Towards a Logic-Based Framework for Analyzing Stream Reasoning

Harald Beck Minh Dao-Tran Thomas Eiter Michael Fink

3rd International Workshop on Ordering and Reasoning

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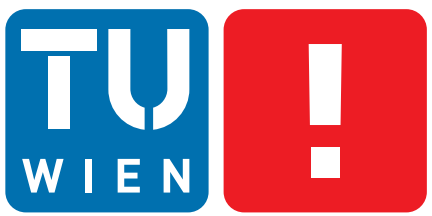

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Faculty of Informatics

What & Why

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- Stream Reasoning

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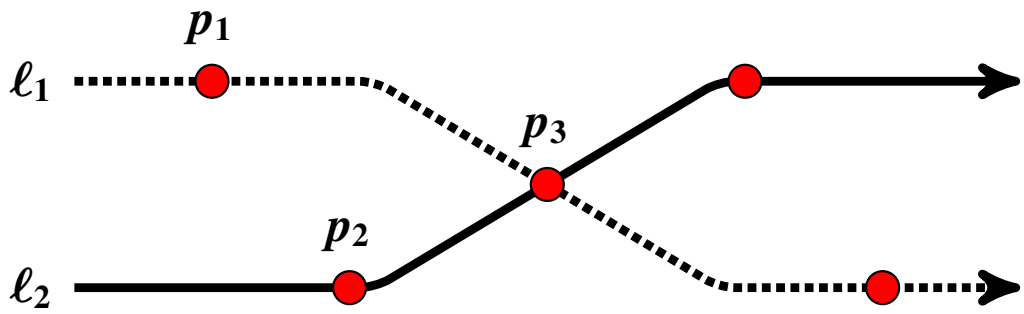
  - Streams = **tuples** (atoms) with **timestamps**
  - Essential aspect: **window** functions
- Logic-Based: Lack of theory
- Analysis: Hard to predict, hard to compare

Example: Public Transportation Monitoring



Example: Public Transportation Monitoring

PLAN			
L	X	Y	Z
ℓ_1	p_1	p_3	8
ℓ_2	p_2	p_3	3
...			

LINE	
ID	L
a_1	ℓ_1
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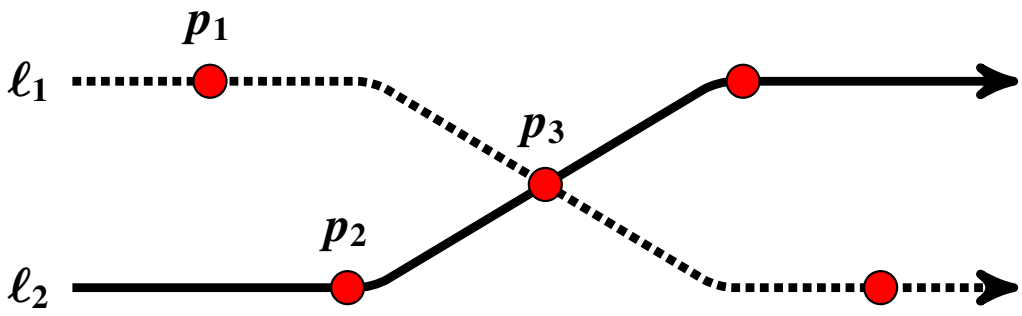
...	

OLD
a_1
...



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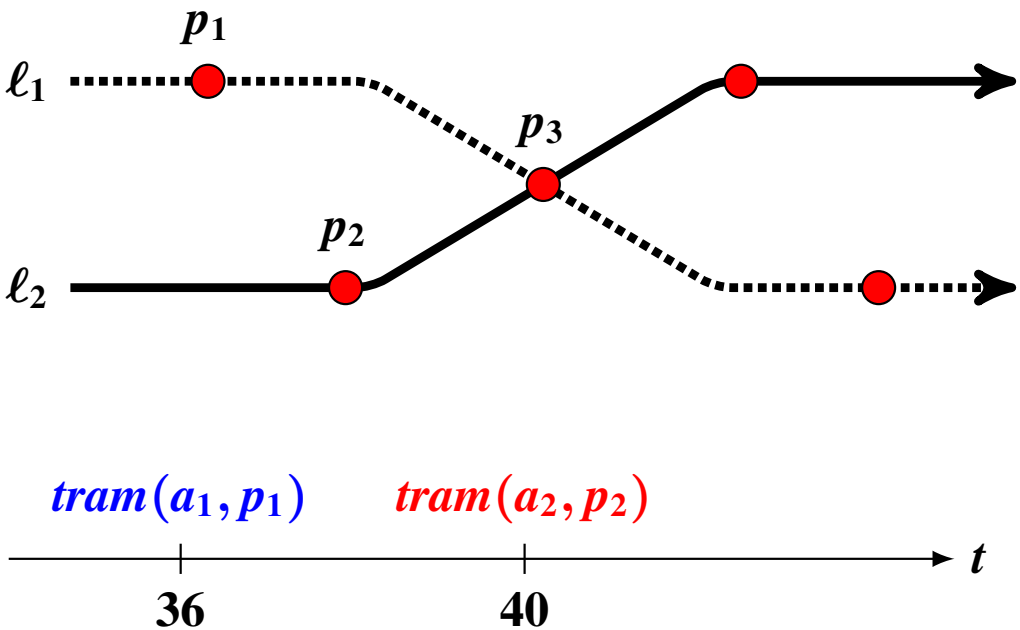

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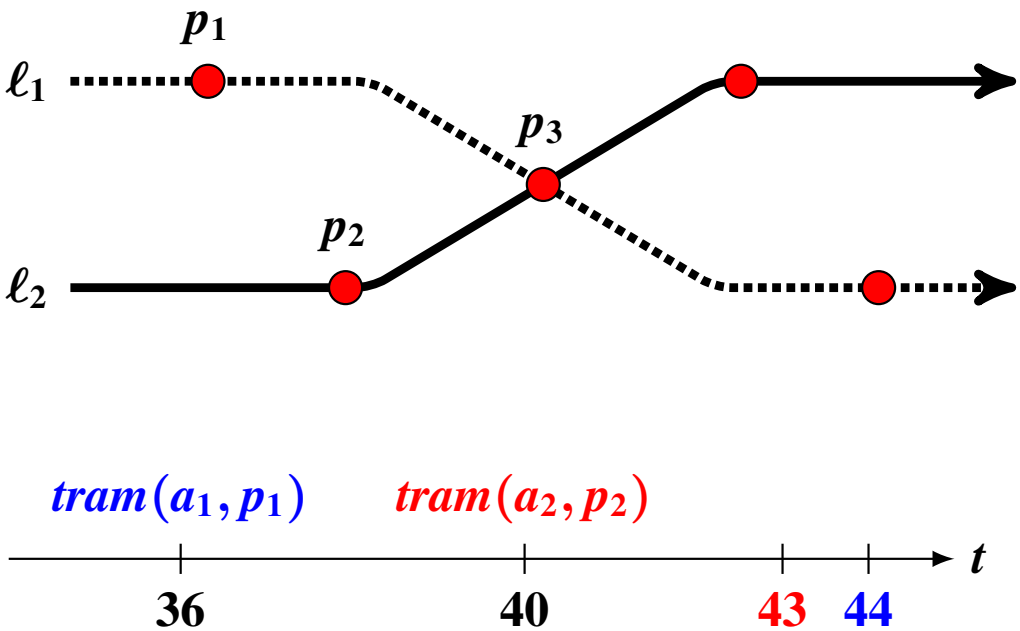

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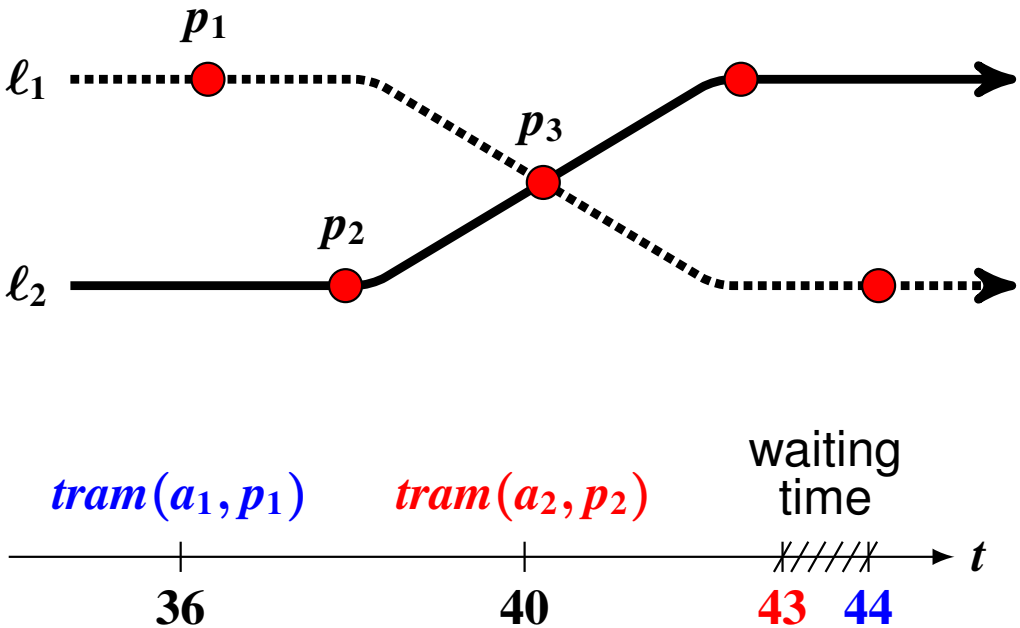

- Report trams' expected arrival time.
- Report good connections between two lines at a given stop.

Streams

- Data Stream $\boldsymbol{D} = (\boldsymbol{T}, \upsilon)$

$$\boldsymbol{T} = [\mathbf{0}, \mathbf{50}]$$

$$\upsilon = \{\mathbf{36} \mapsto \{\boldsymbol{tram}(\boldsymbol{a_1}, \boldsymbol{p_1})\}, \mathbf{40} \mapsto \{\boldsymbol{tram}(\boldsymbol{a_2}, \boldsymbol{p_2})\}\}$$

Streams

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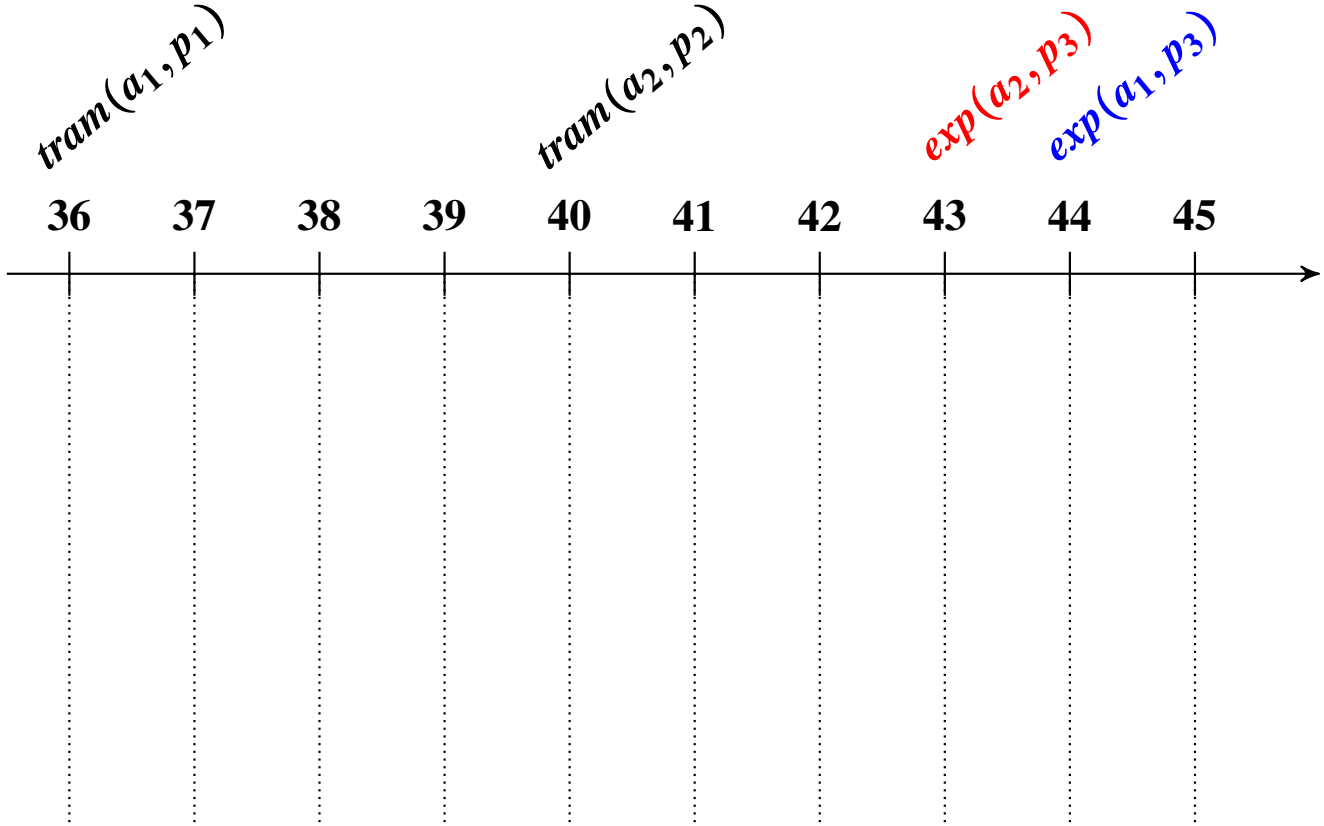
- Interpretation Stream $S^\star = (T^\star, \upsilon^\star) \supseteq D$

  $T^\star = [0, 50]$

  $$\upsilon^\star = \left\{ \begin{array}{ll} 36 \mapsto \{tram(a_1, p_1)\}, & 40 \mapsto \{tram(a_2, p_2)\}, \\ 43 \mapsto \{exp(a_2, p_3)\}, & 44 \mapsto \{exp(a_1, p_3)\} \end{array} \right\}$$

Window Functions



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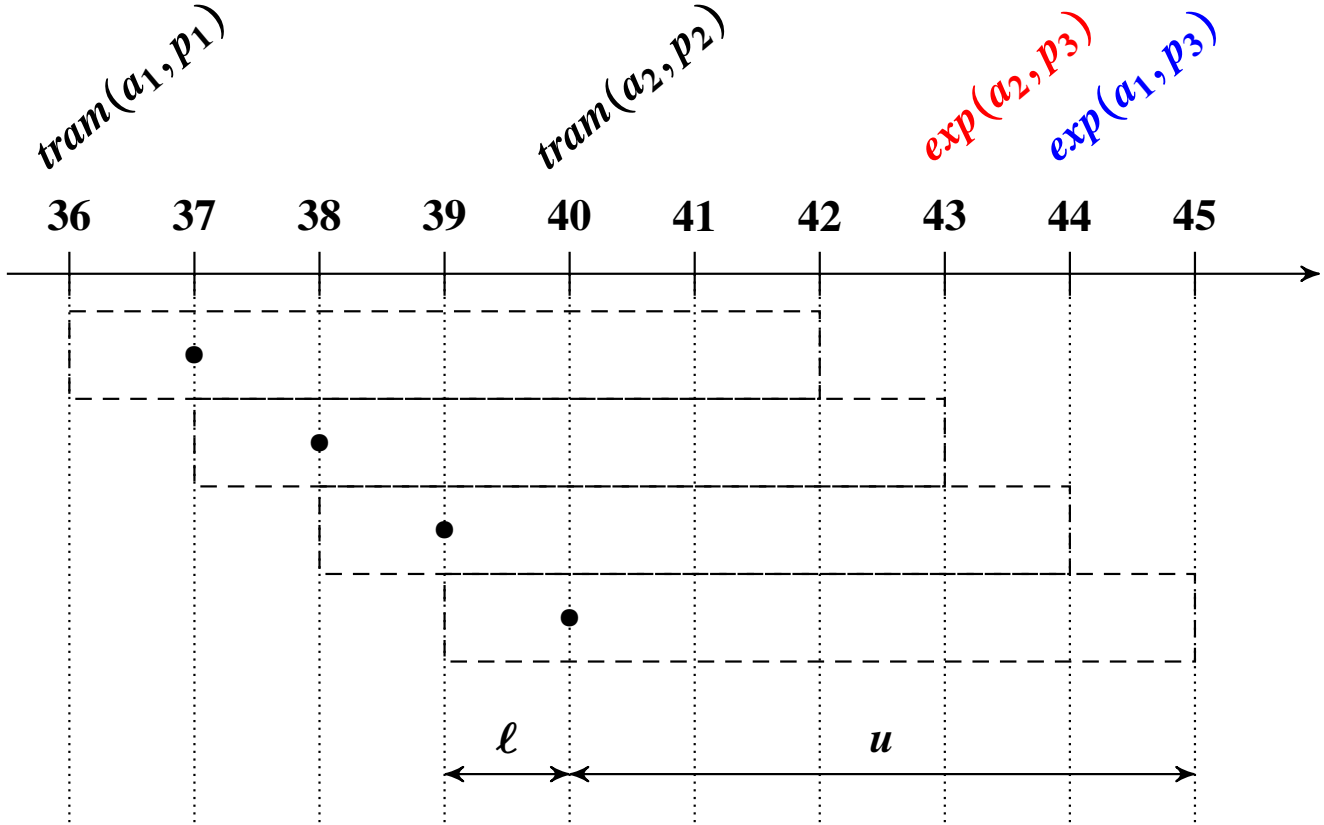

$$S' = w_\tau(S^\star, 40, (1,5,1)) = ([39,45], \left\{ \begin{array}{l} 40 \mapsto \{tram(a_2,p_2)\}, \\ 43 \mapsto \{exp(a_2,p_3)\}, \\ 44 \mapsto \{exp(a_1,p_3)\} \end{array} \right\})$$

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$$\boxplus^{60}_{\tau}\Box\ \boxplus^{5}_{\tau}\ \Diamond tramAt(p_1)$$

- but need rules:

$$tramAt(P) \leftarrow tram(X, P).$$

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$\boldsymbol{M}, \boldsymbol{S}, \boldsymbol{t} \Vdash \boldsymbol{a}$ iff $\boldsymbol{a} \in \boldsymbol{v}(\boldsymbol{t})$,

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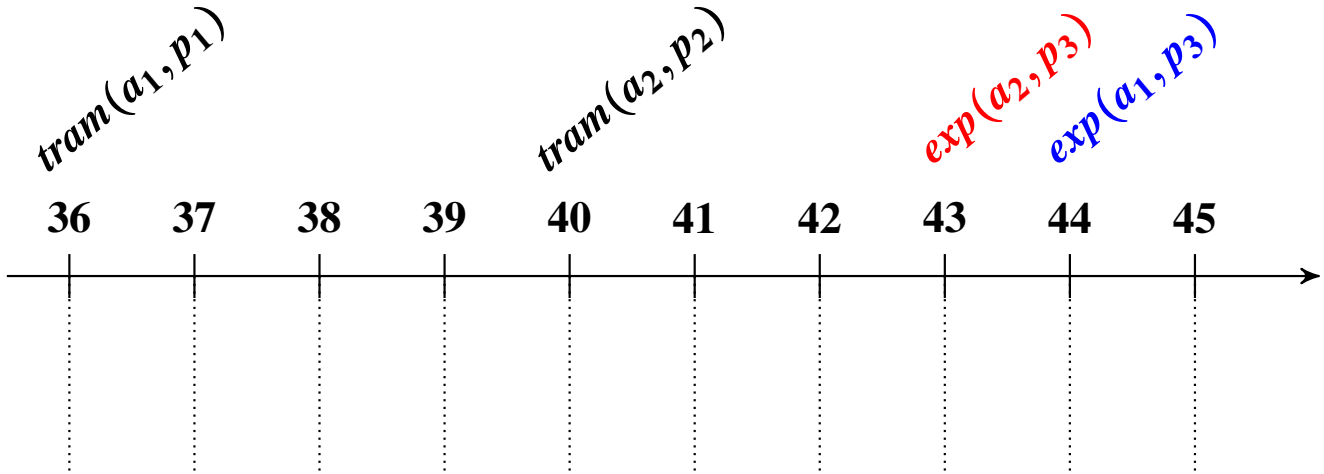
Entailment: Example



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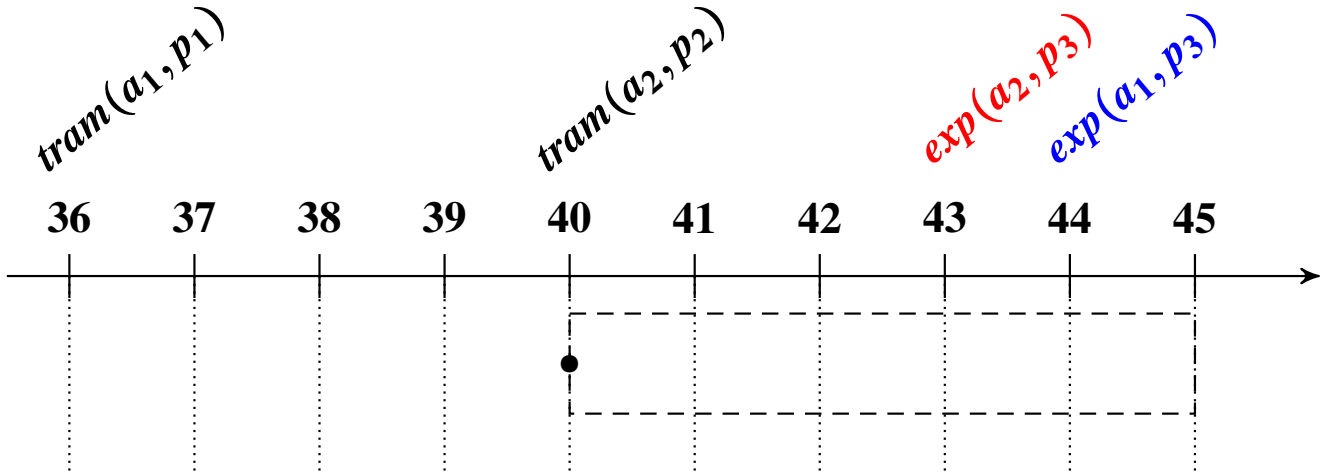

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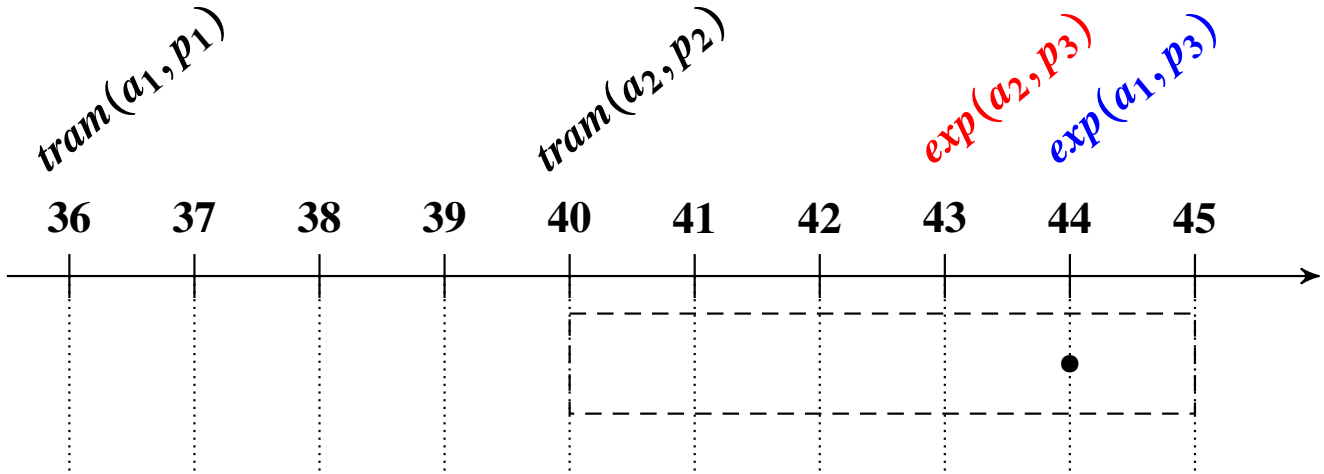

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- Reduct: $P^{M,t} = \{r \in P \mid M, t \models \beta(r)\}$
- Answer: M is an answer of P (for D at time t) iff M is a minimal model of $P^{M,t}$

Conclusion Stream

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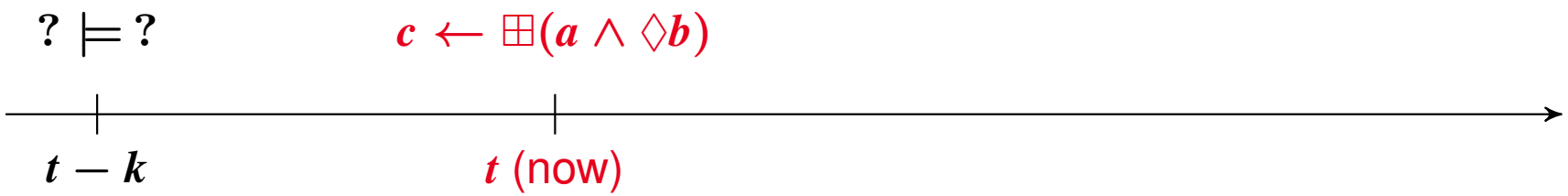

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  - time reference / time abstraction
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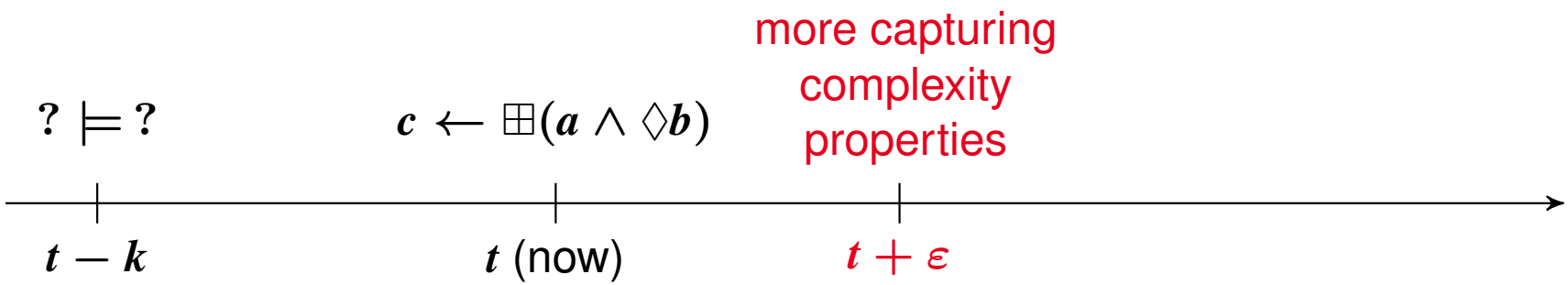

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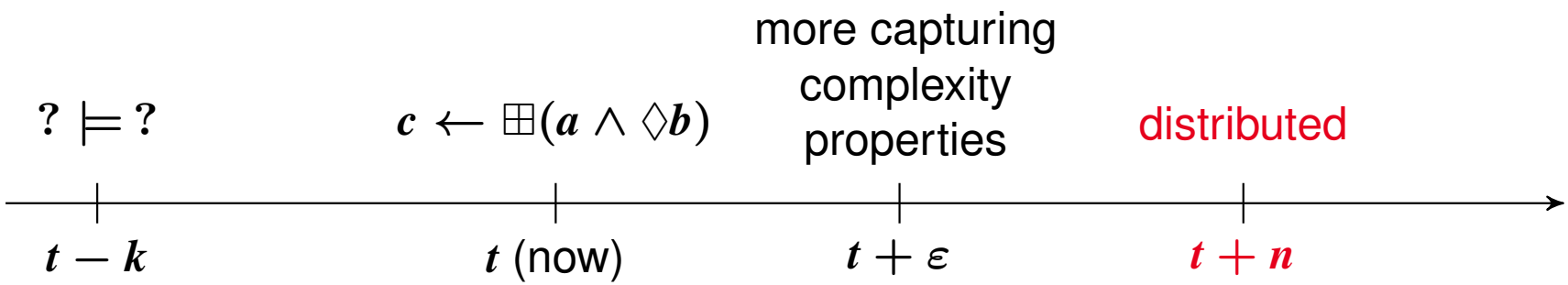
- Later: Language properties, complexity analysis, capture CQL, ETALIS, C-SPARQL, CQELS,...

Conclusion Stream



- Past: Lack of theoretical underpinning for stream reasoning
- Now: First language for modelling semantics precisely
  - flexible window operator (first class citizen)
  - time reference / time abstraction
  - rule-based semantics
  - more: capturing a fragment of CQL
- Later: Language properties, complexity analysis, capture CQL, ETALIS, C-SPARQL, CQELS,...
- Eventually: Distributed setting, heterogeneous nodes