Inferences and Dialogues in Ludics

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Objectives of this work

Define a fundamental framework:

- that combines representations of dialogues and of reasoning
- that contains only one kind of objects
  => composition of objects logically sound
- that does not refer to formulas when there is no necessity (e.g. arguments in dialogues)
  => stay in a monotonous setting

Logics, Argumentation, Reasoning

- In Logics, two notions of inference:
  - Cut-elimination
  - Modus Ponens

  and a relation between computation/proofs and formulas:
  - Typing

- They may be used to model dialogues and reasoning:

Computation	Logics	Dialogue/Reasoning
dynamics of computation	Cut-elimination	dialogue process
computation of a result	Modus Ponens	reasoning process
typing	formula	semantics of utterances

Logics and Contradiction

Remark that:

- A Modus Ponens between a formula and its negation induces a contradiction.
- A formula may be denoted by its set of proofs.
- A term may be used as an argument for a function even if it is incorrect as the level of types ($A \oplus B$ vs A).

Motto

– Use proofs to model dialogues and argumentation structures
– Use formulas to define/characterize utterances, . . .

Interaction in dialogues

A rough attempt to focus on interaction in natural language dialogues:

associate *actions* to interventions

- actions are polarized: **positive** for the locutor who produces them, **negative** for the locutor who receives them
- actions/interventions of each locutor are organized in a tree-like structure: a **design**
- the dialogue is the **trace** of the interaction between two designs

Example (A. Dumas, Le Comte de Montecristo)

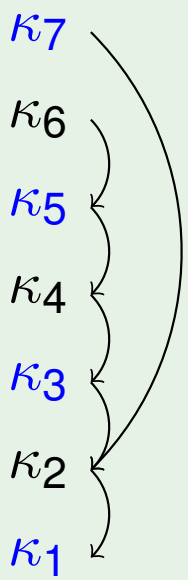
Dialogue between Edmond and Faria:

F	l_1 :	What was your life at this time?
E	l_2 :	I was ready to become captain of the Pharaon; I was about to marry a beautiful young girl.
F	l_3 :	Was anyone interested in you not becoming the captain of the *Pharaon*?
E	l_4 :	[. . .] Only one man [. . .],
F	l_5 :	Who was he?
E	l_6 :	Danglars.
F	l_7 :	Well, tell me about that young girl . . .

Example (A. Dumas, Le Comte de Montecristo)

We associate to each intervention an action: $\kappa_1, \ldots, \kappa_7$ and a justification relation between them.

- Each intervention refers to a previous one.
- Action κ_1 is initial: *F* initiates the dialogue.
- Action κ_7 is justified by action κ_2.



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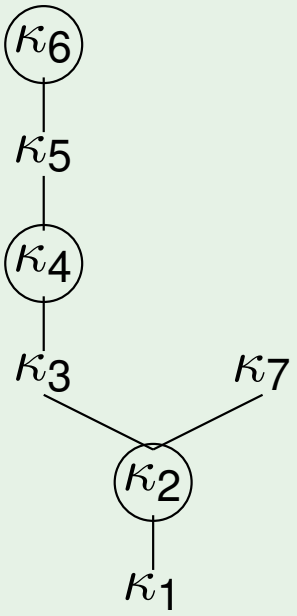
I_7 : Well, tell me about that young girl . . .

Example (A. Dumas, Le Comte de Montecristo)

The interventions polarised and organised according to both justification and chronological relations:

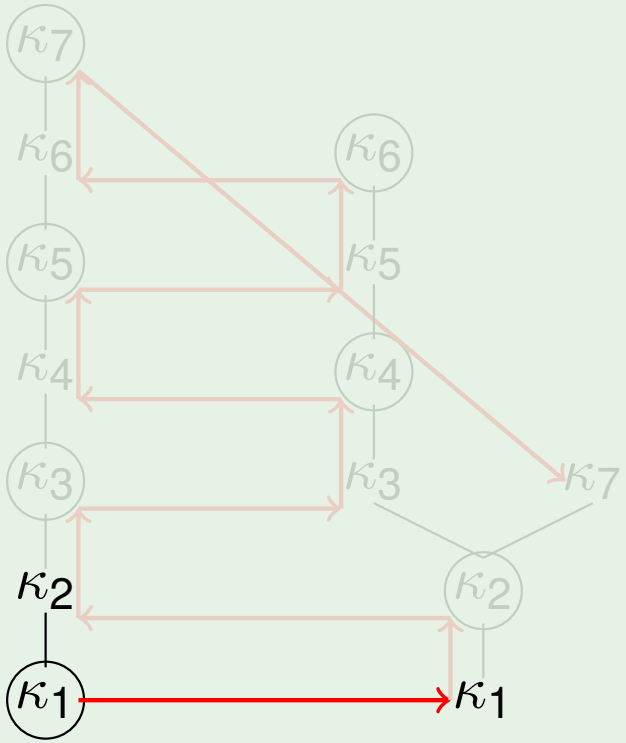
Point of view of Faria



Point of view of Edmond

Example (A. Dumas, Le Comte de Montecristo)

The dialogue as a step by step interaction between two designs:



Faria's viewpoint — Edmond's viewpoint

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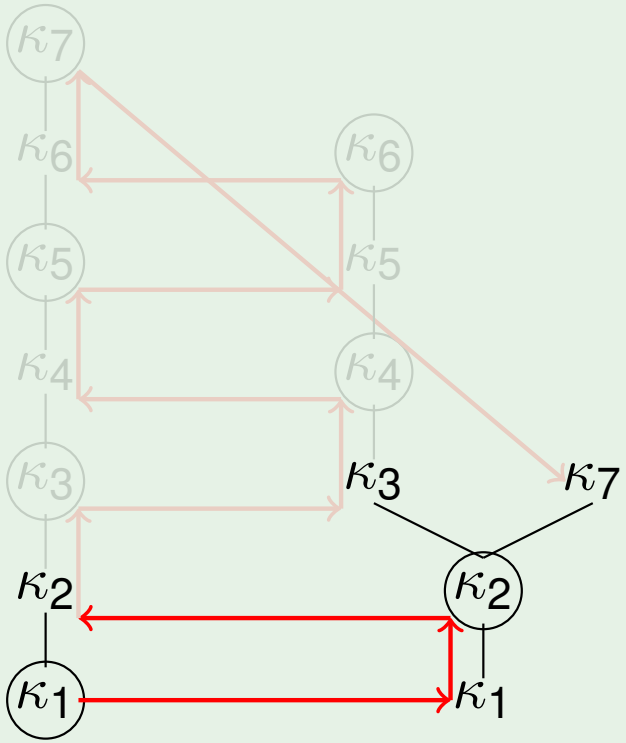

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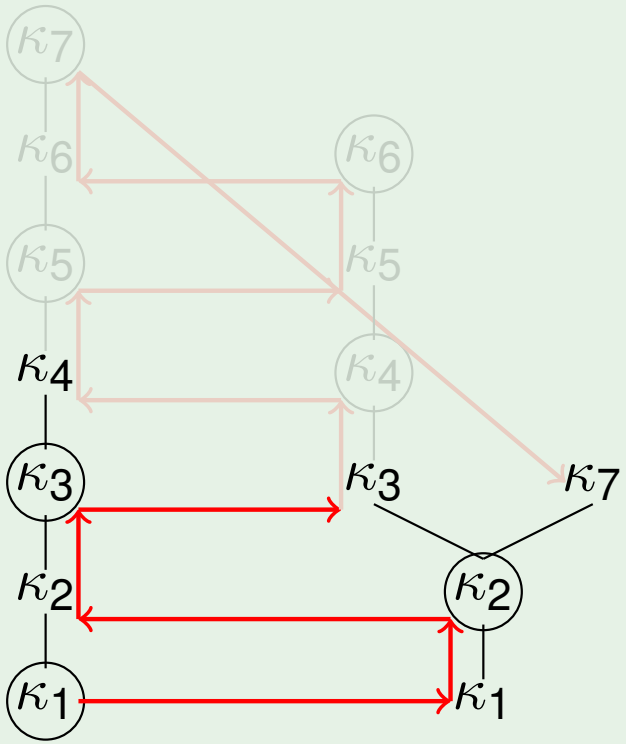

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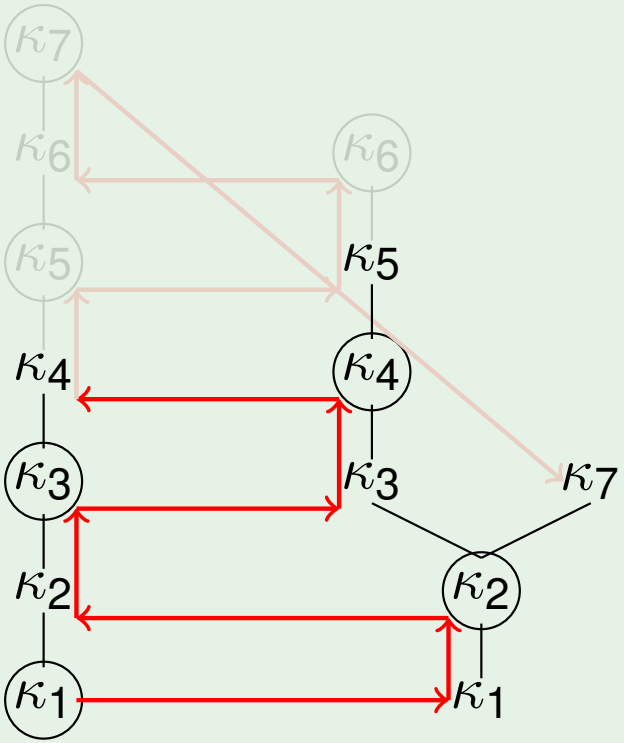

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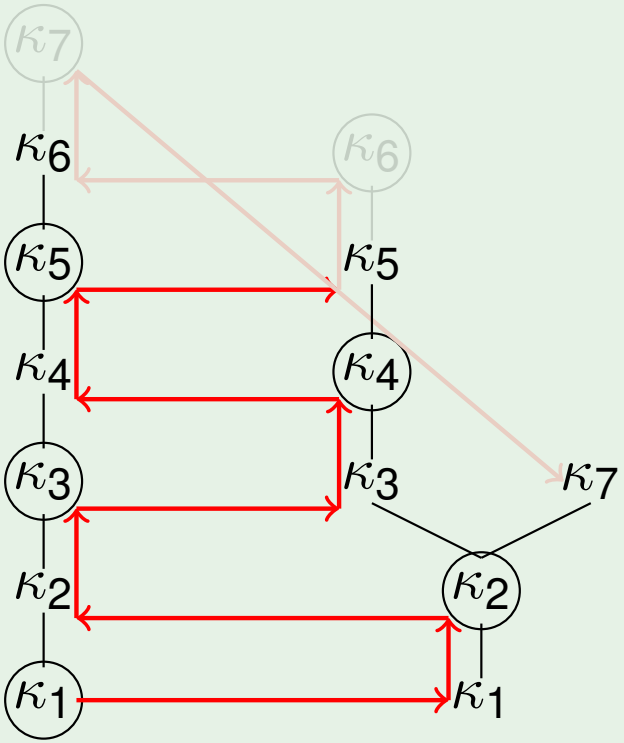

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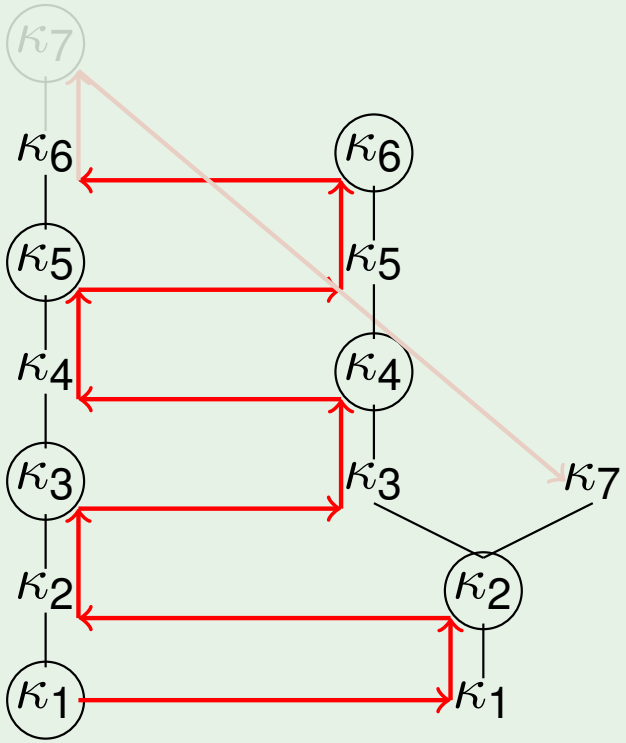

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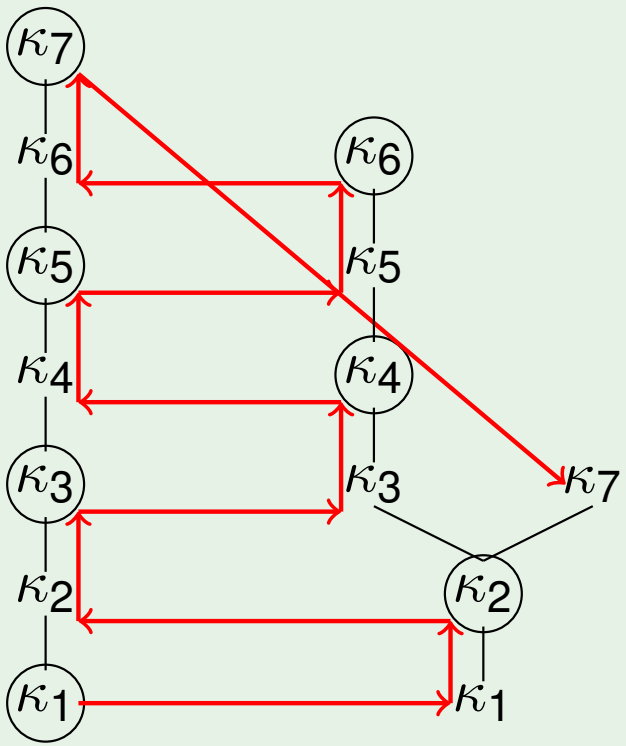

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What is a *dialog act*?

Following Landragin, we define a ***dialog act*** as

"**the minimal unit of communication in a dialogic context**".

What is a *dialog act*?

A dialog act is a communicational fact whose role is to allow the dialogue to progress and to determine the dialogue shape:

Definition (Dialog Act)

A **dialog act** κ is:

- either a proper dialog act, i.e. a tuple $(+/-, L, I, e)$ (see next slide)
- or a particular positive dialog act, called **daimon** and noted $(\dagger, e)$, that shows the end of an interaction that went well.

What is a *dialog act*

When the dialog act is a proper one $\kappa = (+/-, L, I, e)$:

- L is the **focus** of κ : the address on which the act is localized with respect to the dialogic interaction one considers,
- $I = \{L_1, \dots\}$ is the **ramification** of κ : the openings created by the dialog act on which new dialog acts may be produced,
- e is the **expression** of the dialog act, i.e. the language (or communication) fact by which the dialog act is reflected:
  - a (sequence of) proposition(s), word, prosodic element, non verbal sign.

Interpreting a Dialogue / Dialogue in progress

A dialogue is represented as an interaction between two **dialog designs**, i.e. designs with dialog acts.

- Dialog designs are built incrementally from the interventions, i.e. the turns of speech of the two persons. To each intervention corresponds a set of dialog acts that completes the current design of the speaker.
- Such a set may be a unique dialog act, an alternate sequence of dialog acts or a partial design. The design completed by such a set should still be a design.
- Finally, an intervention must begin and end with a positive dialog act: hence, if not ending with a daimon, the intervention of a speaker allows the addressee to speak.

The controversy: a particular case of dialogue

Among the dialogues, controversies own some specific features:

- they are composed by means of only a few speech acts: assertions, argumentations, denegations, concessions ...
- a notion of "gain" arises.
  It is out of purpose in most cases of dialogues.
  But it is essential when the dialogue is a controversy.

How give an account of these specific dialogues ?

Lots of argumentation studies make use of games theory BUT there are two important distinctions between the argumentative frame and the model of games.

- the only relevant rule in the argumentative frame is the one relative to keeping the dialogue convergent.
- in games, each player makes an elementary move. In dialogues, one intervention may contain several speech acts.

A case study

We consider an example developed by Prakken. It is a juridic controversy between a plaintiff and a defendant.

Plaintiff claimed that defendant owes him 500 euro, because both signed a contract ; himself delivered but defendant did not pay.

Defendant will give two counter arguments: 1. he does not recognize his signature, 2. he was insane during the signature of the contract.

I_1	*Plaintiff:*	I claim that defendant owes me 500 euro.
I_2	*Defendant:*	I dispute plaintiff's claim.
...	...	
J_4	*Judge (deciding the dispute)*:	I am conviced by plaintiff's evidence that defendant's signature under the contract is authentic. Yet I cannot grant plaintiff's claim since the fact that defendant looked normal during the negociations is insufficient to conclude that defendant's insanity could not be known to plaintiff: he might have known if he had checked the court's register. Therefore I deny plaintiff his claim.

The dispute in Ludics

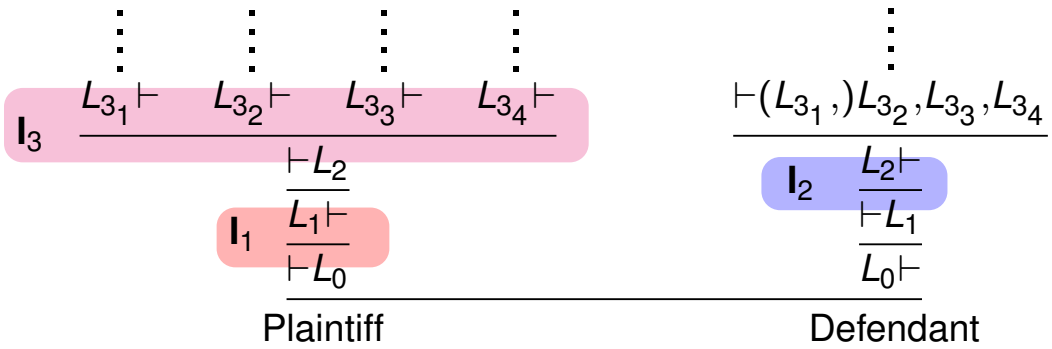
We represent the dispute between *plaintiff* and *defendant* by

an interaction between two designs,

as if this controversy were a dialogue between only these two locutors.

Inside this representation, the **interventions of the judge** are given into account by means of some forced dialog acts for either one locutor or the other one.

The three first interventions: $I_1 \ldots I_3$



I_1 : I claim that defendant owes me 500 euro.
I_2: I dispute plaintiff's claim.
I_3 : Defendant owes me 500 euro by r_1 since we conclude a valid sales contract, I delivered but defendant did not pay.

And next intervention:

I_4: I concede that plaintiff delivered and I did not pay, but I dispute that we have valid contract.

Look at speech acts modelling . . .

Towards a model of the speech acts of controversy

- **To claim a thesis** This corresponds to posing a proposition on which the interlocutor may continue the dialogue by negating it or by conceding it or by asking more explanations.

  In Ludics: $(+, L, I, e)$.
- **To argue, to negate, to ask, to request some justification . . . .**

  They are represented as a claim, by a positive proper dialog act.

The speech acts of controversy

- **To concede**. This consists in accepting one assertion that the interlocutor claimed. The dialogue will not continue on this element.

$$\text{sequence } (+, L, \{L'\}, e_0)(-, L', \emptyset, e_1)$$

$(+, L, \{L'\}, e_0)$ expresses what is conceded, its focus is the one created by the affirmation that one concedes and its ramification is a singleton.

$(-, L', \emptyset, e_1)$ makes the conceded affirmation disappear: it is focused on L', i.e. the immediate previous act created, it has an empty ramification.

Winning a controverse

During a controversy, one of the locutors **becomes loser** when:

- It is his turn
- No addresses are avalaible
- He is obliged to play the **daïmon**.

The winner has the last word.

The fourth intervention : I_4

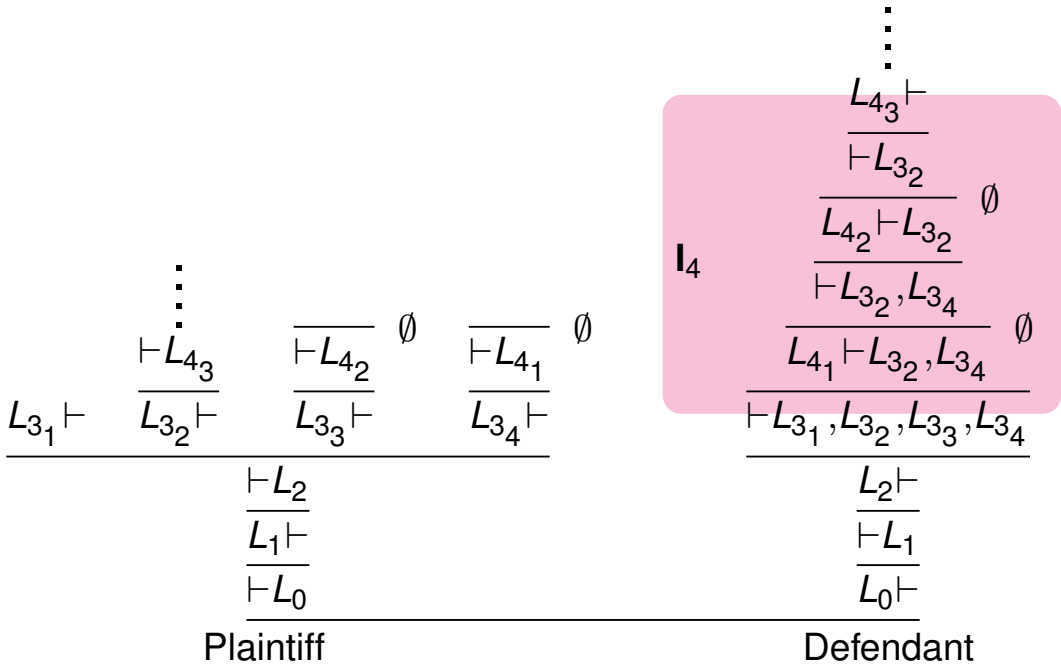
I_4: I concede that plaintiff delivered and I did not pay, but I dispute that we have valid contract.

We give an account of this one not by a unique dialog act but by a sequence of dialog acts:

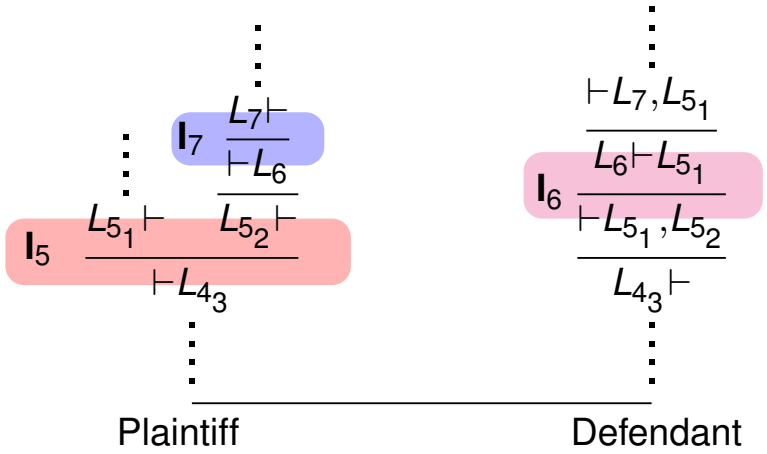
speech act	**dialog act**	**expression**
concession	$(+, L_{3_3}, \{L_{4_1}\}, e_1)$	I concede that
	$(-, L_{4_1}, \emptyset, e_2)$	plaintiff delivered
concession	$(+, L_{3_4}, \{L_{4_2}\}, e_3)$	(I concede that)
	$(-, L_{4_2}, \emptyset, e_3)$	I did not pay
negation	$(+, L_{3_2}, \{L_{4_3}\}, e_4)$	but I dispute that we have a valid contract

The dispute

until the intervention I_4: I concede that plaintiff delivered and I did not pay, but I dispute that we have valid contract.



The dispute continues



l_5 : We have a valid contract by r_2
since this document is a contract signed by us.

l_6 : I dispute that this is my signature.

l_7 : Why?

The first judge's intervention: J_1

J_1 : By r_3 the party who invokes a signature under a document which is not an avidavit has the burden to prove that it is authentic when this is disputed so plaintiff must prove this is defendant's signature.

- It occurs inside the dispute as an intervention of the defendant.
- It is a sequence of dialog acts:
  it starts with a positive one (arguing), opens three elements.
  The two first elements are immediately closed: it is not possible to discuss neither a law (r_3) nor a fact (the document is not an avidavit).
- It gives the turn to plaintiff.

The first judge's intervention: J_1

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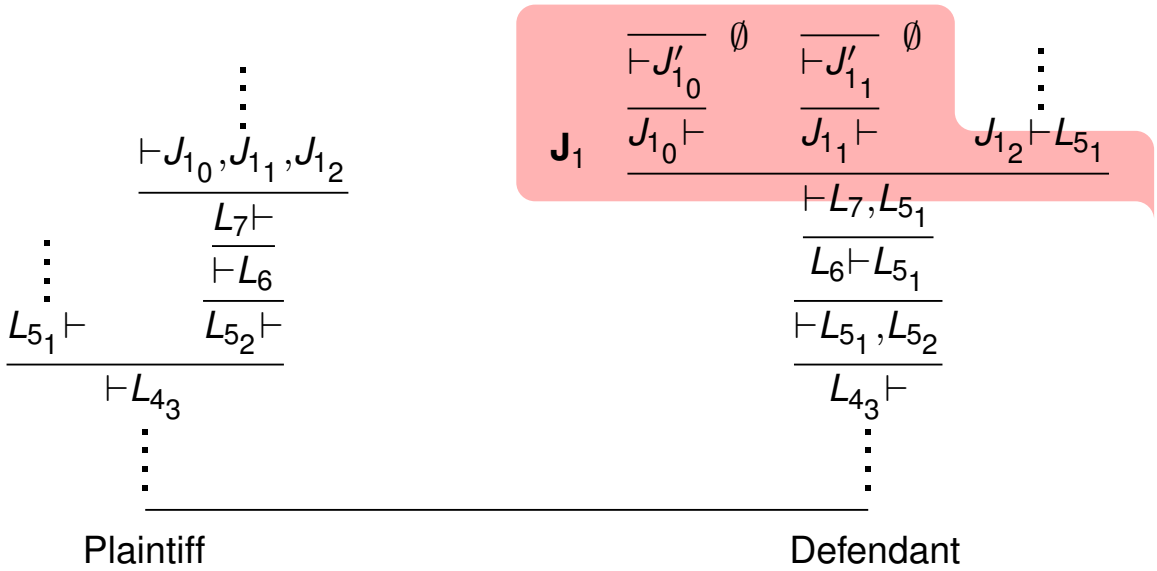
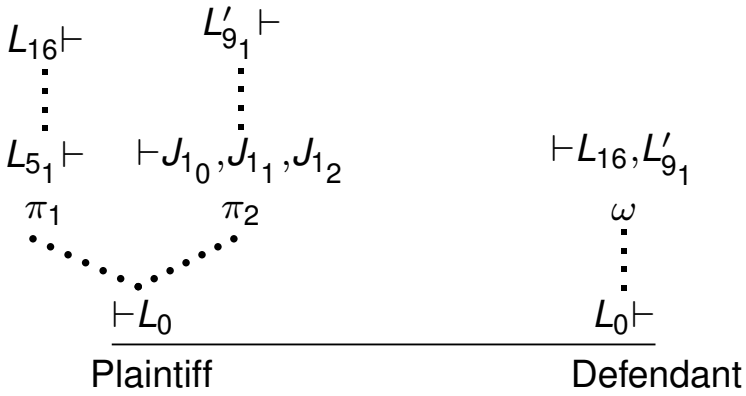


The Judge's sentence

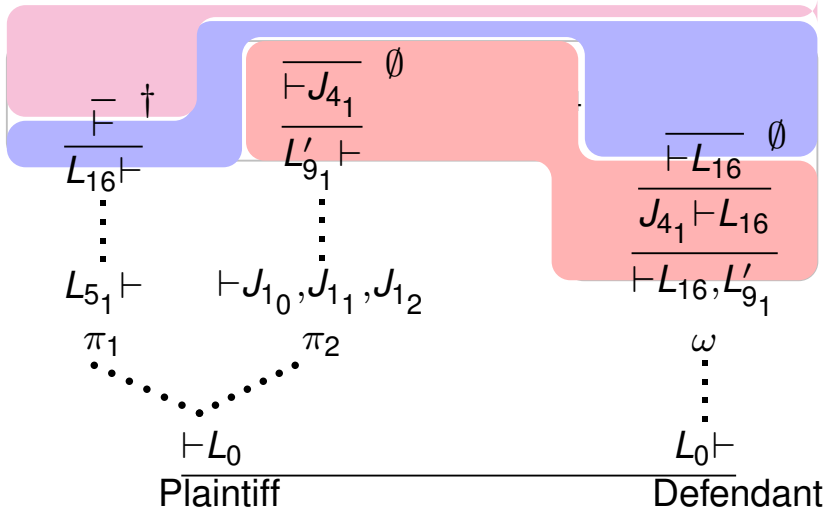
Before



It is the defendant's turn. Two addresses are available:

- L'_{9_1} (*his signature is not valid*)
- L_{16} (*his illness*)

After



I am convinced by plaintiff's evidence that defendant's signature under the contract is authentic.
Yet I cannot grant plaintiff's claim
since the fact that defendant looked normal during the negotiations is insufficient to conclude that defendant's insanity could not be known to plaintiff: he might have known if he had checked the court's register.
Therefore I deny plaintiff his claim.

Back to intervention I_3 of the plaintiff

I_3 : Defendant owes me 500 euro by r1 since we conclude a valid sales contract, I delivered but defendant did not pay.

- This expresses a contradiction (pay/not pay) according to plaintiff's viewpoint.
  How can we make this explicit without yielding a logical absurdity?

- The judge overcomes this contradiction when giving the sentence.
  How can we modify plaintiff's knowledge?

Inferential rôle of interventions

We consider a framework close to ISU
(*Informative states update*, Asher, Ginzburg, . . .)

- **Dialogue surface**: an interaction between designs made of dialogue acts.
- **Dialogue context**: one cognitive base for each locutor containing a state of their knowledge, their entitlements, . . . , and updated after each intervention. Such a dialogue context is a set of designs.

- An intervention is *built* from elements of the cognitive base.

Back to intervention I_3 of the plaintiff

I_3 : Defendant owes me 500 euro by r1 since we conclude a valid sales contract, I delivered but defendant did not pay.

- In the modelling of the dialogue:

$$\frac{\begin{array}{cccc} \mathcal{D}_{r_1} & \mathcal{D}_{val-contract} & \mathcal{D}_{del} & \mathcal{D}_{not-paid} \\ \vdots & \vdots & \vdots & \vdots \\ L_{3_1} \vdash & L_{3_2} \vdash & L_{3_3} \vdash & L_{3_4} \vdash \end{array}}{\vdash L_2}$$

- Plaintiff's base includes designs $\mathcal{D}_{r_1}$, $\mathcal{D}_{val-contract}$, $\mathcal{D}_{del}$ and $\mathcal{D}_{not-paid}$, that are *delocalized* to build his argumentation.

Plaintiff's designs

- Designs modelling facts he put forward and that are conceded, $\mathcal{D}_{del}$ et $\mathcal{D}_{not.paid}$, together with a design $\mathcal{D}_{\neg pay}$ interpreting the fact: *'to pay' is the logical negation of 'not to pay'*:

$$\mathcal{D}_{del} = \dfrac{}{\vdash L_{Del}}\,\emptyset \qquad \mathcal{D}_{not-paid} = \dfrac{}{\vdash L_{notPaid}}\,\emptyset \qquad \mathcal{D}_{\neg pay} = \dfrac{\dfrac{}{\vdash}\,\dagger}{L_{Pay} \vdash}\,\emptyset$$

- The design $\mathcal{D}_{val-contract}$ (the validity of a contract relies on the validity of the signature):

$$\mathcal{D}_{val-contract} = \dfrac{\dfrac{\dfrac{}{\vdash L_{sign}}\,\emptyset}{L_{non-sign} \vdash}}{\vdash L_{val-contract}}$$

Interaction in plaintiff's base

Finally, there is a design corresponding to the legal rule r_1:

$$\mathcal{D}_{r_1} = \dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{}{\vdash L_{Pay}}\,\emptyset}{L_{Del} \vdash L_{Pay}}\,\emptyset}{\vdash L_{not-Del}, L_{Pay}}}{L_{sign} \vdash L_{not-Del}, L_{Pay}}\,\emptyset}{\vdash L_{not-sign}, L_{not-Del}, L_{Pay}}}{L_{val-contract} \vdash L_{not-Del}, L_{Pay}}}{\vdash L_{not-val-contract}, L_{not-Del}, L_{Pay}}}{L_{Cont-and-Del} \vdash L_{Pay}}$$

Interaction in plaintiff's base

The result of the interaction between

$$\mathcal{D}_{r_1} = \dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{}{\vdash L_{Pay}}\,\emptyset}{L_{Del} \vdash L_{Pay}}\,\emptyset}{\vdash L_{not-Del}, L_{Pay}}}{L_{sign} \vdash L_{not-Del}, L_{Pay}}\,\emptyset}{\vdash L_{not-sign}, L_{not-Del}, L_{Pay}}}{L_{val-contract} \vdash L_{not-Del}, L_{Pay}}}{\vdash L_{not-val-contract}, L_{not-Del}, L_{Pay}}}{L_{Cont-and-Del} \vdash L_{Pay}}$$

and

$$\dfrac{\dfrac{\dfrac{\dfrac{}{\vdash L_{sign}}\,\emptyset}{L_{not-sign} \vdash}}{\vdash L_{val-contract}}}{L_{not-val-contract} \vdash} \quad \dfrac{\dfrac{}{\vdash L_{Del}}\,\emptyset}{L_{not-Del} \vdash}}{\vdash L_{Cont-and-Del}}$$

gives

$$\dfrac{}{\vdash L_{Pay}}\,\emptyset$$

A “contradiction” in plaintiff’s base

Designs $\mathcal{D}_{pay}$ and $\mathcal{D}_{\neg pay}$ are in plaintiff’s base. Their interaction yields a contradiction:

$$\dfrac{\dfrac{}{\vdash L_{Pay}}\emptyset \qquad \dfrac{\dfrac{}{\vdash}\dagger}{L_{Pay} \vdash}\emptyset}{} \quad \text{gives} \quad \dfrac{}{\vdash}\dagger$$

This design is *not* a formula corresponding to a logical absurdity!

The aim of the judge consists in overcoming this contradiction.

Example ctd (simplified)

The judge overcomes the contradiction as he decides that legal rule r_1 cannot be applied.

- We interpret the judge's argument as: the legal rule r_1 needs two premisses (and not one as plaintiff supposes).
- In other words, the validity of a contract requires two conditions (hence two sub-addresses): validity of the signature and non-insanity of those signing.

Example ctd (simplified)

Formally, plaintiff's base is changed (by interactions)

- either to 'delete' the (false) design corresponding to legal rule r_1 plaintiff has.
- or to 'refine' design $\mathcal{D}_{val-contract}$.

'Deletion' and 'refinement' are in fact done by inferring (hence with interactions) new designs.

Specificities of our approach

With respect to the usual approaches (concerning the juridic controversies):

- We refine speech acts as sequences of (more elementary) **dialog acts**.
- Instead of considering a game between three players, the judge directly intervenes inside the interaction between two protagonists.
- Reasoning is modelled at a more primitive level than with formulas.

Argumentation and Logics

The notions of formal proof and of formula are simultaneously **too demanding** and **too simplistic** to account for argumentation:

- during a controversy, one can agree on the validity of a statement, without this statement to be necessarily fully determined as a formal proposition,
- one may concede the correctness of a position without necessarily having explored all its premises,
- a locutor can win a debate, simply because her addressee surrendered.

Argumentation and Ludics

Why Ludics?

- Designs are the basic objects: Formulas and proofs are not given *a priori*
- Ludics gives a uniform framework for dealing with different levels, and for combining elements from these levels.
- Interaction is the main ingredient for modelling reasoning and dialogue.

Ludics in a nutshell

In Ludics:

- objects are abstract proof trees: the **designs**
- interaction between objects may be done to
  - test the validity of an object,
  - infer a result (similar to Modus Ponens)
- interaction between two dual designs is the core of orthogonality
- closed sets of objects help to recover formulas, hence recover logics

Ludics in a nutshell

Key points:

- No more formulas but addresses.
- No more logical rules but actions:

$$\frac{A^{\perp} \vdash \qquad B^{\perp} \vdash}{\vdash (A \otimes B) \oplus (A \otimes C)}$$

corresponds to one positive action:
$(+, L, \{L_1, L_2\})$

$$\frac{\vdash A^{\perp}, B^{\perp} \qquad \vdash A^{\perp}, C^{\perp}}{(A \otimes B) \oplus (A \otimes C) \vdash}$$

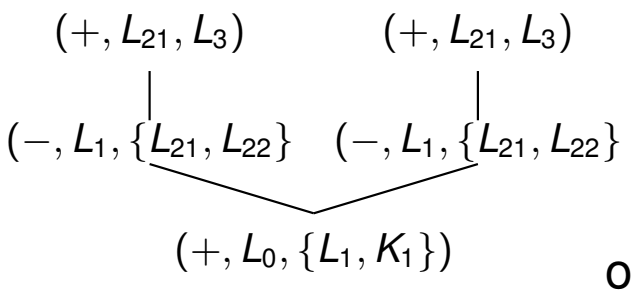
corresponds to two negative actions:
$(-, L, \{L_1, L_2\})$ and $(-, L, \{L_3, L_4\})$

Ludics in a nutshell

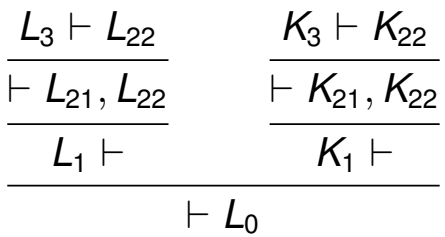
- No more proofs but designs:

$$\dfrac{\dfrac{\dfrac{\phi \vdash \phi}{\vdash \phi^{\perp}, \phi}}{\phi \otimes \phi^{\perp} \vdash} \qquad \dfrac{\dfrac{\psi \vdash \psi}{\vdash \psi^{\perp}, \psi}}{\psi \otimes \psi^{\perp} \vdash}}{\vdash ((\phi^{\perp} \oplus \phi) \otimes (\psi^{\perp} \oplus \psi)) \oplus \rho}$$

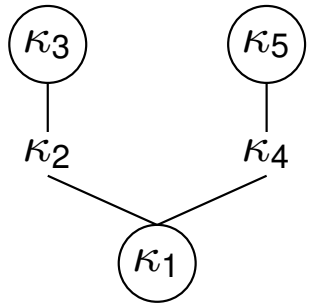
becomes (three notations)



or



or



Ludics in a nutshell

A design of base $(L_0) \vdash L_1, \ldots, L_n$ is a set of alternate sequences of actions, satisfying a few constraints:

- In each sequence, actions are either initial, i.e. in the base, or justified by an action that precedes in the sequence.
- The set is closed by prefix, total, positive, coherent.

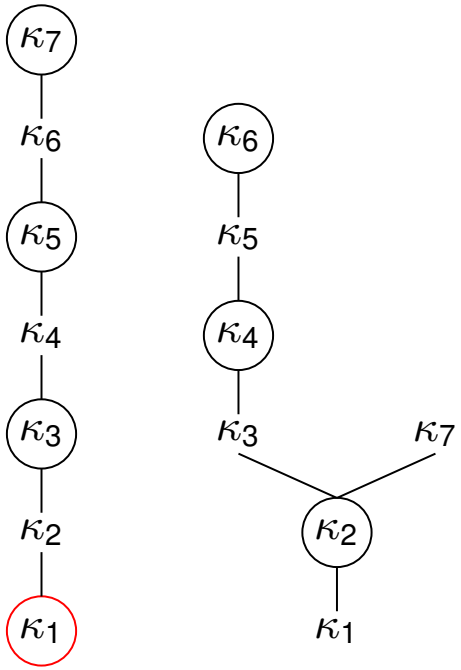
Interaction between designs

- No more cut-elimination but interaction

An interaction occurs between designs based on dual addresses:

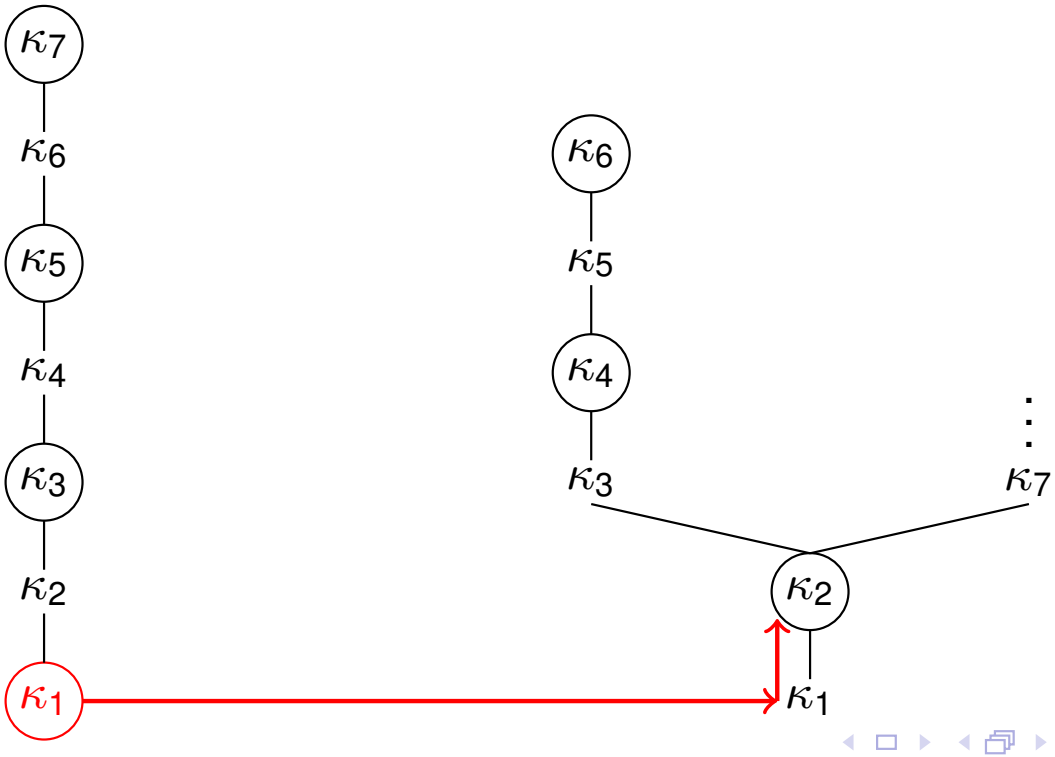
$$\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{L_7 \vdash L_6}{\vdash L_6, L_{22}}}{L_5 \vdash L_{22}}}{\vdash L_4, L_{22}}}{L_3 \vdash L_{22}}}{\vdash L_{21}, L_{22}}}{L_1 \vdash}}{\vdash L_0} \qquad \dfrac{\dfrac{\dfrac{\dfrac{L_6 \vdash}{\vdash L_5}}{L_4 \vdash}}{\vdash L_3}}{L_{21} \vdash \qquad L_{22} \vdash}}{\vdash L_1}}{L_0 \vdash}$$

or



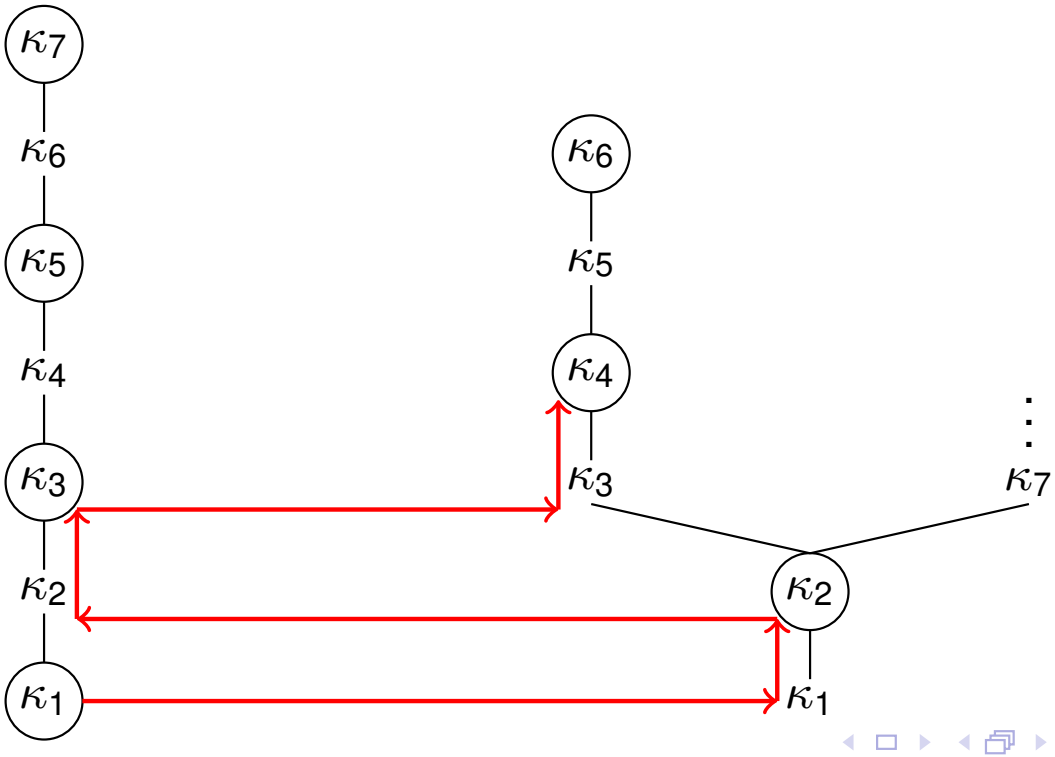
Interaction between designs

Interaction begins on the design that has a positive base.
Each time a positive action $\textcircled{\kappa}$ is visited, the travel continues on the dual (negative) action κ in the other design (if it exists), then goes to the unique positive action after κ in this design (bottom-up reading).



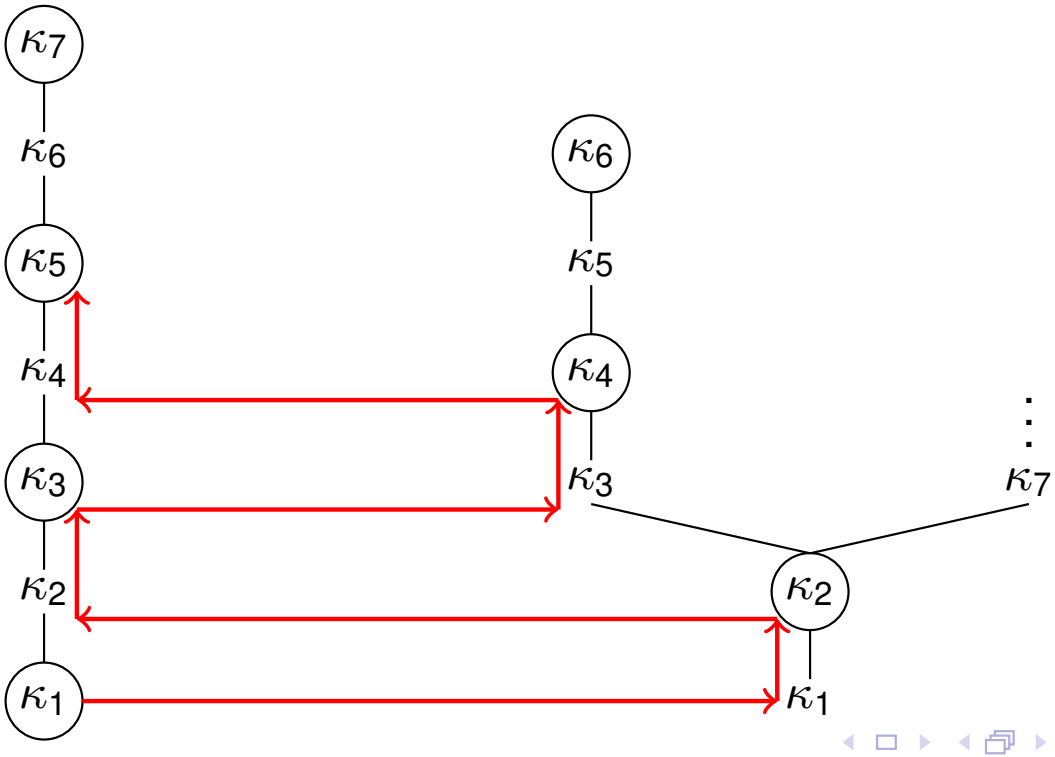
Interaction between designs

. . . and so on.



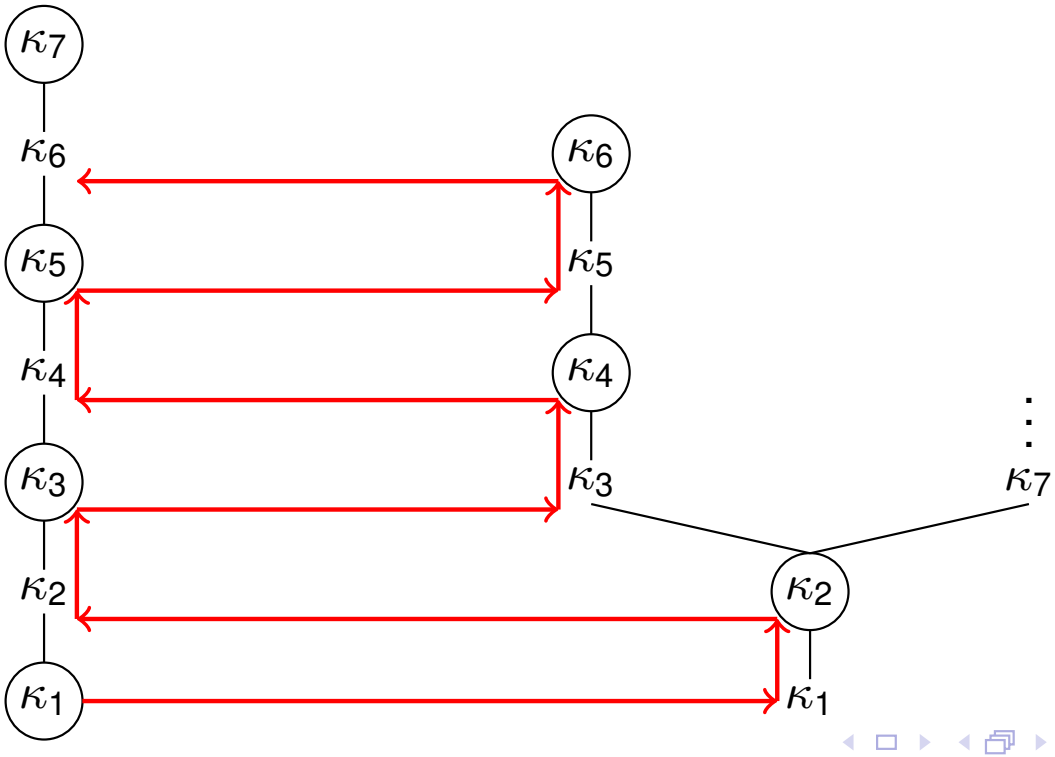
Interaction between designs

. . . and so on.



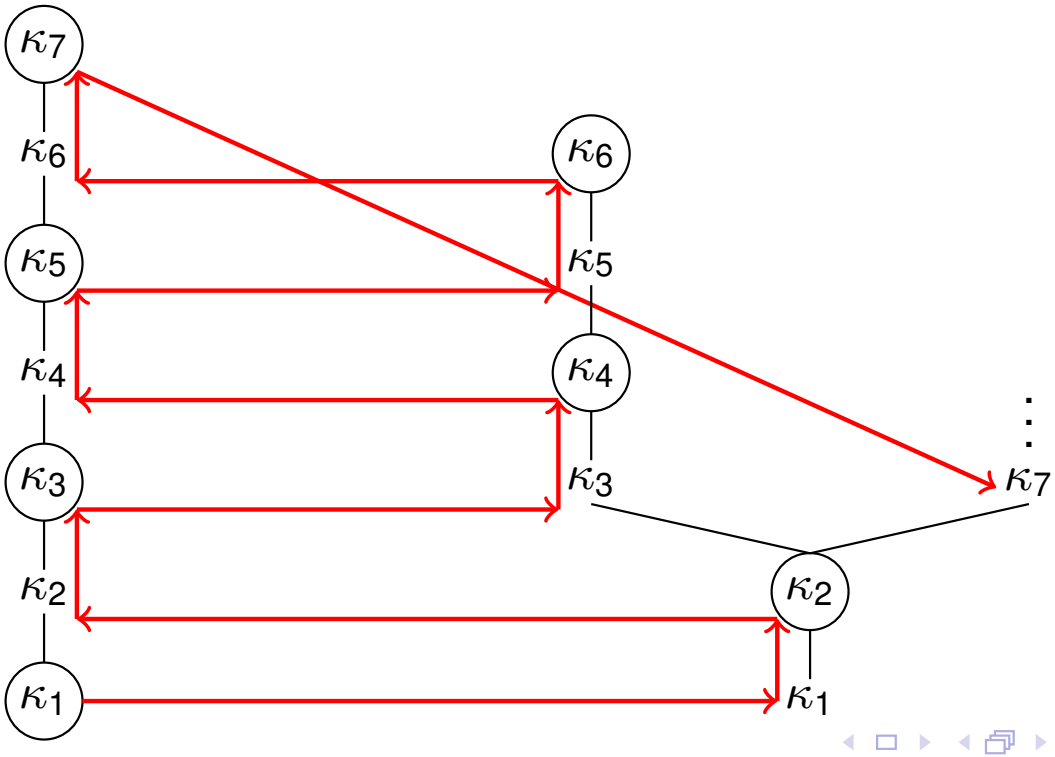
Interaction between designs

. . . and so on.



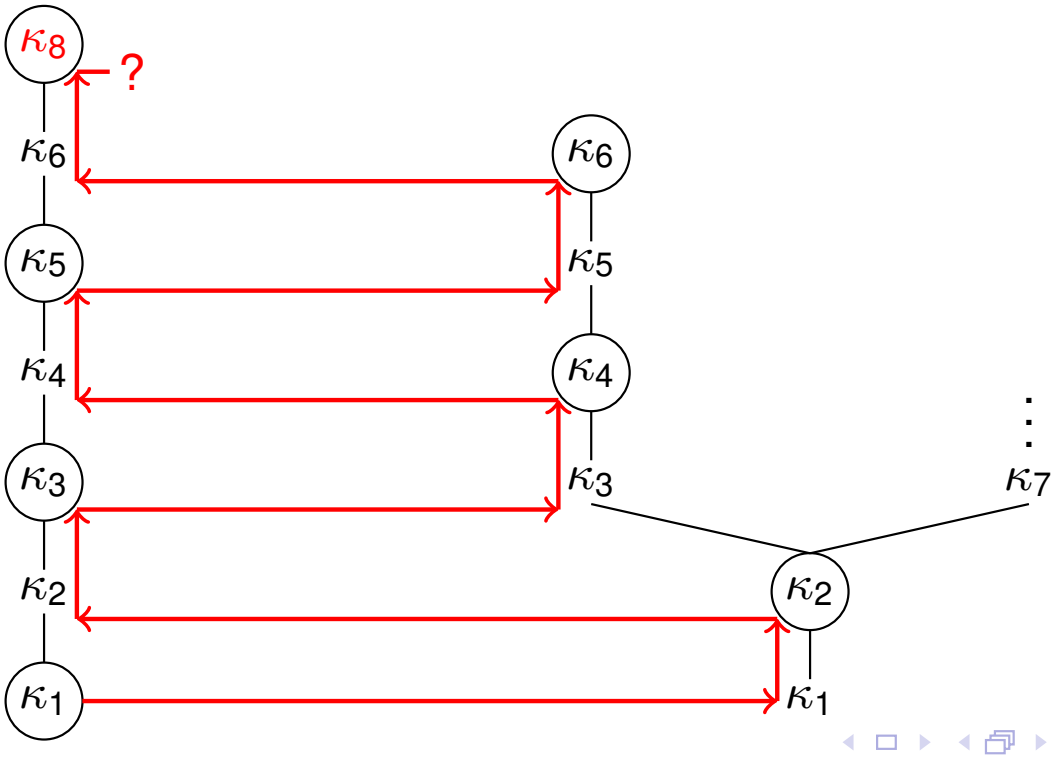
Interaction between designs

. . . and so on.



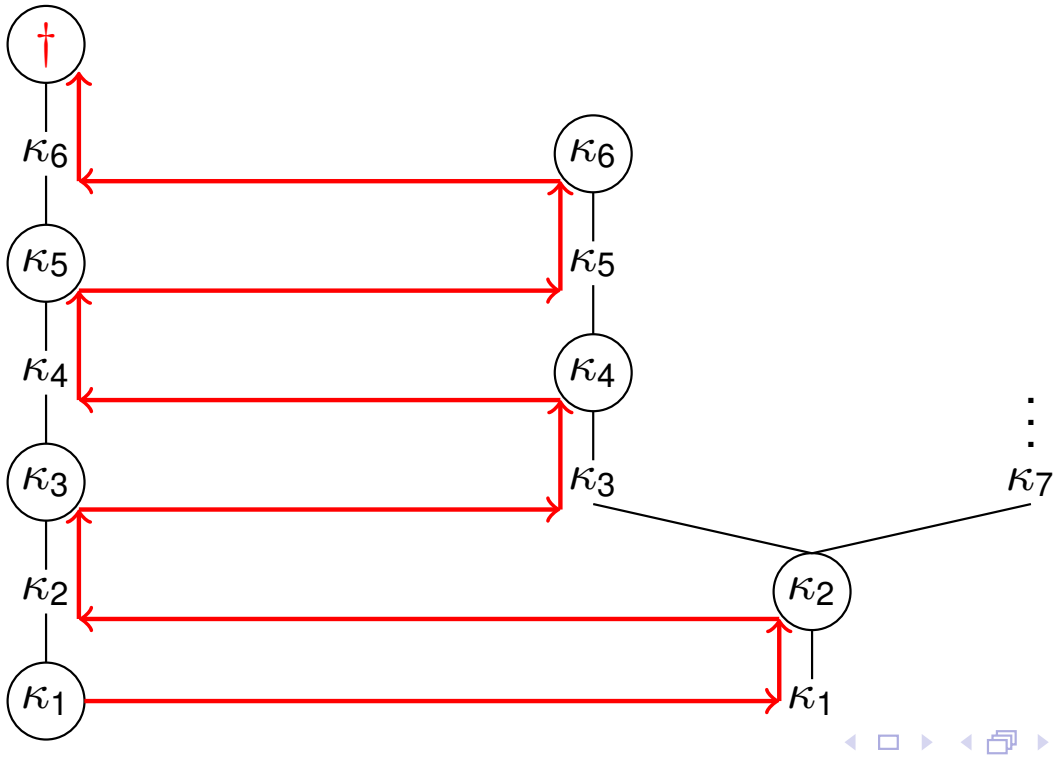
Interaction between designs

. . . if the negative action does not exist, the interaction fails, diverges.



Interaction between designs

. . . if the daimon is reached, the interaction succeeds, converges.



Results in Ludics

- Two designs are **orthogonal** when their interaction succeeds.
- Separation: A design is fully defined by its counter-designs.
- A formula is retrieved as a set of designs closed by bi-orthogonality: such sets are called **behaviors**.
- Completeness: A **good design** belongs to the interpretation of a formula iff it is the interpretation of a proof.
- A formula is valid when the behavior that interprets it contains such a *good* design.