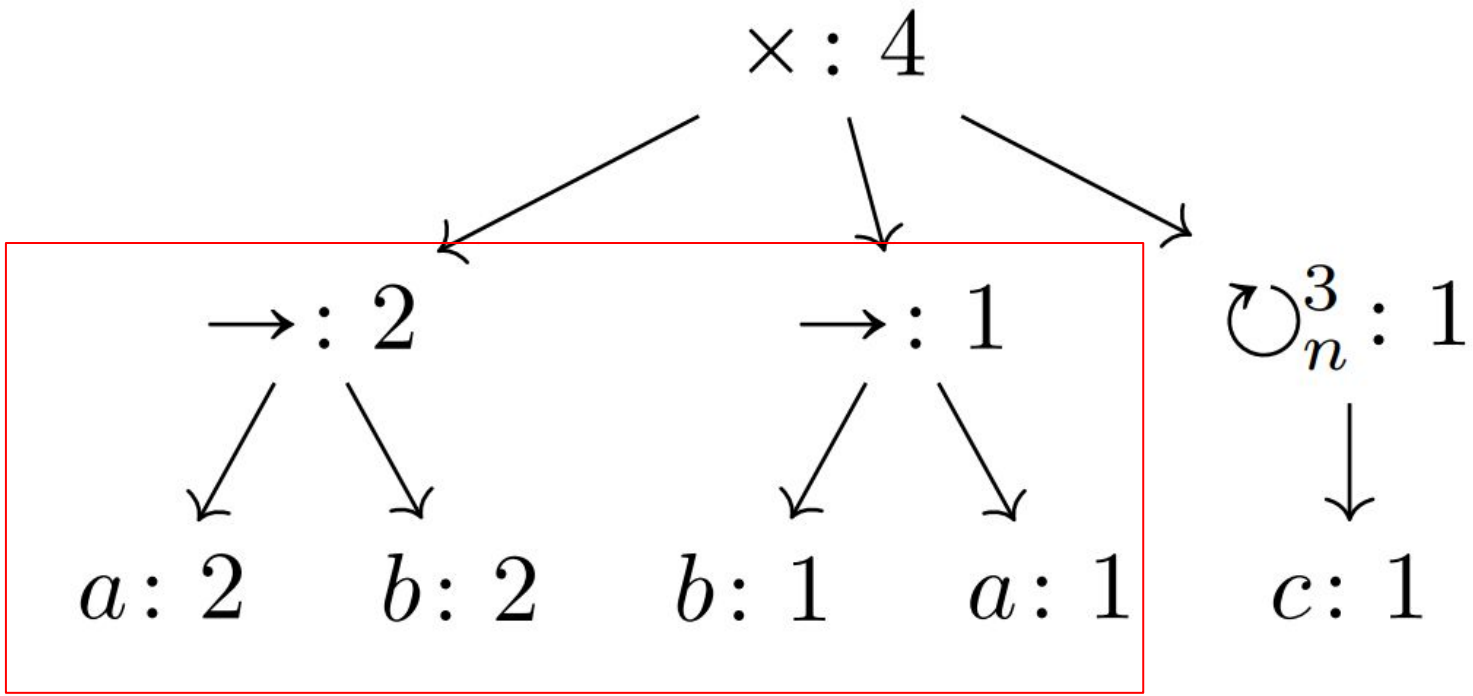


Toothpaste miner

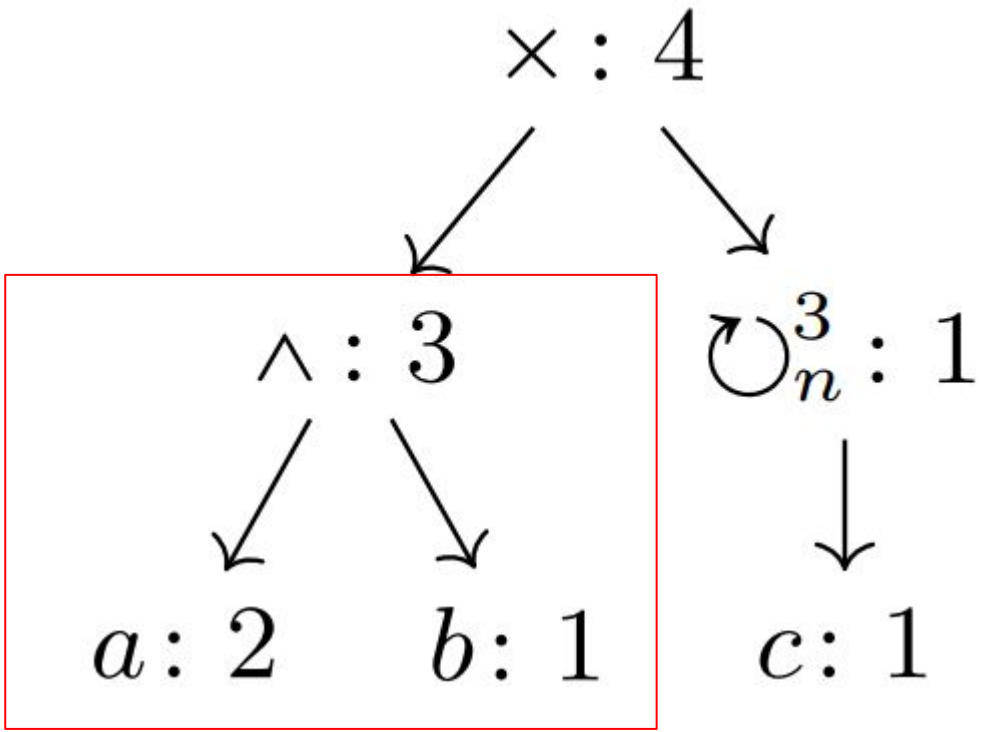


Toothpaste miner

Probabilistic Process Trees

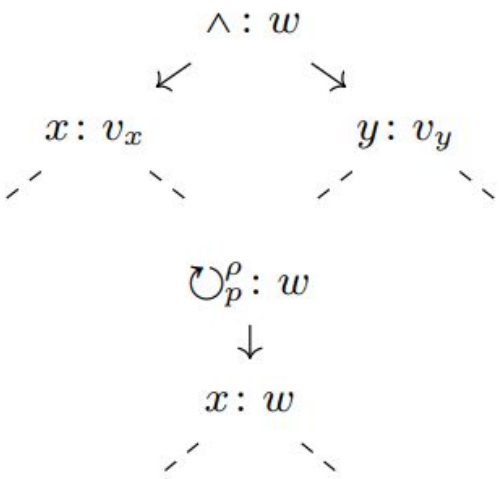


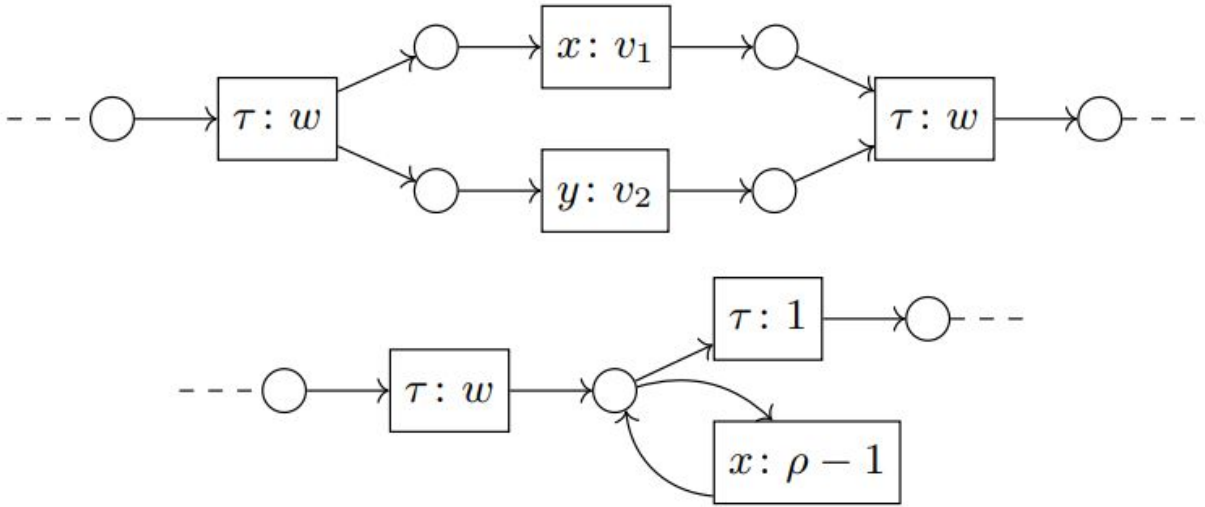
Concurrent Reduction - Probabilistic Process Trees



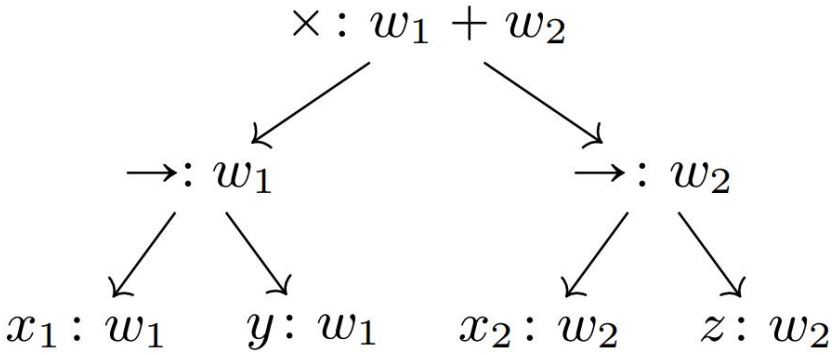
PPT ⊂ Generalized Stochastic Labelled Petri Nets

Probabilistic Process Tree	GSLPN

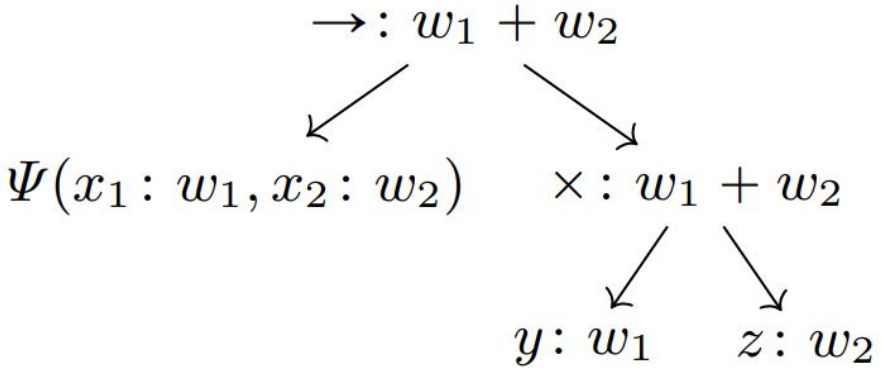


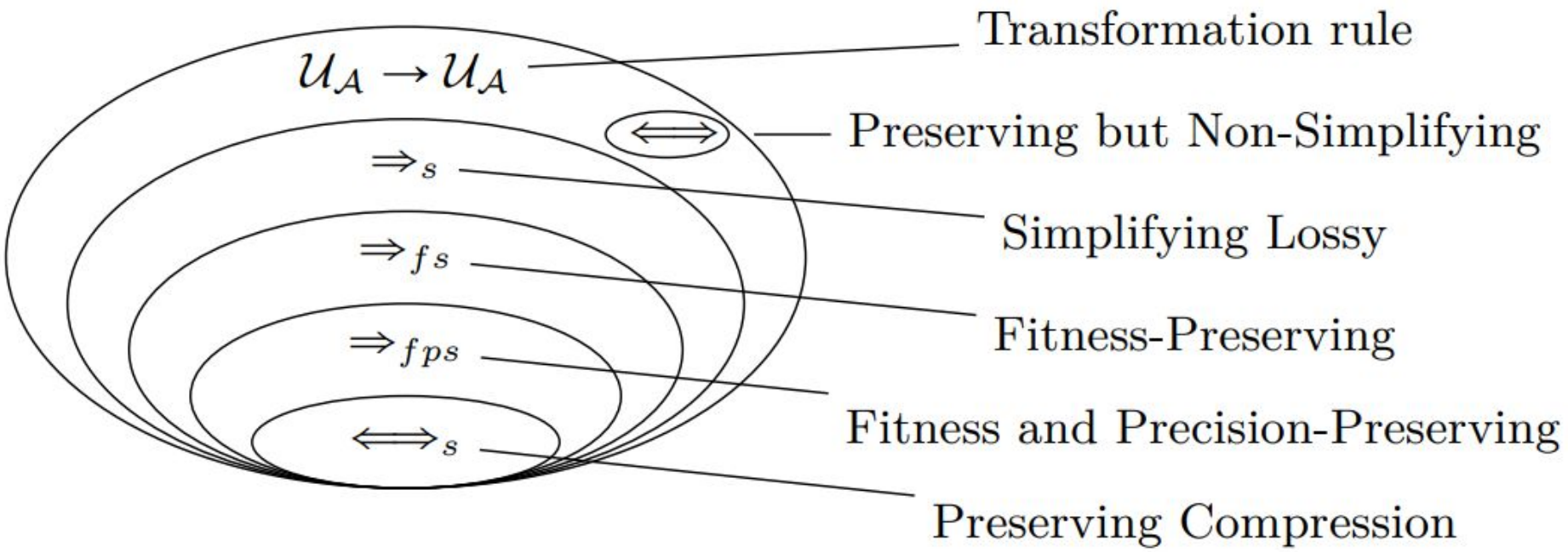


Transformation Rule (Choice Folding)



$\Longrightarrow fps$




$\mathcal{U}_{\mathcal{A}} \to \mathcal{U}_{\mathcal{A}}$
$\Rightarrow_s$
$\Rightarrow_{fs}$
$\Rightarrow_{fps}$
$\Leftrightarrow_s$
Transformation rule
Preserving but Non-Simplifying
Simplifying Lossy
Fitness-Preserving
Fitness and Precision-Preserving
Preserving Compression

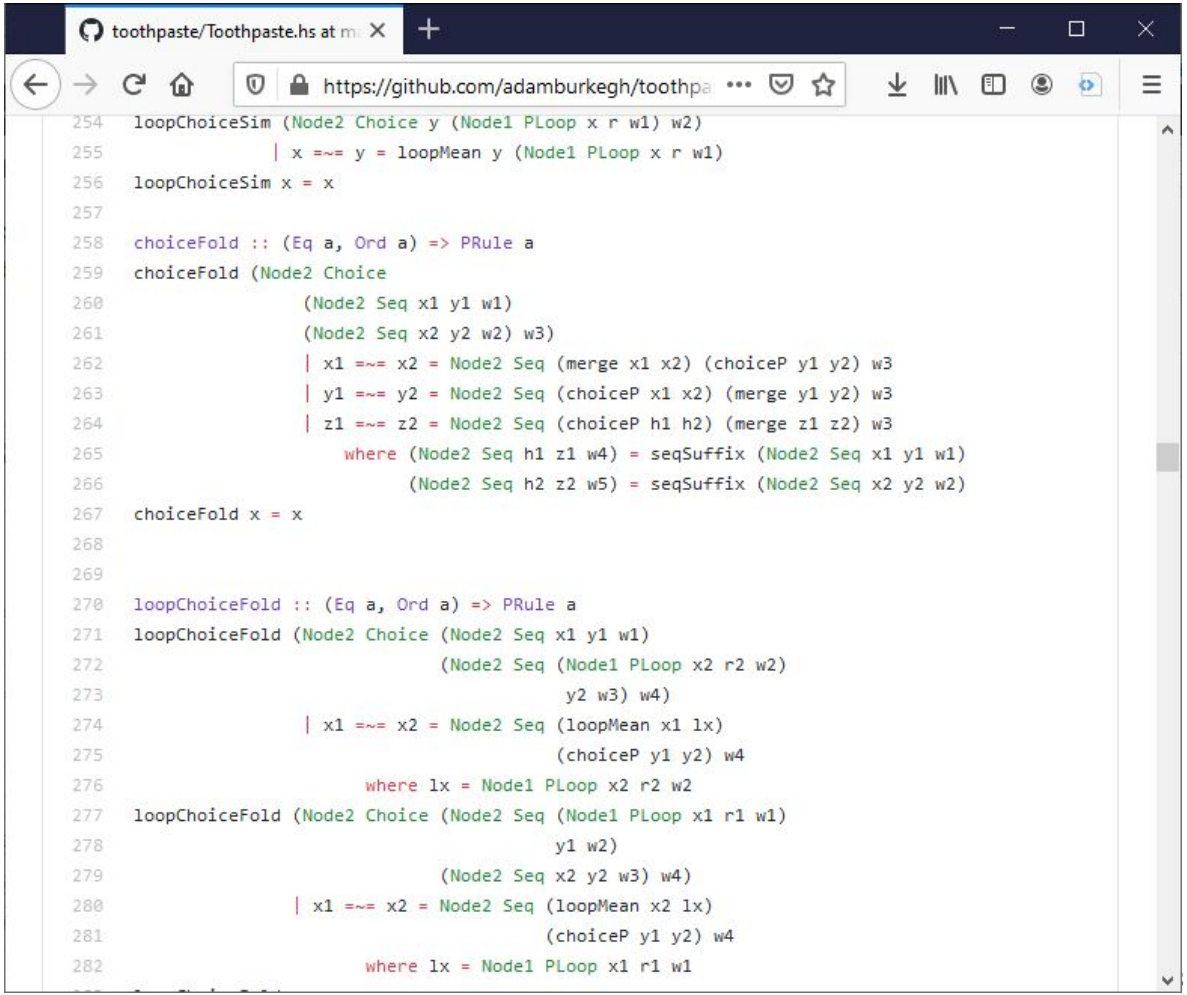
Toothpaste Miner Variations

- Batch miner
- Incremental miner
- K-retries

Prototype

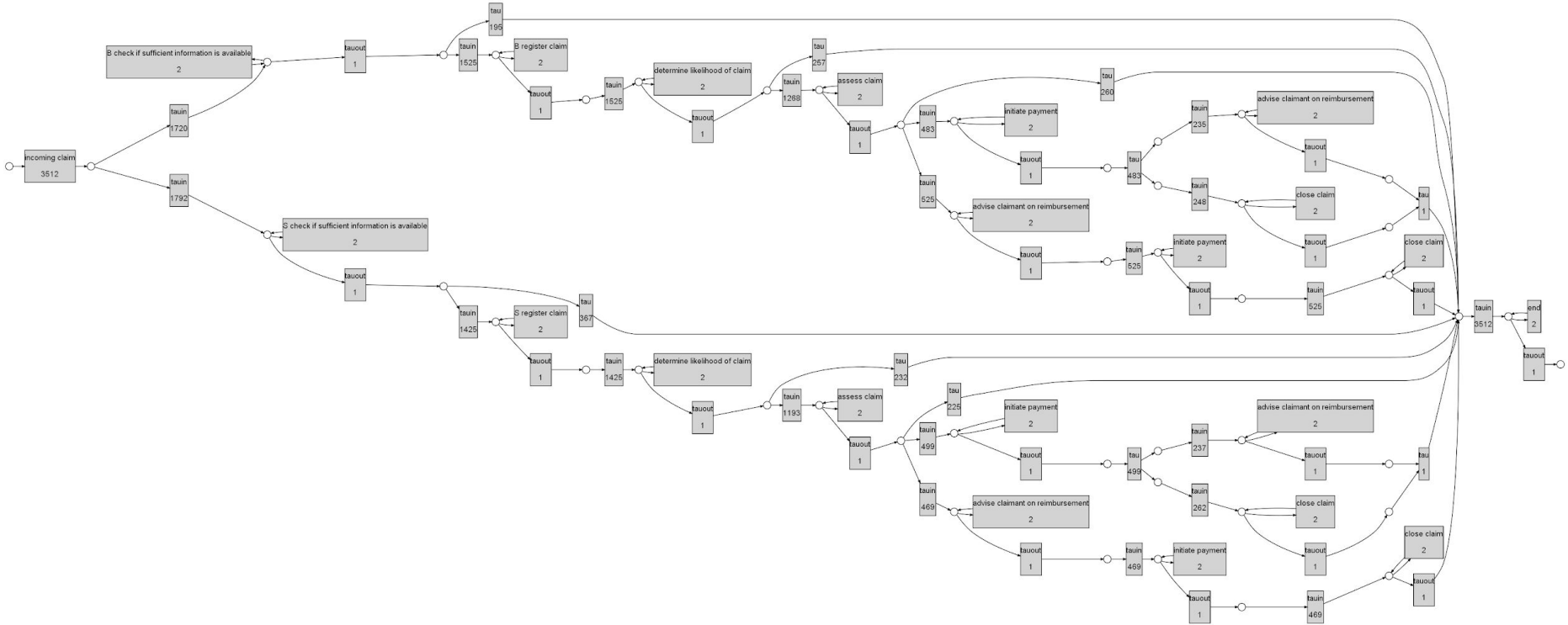
- Batch miner prototype implemented in Haskell
- Rules nice fit with Haskell pattern matching

https://github.com/adamburkegh/toothpaste

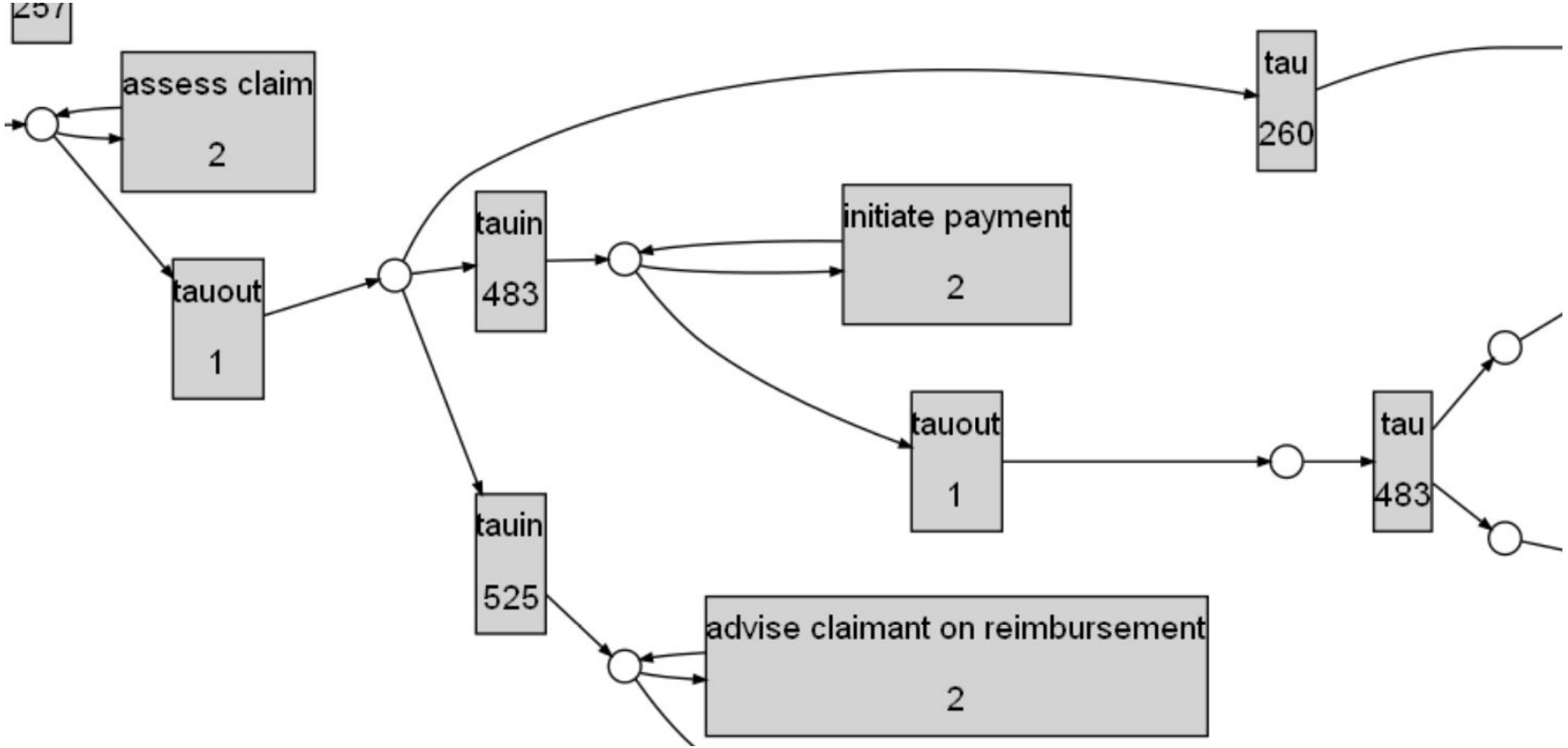



```
254 loopChoiceSim (Node2 Choice y (Node1 PLoop x r w1) w2)
255             | x =~= y = loopMean y (Node1 PLoop x r w1)
256 loopChoiceSim x = x
257
258 choiceFold :: (Eq a, Ord a) => PRule a
259 choiceFold (Node2 Choice
260                (Node2 Seq x1 y1 w1)
261                (Node2 Seq x2 y2 w2) w3)
262                | x1 =~= x2 = Node2 Seq (merge x1 x2) (choiceP y1 y2) w3
263                | y1 =~= y2 = Node2 Seq (choiceP x1 x2) (merge y1 y2) w3
264                | z1 =~= z2 = Node2 Seq (choiceP h1 h2) (merge z1 z2) w3
265                    where (Node2 Seq h1 z1 w4) = seqSuffix (Node2 Seq x1 y1 w1)
266                          (Node2 Seq h2 z2 w5) = seqSuffix (Node2 Seq x2 y2 w2)
267 choiceFold x = x
268
269
270 loopChoiceFold :: (Eq a, Ord a) => PRule a
271 loopChoiceFold (Node2 Choice (Node2 Seq x1 y1 w1)
272                              (Node2 Seq (Node1 PLoop x2 r2 w2)
273                                         y2 w3) w4)
274                | x1 =~= x2 = Node2 Seq (loopMean x1 lx)
275                                        (choiceP y1 y2) w4
276                    where lx = Node1 PLoop x2 r2 w2
277 loopChoiceFold (Node2 Choice (Node2 Seq (Node1 PLoop x1 r1 w1)
278                                         y1 w2)
279                              (Node2 Seq x2 y2 w3) w4)
280                | x1 =~= x2 = Node2 Seq (loopMean x2 lx)
281                                        (choiceP y1 y2) w4
282                    where lx = Node1 PLoop x1 r1 w1
```

Toothpaste on teleclaims [1]



Teleclaims discovered model (detail)



Experimental Evaluation

- Two real-life logs
  - incident management (BPIC2013)
  - Sepsis hospital process
- Established dataset - teleclaims (call centre)
- Two other stochastic discovery techniques - GDT_SPN and estimator
- Conformance measures
  - Earth movers' distance (*tEMSC)*
  - Entity count
- *k*-fold cross-validation

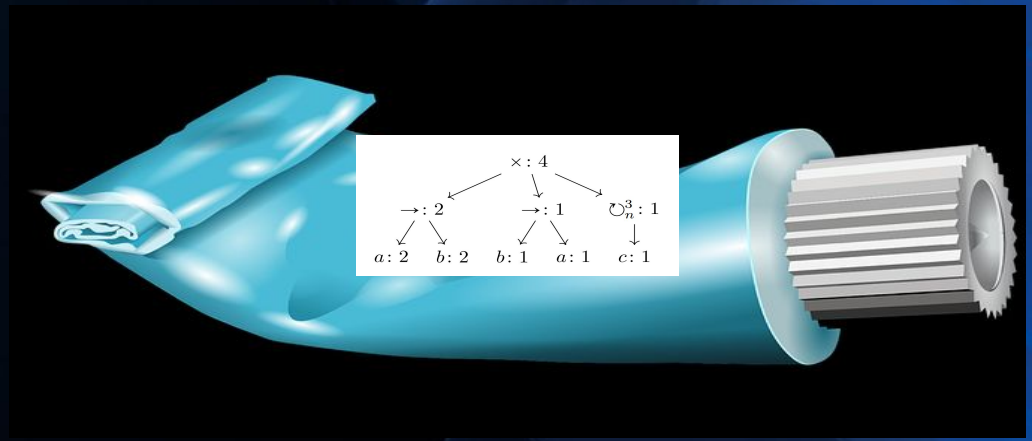
Evaluation Results

- Prototype
  - Trades off simplicity for quality
  - Good at preserving quality as represented by truncated Earth Movers' Distance (*tEMSC)*

Overall

- Direct Stochastic Process Discovery based on rules
- Polynomial
- Works directly on Generalized Stochastic Petri Nets
- Prototype shows viability and promising preservation of quality (*tEMSC*)

Discovering Stochastic Process Models By Reduction and Abstraction



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References

[1] van der Aalst - Process Mining: Data Science In Action