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Debugging knowledge by means of a spatial metaphor

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Grupo de Lógica Computacional (TIC 137)

Bio




- Professor at the Department of Information Technology.
 - School of Engineering
 - University of Huelva. Spain
 - Head of Master of Economy, Finance and Computation.
- PhD in Computer Science and Artificial Intelligence.
 - University of Sevilla – Spain
 - Bachelor in Physics – University Complutense - Madrid
- My research interests include knowledge management, formal verification, logic, formal concept analysis, ontologies, multiagent systems, etc...
- Current projects include design and build cognitive tools to manage knowledge, extract information to transform into knowledge.

Aim of this talk

- The aim of this talk is to present a tool with 3 main goals:
 - Debug knowledge, preserving consistency and reasoning, using a graphical interface
 - Non-expert users should be able to use it.
 - Transformation applied to KB must be formally verified.


What means Debugging?



PAELLA
Framework

Jesús Valeo Fernández
Universidad de Huelva

Cargando módulo DUMMY... 30%



What is Paella?

- Its a...
 - FrameWork
 - It is designed to manage different kind of knowledge bases... and can be extended!
 - Visual editor for knowledge bases
 - Based on relations about concepts (not on concepts)

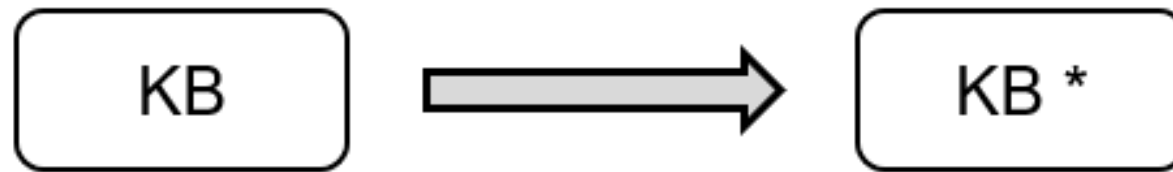
G. A. Aranda-Corral, J. Borrego-Díaz and A. M. Chávez-González, "Repairing conceptual relations in ontologies by means of an interactive visual reasoning: Cognitive and design principles," *2012 IEEE 3rd International Conference on Cognitive Infocommunications (CogInfoCom)*, Kosice, Slovakia, 2012, pp. 739-744, doi: 10.1109/CogInfoCom.2012.6421949.

Who is Paella?

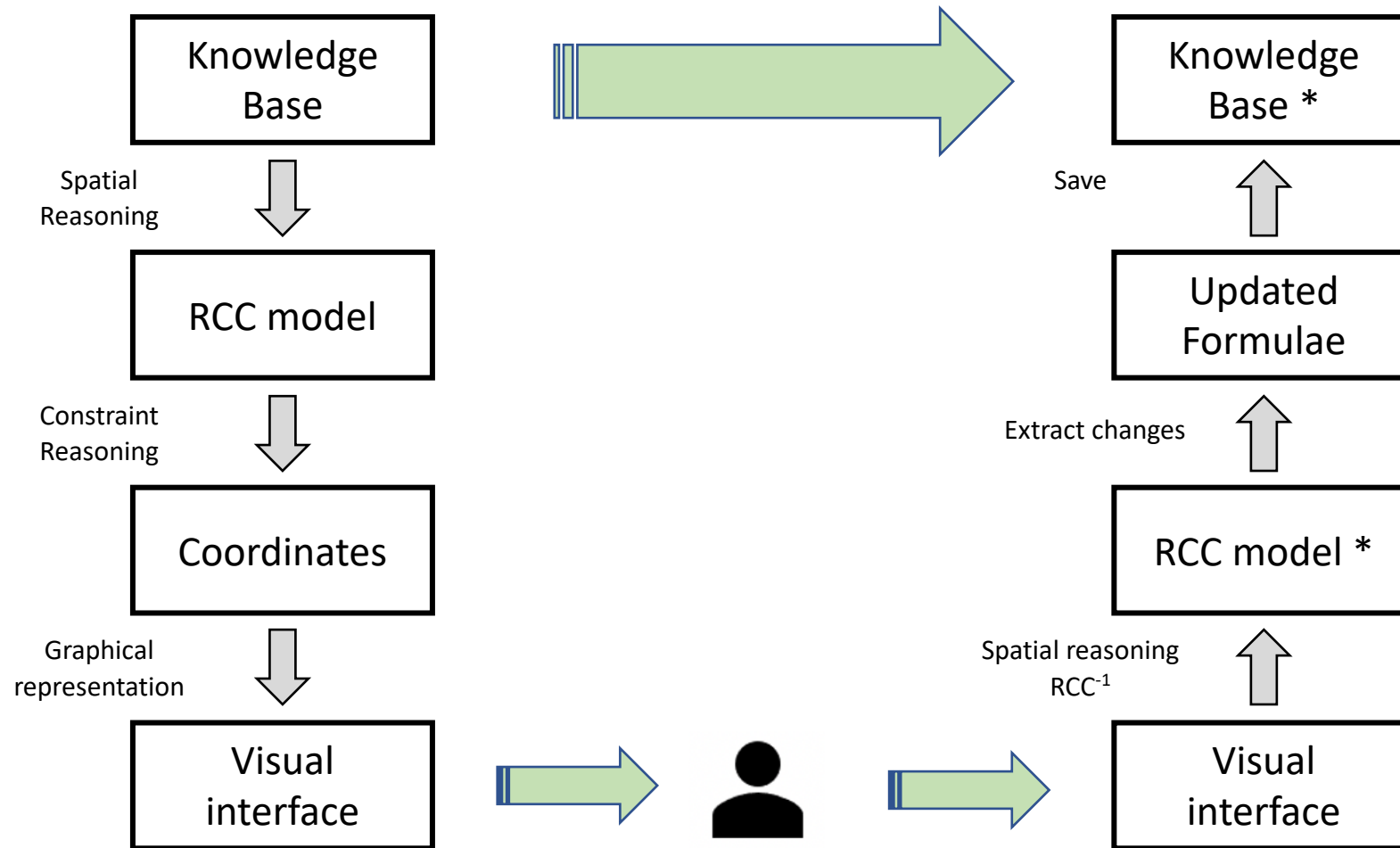
- Researchers:
 - ***Joaquín Borrego-Díaz (US)***
 - Antonia M. Chávez-González (US)
 - ***Gonzalo A. Aranda Corral (UHU)****
- Developers:
 - Jesús Valeo Fernández (Student UHU)
 - Álvaro Martín Boza (Student UHU)
 - ***Gonzalo A. Aranda-Corral (UHU)****

How can we modify this "alignment"?

- We call the Paella's cycle...



How: Complete cycle



Where can be executed?

- Initially was born to be a Protégé plugin.
- In order to manage different kinds of Kb, evolves to Standalone
- Now, after a BIG restructure, we are considering to port some piece to Protégé, and be combined both versions.

Formal background

- Cognitive Principles

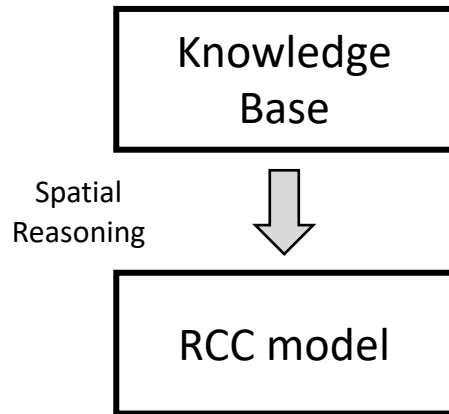
First Cognitive Principle (CP1): The concepts of a conceptualization associate to a clear ontology can be topologically represented by means of regular non-empty regions.

- For this, we use RCC (Region Connection Calculus) is a mereotopological approach to QSR (Qualitative Spatial Reasoning)

RCC

- In RCC, the spatial entities are non-empty regular sets.
- The ground relation is the connection, $C(x,y)$,
 - with intended meaning:
“the topological closures of x and y intersect”.
- The basic properties that $C(x,y)$ must hold are
 - Reflexive $\forall x[C(x,x)]$
 - Symmetric $\forall x,y[C(x,y) \rightarrow C(y,x)]$

RCC Theory



First Cognitive Principle (CP1): The concepts of a conceptualization associated to a clear ontology can be topologically represented by means of regular non-empty regions.

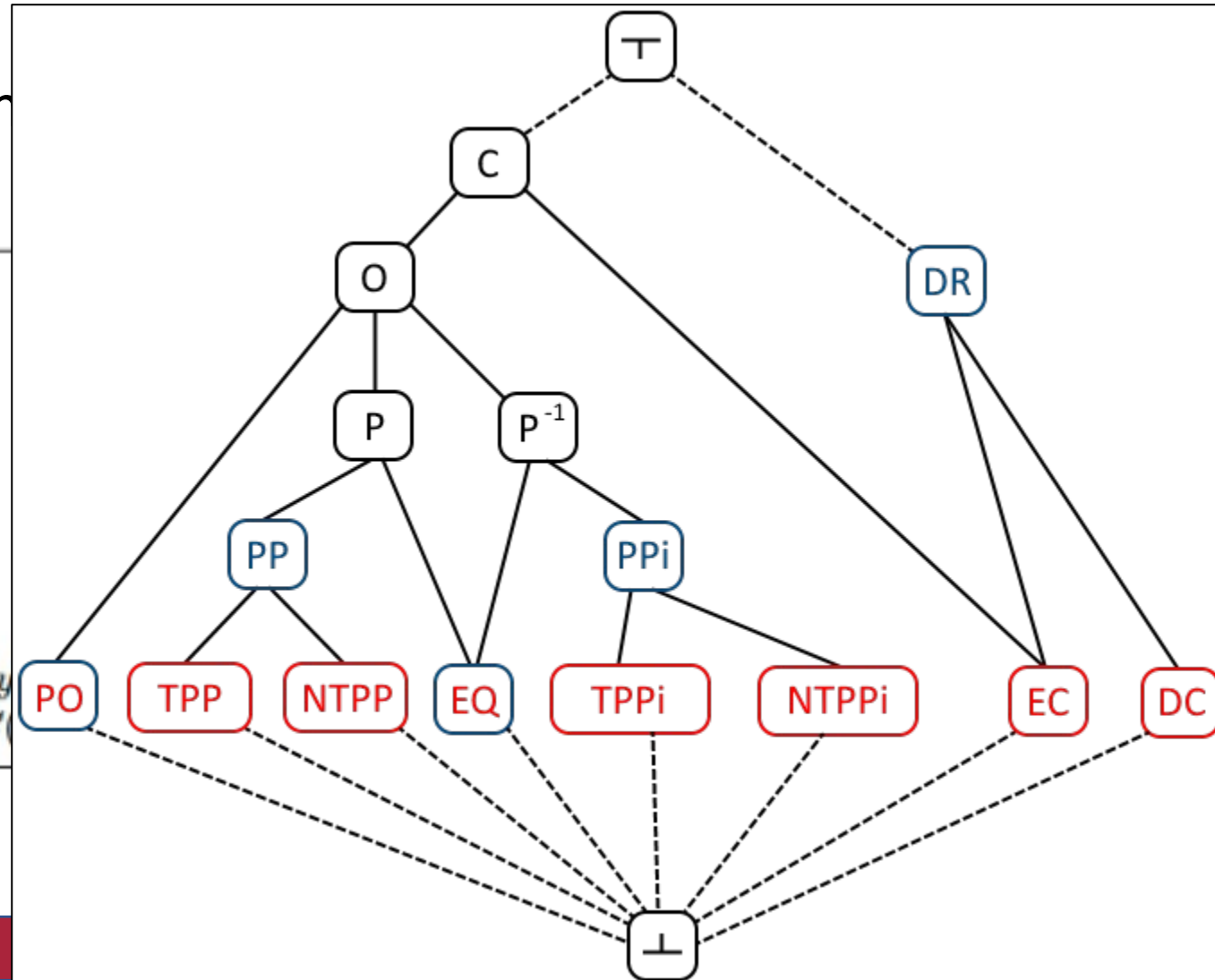
Theorem 3. [10] *The following conditions are equivalent:*

1. $C_{\Sigma}(C_1, C_2)$
2. *There is a spatial interpretation I of Σ such that $I \models C(C_1, C_2)$.*

RCC

- Based on this definition, we can

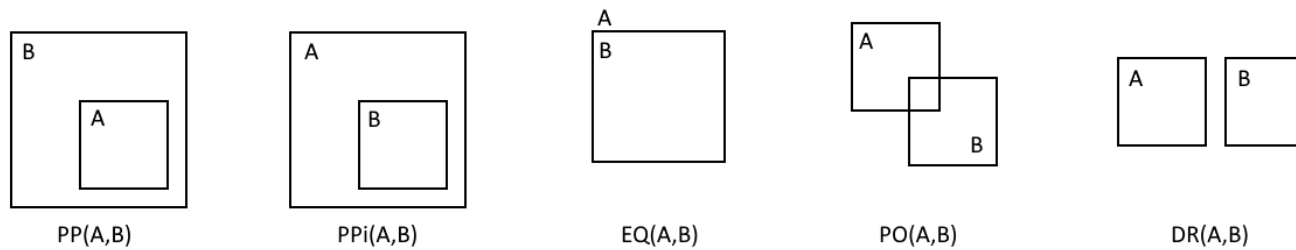
$DC(x, y) \leftrightarrow \neg C(x, y)$
 $P(x, y) \leftrightarrow \forall z[C(z, x) \rightarrow C(z, y)]$
 $PP(x, y) \leftrightarrow P(x, y) \wedge \neg P(y, x)$
 $EQ(x, y) \leftrightarrow P(x, y) \wedge P(y, x)$
 $O(x, y) \leftrightarrow \exists z[P(z, x) \wedge P(z, y)]$
 $DR(x, y) \leftrightarrow \neg O(x, y)$
 $PO(x, y) \leftrightarrow O(x, y) \wedge \neg P(x, y) \wedge \neg P(y, x)$
 $EC(x, y) \leftrightarrow C(x, y) \wedge \neg O(x, y)$
 $TPP(x, y) \leftrightarrow PP(x, y) \wedge \exists z[EC(z, x) \wedge EC(z, y)]$
 $NTPP(x, y) \leftrightarrow PP(x, y) \wedge \neg \exists z[EC(z, x) \wedge EC(z, y)]$



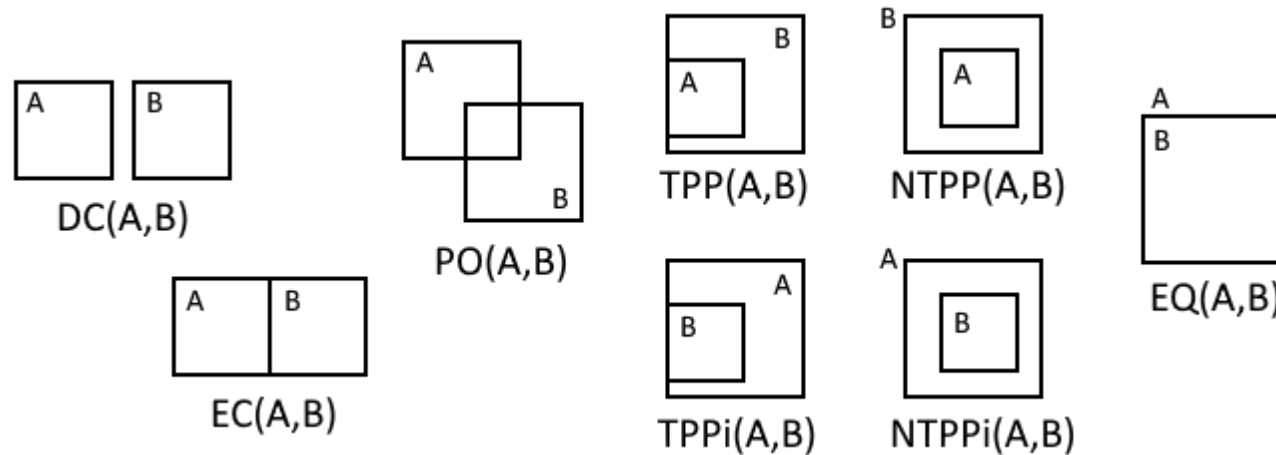
RCC

- Graphically:

- RCC5



- RCC8



JEPD

RCC

- It is not about CONCEPTS...

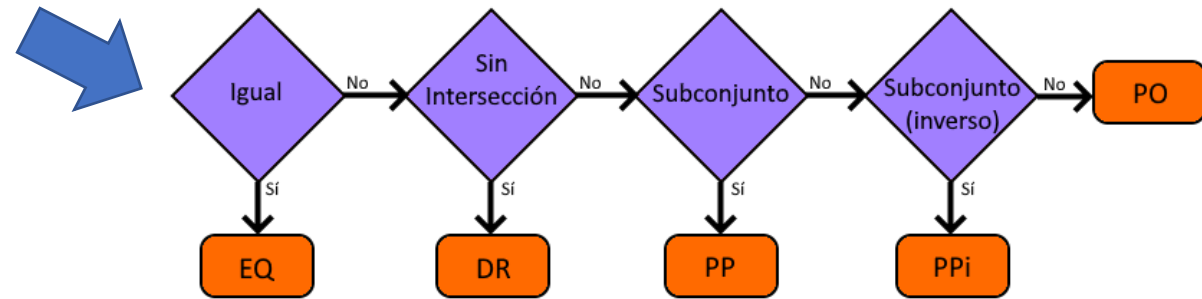
It is about RELATIONS BETWEEN CONCEPTS

- We are not working with the definition of the concepts, just with their relations.

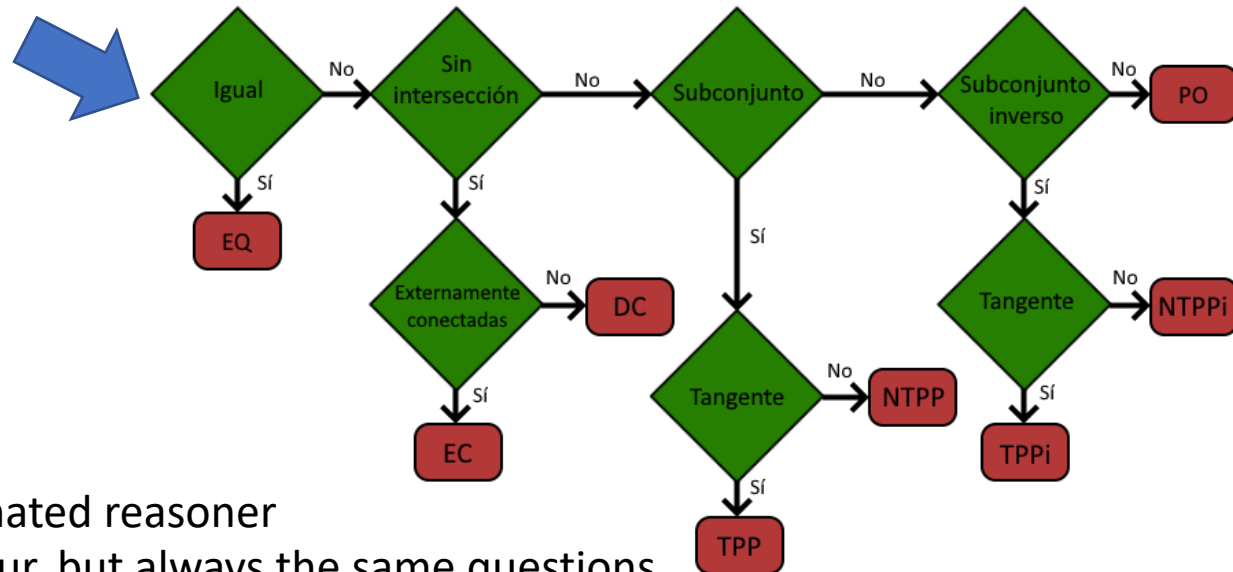


RCC (algorithm)

- RCC5



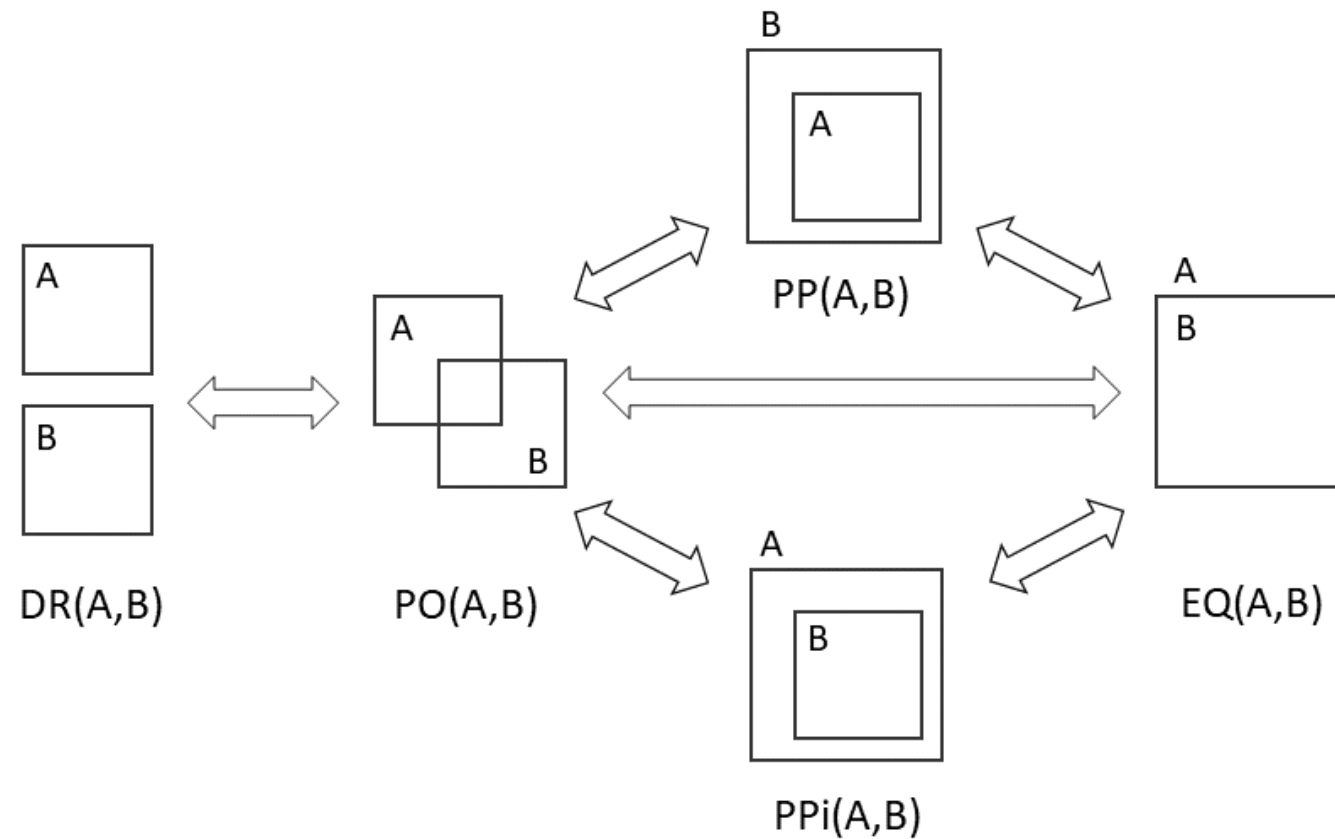
- RCC8



- Those questions are made to an automated reasoner
- The reasoner is different for each flavour, but always the same questions

RCC

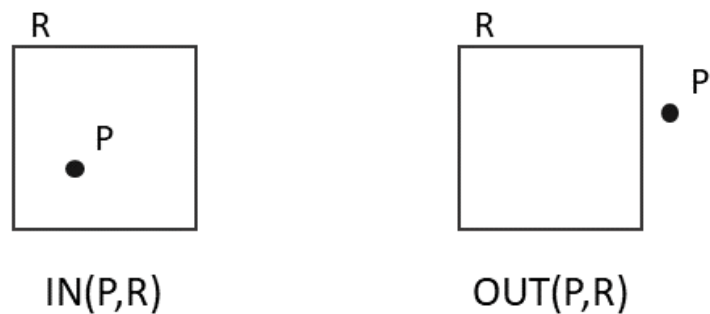
- Movements & neighbor's graph



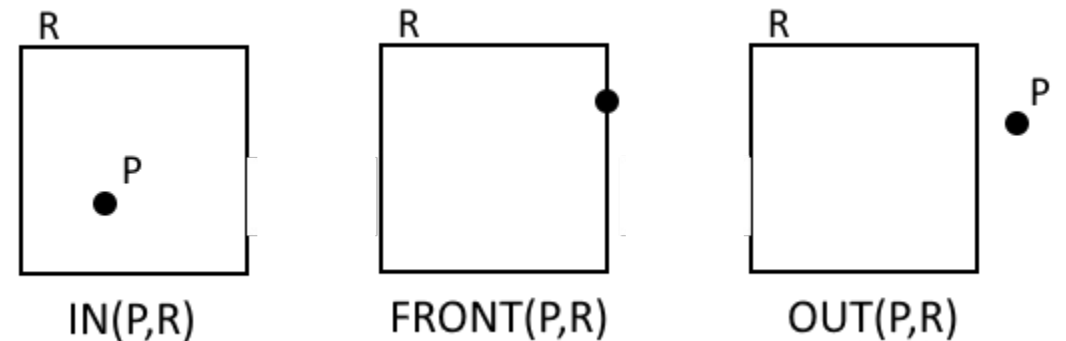
RCC

- Extension to “points”

- We consider Individuals as “small” regions: $\text{Area} > 0$, but cannot contain elements (only itself)
- Then, we can reduce the expressions:



RCC5*



RCC8*

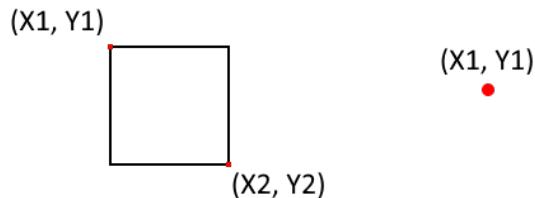
RCC

- To transform a Kb into a RCC representation, we have to calculate ALL pairs of relations:
 - #relations = HUGE NUMBER!!
- Optimize: Removing redundant relations.

$R(a,b) \backslash R(b,c)$	DR	PO	PP	PPi	EQ
DR	*	*	*	DR	DR
PO	*	*	*	*	DR
PP	DR	*	PP	*	PP
PPi	*	*	*	PPi	PPi
EQ	DR	PO	PP	PPi	EQ

From RCC to Graphical representation

- Transform RCC relations into a CSP problem.
- Areas are rectangles (mereotopology)
- Variables:

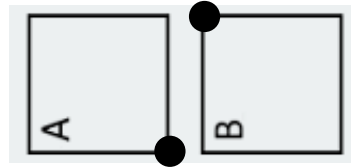
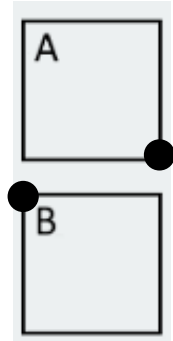


- Domains: Screen width and height ($640*480$)
- Constraints:
 - Area > 0 : $X2 \#> X1$ AND $Y2 \#> Y1$
 - ALL related to RCC-relations

From RCC to Graphical representation

- Constraint

- Ex: DR(A,B)



- Constraint: $Y2A \#< Y1B$ OR $X1B \#> X2A$ OR

- Translate ALL relations... but 1!! (JEPD)

- With this... we obtain the coordinates to represent the relations.

From RCC to Graphical representation

Definition 2. *A spatial interpretation I of Σ is a interpretation in the language of Σ , such that $I : \text{concepts}(\Sigma) \cup \text{indiv}(\Sigma) \rightarrow \Omega$, where Ω is a T_3 connected topological space such that $I \models \Sigma$ and for each $C \in \text{concepts}(\Sigma)$, $I(C)$ is an open regular set in Ω and for each $a \in \text{indiv}(\Sigma)$, $I(a)$ is a point.*

A spatial model of Σ is a spatial interpretation which is a model of Σ .

Theorem 2. *[10] The CSP associate to Σ is spatially consistent if Σ is consistent.*

Moreover, it is possible to obtain a spatial model on the plane formed by polygonal regions [25].

From RCC to Graphical representation

- CSP is solved by an existing library... called CHOCO©



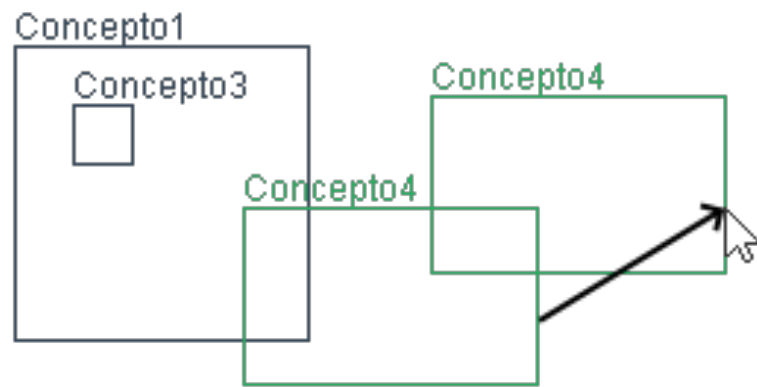
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author = {Charles Prud'homme and Jean-  
Guillaume Fages}, title = {Choco-solver: A  
Java library for constraint programming},  
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}
```

User Interface

The screenshot displays the Paella Framework user interface. At the top, a menu bar includes 'Archivo', 'Edición', and 'Ayuda'. A toolbar below it contains icons for file operations and communication. The main workspace is titled 'Dummy Flavour' and shows a diagram with nodes 'Concepto1', 'Concepto3', 'Individuo2', 'Individuo1', and 'Concepto4'. A large blue loading dialog is centered over the workspace, displaying 'PAELLA Framework', 'Jesús Valeo Fernández', 'Universidad de Huelva', and a progress bar at '30%' with the text 'Cargando módulo DUMMY...'. The dialog is annotated with a '1' in a blue box. To the left, a 'Conceptos' panel lists 'Concepto1' through 'Concepto4' and is annotated with a '2'. Below it, an 'Individuos' panel lists 'Individuo1' through 'Individuo3' and is annotated with a '3'. On the right, a 'Relaciones' panel shows a list of relationships under the 'Optimizadas' tab, including 'EQ(Concepto1, Concepto2)', 'PP(Concepto3, Concepto1)', and 'IN(Individuo1, Concepto1)'. This panel is annotated with a '5'. Below the 'Relaciones' panel, another section is partially visible, annotated with a '6'. A 'RCC5' button is located in the top right of the workspace area.

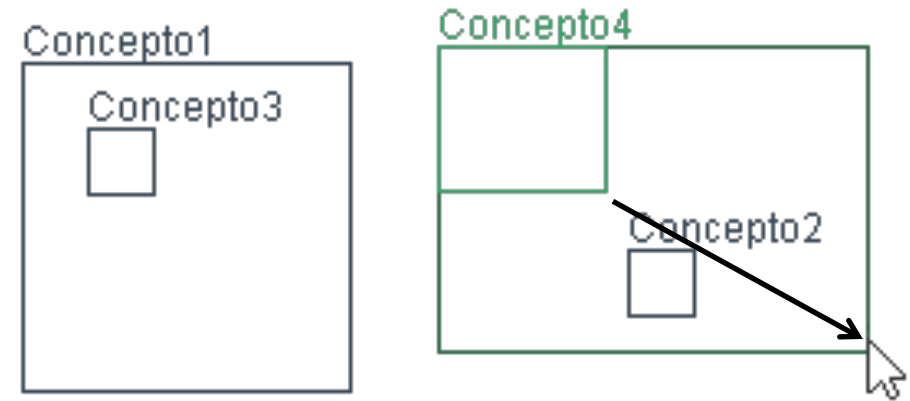
Movements

DRAG (left button)



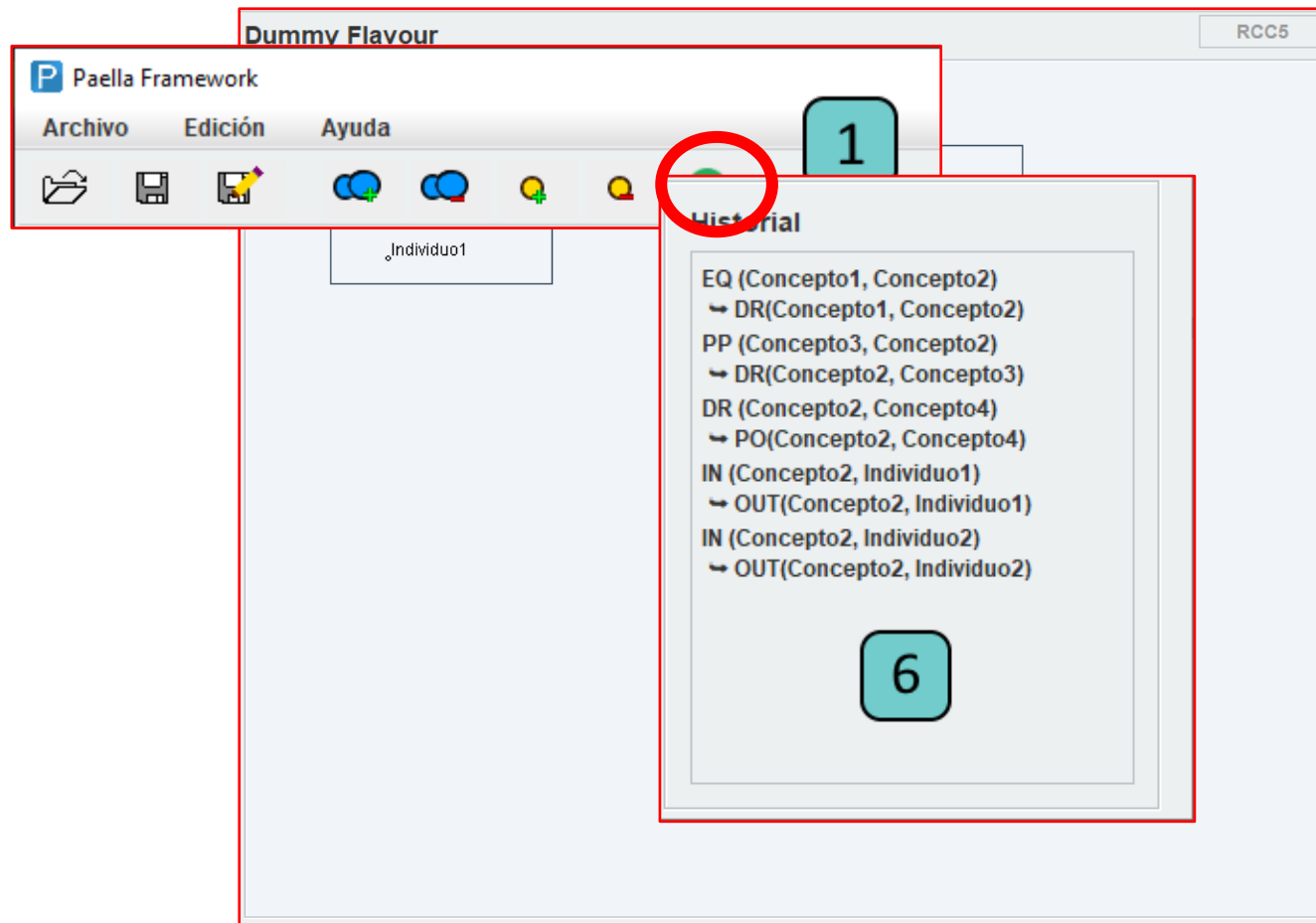
$PO(C3,C4) \rightarrow DR(C3,C4)$

REDIM (right button)



$DR(C2,C4) \rightarrow PP(C2,C4)$

Movements



Visual Editor



Nuevo Concepto

Nombre

Concepto5 El nombre es válido.

Individuos

Resto de Individuos

Individuo1
Individuo3

Agregar

Individuos del Concepto

Individuo2

Eliminar

Agregar Concepto

The 'Nuevo Concepto' dialog box is shown. It has a title bar with a 'P' icon and the text 'Nuevo Concepto'. The main area contains a 'Nombre' label and a text input field containing 'Concepto5'. To the right of the input field is a green message: 'El nombre es válido.'. Below this is a section titled 'Individuos' which is divided into two panes. The left pane is titled 'Resto de Individuos' and contains a list with 'Individuo1' and 'Individuo3', and an 'Agregar' button below it. The right pane is titled 'Individuos del Concepto' and contains a list with 'Individuo2', and an 'Eliminar' button below it. At the bottom right of the dialog is an 'Agregar Concepto' button.

Nuevo Individuo

Nombre

Individuo3

Nombre no válido. Prueba con otro.

Conceptos

Selecciona los conceptos a los que pertenece el individuo.

Concepto1
 Concepto2
 Concepto3
 Concepto4

Agregar Individuo

The 'Nuevo Individuo' dialog box is shown. It has a title bar with a 'P' icon and the text 'Nuevo Individuo'. The main area contains a 'Nombre' label and a text input field containing 'Individuo3'. Below the input field is a red message: 'Nombre no válido. Prueba con otro.'. Below this is a section titled 'Conceptos' with the instruction 'Selecciona los conceptos a los que pertenece el individuo.'. It contains a list of four concepts with checkboxes: 'Concepto1' (checked), 'Concepto2' (unchecked), 'Concepto3' (checked), and 'Concepto4' (unchecked). At the bottom right of the dialog is an 'Agregar Individuo' button.

Eliminar Concepto

Selecciona el nombre del Concepto a eliminar.

Concepto3

Eliminar Cancelar

The 'Eliminar Concepto' dialog box is shown. It has a title bar with a 'P' icon and the text 'Eliminar Concepto'. The main area contains the instruction 'Selecciona el nombre del Concepto a eliminar.' and a dropdown menu currently showing 'Concepto3'. At the bottom of the dialog are two buttons: 'Eliminar' and 'Cancelar'.

Eliminar Individuo

Selecciona el nombre del Individuo a eliminar.

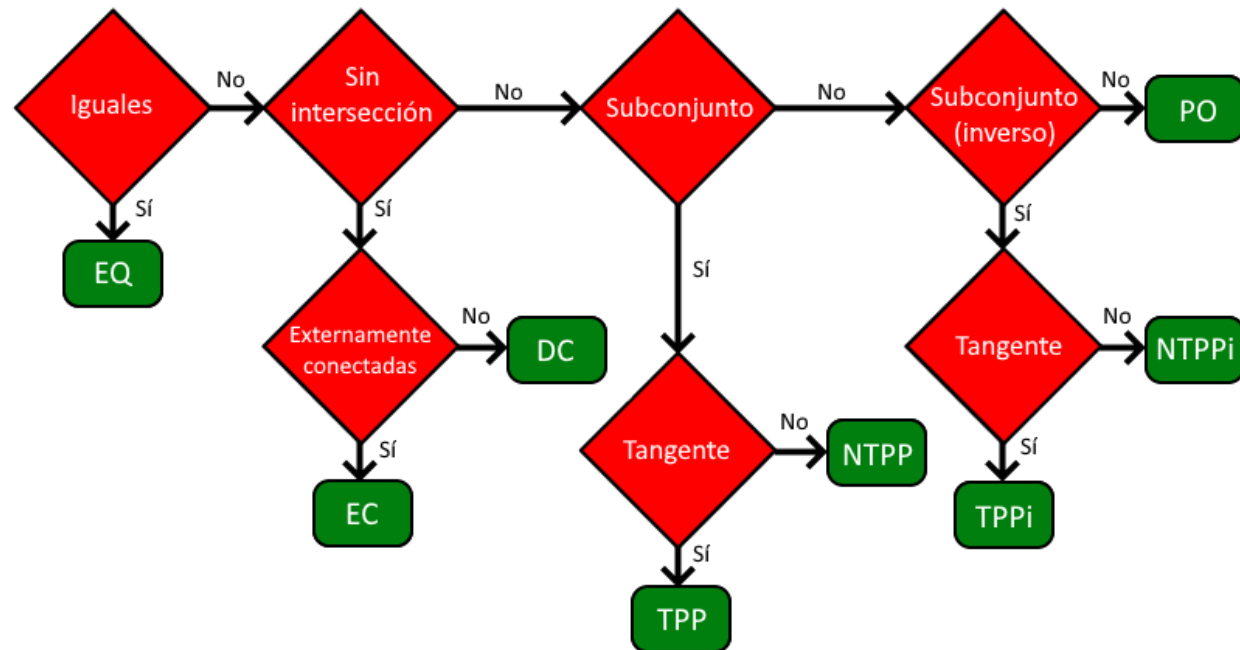
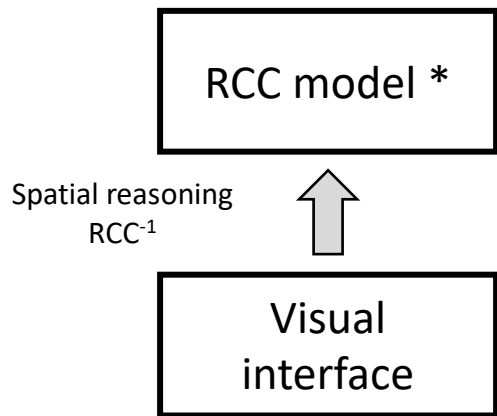
Individuo1

Eliminar Cancelar

The 'Eliminar Individuo' dialog box is shown. It has a title bar with a 'P' icon and the text 'Eliminar Individuo'. The main area contains the instruction 'Selecciona el nombre del Individuo a eliminar.' and a dropdown menu currently showing 'Individuo1'. At the bottom of the dialog are two buttons: 'Eliminar' and 'Cancelar'.

From UI to RCC (we call: RCC⁻¹)

- Transformation from coordinates to RCC-relations
- Similar algorithm (same questions) with totally different implementation

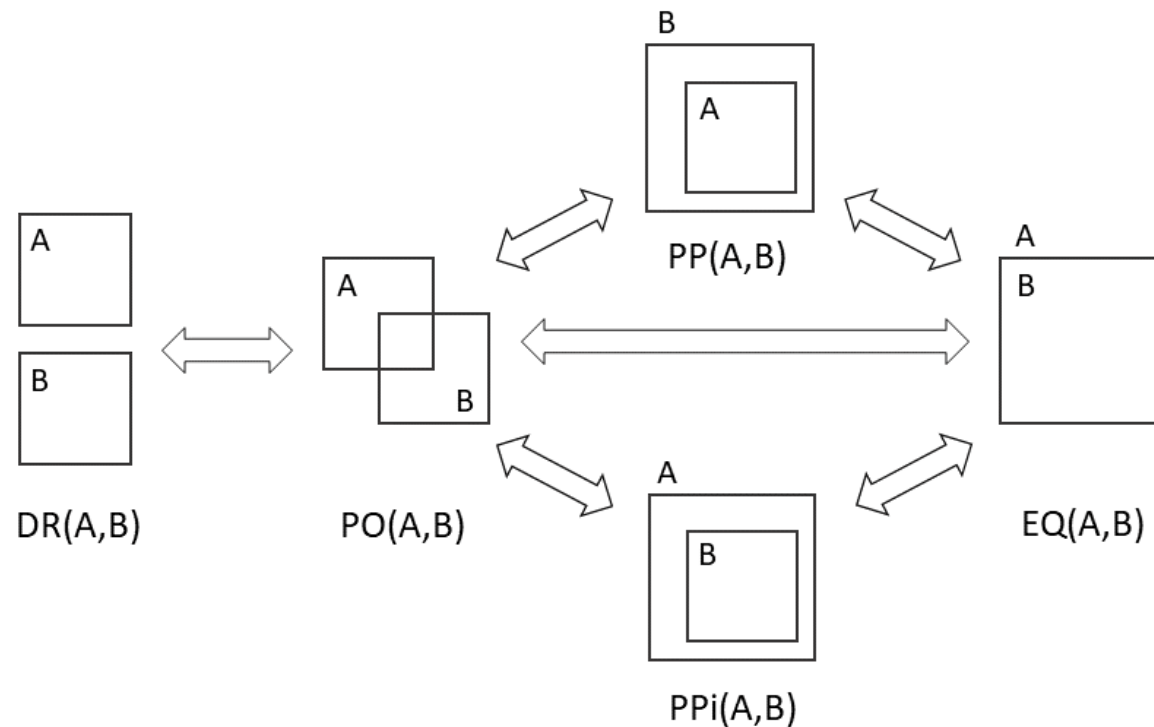


Applying changes

- This is the most difficult section.
- Depends a lot on what type of Kb we are working on.
 - Extensives: changes are only creation of new individuals or classes. Inconsistences cannot exists (Our diagram is a model)
 - Intensives: (as Ontologies) Changes mean introduce (or remove) individuals, concepts AND AXIOMS!
 - Sometimes, we need to add, pj ex, ALL_DISJOINT axiom, or remove it.
 - THIS CAN INTRODUCE INCONSISTENCES. (because the draw is a model of that part of the ontology, but not all the ontology)

Applying Movements

- A change can be seen as a path of basic steps in the graph.
 - This is a first approach for **an automated repairing system**.



Applying changes (example)

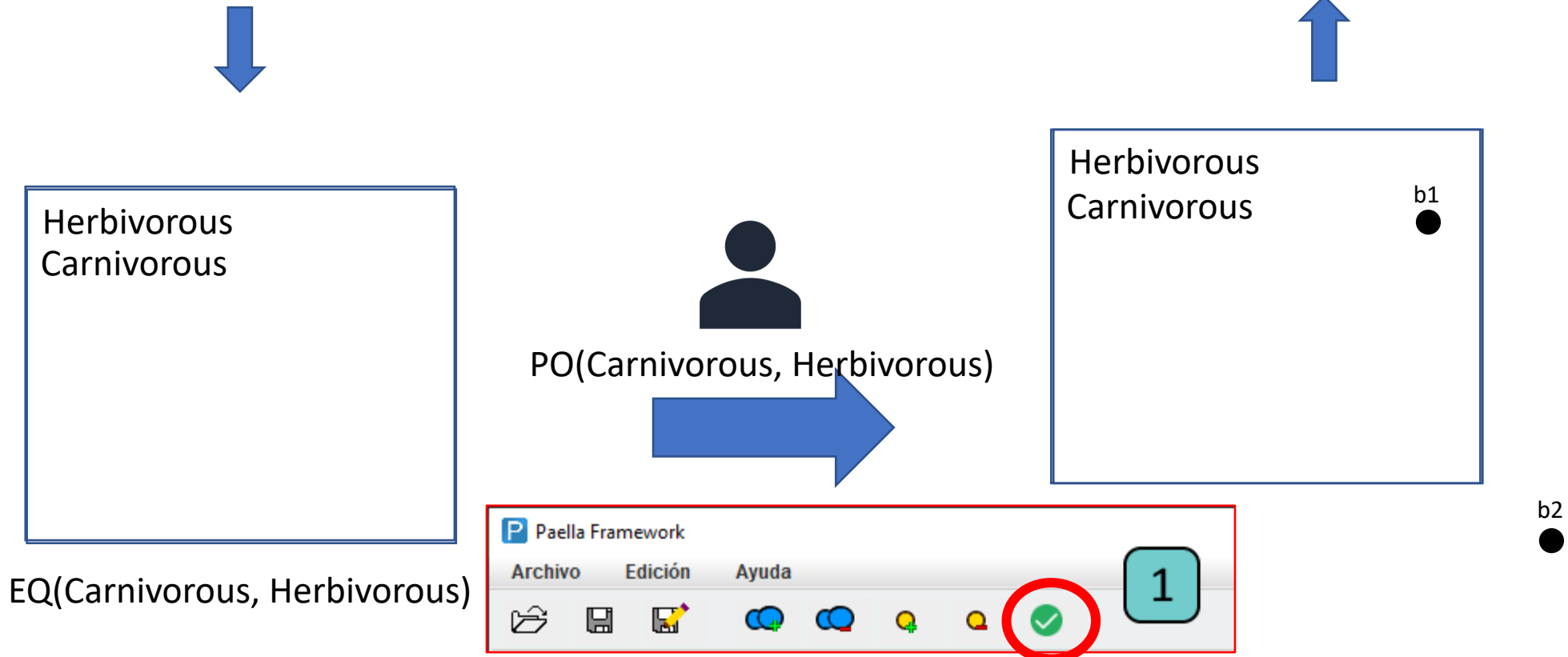
$$\Sigma = \begin{cases} \text{Omnivorous} \sqsubseteq \text{Carnivorous} \sqcap \text{Herbivorous} \\ \text{Carnivorous} \sqsubseteq \text{Animal}, \quad \text{Herbivorous} \sqsubseteq \text{Animal} \\ \text{Omnivorous}(\text{Bear}) \end{cases}$$

We deduce that $PO_{\Sigma}(\text{Carnivorous}, \text{Herbivorous}) \wedge EQ_{\Sigma}^{\sigma}(\text{Carnivorous}, \text{Herbivorous})$.

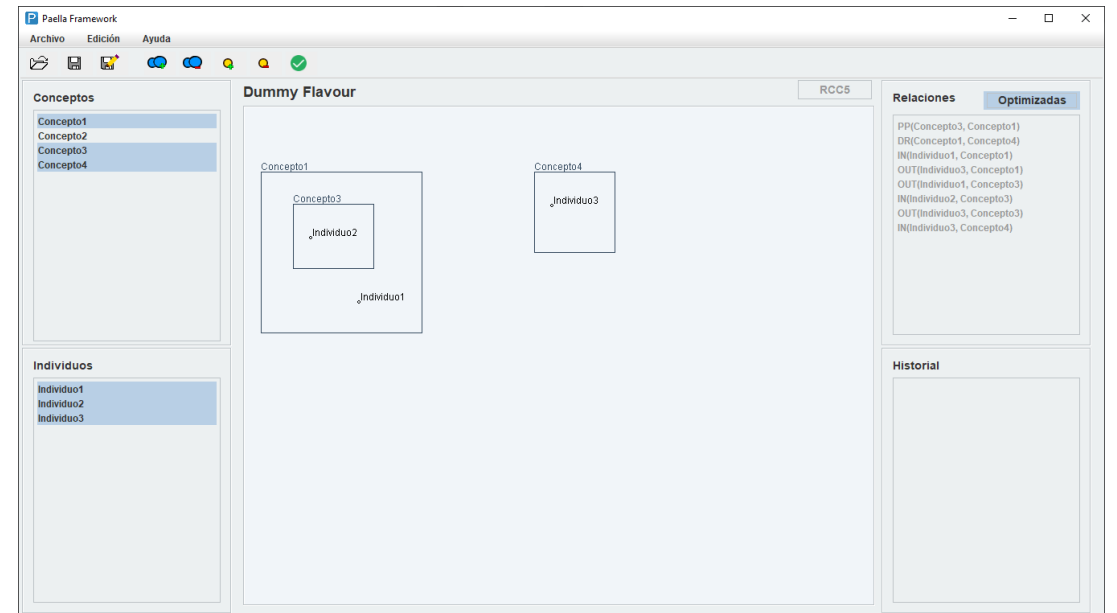
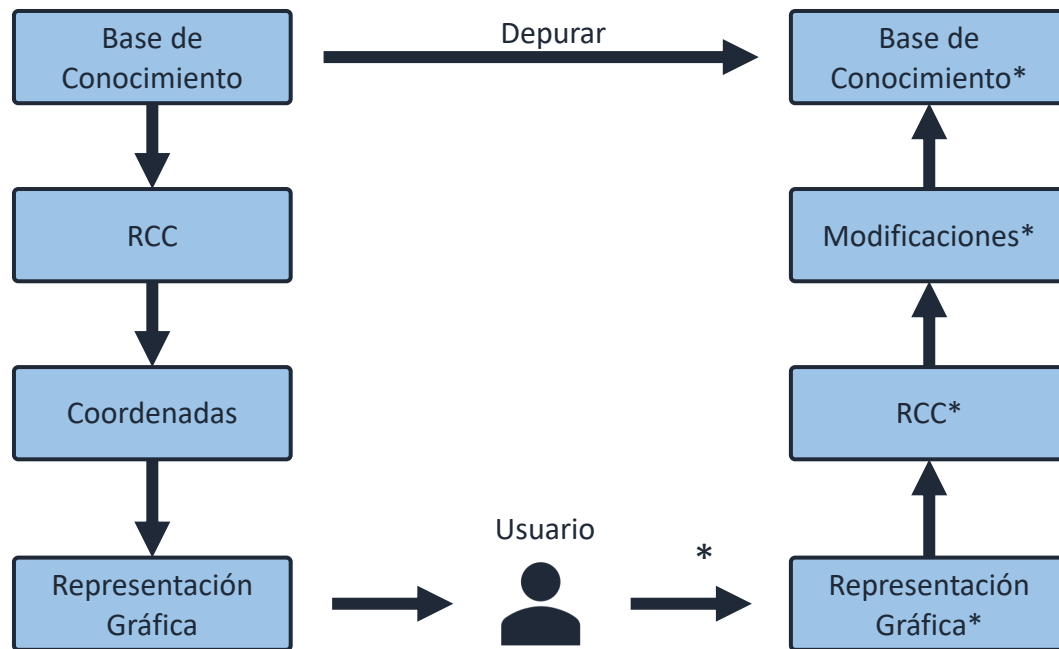
Applying changes (example)

$$\Sigma = \begin{cases} \text{Omnivorous} \sqsubseteq \text{Carnivorous} \sqcap \text{Herbivorous} \\ \text{Carnivorous} \sqsubseteq \text{Animal}, \quad \text{Herbivorous} \sqsubseteq \text{Animal} \\ \text{Omnivorous}(\text{Bear}) \end{cases}$$

$$\Sigma' = \begin{cases} \text{Omnivorous} \sqsubseteq \text{Carnivorous} \sqcap \text{Herbivorous} \\ \text{Carnivorous} \sqsubseteq \text{Animal} \sqcap \neg\{b_2\}, \quad \text{Herbivorous} \sqsubseteq \text{Animal} \sqcap \neg\{b_1\} \\ \text{Herbivorous}(b_2), \text{Carnivorous}(b_1), \text{Omnivorous}(\text{Bear}) \end{cases}$$



Cycle done!



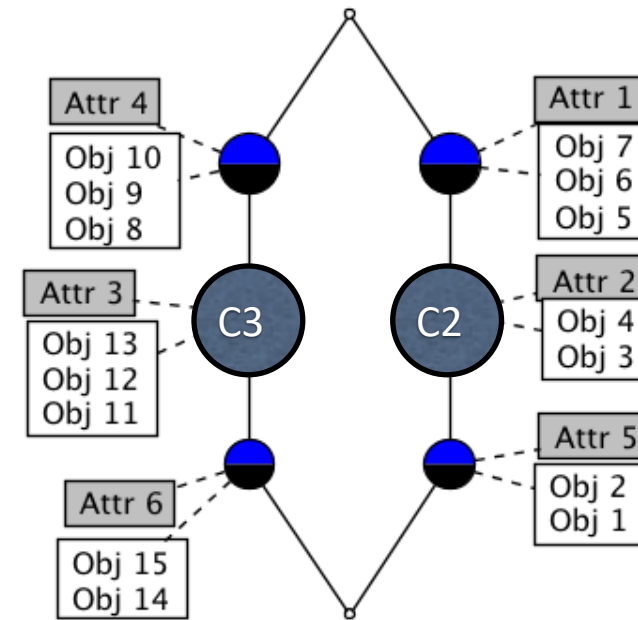
TinyPaella

Situaciones RCC5 y movimientos

Initial knowledge base

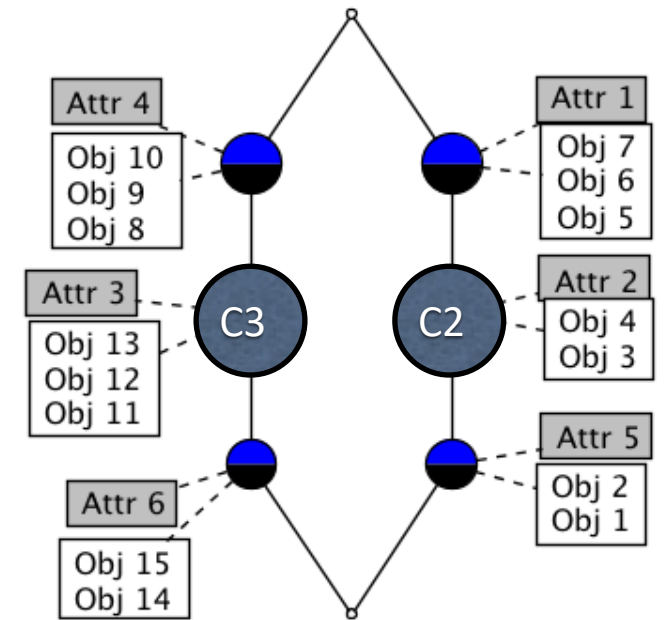
- Contexto y retículo inicial

	A	B	C	D	E	F	G
		Attr 1	Attr 2	Attr 3	Attr 4	Attr 5	Attr 6
Obj 1		X	X			X	
Obj 2		X	X			X	
Obj 3		X	X				
Obj 4		X	X				
Obj 5		X					
Obj 6		X					
Obj 7		X					
Obj 8							
Obj 9					X		
Obj 10					X		
Obj 11				X	X		
Obj 12				X	X		
Obj 13				X	X		
Obj 14				X	X		X
Obj 15				X	X		X

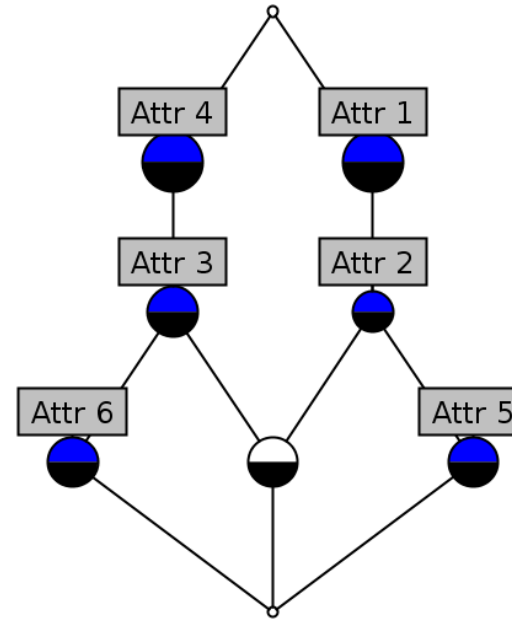
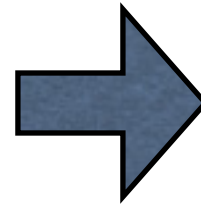
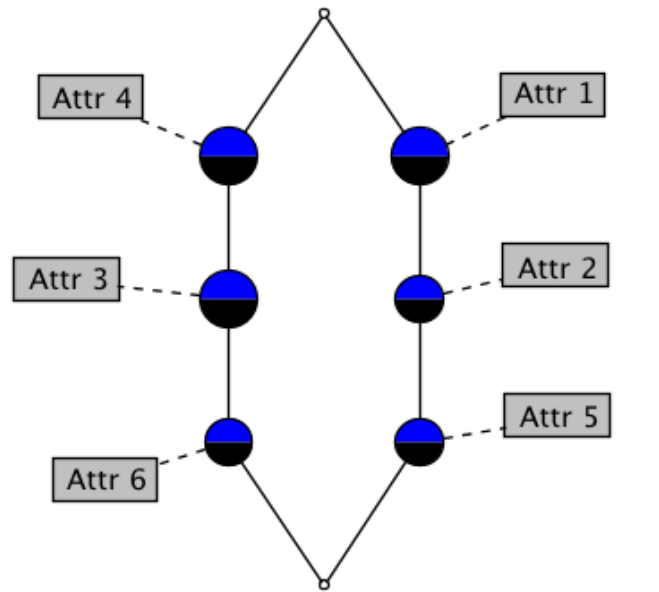


$$DR(C2, C3) \rightarrow PO(C2, C3)$$

- DR means they are not related: no individuals in common.
- PO means that:
 - ,at least, 1 common object
 - ,at least, 1 object that only holds C2
 - and, at least, 1 object that only holds C3



DR(C2,C3) \rightarrow PO(C2,C3)



	A	B	C	D	E	F	G
	Attr 1	Attr 2	Attr 3	Attr 4	Attr 5	Attr 6	
Obj 1		X	X			X	
Obj 2		X					
Obj 3		X	X				
Obj 4		X					
Obj 5		X	X				
Obj 6		X					
Obj 7		X					
Obj 8							
Obj 9					X		
Obj 10					X		
Obj 11				X	X		
Obj 12				X	X		
Obj 13				X	X		
Obj 14				X	X		
Obj 15				X	X		X
Obj 16				X	X		X

	Attr 1	Attr 2	Attr 3	Attr 4	Attr 5	Attr 6
Obj 1	X	X			X	
Obj 2	X	X				
Obj 3	X	X				
Obj 4	X	X				
Obj 5	X					
Obj 6	X					
Obj 7	X					
Obj 8				X		
Obj 9				X		
Obj 10				X		
Obj 11			X	X		
Obj 12			X	X		
Obj 13			X	X		
Obj 14			X	X		
Obj 15			X	X		X
Obj 16	X	X	X	X		X

$DR(C2, C3) \rightarrow PO(C2, C3)$

- Automatic repairing:
 - Insert a new “object” which holds all the attributes of both concepts.
 - Optional: we can suggest a new tag, only for this object.
 - Disadvantages: BIG POPULATION of individuals

Conclusions

- We have a **framework** to **DEBUG** knowledge
 - Extendable
- It is intended for **non-expert** users.
 - Spatial reasoning
 - Visual interface
- It is (somehow) **formal**
- It is a first step to **automatic** repairing theories.



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