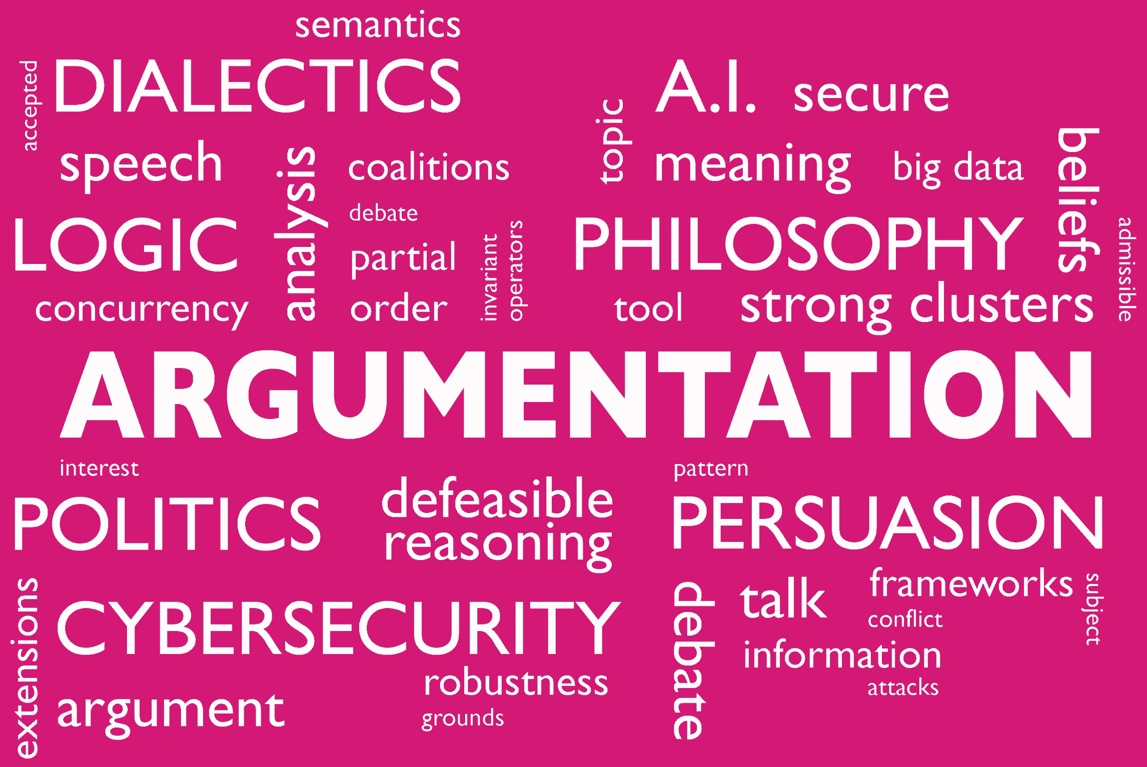
UNIVERSITÀ DEGLI STUDI
DI PERUGIA

Università degli Studi "G. d'Annunzio"

Timed Concurrent Language for Argumentation

Stefano Bistarelli, Maria Chiara Meo, <u>Carlo Taticchi</u>

CILC 2021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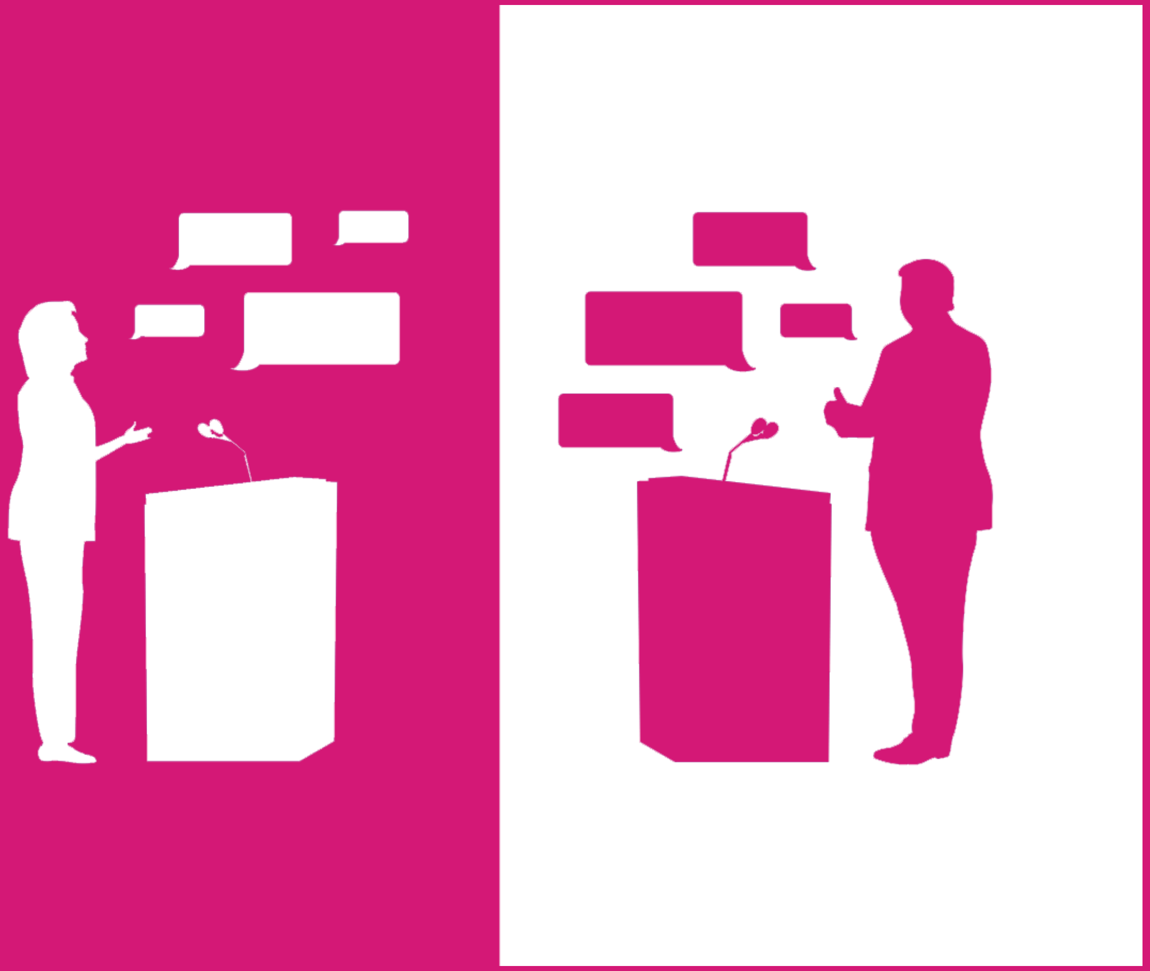
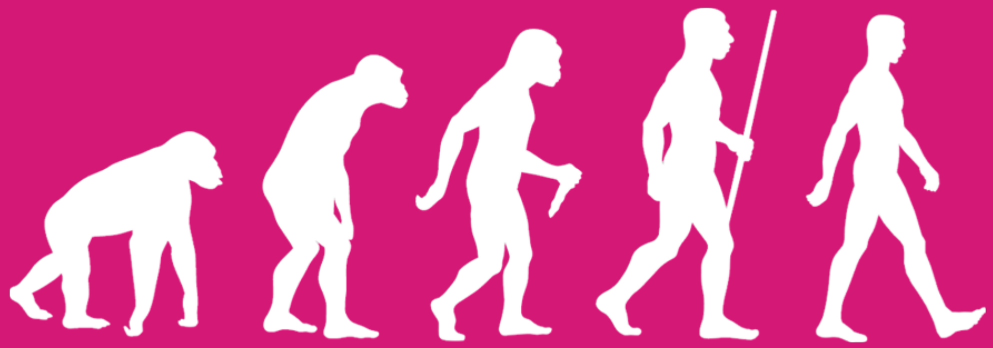
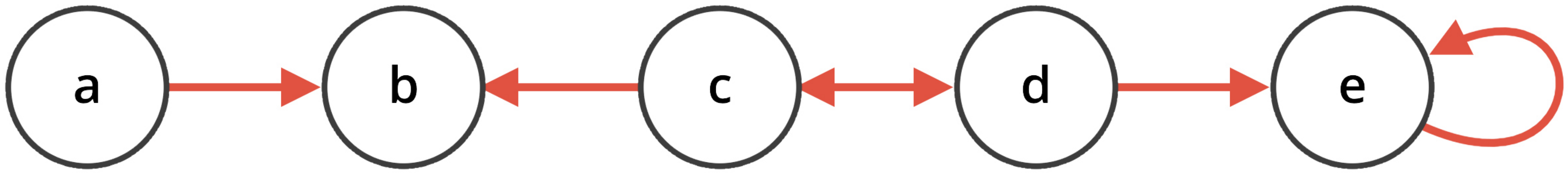




Overview

- Argumentation Frameworks (AFs)
  - Acceptable arguments
  - Timed AFs
- Timed Concurrent Language for Argumentation (`tcla`)
  - Syntax
  - Operational semantics
- Modelling Timed AFs
  - Running example
- Conclusion and Future Work

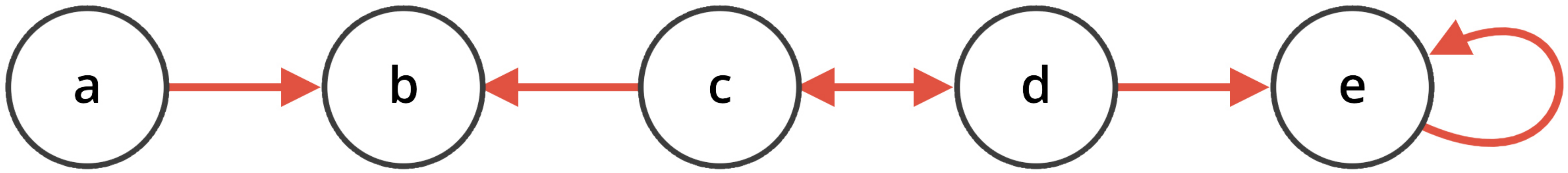
Argumentation Frameworks



Argumentation Frameworks

Acceptable arguments

- Conflict-Free: `{}, {a}, {b}, {c}, {d}, {a,c}, {a,d}, {b,d}`
- Admissible: `{}, {a}, {b}, {c}, {d}, {a,c}, {a,d}, {b,d}`
- Complete: `{}, {a}, {b}, {c}, {d}, {a,c}, {a,d}, {b,d}`
- …



Extension-based semantics

Argumentation Frameworks

Acceptable arguments

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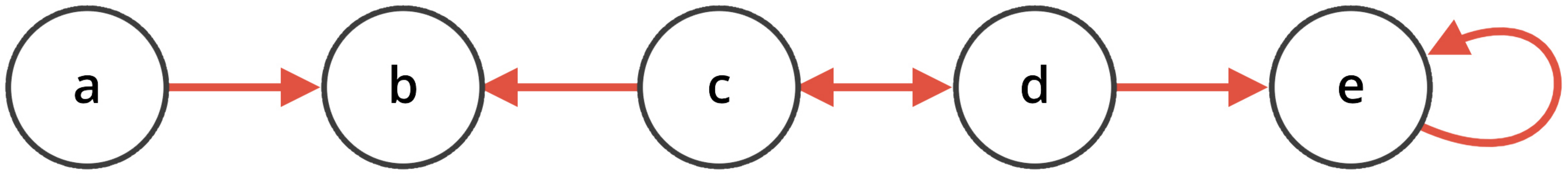
- Admissible: `{}, {a}, {b}, {c}, {d}, {a,c}, {a,d}, {b,d}`
- Complete: `{}, {a}, {b}, {c}, {d}, {a,c}, {a,d}, {b,d}`
- …

Credulously accepted



Extension-based semantics

Argumentation Frameworks

Acceptable arguments

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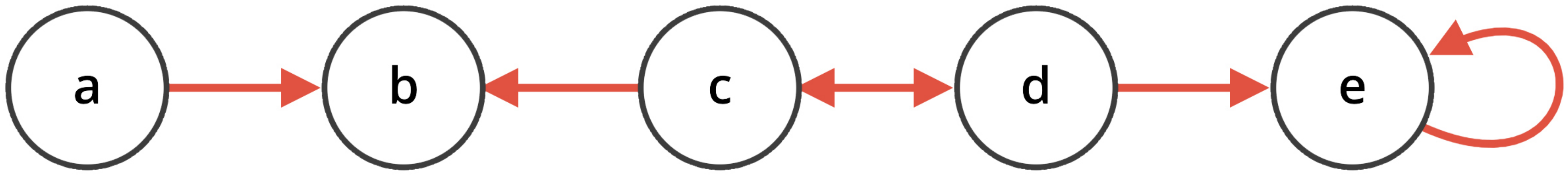
- Admissible: {}, {a}, {b}, {c}, {d}, {a,c}, {a,d}, {b,d}
- Complete: {}, {a}, {b}, {c}, {d}, {a,c}, {a,d}, {b,d}
- … Skeptically accepted Credulously accepted



Extension-based semantics

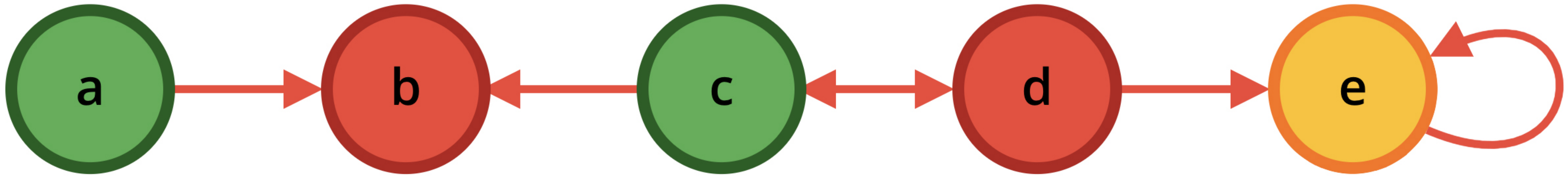
Argumentation Frameworks

Acceptable arguments

IN if it is attacked only by **OUT** arguments

OUT if it is attacked by at least an **IN** argument

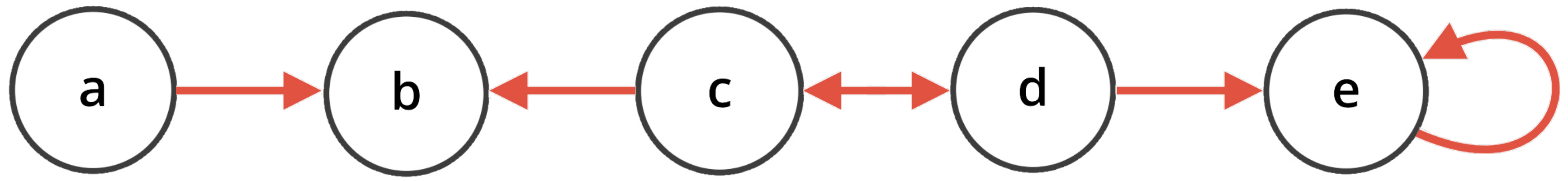
UNDEC otherwise

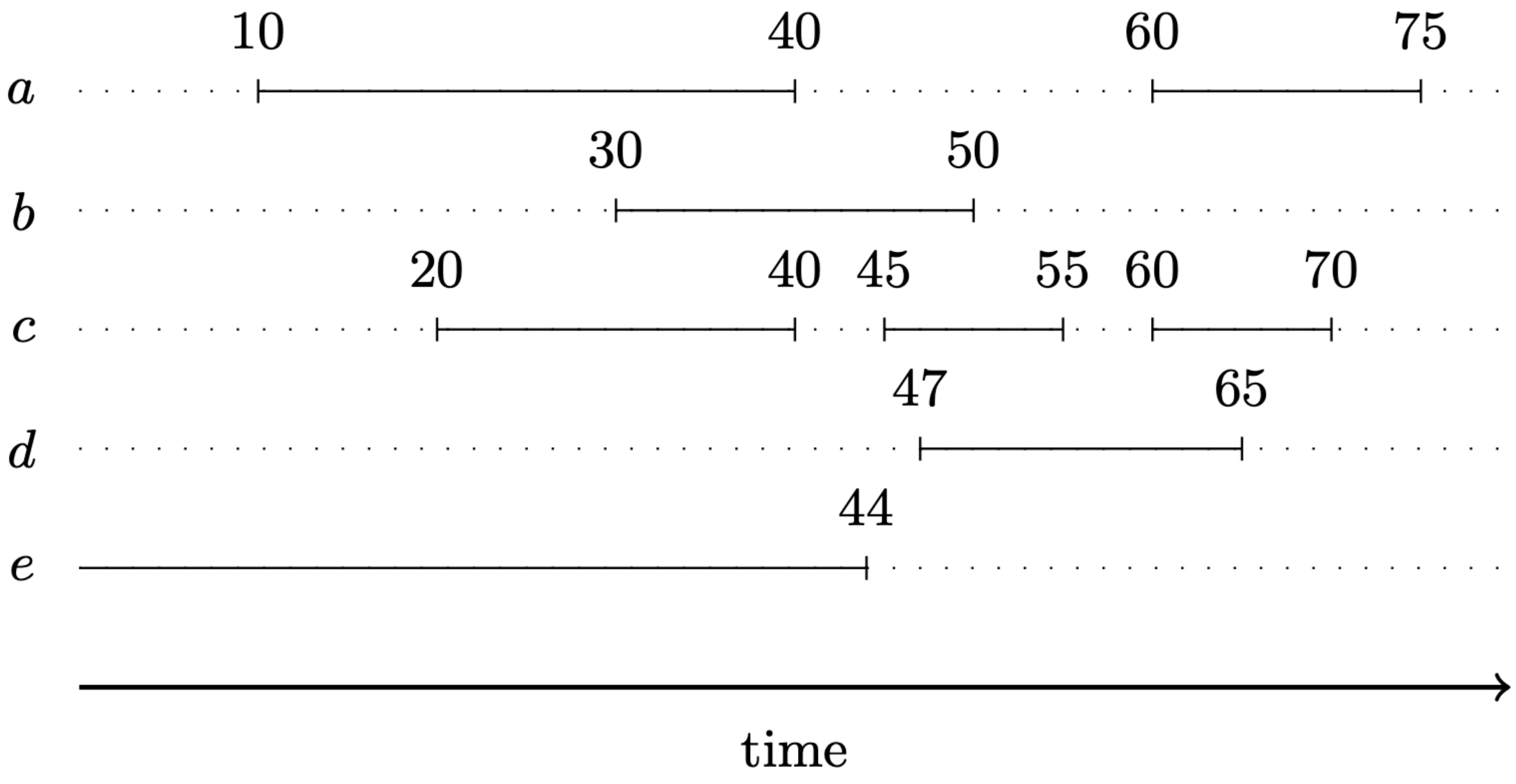


Reinstatement labelling identifies complete extensions

Argumentation Frameworks

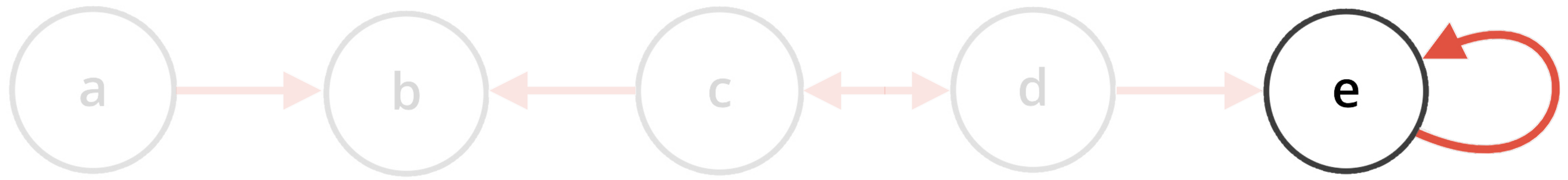
Timed AFs

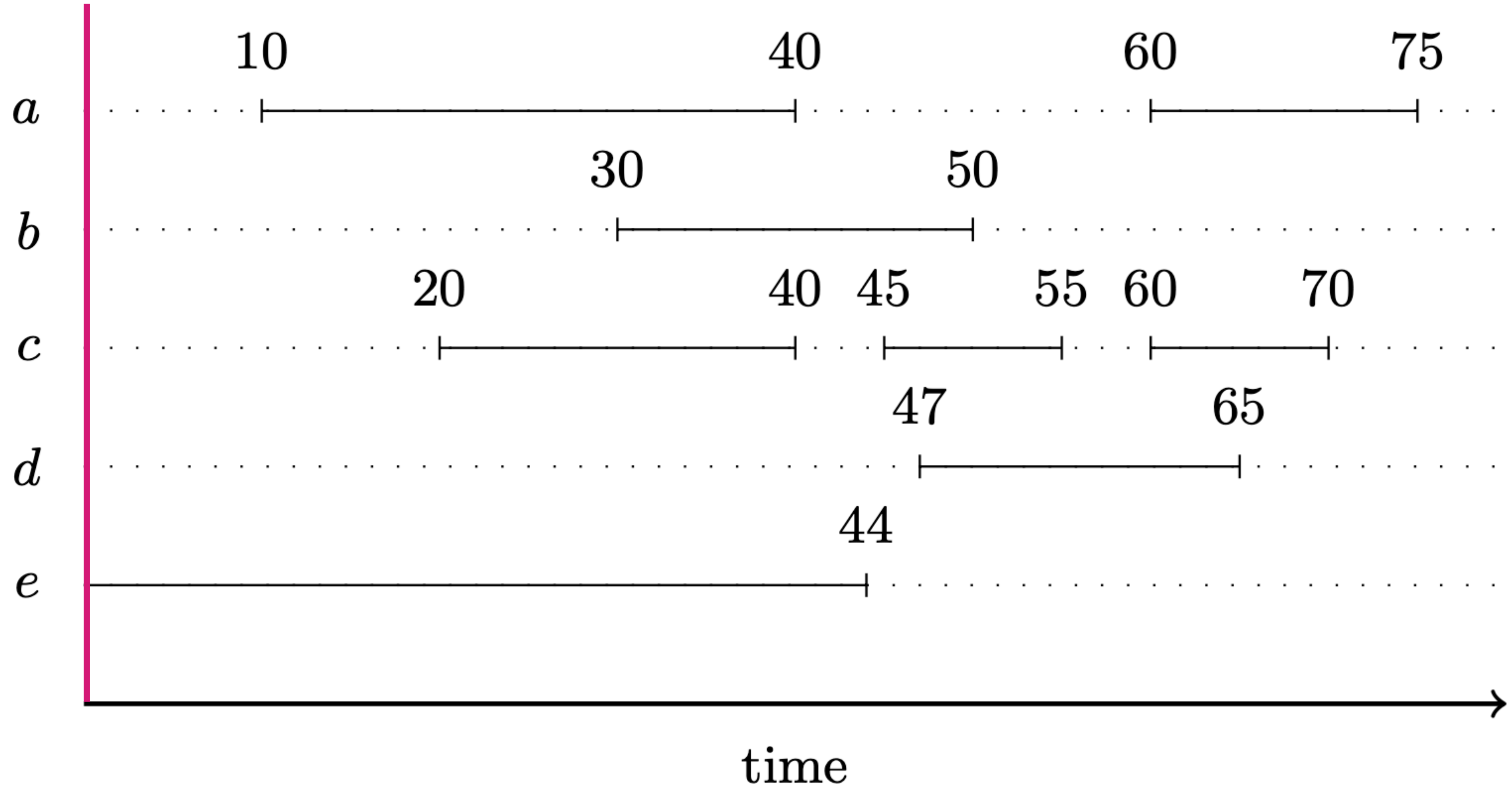




Argumentation Frameworks

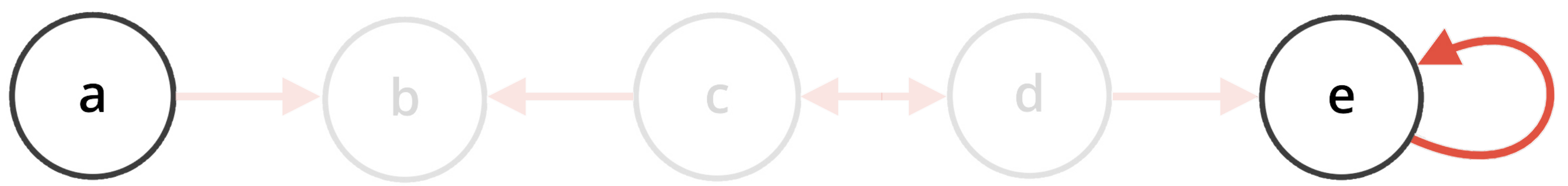
Timed AFs

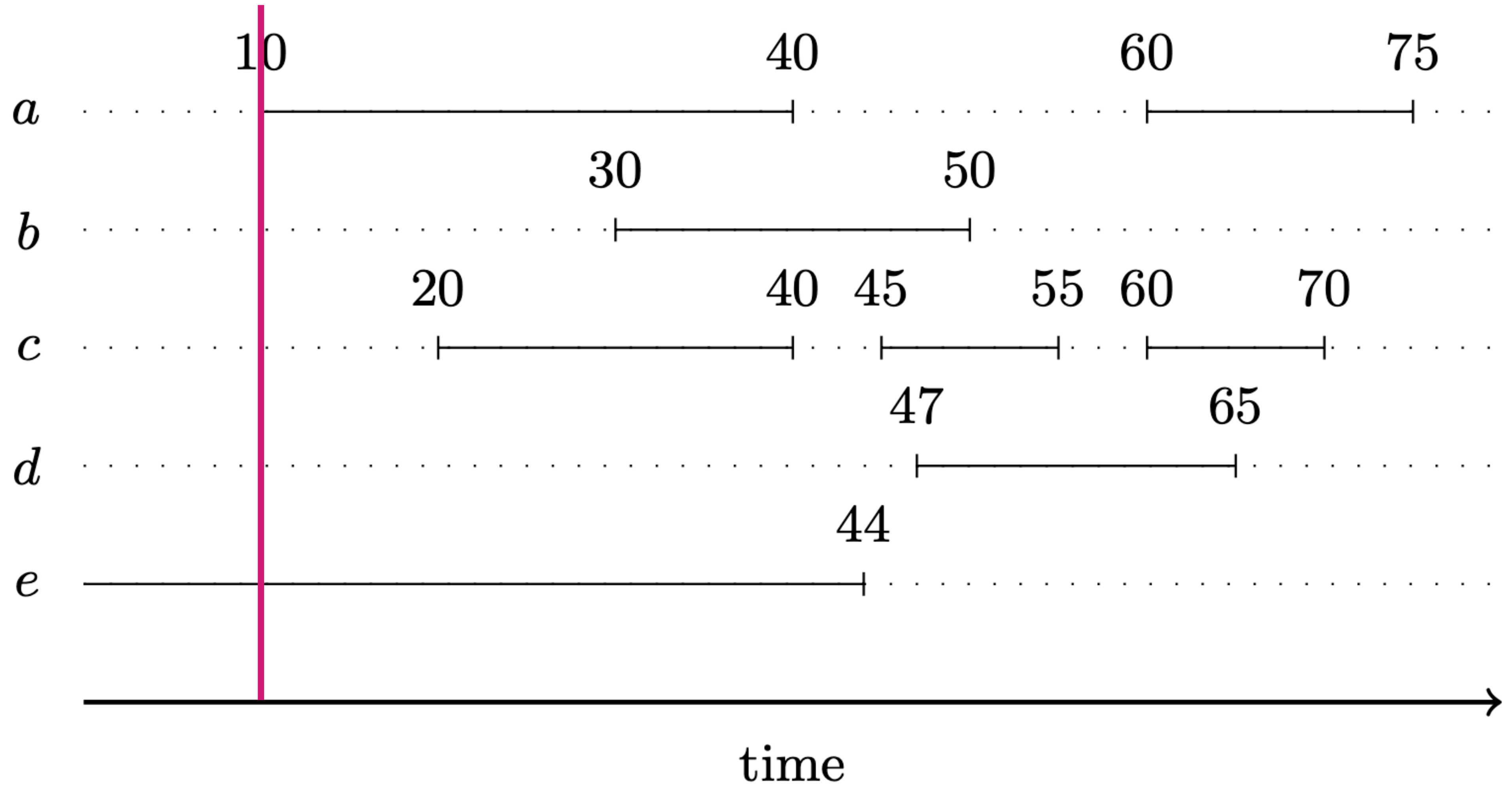




Argumentation Frameworks

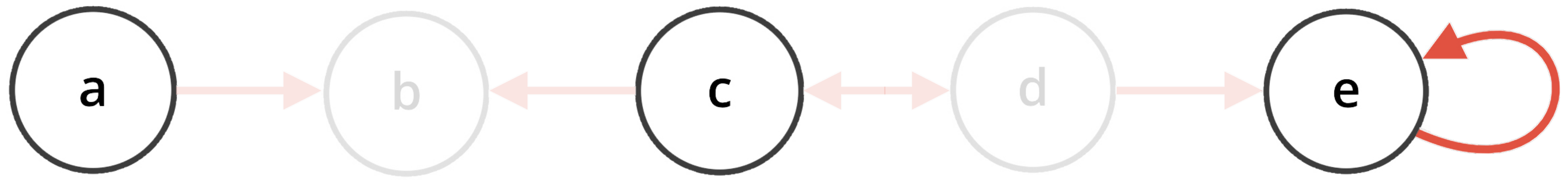
Timed AFs

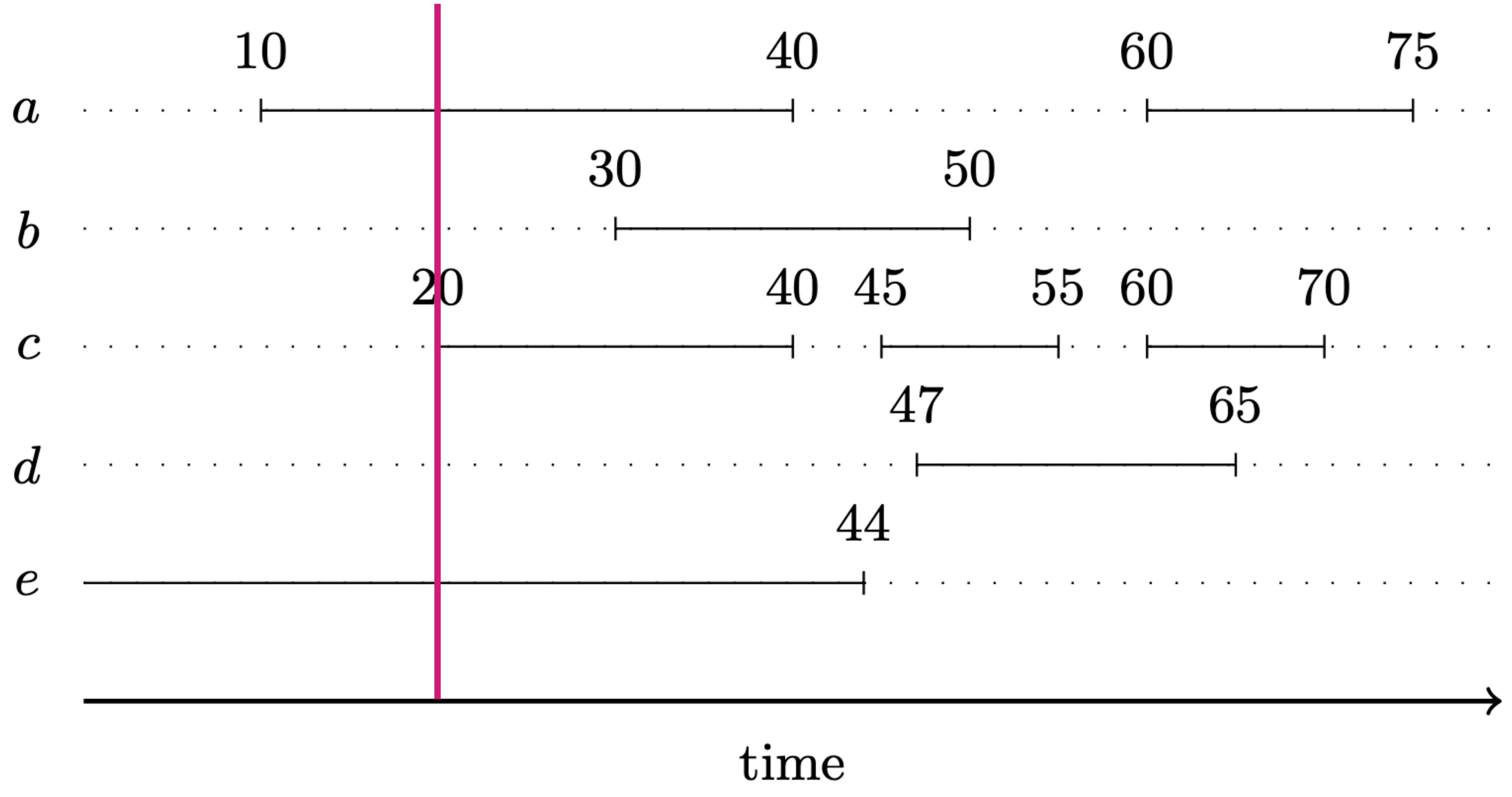




Argumentation Frameworks

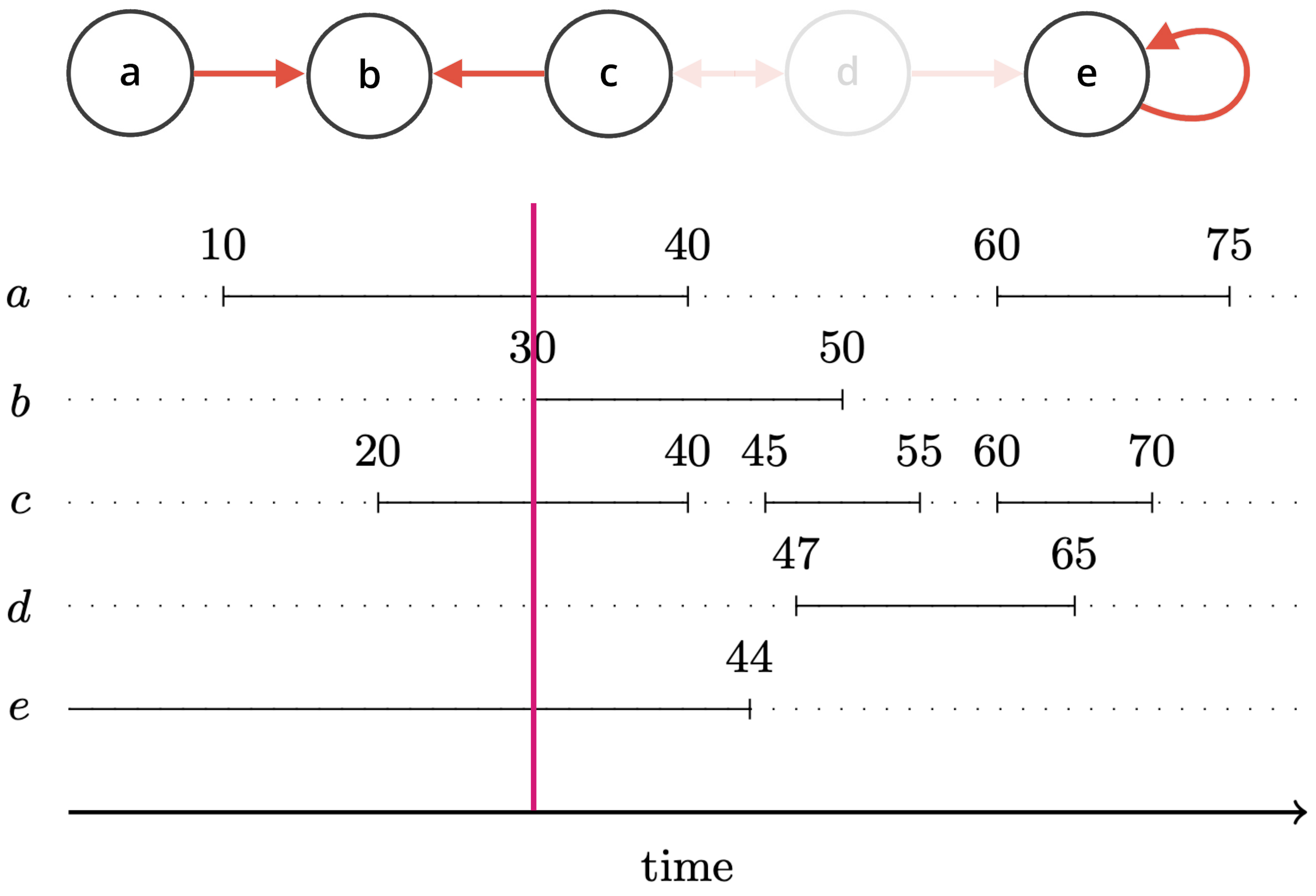
Timed AFs





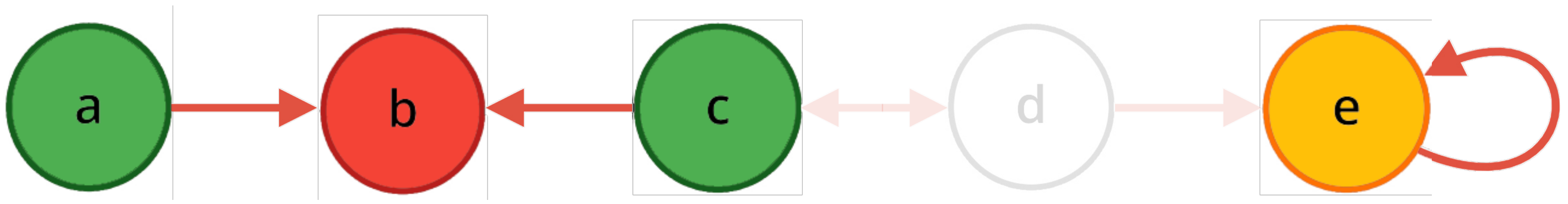
Argumentation Frameworks

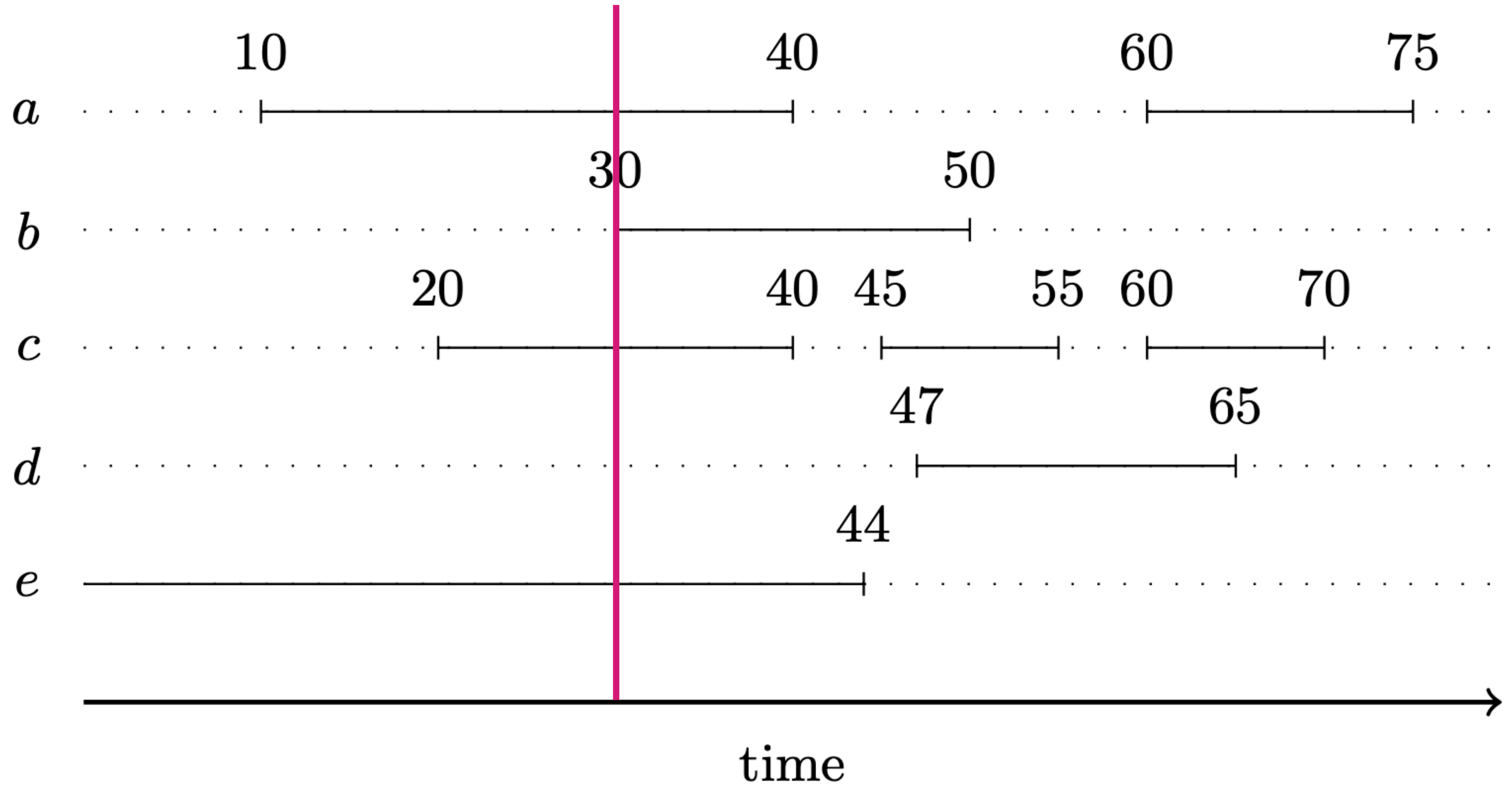
Timed AFs



Argumentation Frameworks

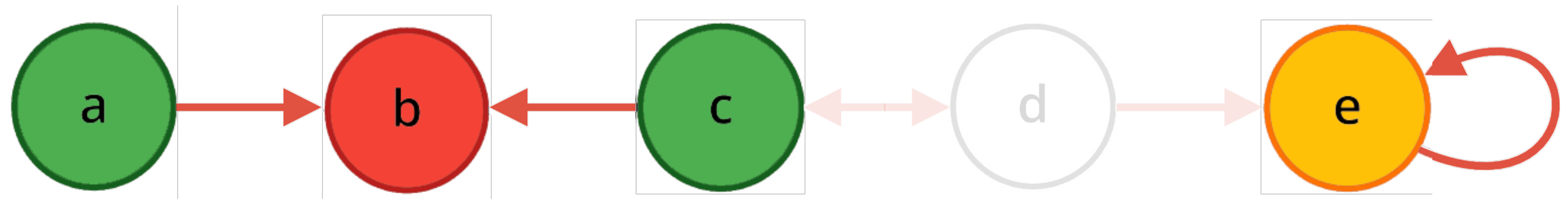
Timed AFs

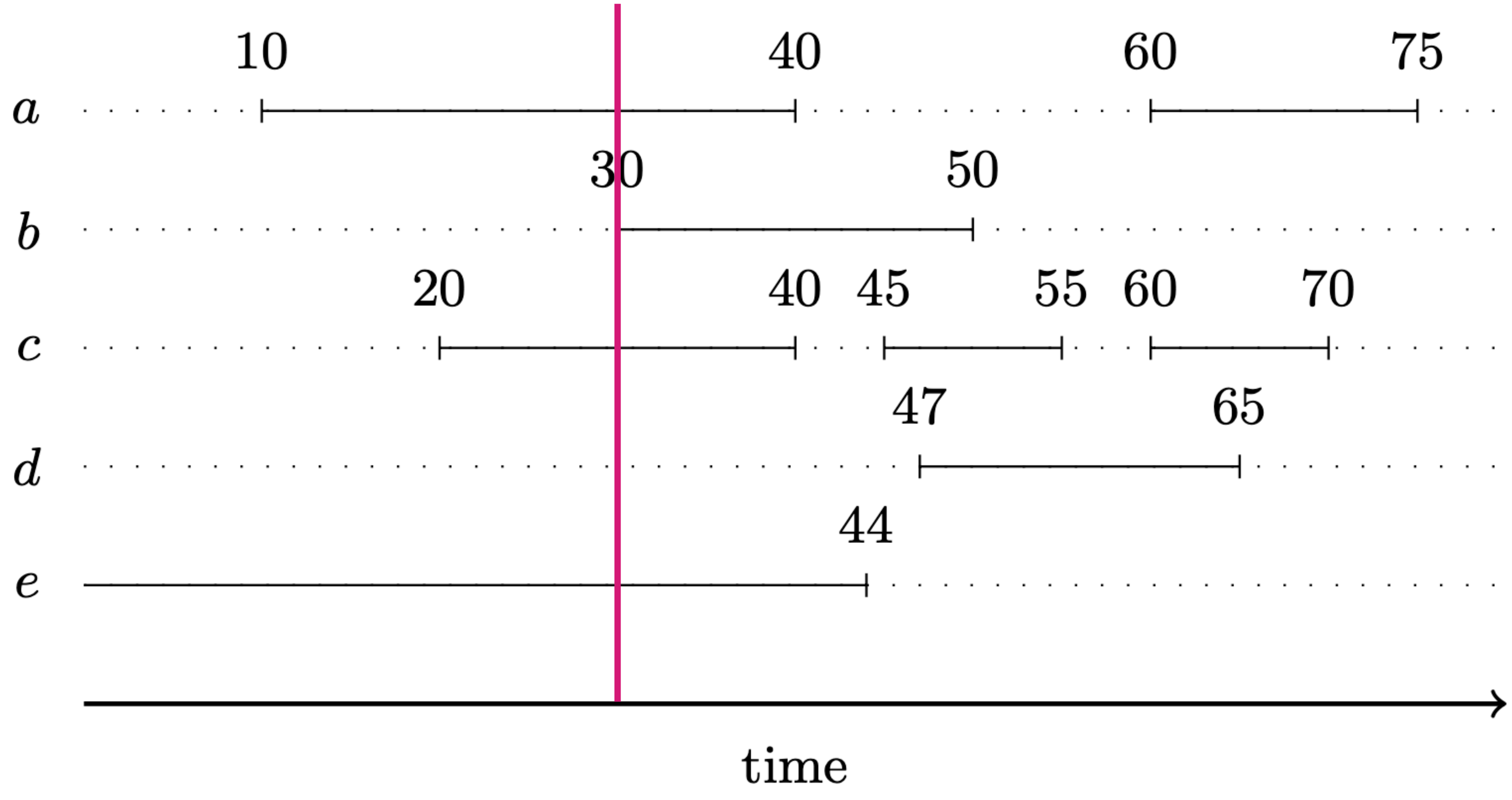




Argumentation Frameworks

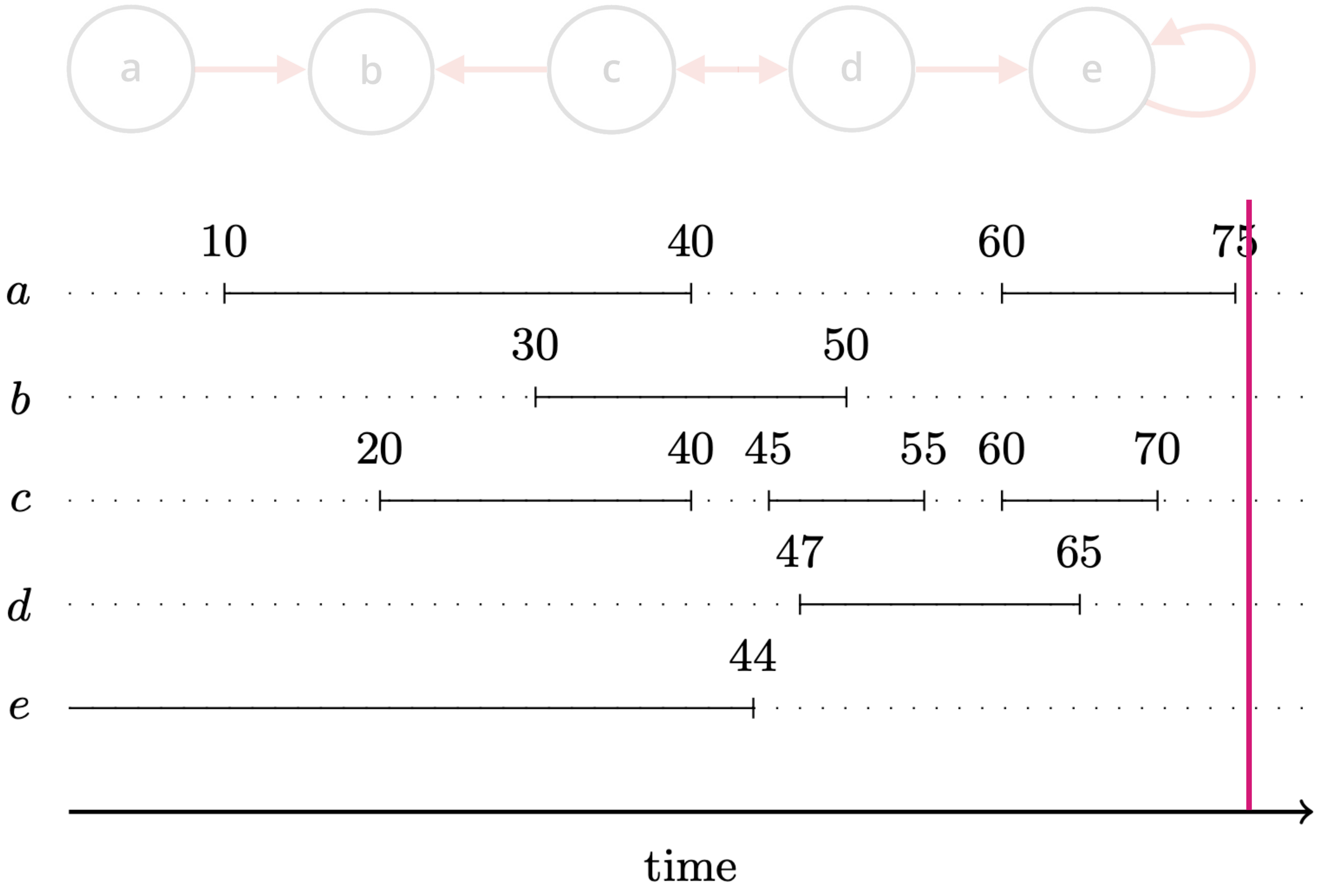
Timed AFs





Argumentation Frameworks

Timed AFs



Timed Concurrent Language for Argumentation

Syntax

- Models concurrent processes taking place over time
- Knowledge base represented through AFs
- Bounded asynchrony and maximal parallelism

- $A ::= success \mid failure \mid add(Arg, R) \rightarrow A \mid rmv(Arg, R) \rightarrow A$
  $\mid A \| A \mid \exists_x A \mid E \mid p(a, l, \sigma, i)$
- $E ::= test_{c,t}(a, l, \sigma) \rightarrow A \mid test_{s,t}(a, l, \sigma) \rightarrow A \mid check_t(Arg, R) \rightarrow A$
  $\mid E + E \mid E +_P E \mid E \|_G E$

Timed Concurrent Language for Argumentation

Operational Semantics (1)

$$\begin{array}{c}\langle add(Arg', R') \rightarrow A, \langle Arg, R\rangle\rangle \longrightarrow \langle A, \langle Arg \cup Arg', R \cup R''\rangle\rangle \\ \text{where } R'' = \{(a,b) \in R' \mid a, b \in Arg \cup Arg'\}\end{array} \qquad \text{Add}$$

$$\begin{array}{c}\langle rmv(Arg', R') \rightarrow A, \langle Arg, R\rangle\rangle \longrightarrow \langle A, \langle Arg \setminus Arg', R \setminus \{R' \cup R''\}\rangle\rangle \\ \text{where } R'' = \{(a,b) \in R \mid a \in Arg' \vee b \in Arg'\}\end{array} \qquad \text{Rmv}$$

$$\frac{Arg' \subseteq Arg \wedge R' \subseteq R \qquad t > 0}{\langle check_t(Arg', R') \rightarrow A, \langle Arg, R\rangle\rangle \longrightarrow \langle A, \langle Arg, R\rangle\rangle} \qquad \text{Ch (1)}$$

$$\frac{Arg' \not\subseteq Arg \vee R' \not\subseteq R \qquad t > 0}{\langle check_t(Arg', R') \rightarrow A, \langle Arg, R\rangle\rangle \longrightarrow \langle check_{t-1}(Arg', R') \rightarrow A, \langle Arg, R\rangle\rangle} \qquad \text{Ch (2)}$$

$$\langle check_0(Arg', R') \rightarrow A, F\rangle \longrightarrow \langle failure, F\rangle \qquad \text{Ch (3)}$$

Timed Concurrent Language for Argumentation

Operational Semantics (2)

$$\frac{\exists L \in S_\sigma(F) \mid l \in L(a) \quad t > 0}{\langle test_{c,t}(a,l,\sigma) \rightarrow A, F\rangle \longrightarrow \langle A, F\rangle} \qquad \text{CT (1)}$$

$$\frac{\forall L \in S_\sigma(F).l \notin L(a) \quad t > 0}{\langle test_{c,t}(a,l,\sigma) \rightarrow A, F\rangle \longrightarrow \langle test_{c,t-1}(a,l,\sigma) \rightarrow A, F\rangle} \qquad \text{CT (2)}$$

$$\langle test_{c,0}(a,l,\sigma) \rightarrow A, F\rangle \longrightarrow \langle failure, F\rangle \qquad \text{CT (3)}$$

$$\frac{\forall L \in S_\sigma(F).l \in L(a) \quad t > 0}{\langle test_{s,t}(a,l,\sigma) \rightarrow A, F\rangle \longrightarrow \langle A, F\rangle} \qquad \text{ST (1)}$$

$$\frac{\exists L \in S_\sigma(F) \mid l \notin L(a) \quad t > 0}{\langle test_{s,t}(a,l,\sigma) \rightarrow A, F\rangle \longrightarrow \langle test_{s,t-1}(a,l,\sigma) \rightarrow A, F\rangle} \qquad \text{ST (2)}$$

$$\langle test_{s,0}(a,l,\sigma) \longrightarrow A, F\rangle \longrightarrow \langle failure, F\rangle \qquad \text{ST (3)}$$

Timed Concurrent Language for Argumentation

Operational Semantics (3)

$$\frac{\langle A_1, F\rangle \longrightarrow \langle A_1', F'\rangle, \quad \langle A_2, F\rangle \longrightarrow \langle A_2', F''\rangle}{\langle A_1 \| A_2, F\rangle \longrightarrow \langle A_1' \| A_2', *(F, F', F'')\rangle} \qquad \text{Pa}$$

$$\frac{\langle E_1, F\rangle \longrightarrow \langle A_1, F\rangle, \ \langle E_2, F\rangle \longrightarrow \langle A_2, F\rangle, \quad E_1, E_2 \notin \mathcal{E}_0, \quad A_1 \notin \mathcal{E}}{\langle E_1 \|_G E_2, F\rangle \longrightarrow \langle A_1 \| A_2, F\rangle} \qquad \text{GP (1)}$$

$$\frac{\langle E_1, F\rangle \longrightarrow \langle E_1', F\rangle, \ \langle E_2, F\rangle \longrightarrow \langle E_2', F\rangle, \quad E_1, E_2 \notin \mathcal{E}_0, \quad E_1', E_2' \in \mathcal{E}}{\langle E_1 \|_G E_2, F\rangle \longrightarrow \langle E_1' \|_G E_2', F\rangle} \qquad \text{GP (2)}$$

$$\frac{E_1 \in \mathcal{E}_0, \langle E_2, F\rangle \longrightarrow \langle A_2, F\rangle}{\langle E_1 \|_G E_2, F\rangle \longrightarrow \langle A_2, F\rangle} \qquad \text{GP (3)}$$

Timed Concurrent Language for Argumentation

Operational Semantics (4)

$$\frac{\langle E_1, F\rangle \longrightarrow \langle A_1, F\rangle, \quad E_1 \notin \mathcal{E}_0, \quad A_1 \notin \mathcal{E}}{\langle E_1 + E_2, F\rangle \longrightarrow \langle A_1, F\rangle} \qquad \frac{E_1 \in \mathcal{E}_0, \langle E_2, F\rangle \longrightarrow \langle A_2, F\rangle}{\langle E_1 + E_2, F\rangle \longrightarrow \langle A_2, F\rangle} \text{ ND (1)}$$

$$\frac{\langle E_1, F\rangle \longrightarrow \langle E_1', F\rangle, \; \langle E_2, F\rangle \longrightarrow \langle E_2', F\rangle, \quad E_1, E_2 \notin \mathcal{E}_0, \quad E_1', E_2' \in \mathcal{E}}{\langle E_1 + E_2, F\rangle \longrightarrow \langle E_1' + E_2', F\rangle} \qquad \text{ND (2)}$$

$$\frac{\langle E_1, F\rangle \longrightarrow \langle A_1, F\rangle, \quad E_1 \notin \mathcal{E}_0, \quad A_1 \notin \mathcal{E}}{\langle E_1 +_P E_2, F\rangle \longrightarrow \langle A_1, F\rangle} \qquad \text{If (1)}$$

$$\frac{\langle E_1, F\rangle \longrightarrow \langle E_1', F\rangle, \quad E_1 \notin \mathcal{E}_0, \quad E_1' \in \mathcal{E}}{\langle E_1 +_P E_2, F\rangle \longrightarrow \langle E_1' +_P E_2, F\rangle} \qquad \frac{E_1 \in \mathcal{E}_0, \langle E_2, F\rangle \longrightarrow \langle A_2, F\rangle}{\langle E_1 +_P E_2, F\rangle \longrightarrow \langle A_2, F\rangle} \qquad \text{If (2)}$$

Modelling Timed AFs

Example

- Each agent handles one argument
- Agent_a: $sleep(9) \rightarrow (add(\{a\},\{(b,a),(d,a)\}) \rightarrow (sleep(30) \rightarrow (rmv(\{a\},\{\}) \rightarrow (sleep(18) \rightarrow (add(\{a\},\{(b,a),(d,a)\}) \rightarrow (sleep(15) \rightarrow (rmv(\{a\},\{\}) \rightarrow success))))))$
- Agent_b: $sleep(29) \rightarrow (add(\{b\},\{(b,a),(c,b)\}) \rightarrow (sleep(20) \rightarrow (rmv(\{b\},\{\}) \rightarrow success)))$
- Agent_a || Agent_b

$sleep(t) \rightarrow A$ is a shortcut for

$$\begin{cases} A & \text{if } t \leq 0 \\ check_1(\{\},\{\}) \rightarrow (sleep(t-1) \rightarrow A) & \text{otherwise} \end{cases}$$

Modelling Timed AFs

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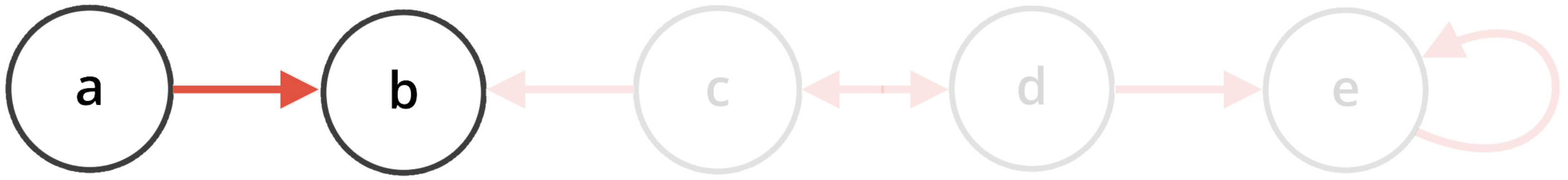
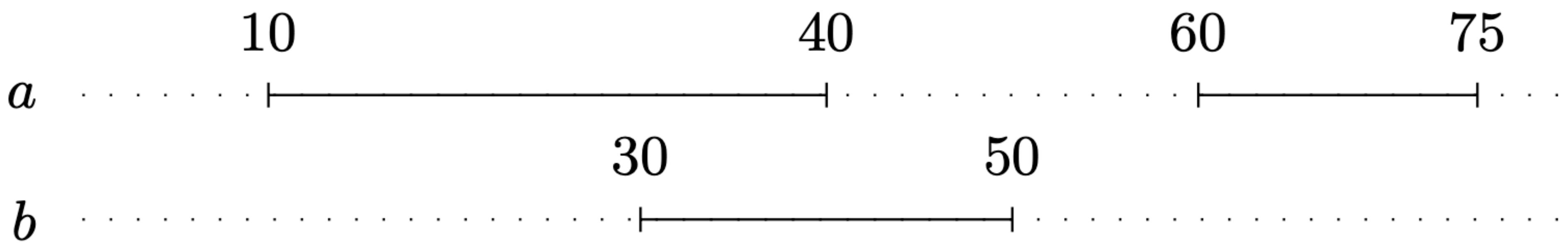
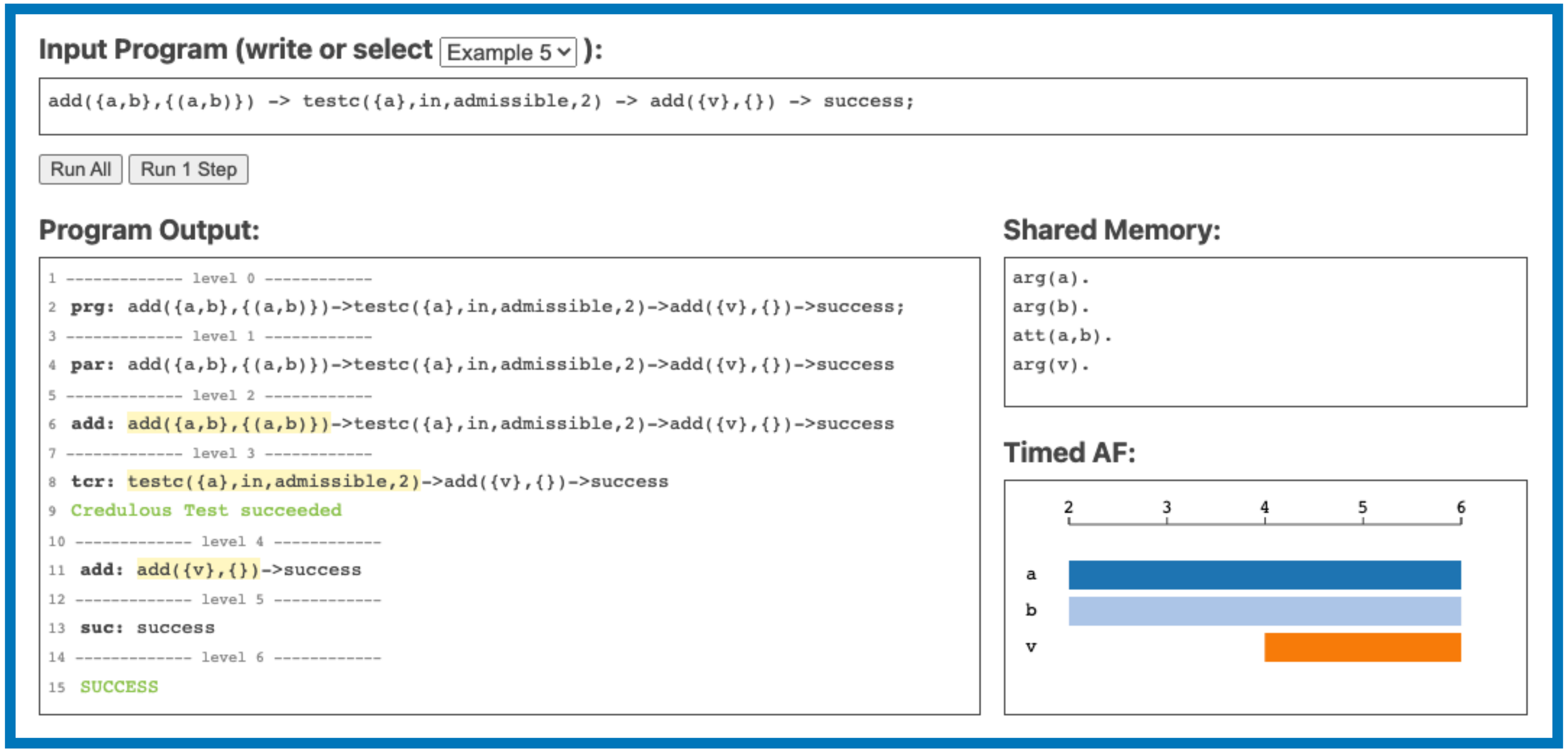




tcla Web Interface

- http://conarg.dmi.unipg.it/tcla
- Run all / step-by-step execution
- Shows program output + shared memory status + Timed AF



```
add({a,b},{(a,b)}) -> testc({a},in,admissible,2) -> add({v},{}) -> success;
```

```
------------- level 0 ------------
prg: add({a,b},{(a,b)})->testc({a},in,admissible,2)->add({v},{})->success;
------------- level 1 ------------
par: add({a,b},{(a,b)})->testc({a},in,admissible,2)->add({v},{})->success
------------- level 2 ------------
add: add({a,b},{(a,b)})->testc({a},in,admissible,2)->add({v},{})->success
------------- level 3 ------------
tcr: testc({a},in,admissible,2)->add({v},{})->success
Credulous Test succeeded
------------- level 4 ------------
add: add({v},{})->success
------------- level 5 ------------
suc: success
------------- level 6 ------------
SUCCESS
```

```
arg(a).
arg(b).
att(a,b).
arg(v).
```

Conclusion

- `tcla` models concurrent argumentation processes over time

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    - the arguments in the store at time t are all and only the arguments available at t in the original Timed AF

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  - the set of accepted arguments in the store at t coincides with the set of extensions at t in the original Timed AF

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- Working implementation available online

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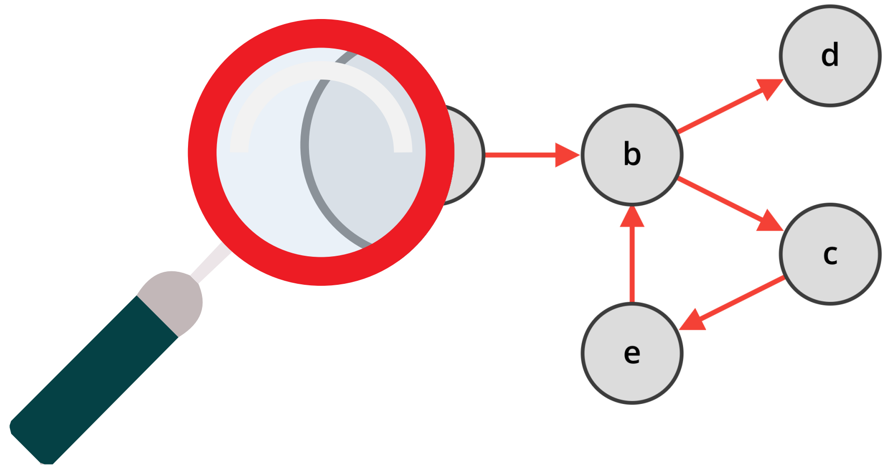
… `tcla` can do more than just modelling Timed AFs!

Future Work

- Negotiation/debating/persuasion between agents



Future Work

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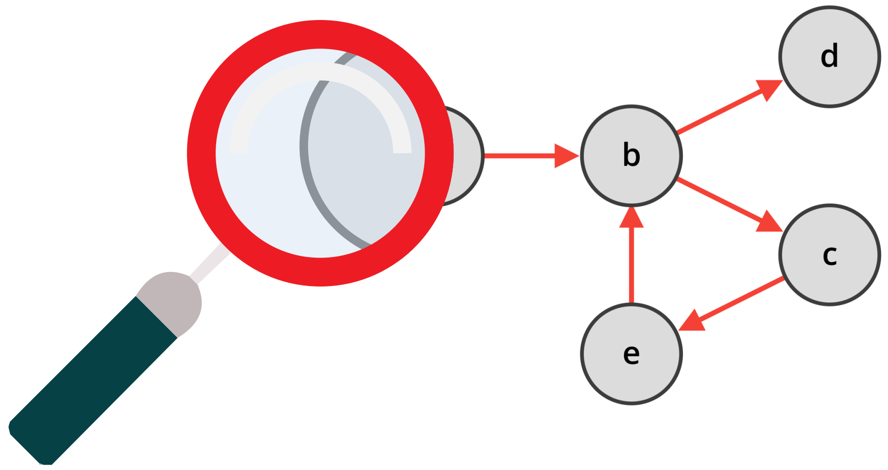
- Use interleaving instead of maximal parallelism for time passing



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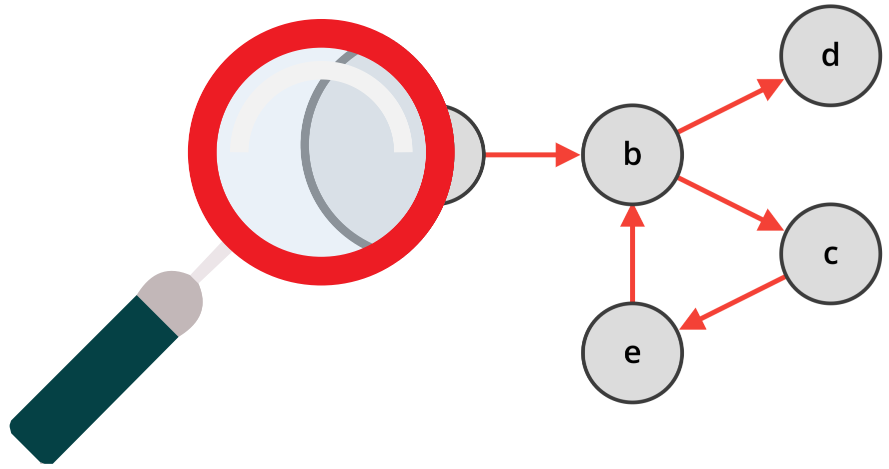

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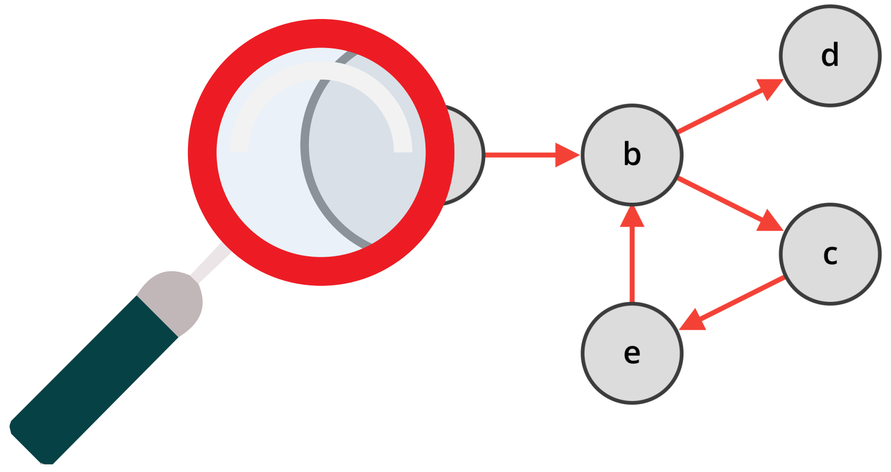
- Connections with the AGM Framework



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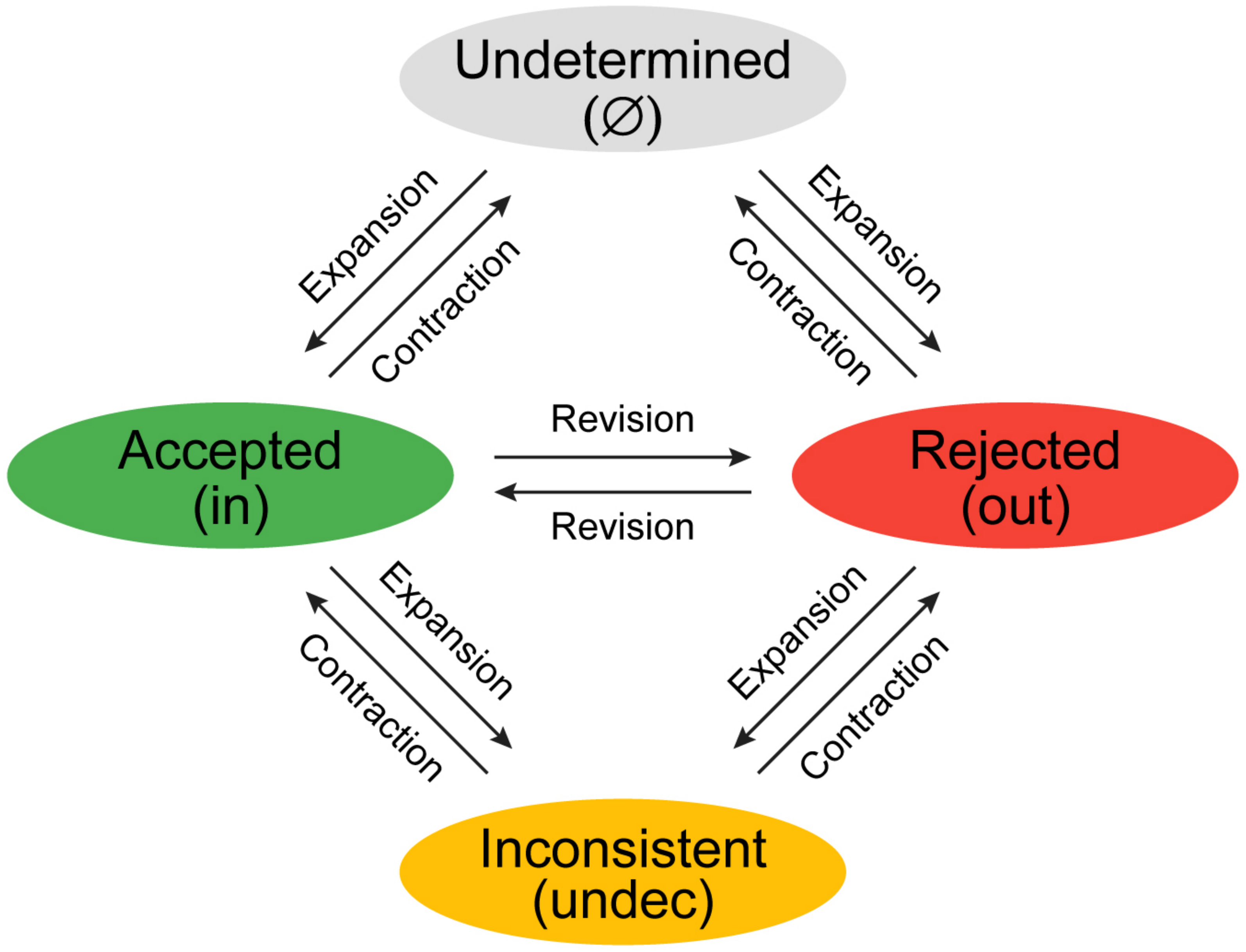
Undetermined (∅)
Expansion
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