On the Unification of Process Semantics: Logical Semantics

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Outline

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Introduction

- At the abstract level a semantics is just defined by a preorder or an equivalence relation between processes.
- These can be defined by using different frameworks.
- A unified presentation of both, the observational and the equational semantics, has been discussed here previously.

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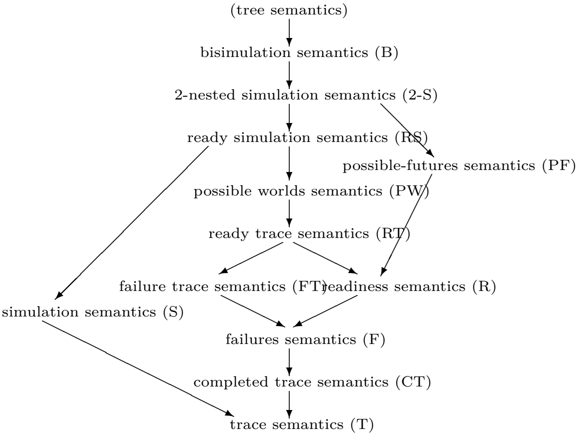

The classical ltbt-spectrum

Introduction

- Next we present a unified view of the logical semantics.
- Each language $\mathcal{L} \subseteq$ HML defines a preorder $<_{\mathcal{L}}$, given by $(\mathrm{p} <_{\mathcal{L}} \mathrm{q} \Leftrightarrow (\mathrm{p} \models \varphi \Rightarrow \mathrm{q} \models \varphi))$.
- (A bit surprisingly!) We look for sets of formulas, characterizing each semantics, as large as possible.

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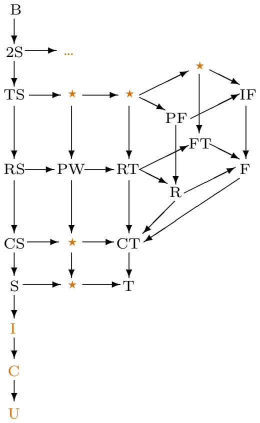

(A part of) the enlarged spectrum

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Some useful definitions

All the semantics that we consider can be defined over arbitrary (possibly infinite) processes whose operational semantics is defined by a lts

$$\mathcal{P} = (\text{Proc}, \text{Act}, \rightarrow)$$

We will use $p \stackrel{a}{\rightarrow} p'$ to represent the transitions between processes.

Definition (BCCSP)

Given a set of actions Act, the set BCCSP(Act) of processes is defined by the BNF-grammar:

$$p ::= 0 \mid a\,p \mid p + q$$

Some useful definitions

Definition (N-Constrained simulation)

Given a relation N over BCCSP processes, an N-constrained simulation is a relation S_N such that $S_N \subseteq N$, and whenever $p\, S_N\, q$ and $p \xrightarrow{a} p'$, there exists q' with $q \xrightarrow{a} q'$ and $p' S_N\, q'$. We say that p is N-simulated by q, or that q N-simulates p, written $p \sqsubseteq_{NS} q$, when there exists an N-constrained simulation S_N such that $p\, S_N\, q$.

Definition (Hennessy-Milner logic, HML)

The set $\mathcal{L}_{HM}$ of Hennessy-Milner logical formulas is defined by:

- If $\varphi_i \in \mathcal{L}_{HM}$ $\forall i \in I$ then $\bigwedge_{i \in I} \varphi_i \in \mathcal{L}_{HM}$.
- If $a \in Act$ and $\varphi \in \mathcal{L}_{HM}$ then $a\varphi \in \mathcal{L}_{HM}$.
- If $\varphi \in \mathcal{L}_{HM}$ then $\neg\varphi \in \mathcal{L}_{HM}$.

Some useful definitions

Definition (Satisfaction relation)

For each lts $\mathbb{P}$, the satisfaction relation $\models \subseteq \mathbb{P} \times \mathcal{L}_{\mathrm{HM}}$ is defined by:

- $p \models a\varphi$ if there exists $q \in \mathbb{P} : p \xrightarrow{a} q$ and $q \models \varphi$;
- $p \models \bigwedge_{i \in I} \varphi_i$ if for all $i \in I : p \models \varphi_i$.
- $p \models \neg\varphi$ if $p \not\models \varphi$.

Definition

Any subset $\mathcal{L}$ of $\mathcal{L}_{\mathrm{HM}}$ induces a logical semantics for processes, given by the preorder $\sqsubseteq_{\mathcal{L}}$: We have $p \sqsubseteq_{\mathcal{L}} q$ if, and only if, for all $\varphi \in \mathcal{L}$ $(p \models \varphi \Rightarrow q \models \varphi)$. We say that $\mathcal{L}$ and $\mathcal{L}'$ are equivalent, and we write $\mathcal{L} \sim \mathcal{L}'$, if they induce the same semantics, that is $\sqsubseteq_{\mathcal{L}} = \sqsubseteq_{\mathcal{L}'}$.

Van Glabbeek's logical characterizations

Formulas \ Semantics ($\mathcal{Z}$)	T	S	CT	CS	F	FT	R	RT	PW	RS	PF	2S	B
$\top \in \mathcal{L}_\mathcal{Z}$	•	ν	•	ν	•	•	•	•	ν	ν	ν	ν	ν
$0 \in \mathcal{L}_\mathcal{Z}$			•	•	ν	ν	ν	ν	ν	ν	ν	ν	ν
$\varphi \in \mathcal{L}_\mathcal{Z}$, $a \in Act \Rightarrow$ $a\varphi \in \mathcal{L}_\mathcal{Z}$	•	•	•	•	•	•	•	•	ν	•	•	•	•
$X \subseteq Act \Rightarrow$ $\widetilde{X} \in \mathcal{L}_\mathcal{Z}$					•	ν	ν	ν	ν	ν	ν	ν	ν
$X \subseteq Act \Rightarrow$ $X \in \mathcal{L}_\mathcal{Z}$							•	ν	•	•	ν	ν	ν
$\varphi \in \mathcal{L}_\mathcal{Z}$, $X \subseteq Act \Rightarrow$ $\widetilde{X}\varphi \in \mathcal{L}_\mathcal{Z}$						•		ν	ν	ν		ν	ν
$\varphi \in \mathcal{L}_\mathcal{Z}$, $X \subseteq Act \Rightarrow$ $X\varphi \in \mathcal{L}_\mathcal{Z}$								•	ν	ν		ν	ν
$\varphi_i \in \mathcal{L}_\mathcal{Z}$ $\forall i \in I \Rightarrow$ $\bigwedge_{i\in I} \varphi_i \in \mathcal{L}_\mathcal{Z}$		•		•						•		•	•
$X \subseteq Act$, $\varphi_a \in \mathcal{L}_\mathcal{Z}$ $\forall a \in X \Rightarrow$ $\bigwedge_{a\in X} a\varphi_a \in \mathcal{L}_\mathcal{Z}$									•	ν		ν	ν
$\varphi_i, \varphi_j \in \mathcal{L}_T$ $\forall i \in I$ $\forall j \in J \Rightarrow$ $\bigwedge_{i\in I} \varphi_i \wedge \bigwedge_{j\in J} \neg\varphi_j \in \mathcal{L}_\mathcal{Z}$											•	ν	ν
$\varphi \in \mathcal{L}_S \Rightarrow$ $\neg\varphi \in \mathcal{L}_\mathcal{Z}$												•	ν
$\varphi \in \mathcal{L}_\mathcal{Z} \Rightarrow$ $\neg\varphi \in \mathcal{L}_\mathcal{Z}$													•

Van Glabbeek's logical characterizations

Some syntactic sugar for Van Glabbek's logics...

$$\widetilde{X} := \bigwedge_{a \in X} \neg a \top \qquad \widetilde{X}\varphi' := \widetilde{X} \wedge \varphi' \qquad 0 := \widetilde{Act}$$

$$\varphi_1 \wedge \varphi_2 := \bigwedge_{i \in \{1,2\}} \varphi_i \qquad X := \bigwedge_{a \in X} a\top \wedge \bigwedge_{a \notin X} \neg a \top$$

$$X\varphi' := X \wedge \varphi' \qquad \widetilde{a} := \neg a \top$$

Van Glabbeek's logical characterizations

Theorem (Disjunction theorem)

If we define $\mathcal{L}_Z^{\vee}$ with $Z \in \{T, CT, F, FT, R, RT, PF, S, CS, RS, 2S, PW, B\}$, by adding to the definition of $\mathcal{L}_Z$ the clause

$$\sigma_i \in \mathcal{L}_Z^{\vee} \ \ \forall i \in I \Rightarrow \bigvee_{i \in I} \sigma_i \in \mathcal{L}_Z^{\vee}$$

and replacing $\mathcal{L}_Z$ by $\mathcal{L}_Z^{\vee}$ in each of the other clauses, and we take

$$p \models \bigvee \sigma_i ::= \exists i \in I\colon p \models \sigma_i$$

then we have $\mathcal{L}_Z^{\vee} \sim \mathcal{L}_Z$ for any such Z.

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Main ideas

- In order to obtain a uniform presentation of the logics characterizing each of the semantics we look for (simple) sets of formulas, but as large as possible.
- As for other previously studied frameworks, we divide the semantics in two classes: the branching and the linear ones.
- The key point to get the different logics is to use in the proper way in each case, negations and conjunctions.
- Whenever a semantics is finer than other, the logic characterizing the first will contain that for the latter, thus making trivial that relationship.

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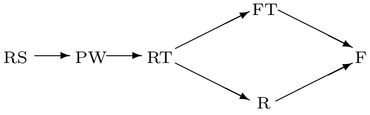
The layer of RS provides some illustrative examples

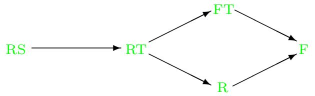
- The most important layer in the extended spectrum is that corresponding to ready simulation.

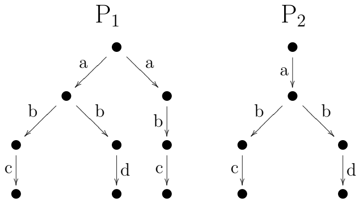


The layer corresponding to ready simulation

- The logical language characterizing the set of initial actions of a process: $\mathcal{L}_{\mathrm{I}} = \{a\top \mid a \in Act\}$.

The layer of RS provides some illustrative examples

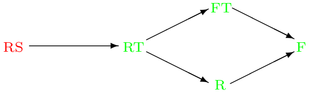


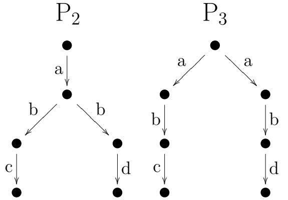


$P_1 \sim_{\{RS\}} P_2$

- Simulation Game.
- Set of Initial actions

The layer of RS provides some illustrative examples



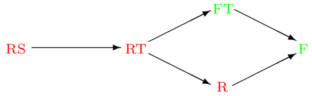


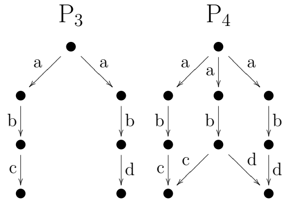
$$P_2 \not\subseteq'_{RS} P_3$$

$P_2 \models a(bc \wedge bd)$, but P_3 does not.

- Branching semantics.
- Unrestricted use of conjunctions.

The layer of RS provides some illustrative examples



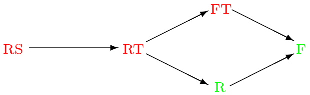


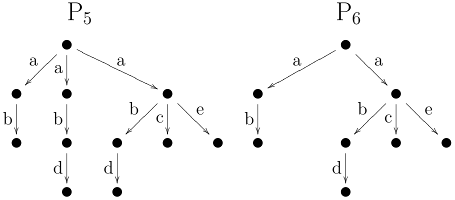
$$P_4 \not\sqsubseteq'_{\{RT,R\}} P_3$$

$$P_4 \models ab(c \wedge d), \text{ but } P_3 \not\models ab(c \wedge d)$$

- Linear semantics (prefix operator).
- Positive information about initial actions.

The layer of RS provides some illustrative examples



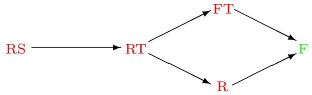


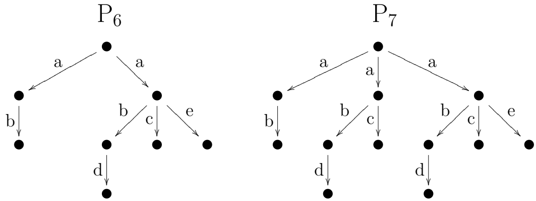
$$P_5 \not\sqsubseteq'_{\{RT,FT\}} P_6$$

$$P_5 \models a(\neg c \wedge b(\neg e \wedge d))$$

- Linear semantics (prefix operator).
- Negative information about initial actions.

The layer of RS provides some illustrative examples



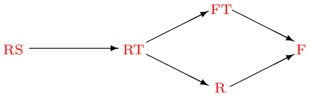


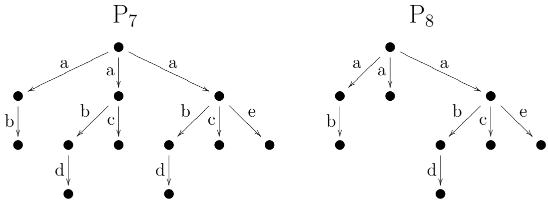
$$P_7 \not\sqsubseteq'_{R,FT} P_6$$

$$P_7 \models a(\neg e \wedge c)$$

- Linear semantics (prefix operator).
- Positive (resp. negative) information about initial actions for the case or R (resp. FT).

The layer of RS provides some illustrative examples





$P_8 \not\sqsubseteq'_F P_7$

$P_8 \models a(\neg b \wedge \neg c)$

- Linear semantics (prefix operator).
- Negative information about initial actions.

Uniform logical characterizations of the semantics at the layer of RS

Definition (Negative closure $\mathcal{L}_N^{\neg}$)

Given a set of formulas $\mathcal{L}'_N$, we define $\mathcal{L}_N^{\neg}$ by:

- $\sigma \in \mathcal{L}'_N \Rightarrow \neg\sigma \in \mathcal{L}_N^{\neg}$
- $\sigma_i \in \mathcal{L}_N^{\neg}\ \forall i \in I \Rightarrow \bigwedge_{i \in I} \sigma_i \in \mathcal{L}_N^{\neg}$

Definition (Failure semantics)

Inspired by the order $\leq_I^{lf\supseteq}$, we define the set of formulas $\mathcal{L}'_F$ by:

- $\top \in \mathcal{L}'_F$
- $\sigma \in \mathcal{L}^{\neg}{}_I \Rightarrow \sigma \in \mathcal{L}'_F$
- $\varphi \in \mathcal{L}'_F,\ a \in Act \Rightarrow a\varphi \in \mathcal{L}'_F$

Uniform logical characterizations of the semantics at the layer of RS

Definition (Negative closure $\mathcal{L}_{\mathrm{N}}^{\neg}$)

Given a set of formulas $\mathcal{L}'_{\mathrm{N}}$, we define $\mathcal{L}_{\mathrm{N}}^{\neg}$ by:

- $\sigma \in \mathcal{L}'_{\mathrm{N}} \Rightarrow \neg\sigma \in \mathcal{L}_{\mathrm{N}}^{\neg}$
- $\sigma_{\mathrm{i}} \in \mathcal{L}_{\mathrm{N}}^{\neg}\ \forall \mathrm{i} \in \mathrm{I} \Rightarrow \bigwedge_{\mathrm{i}\in\mathrm{I}} \sigma_{\mathrm{i}} \in \mathcal{L}_{\mathrm{N}}^{\neg}$

Definition (Failure trace semantics)

Inspired by the order $\leq_{\mathrm{I}}^{\mathrm{l}\supseteq}$, we define the set of formulas $\mathcal{L}'_{\mathrm{FT}}$ by:

- $\top \in \mathcal{L}'_{\mathrm{FT}}$
- $\varphi \in \mathcal{L}'_{\mathrm{FT}},\ \ \sigma \in \mathcal{L}^{\neg}{}_{\mathrm{I}} \ \ \Rightarrow \sigma \wedge \varphi \in \mathcal{L}'_{\mathrm{FT}}$
- $\varphi \in \mathcal{L}'_{\mathrm{FT}},\ \ \mathrm{a} \in \mathrm{Act} \Rightarrow \mathrm{a}\varphi \in \mathcal{L}'_{\mathrm{FT}}$

Uniform logical characterizations of the semantics at the layer of RS

Definition (Symmetric closure $\mathcal{L}_N^{\equiv}$)

Given a set of formulas $\mathcal{L}'_N$, we define $\mathcal{L}_N^{\equiv}$ by:

- $\sigma \in \mathcal{L}'_N \Rightarrow \sigma \in \mathcal{L}_N^{\equiv}$
- $\sigma \in \mathcal{L}'_N \Rightarrow \neg\sigma \in \mathcal{L}_N^{\equiv}$
- $\sigma_i \in \mathcal{L}_N^{\equiv}\ \forall i \in I \Rightarrow \bigwedge_{i \in I} \sigma_i \in \mathcal{L}_N^{\equiv}$

Definition (Readiness semantics)

Inspired by the order $\leq_I^{lf}$, we define the set of formulas $\mathcal{L}'_R$ by:

- $\top \in \mathcal{L}'_R$
- $\sigma \in \mathcal{L}^{\equiv}{}_I \Rightarrow \sigma \in \mathcal{L}'_R$
- $\varphi \in \mathcal{L}'_R,\ \ a \in Act \Rightarrow a\varphi \in \mathcal{L}'_R$

Uniform logical characterizations of the semantics at the layer of RS

Definition (Symmetric closure $\mathcal{L}^{\equiv}_{N}$)

Given a set of formulas $\mathcal{L}'_{N}$, we define $\mathcal{L}^{\equiv}_{N}$ by:

- $\sigma \in \mathcal{L}'_{N} \Rightarrow \sigma \in \mathcal{L}^{\equiv}_{N}$
- $\sigma \in \mathcal{L}'_{N} \Rightarrow \neg\sigma \in \mathcal{L}^{\equiv}_{N}$
- $\sigma_i \in \mathcal{L}^{\equiv}_{N}\ \forall i \in I \Rightarrow \bigwedge_{i\in I} \sigma_i \in \mathcal{L}^{\equiv}_{N}$

Definition (Ready trace semantics)

Inspired by the order $\leq^{l}_{I}$, we define the set of formulas $\mathcal{L}'_{RT}$ by:

- $\top \in \mathcal{L}'_{RT}$
- $\varphi \in \mathcal{L}'_{RT},\ \ \sigma \in \mathcal{L}^{\equiv}_{I}\ \ \Rightarrow \sigma \wedge \varphi \in \mathcal{L}'_{RT}$
- $\varphi \in \mathcal{L}'_{RT},\ \ a \in Act \Rightarrow a\varphi \in \mathcal{L}'_{RT}$

Uniform logical characterizations of the semantics at the layer of RS

Definition (Ready simulation semantics)

We define the set of formulas $\mathcal{L}'_{\mathrm{IS}}$, which is also denoted by $\mathcal{L}'_{\mathrm{RS}}$, that defines the I-constrained simulation semantics by:

- $\sigma \in \mathcal{L}'_{\mathrm{I}} \Rightarrow \sigma \in \mathcal{L}'_{\mathrm{RS}}$
- $\sigma \in \mathcal{L}'_{\mathrm{I}} \Rightarrow \neg\sigma \in \mathcal{L}'_{\mathrm{RS}}$
- For any set I, $\varphi_i \in \mathcal{L}'_{\mathrm{RS}}\ \forall i \in I \Rightarrow \bigwedge_{i \in I} \varphi_i \in \mathcal{L}'_{\mathrm{RS}}$
- $\varphi \in \mathcal{L}'_{\mathrm{RS}},\ a \in Act \Rightarrow a\varphi \in \mathcal{L}'_{\mathrm{RS}}$

Theorem

We have (1) $\mathcal{L}_{\mathrm{RS}} \sim \mathcal{L}'_{\mathrm{RS}}$; (2) $\mathcal{L}_{\mathrm{RT}} \sim \mathcal{L}'_{\mathrm{RT}}$; (3) $\mathcal{L}_{\mathrm{FT}} \sim \mathcal{L}'_{\mathrm{FT}}$; (4) $\mathcal{L}_{\mathrm{R}} \sim \mathcal{L}'_{\mathrm{R}}$ and (5) $\mathcal{L}_{\mathrm{F}} \sim \mathcal{L}'_{\mathrm{F}}$.

Uniform logical characterizations of the semantics at the layer of RS

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Uniform logical characterizations of the semantics at the layer of RS

Definition (Possible Worlds semantics)

We define the formulas of $\mathcal{L}'_{D_I}$, which is also denoted b$\mathcal{L}'_{PW}$, by:

- $\top \in \mathcal{L}'_{PW}$
- $\varphi \in \mathcal{L}'_{PW},\ \ \sigma \in \mathcal{L}^{\equiv}{}_{I} \ \ \Rightarrow \sigma \wedge \varphi \in \mathcal{L}'_{PW}$
- $X \subseteq Act,\ \ \varphi_a \in \mathcal{L}'_{PW}\ \ \forall a \in X \Rightarrow \bigwedge_{a\in X} a\varphi_a \in \mathcal{L}'_{PW}$

In this case $\mathcal{L}_{PW}$ and $\mathcal{L}'_{PW}$ are not equivalent, but this is caused by the fact that the original logical characterization $\mathcal{L}_{PW}$ was wrong!

Uniform logical characterizations of the semantics at the layer of RS

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- $\mathrm{X} \subseteq \mathrm{Act},\ \ \varphi_{\mathrm{a}} \in \mathcal{L}'_{\mathrm{PW}}\ \ \forall \mathrm{a} \in \mathrm{X} \Rightarrow \bigwedge_{\mathrm{a}\in \mathrm{X}} \mathrm{a}\varphi_{\mathrm{a}} \in \mathcal{L}'_{\mathrm{PW}}$

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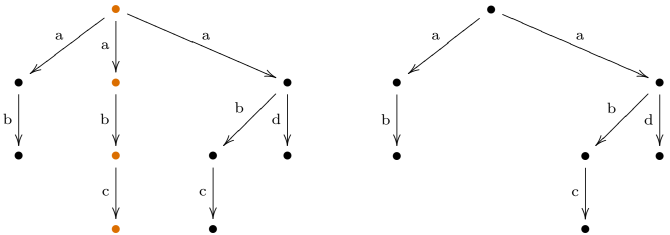
Uniform logical characterizations of the semantics at the layer of RS

$$\varphi \equiv a(\neg d \wedge bc) \in \mathcal{L}'_{PW}$$

$P \models \varphi$ $\qquad$ $Q \not\models \varphi$



- $\top \in \mathcal{L}'_{PW}$
- $\varphi \in \mathcal{L}'_{PW}, \quad \sigma \in \mathcal{L}^{\equiv}_{I} \quad \Rightarrow \sigma \wedge \varphi \in \mathcal{L}'_{PW}$
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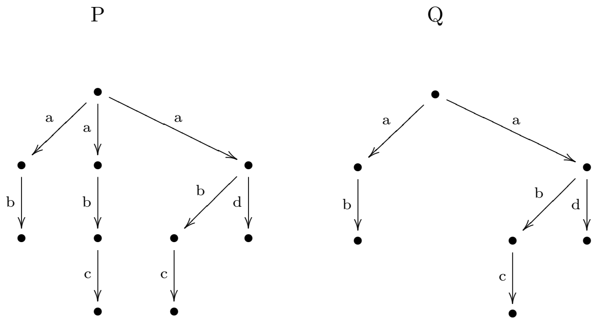
Uniform logical characterizations of the semantics at the layer of RS

$$\varphi \equiv a(\neg d \wedge bc) \notin \mathcal{L}_{PW}$$



- $X \subseteq Act \Rightarrow X \in \mathcal{L}_{PW}$
- $X \subseteq Act, \;\; \varphi_a \in \mathcal{L}_{PW} \;\; \forall a \in X \Rightarrow \bigwedge_{a \in X} a\varphi_a \in \mathcal{L}_{PW}$

Uniform logical characterizations of all the semantics

Logical characterizations of the semantics used as constraints in the N-constrained semantics

Formulas \ Constraints ($\mathcal{N}$)	U	C	I	T	S	B
$\top \in \mathcal{L}'_{\mathcal{N}}$	•	•	•	•	ν	ν
$\neg\top = \bot \in \mathcal{L}'_{\mathcal{N}}$	ν	ν	ν	ν	ν	ν
$\neg 0 \in \mathcal{L}'_{\mathcal{N}}$		•	•	ν	ν	ν
$a \in Act \Rightarrow a\top \in \mathcal{L}'_{\mathcal{N}}$			•	ν	ν	ν
$\varphi \in \mathcal{L}'_{\mathcal{N}}, a \in Act \Rightarrow a\varphi \in \mathcal{L}'_{\mathcal{N}}$				•	•	•
$\varphi_i \in \mathcal{L}'_{\mathcal{N}}\ \forall i \in I \Rightarrow \bigwedge_{i\in I} \varphi_i \in \mathcal{L}'_{\mathcal{N}}$					•	•
$\varphi \in \mathcal{L}'_{\mathcal{N}} \Rightarrow \neg\varphi \in \mathcal{L}'_{\mathcal{N}}$						•

Uniform logical characterizations of all the semantics

Formulas \ Semantics($\mathcal{Y}_{\mathcal{N}}$)	$\leq_N^{lf\supseteq}$	$\leq_N^{lf}$	$\leq_N^{l\supseteq}$	$\leq_N^{l}$	D_N	NS	$N \in \{U, C, I, T, S\}$
	F	R	FT	RT	PW	RS	when $N = I$
$\top \in \mathcal{L}'_{\mathcal{Y}_{\mathcal{N}}}$	•	•	•	•	•	ν	
$\varphi \in \mathcal{L}'_{\mathcal{Y}_{\mathcal{N}}}$, $a \in Act \Rightarrow$ $a\varphi \in \mathcal{L}'_{\mathcal{Y}_{\mathcal{N}}}$	•	•	•	•	ν	•	
$\varphi \in \mathcal{L}_N^{\neg} \Rightarrow$ $\varphi \in \mathcal{L}'_{\mathcal{Y}_{\mathcal{N}}}$	•	ν	ν	ν	ν	ν	
$\varphi \in \mathcal{L}_N^{\equiv} \Rightarrow$ $\varphi \in \mathcal{L}'_{\mathcal{Y}_{\mathcal{N}}}$		•		ν	ν	ν	
$\varphi \in \mathcal{L}'_{\mathcal{Y}_{\mathcal{N}}}$, $\sigma \in \mathcal{L}_N^{\neg} \Rightarrow$ $\sigma \wedge \varphi \in \mathcal{L}'_{\mathcal{Y}_{\mathcal{N}}}$			•	ν	ν	ν	
$\varphi \in \mathcal{L}'_{\mathcal{Y}_{\mathcal{N}}}$, $\sigma \in \mathcal{L}_N^{\equiv} \Rightarrow$ $\sigma \wedge \varphi \in \mathcal{L}'_{\mathcal{Y}_{\mathcal{N}}}$				•	•	ν	
$X \subseteq Act$, $\varphi_a \in \mathcal{L}'_{\mathcal{Y}_{\mathcal{N}}}$ $\forall a \in X \Rightarrow$ $\bigwedge_{a \in X} a\varphi_a \in \mathcal{L}'_{\mathcal{Y}_{\mathcal{N}}}$					•	ν	
$\varphi_i \in \mathcal{L}'_{\mathcal{Y}_{\mathcal{N}}}$ $\forall i \in I \Rightarrow$ $\bigwedge_{i \in I} \varphi_i \in \mathcal{L}'_{\mathcal{Y}_{\mathcal{N}}}$						•	
$\varphi \in \mathcal{L}_N \Rightarrow$ $\varphi \in \mathcal{L}'_{\mathcal{Y}_{\mathcal{N}}}$						•	
$\varphi \in \mathcal{L}_N \Rightarrow$ $\neg\varphi \in \mathcal{L}'_{\mathcal{Y}_{\mathcal{N}}}$						•	

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Partial offers trace and partial offers semantics

- Using a new closure we can define two more semantics at each layer of the spectrum.
- These semantics are defined by observing partial offers along a computation or just at its end.
- Duality between failures and partial offers, causes the picture of the complete layer of linear semantics for each N to become two diamonds, sharing the side corresponding to the readies-based semantics.

Partial offers trace and partial offers semantics

Definition (Positive closure $\mathcal{L}_N^{\surd}$)

Given a logical set $\mathcal{L}'_N$ with $N \in \{U, C, I, T, S\}$, we define:

- $\sigma \in \mathcal{L}'_N \Rightarrow \sigma \in \mathcal{L}_N^{\surd}$
- $\sigma_i \in \mathcal{L}_N^{\surd} \; \forall i \in I \Rightarrow \bigwedge_{i \in I} \sigma_i \in \mathcal{L}_N^{\surd}$

Definition (Partial offers trace semantics)

For the constraint N, is that defined by the logic $\mathcal{L}'_{POT}$, with

- $\top \in \mathcal{L}'_{POT}$
- $\varphi \in \mathcal{L}'_{POT}, \; \sigma \in \mathcal{L}_N^{\surd} \Rightarrow \sigma \wedge \varphi \in \mathcal{L}'_{POT}$
- $\varphi \in \mathcal{L'}_{POT}, \;\; a \in Act \Rightarrow a\varphi \in \mathcal{L'}_{POT}$

Partial offer traces and partial offers semantics

Definition (Positive closure $\mathcal{L}_N^{\surd}$)

Given a logical set $\mathcal{L}'_N$ with $N \in \{U, C, I, T, S\}$, we define:

- $\sigma \in \mathcal{L}'_N \Rightarrow \sigma \in \mathcal{L}_N^{\surd}$
- $\sigma_i \in \mathcal{L}_N^{\surd}\ \forall i \in I \Rightarrow \bigwedge_{i \in I} \sigma_i \in \mathcal{L}_N^{\surd}$

Definition (Partial offer semantics)

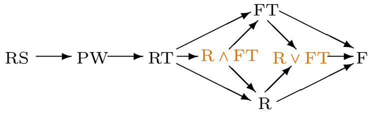
For the constraint N is that defined by the logic $\mathcal{L}'_{PO}$ with

- $\top \in \mathcal{L}'_{PO}$
- $\sigma \in \mathcal{L}_N^{\surd} \Rightarrow \sigma \in \mathcal{L}'_{PO}$
- $\varphi \in \mathcal{L}'{}_{PO},\ \ a \in Act \Rightarrow a\varphi \in \mathcal{L}'{}_{PO}$

Meet and join semantics

- There are another two semantics in each layer of the extended spectrum.

- For the particular case N = I, the meet semantics $R \vee FT$ has been previously studied by Roscoe.



The double diamond below ready simulation

- These semantics are in the linear side of the spectrum, therefore they have a similar structure to those linear semantics studied before.

Meet and join semantics

Definition (Join semantics)

We define the set of formulas $\mathcal{L}'_{\leq_I^{l\supseteq\wedge f}}$, by

- $\top \in \mathcal{L}'_{\leq_I^{l\supseteq\wedge f}}$; $\sigma \in \mathcal{L}^{\equiv}{}_I \Rightarrow \sigma \in \mathcal{L}'_{\leq_I^{l\supseteq\wedge f}}$
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- $\varphi \in \mathcal{L}'_{\leq_I^{l\supseteq\wedge f}}$, $a \in Act \Rightarrow a\varphi \in \mathcal{L}'_{\leq_I^{l\supseteq\wedge f}}$

Definition (Meet semantics)

We define the set of formulas $\mathcal{L}'_{\leq_I^{l\supseteq\vee f}}$ by

- $\top \in \mathcal{L}'_{\leq_I^{l\supseteq\vee f}}$
- $\sigma, \sigma_j \in \mathcal{L}'_I \ \forall j \in J \Rightarrow (\sigma \wedge \bigwedge_{j\in J} \neg\sigma_j \top) \in \mathcal{L}_{\leq_I^{l\supseteq\vee f}}$
- $\varphi \in \mathcal{L}'_{\leq_I^{l\supseteq\vee f}}$, $a \in Act \Rightarrow a\varphi \in \mathcal{L}'_{\leq_I^{l\supseteq\vee f}}$

Meet and join semantics

Definition (Join semantics)

We define the set of formulas $\mathcal{L}'_{\leq_N^{l\supseteq\wedge f}}$, by

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Conclusions

- With this presentation we conclude the work on unification of all the concrete process semantics.
- Our main objective here was to develop a unified approach to the characterisation of the underlying semantics using sublogics of HML with a simple structure.
- The key point was to properly identify the rules for managing the use of negation and conjunction. As a result, we clarify the difference between branching-time and linear-time semantics.
- We have found out two more linear semantics in each layer and we have discovered that the classic logical characterizations of PW was wrong.

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Future work

- We got some partial results in the unified logical characterization of the weak semantics.
- We obtain some interesting results on the characterization of modal semantics.
- The combination of logic and algebra, as recently done by G. Luttgen and W. Vogler, is another interesting direction.

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THANKS!