Jobbers, sentient buildings and lions

A short walk into Robin Milner's tower

Jean Krivine
PPS lab. CNRS & Univ. Paris Diderot

Concurrency

* PhD «Reversible process algebra» at INRIA (sup. JJL, 2006)
* Transactional systems, distributed transactions, self assembly
* Formal methods in systems biology (Danos, Fontana)
* Bigraph theory, stochastic semantics (Milner)

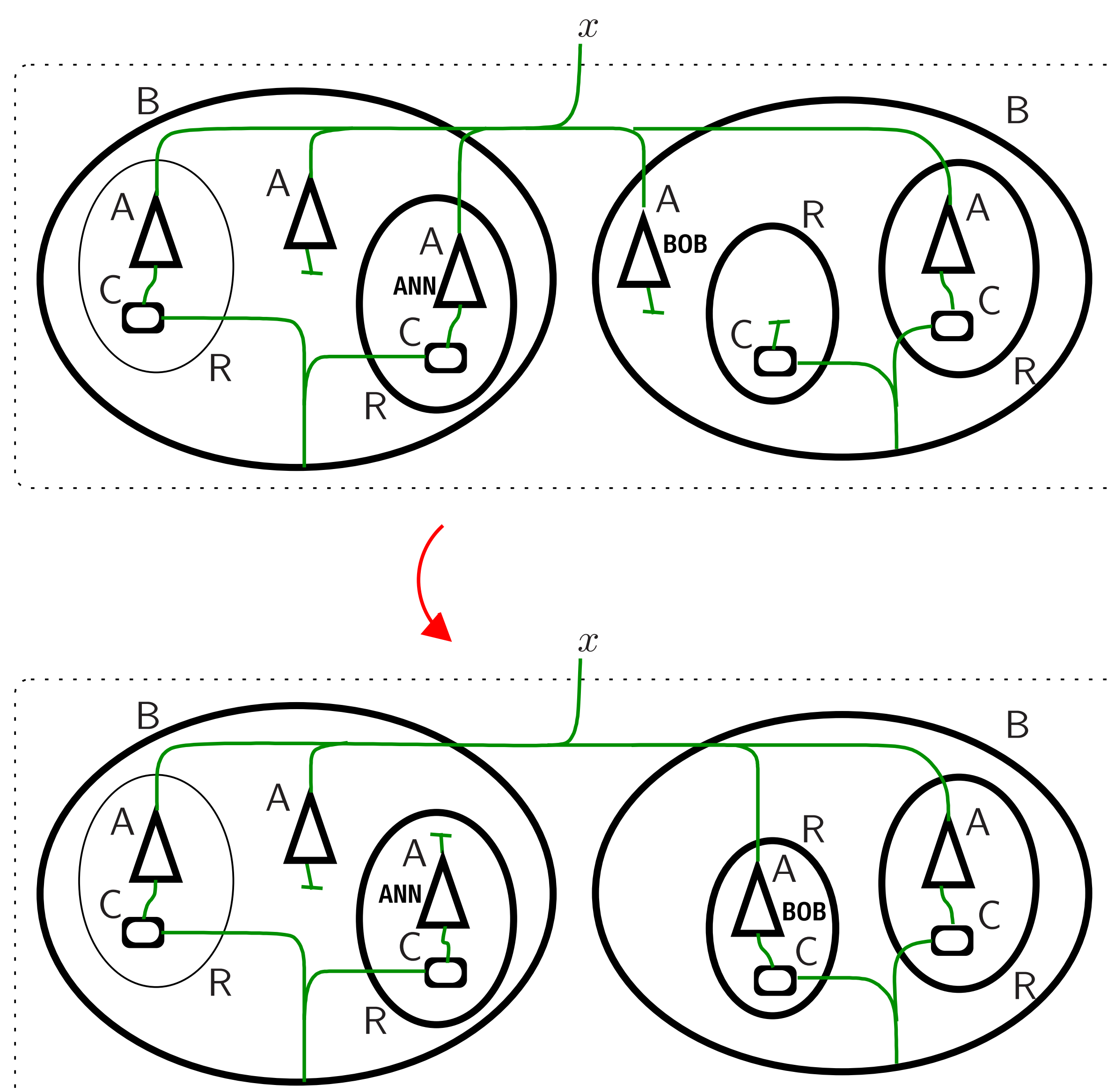
Meeting a great scientist

Someone to employ, please?

Someone to employ, please?

An example

Here is a example, describing a simple interaction discipline that models *sentient buildings* —buildings whose infrastructure of sensors and computers assists the performance of human occupants.



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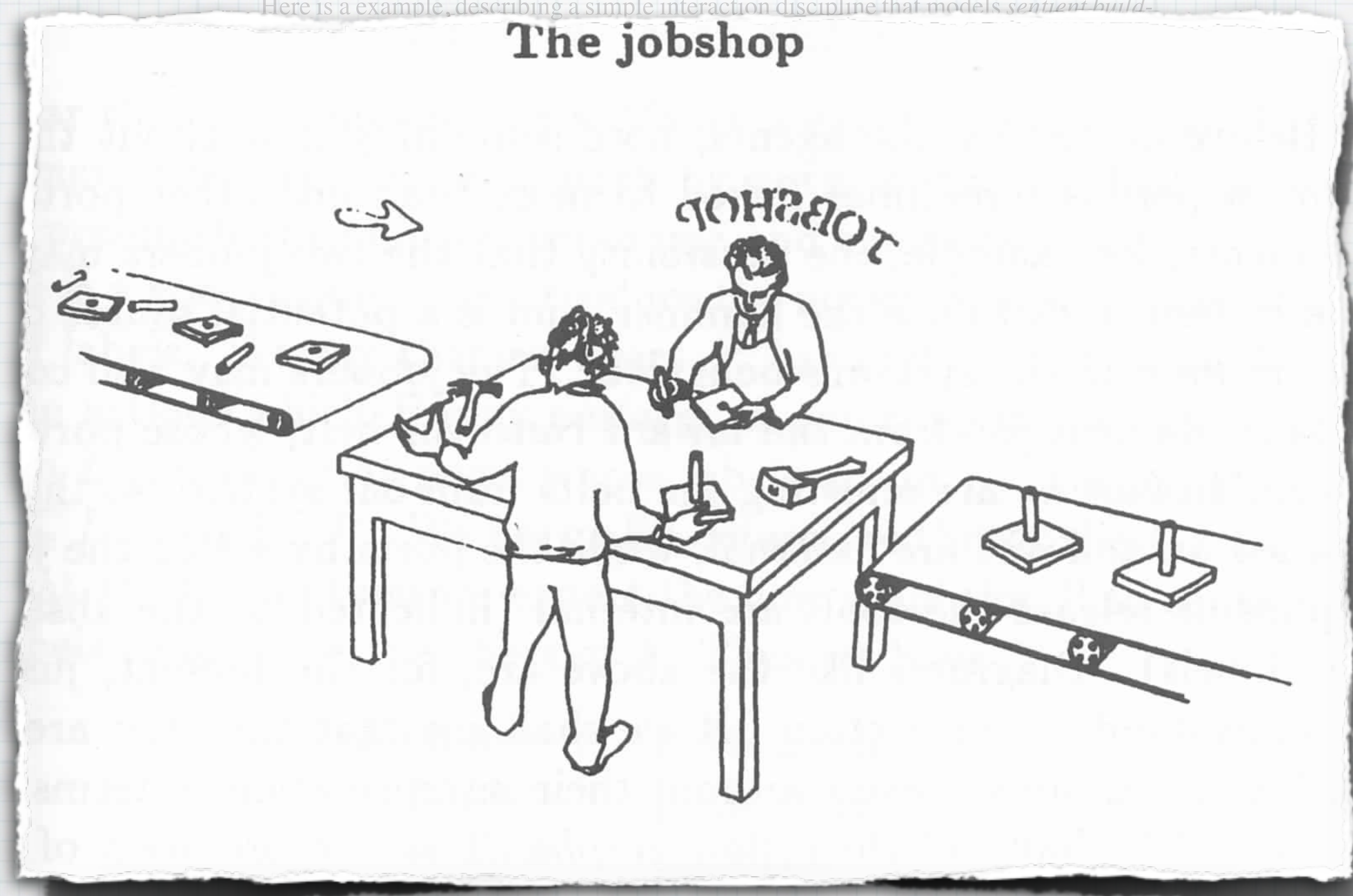

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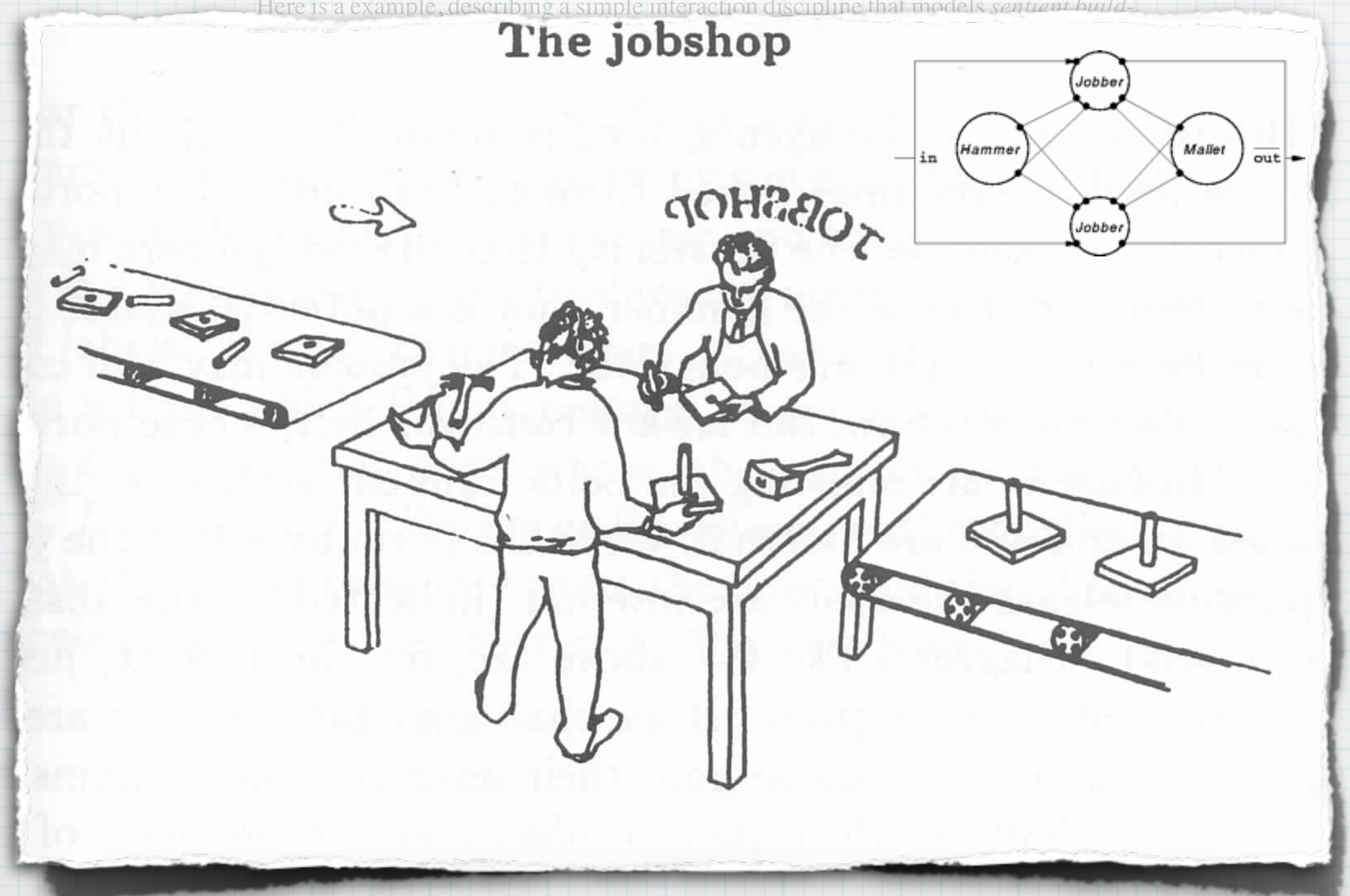

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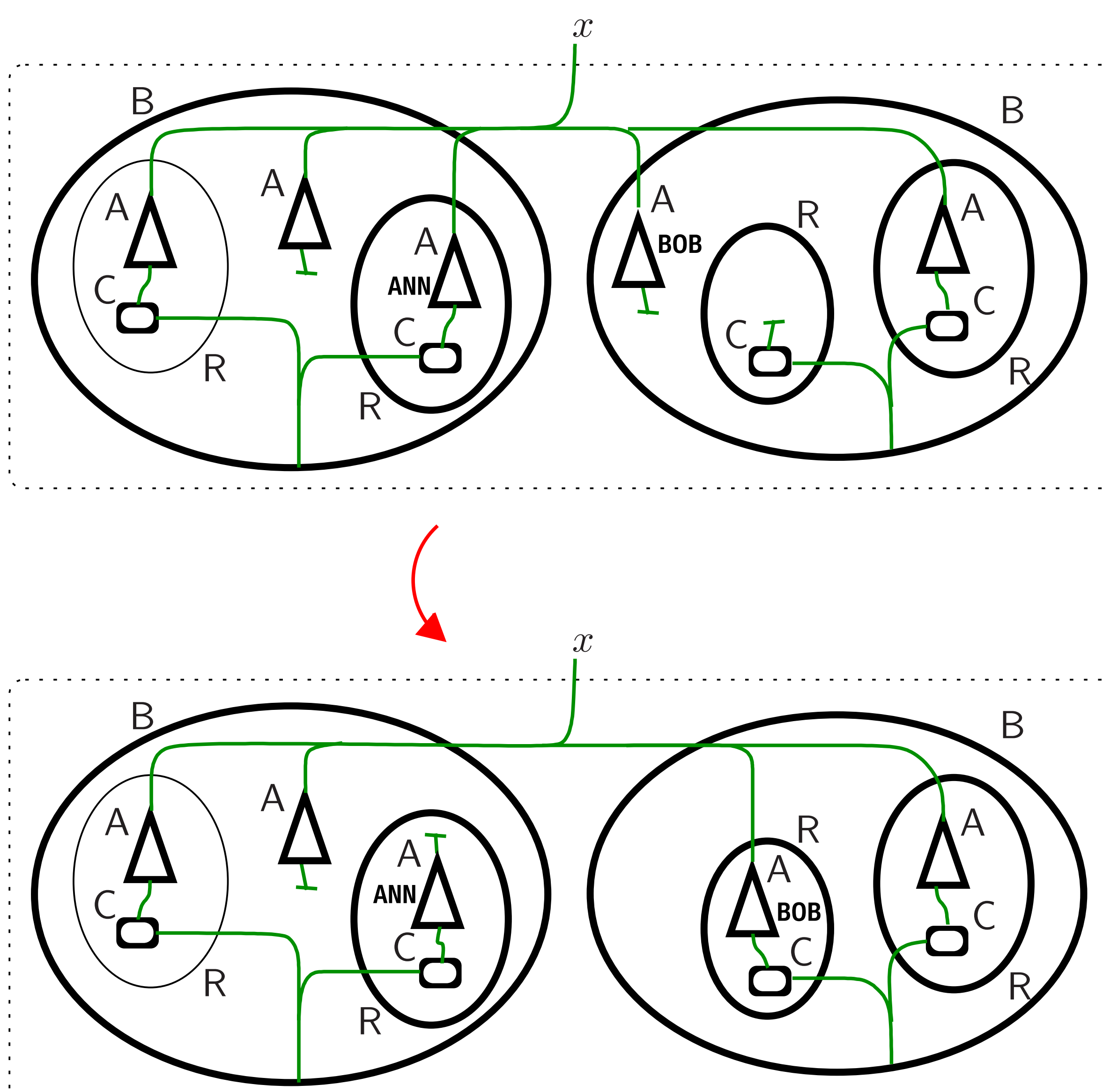

Robin Milner

Robin Milner

Comprehension axiom

Robin always understands what you say

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Explains the gradient of interest:

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«I don't understand»

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... why we are still talking about this

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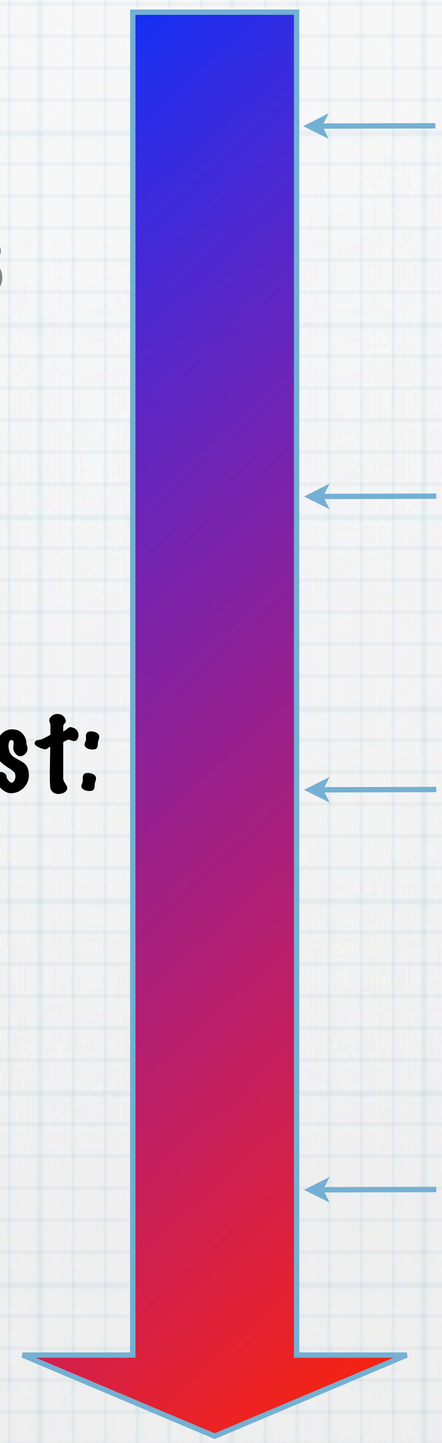

«I don't understand»

... why we are still talking about this

«That's fascinating»

«This is interesting»

Eyebrow scratching

Contribution

* Stochastic semantics for bigraphs (w Angelo Troina, Turin Univ.)
* BRS generators and application to systems biology
* (Beginning of an) abstract machine

Small contribution, but learned a lot...

A tower against the jungle

Someone to employ, please?

Finally, bigraphs represent the abstract as well as the concrete. For example, there is a BRS representing the π-caclulus and another representing Mobile Ambients. By combining the abstract with the concrete we can, for example, describe both the physical and the informatic activity in a building.

Tower of informatic models

Consider also a model of humans interacting with a computer; the model of the human components may involve human attributes such as belief or sensation, as distinct from the way the computer is described. These two examples show the need not only to combine informatic models, but to combine them with others that are not informatic.

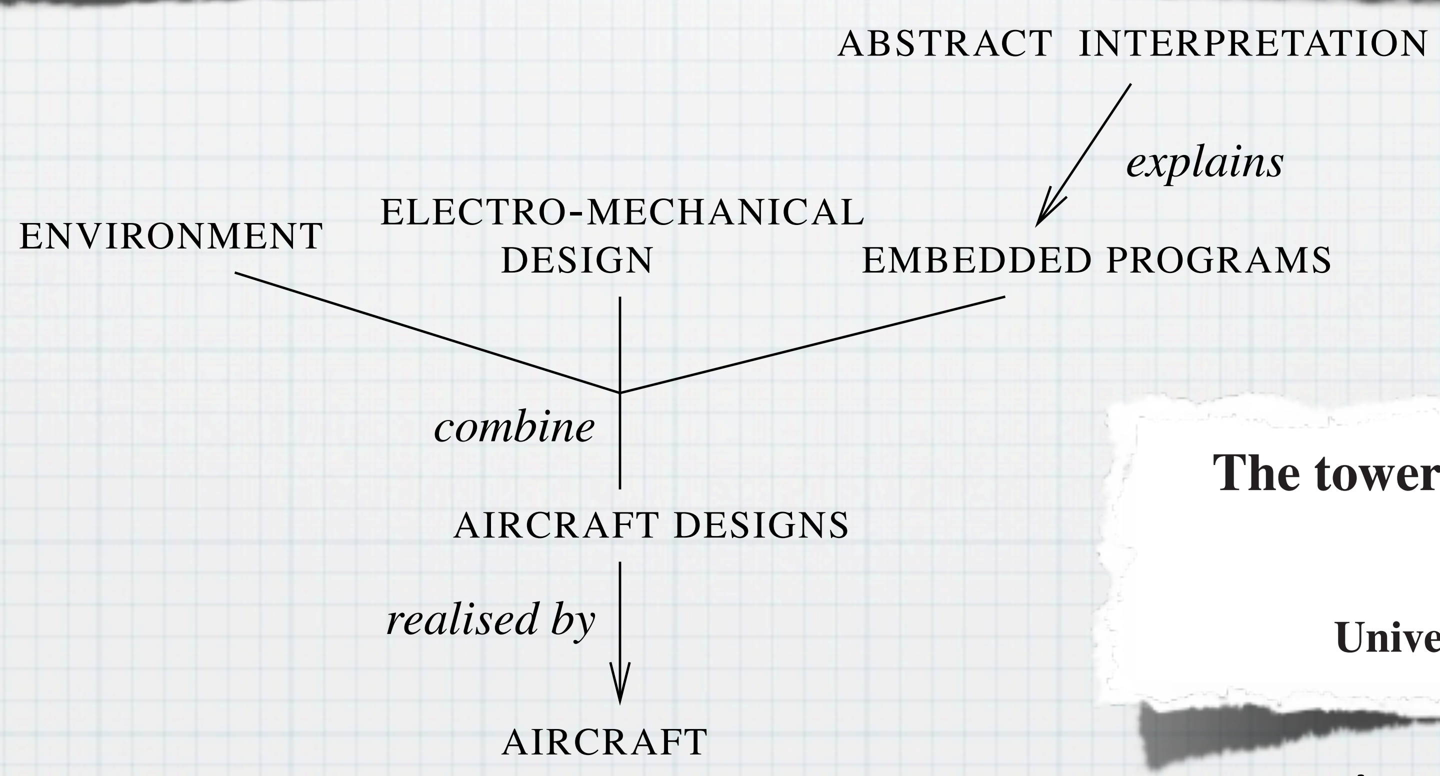

Figure 4: A simplified model tower for aircraft construction

The tower of informatic models

Robin Milner

University of Cambridge

in memory of Gilles Kahn, 2009

In Milner's Tower

Communication

Concurrency

Mobility

Space and motion

In Milner's Tower

Communication

combine

Concurrency

describes

Mobility

Distributed computation

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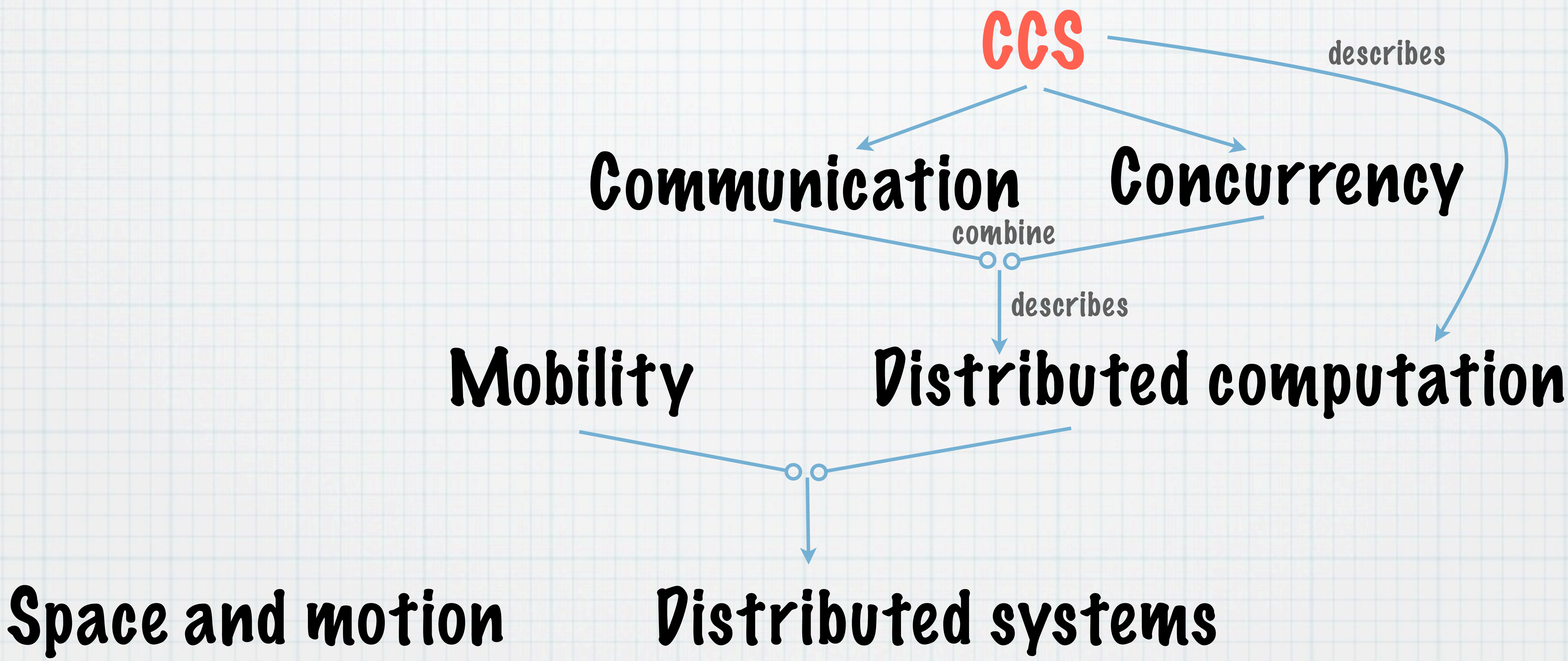

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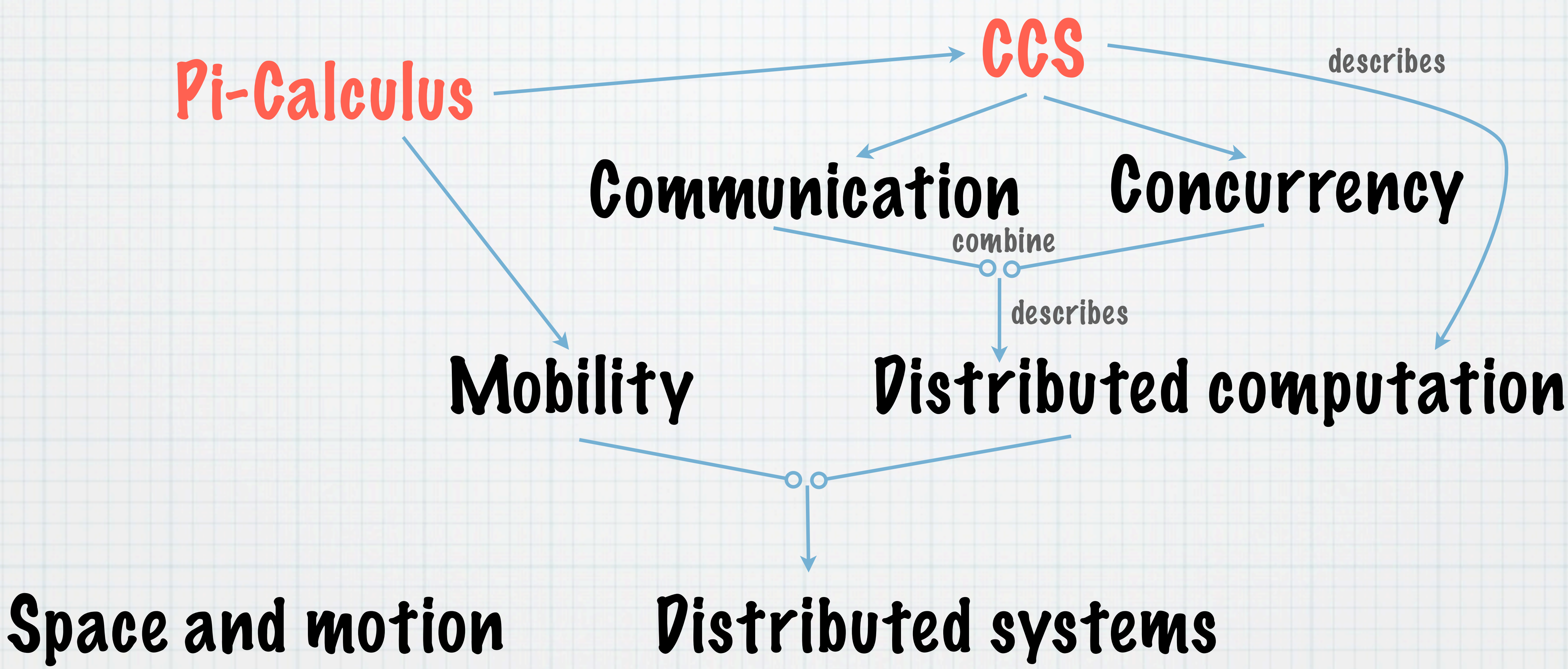

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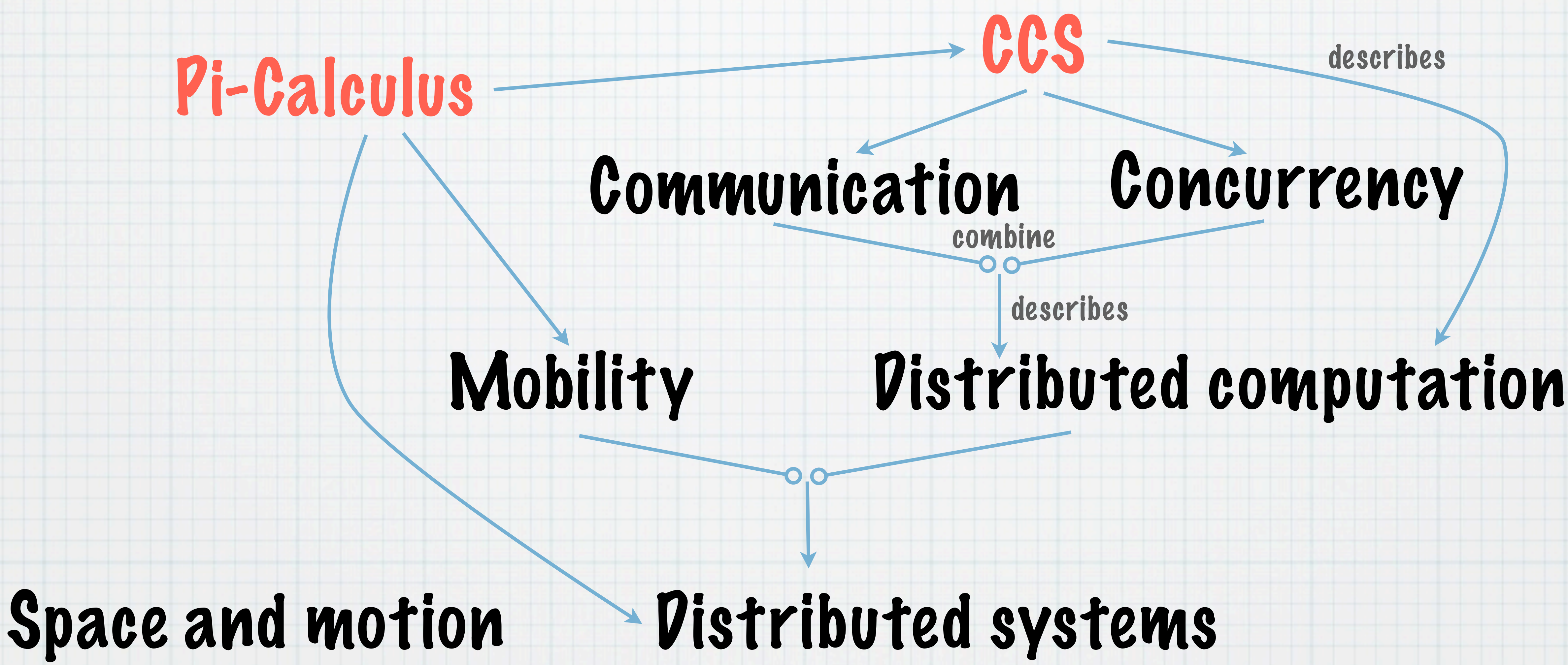

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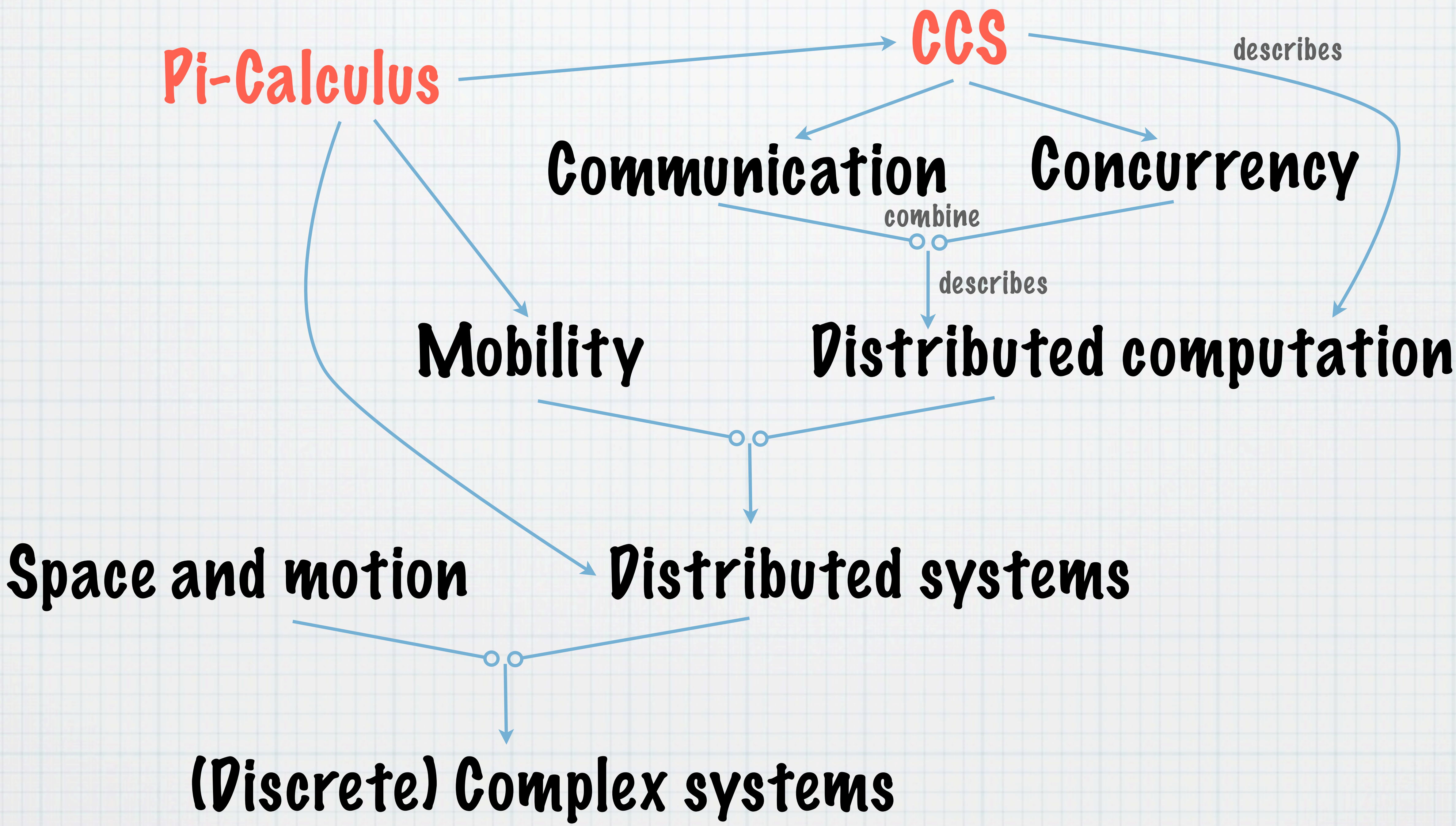

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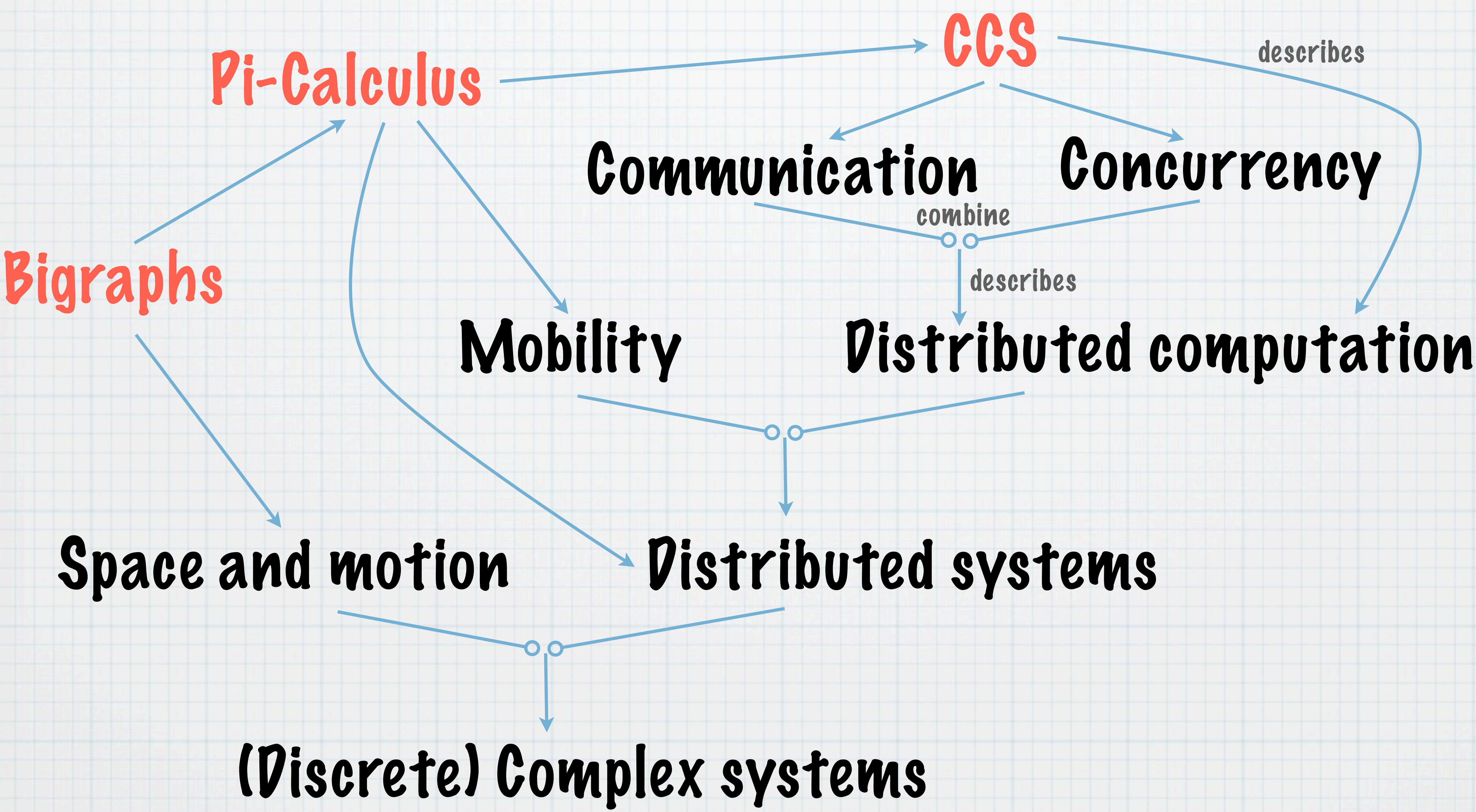
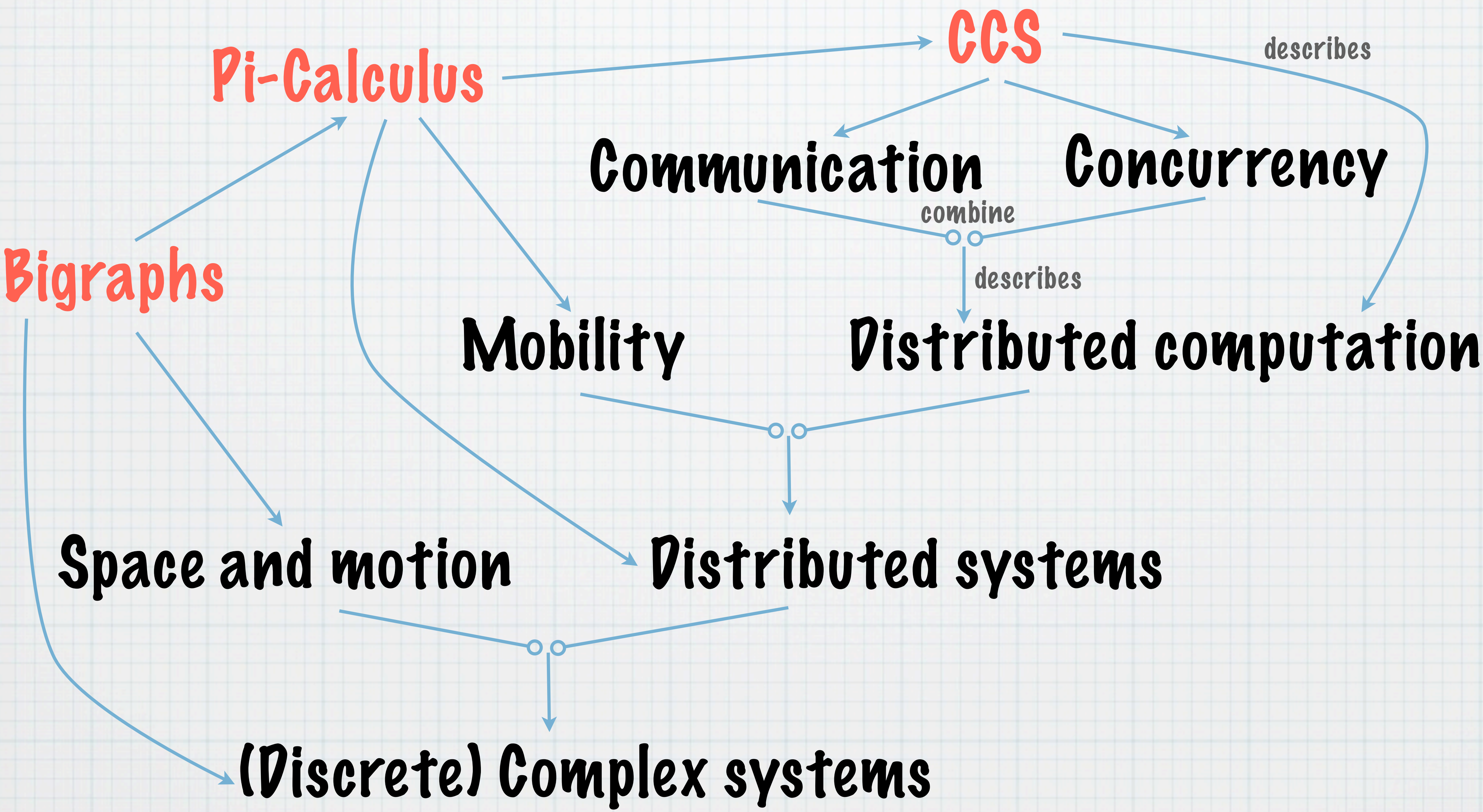


In Milner's Tower



Populating the tower

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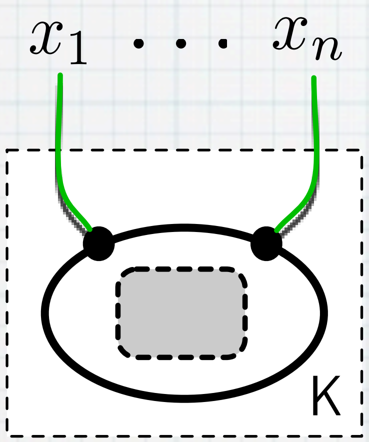
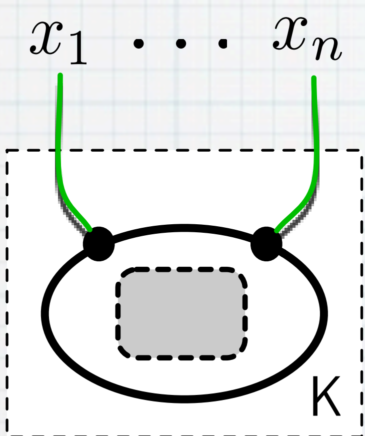


$$K_{\vec{x}}(\Box) : \langle \emptyset, 1 \rangle \longrightarrow \langle \{x_1, \ldots, x_n\}, 1 \rangle$$

Populating the tower



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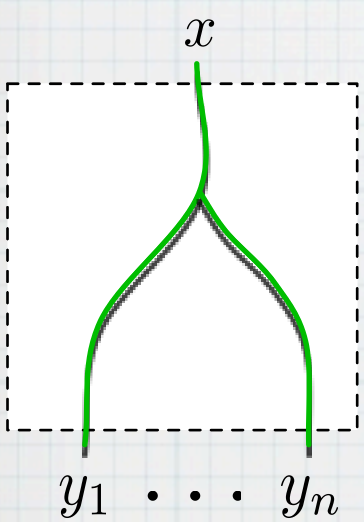
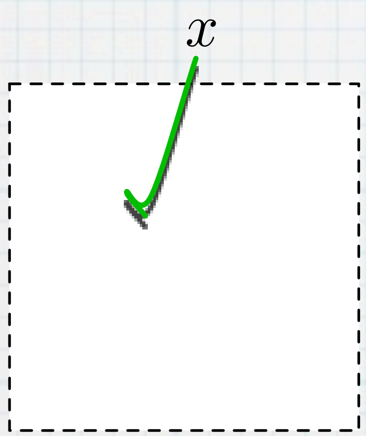
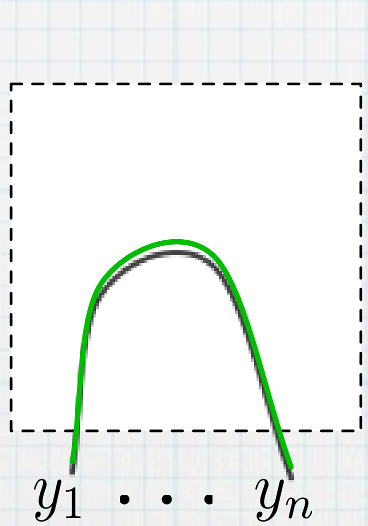


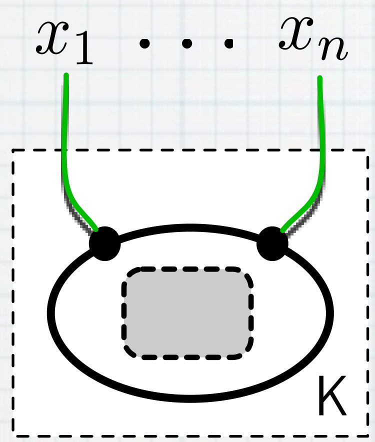




$$\backslash\vec{y} : \langle \{y_1, \ldots, y_n\}, 0\rangle \to \langle \emptyset, 1\rangle$$

$$x\backslash\vec{y} : \langle \{y_1, \ldots, y_n\}, 0\rangle \to \langle \{x\}, 1\rangle$$

Populating the tower



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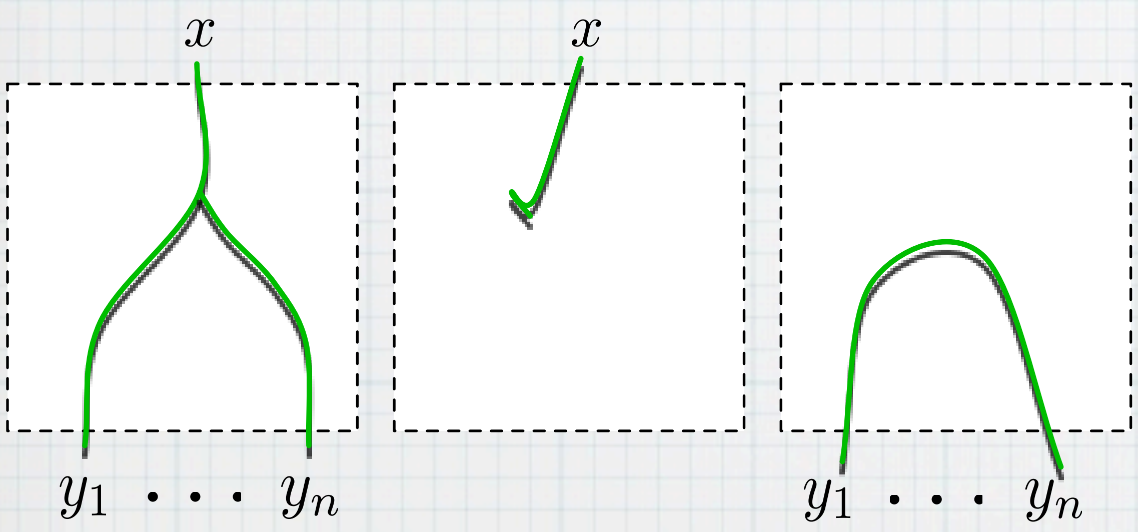

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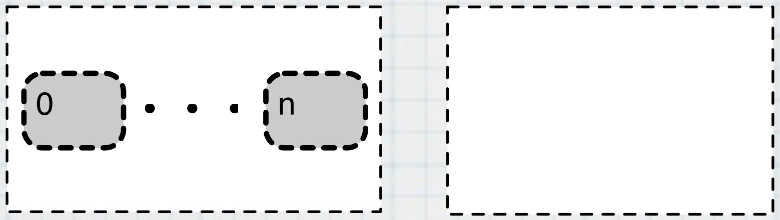
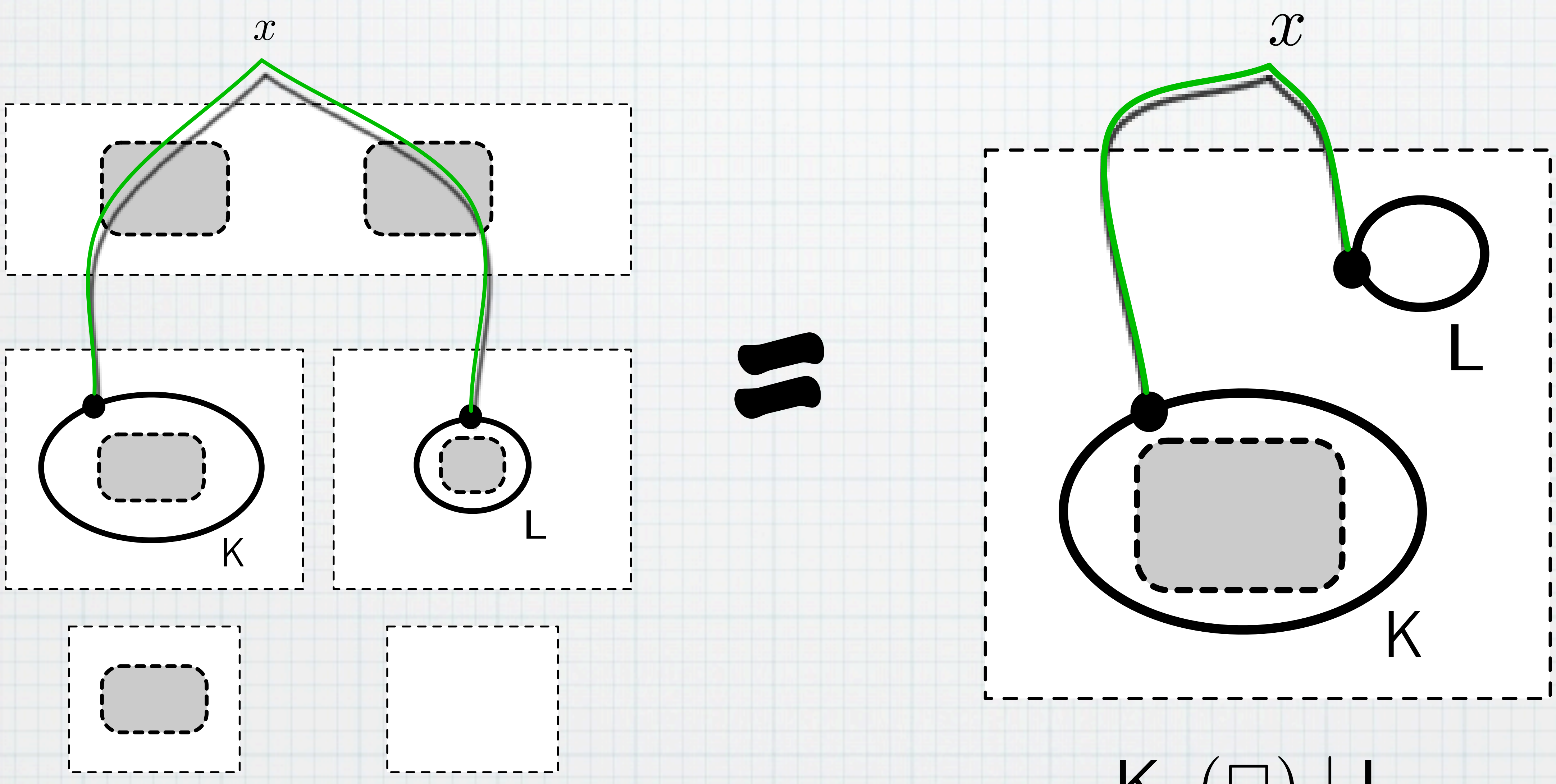


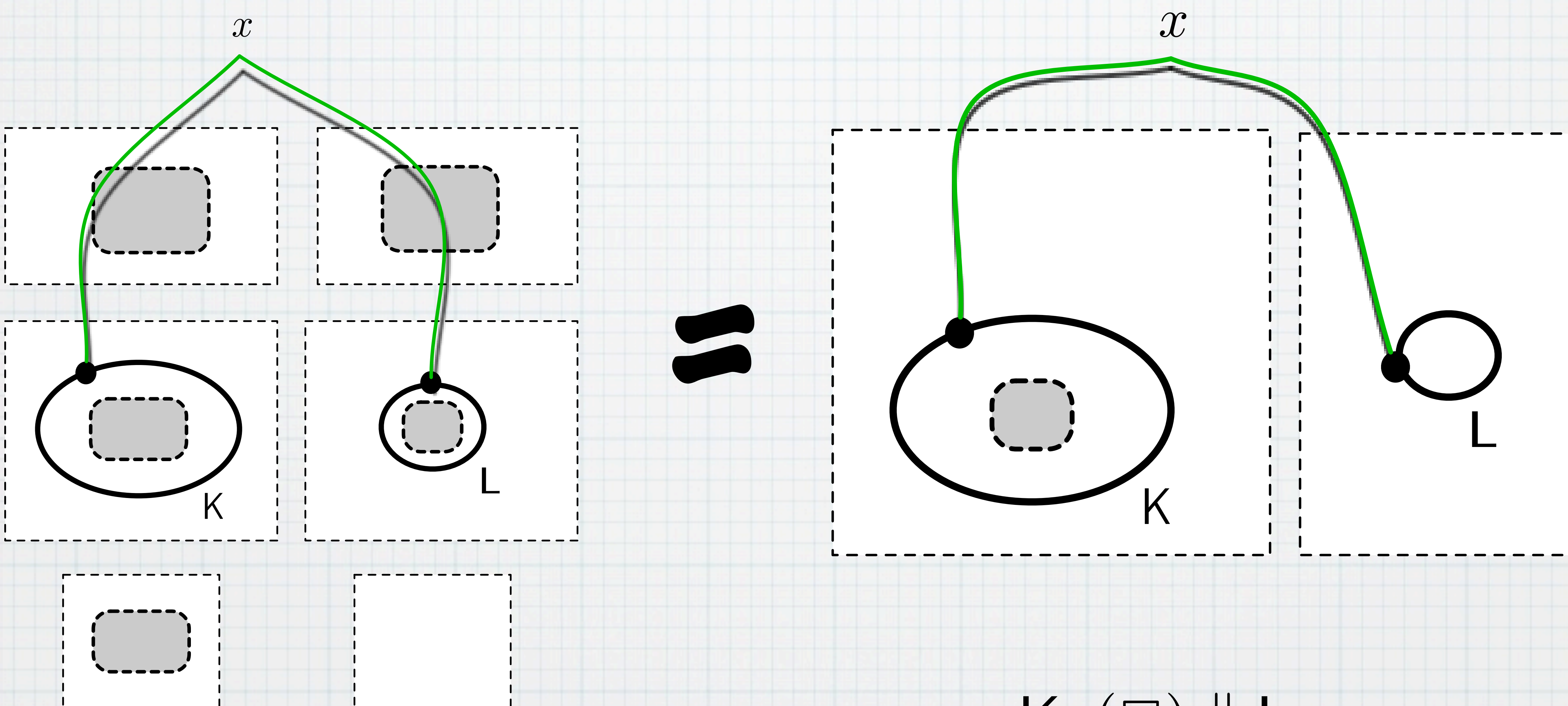
$$merge_n : \langle \emptyset, n \rangle \longrightarrow \langle \emptyset, 1 \rangle$$

Populating the tower



$K_x(\square) \mid L_x$

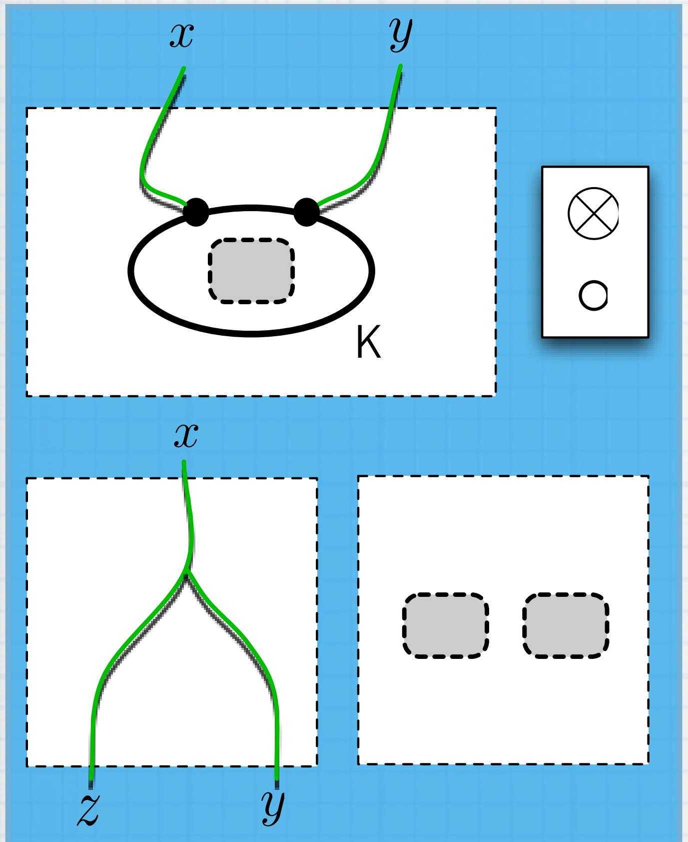
Populating the tower



$\mathsf{K}_x(\square) \parallel \mathsf{L}_x$

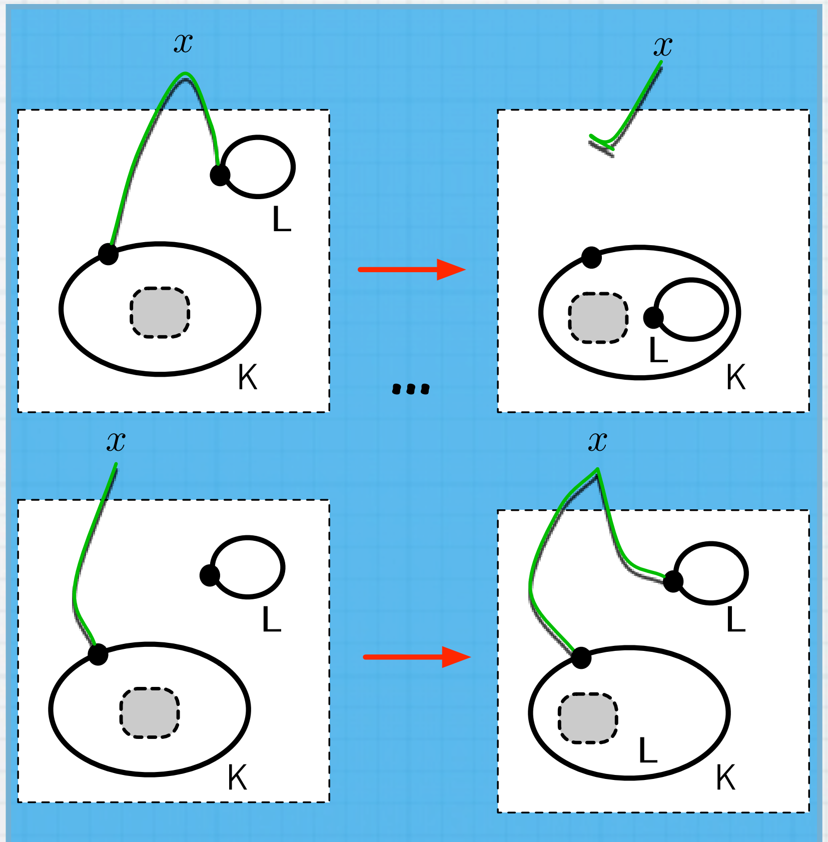
Populating the tower

Syntax



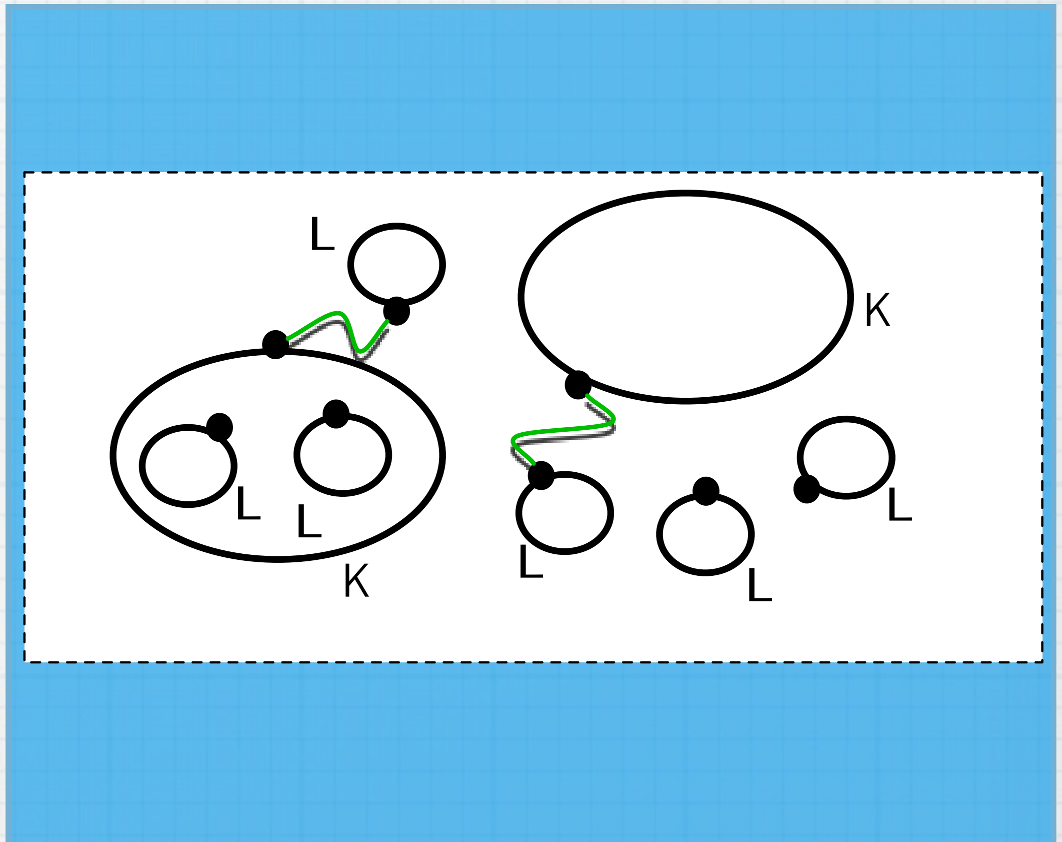
Bigraph toolbox

BRS



Rule set

Instance



Initial bigraph

Bigraphs are lego pieces...

that can be assembled to form a reactive system...

and applied on a particular initial bigraph.

Modeling the tea coffee machine... and the drinker

A simple tower: Hunting deers

Kids behaviors

Game of lions & deers

A simple tower: Hunting deers

Kids behaviors

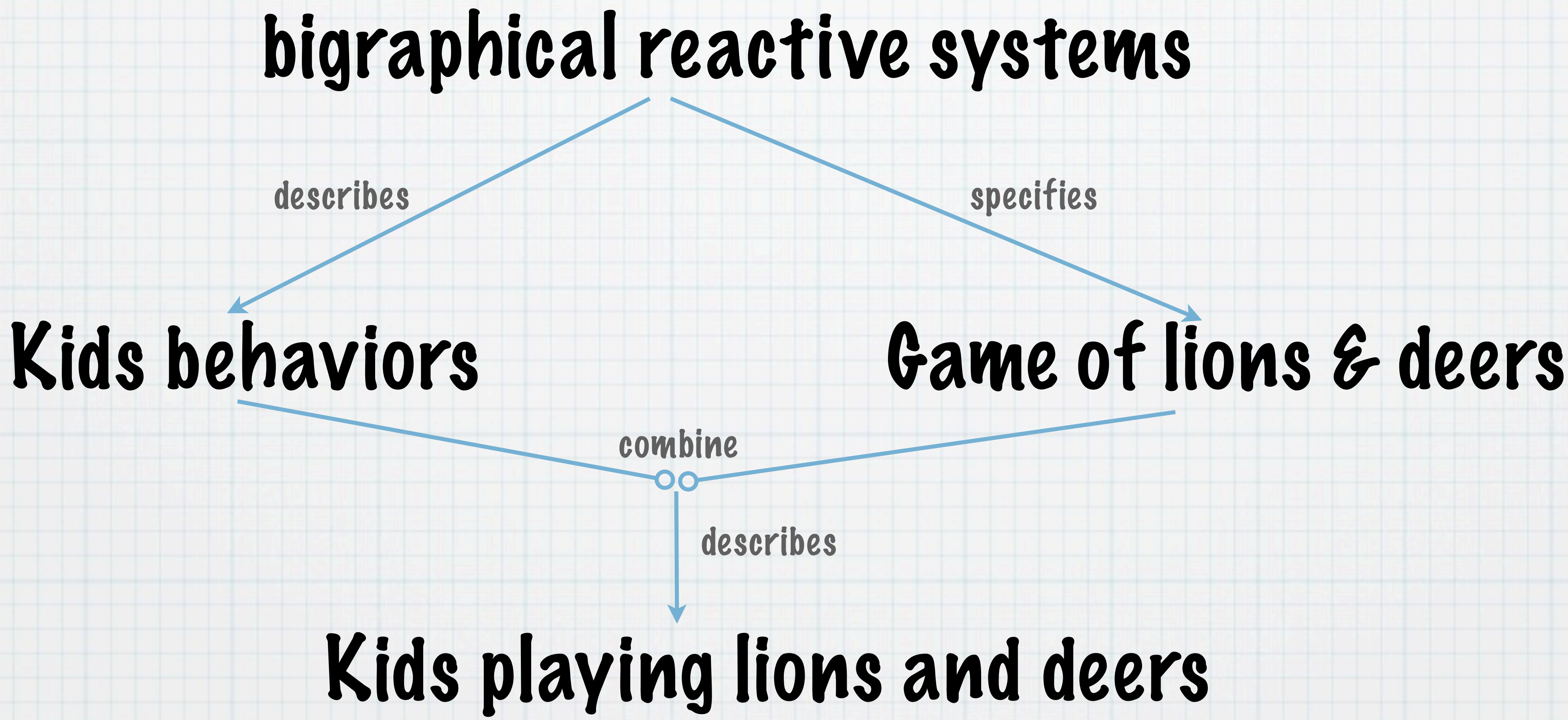
Game of lions & deers

combine

describes

Kids playing lions and deers

A simple tower: Hunting deers



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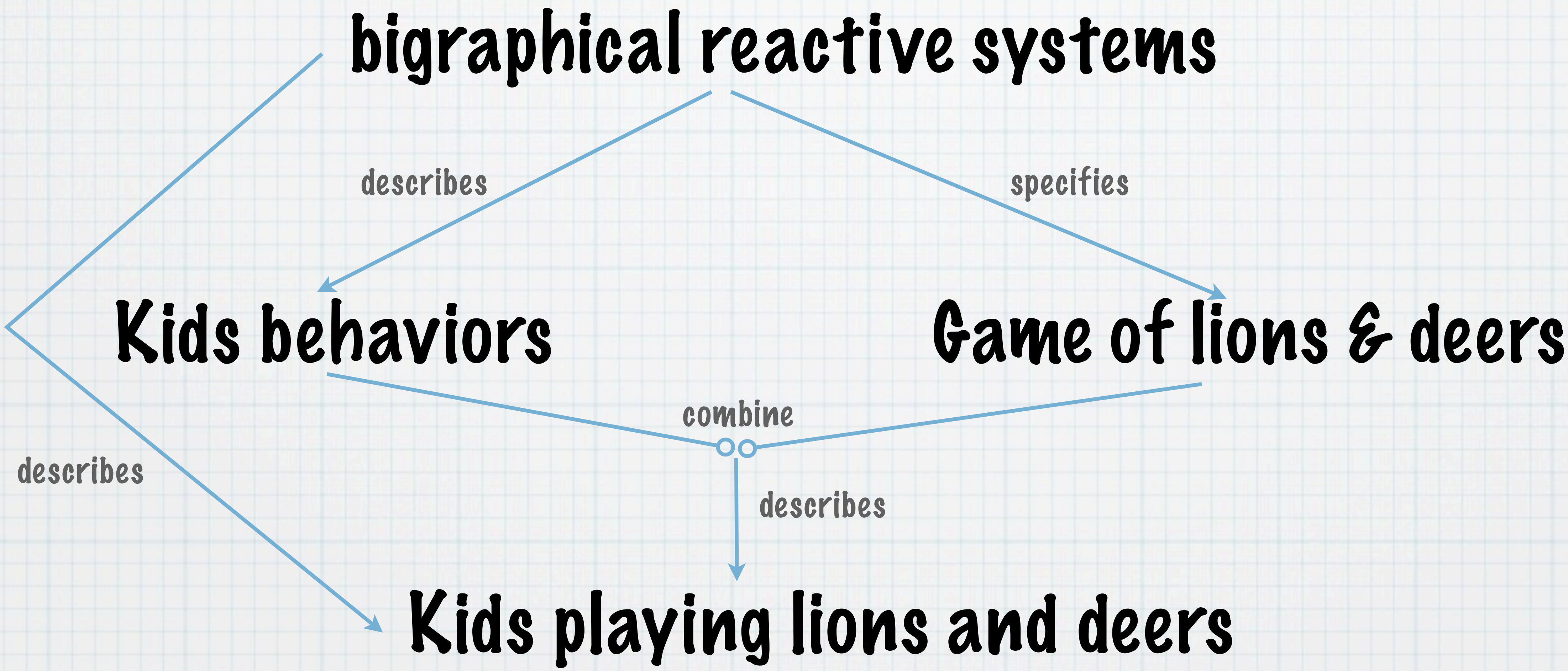

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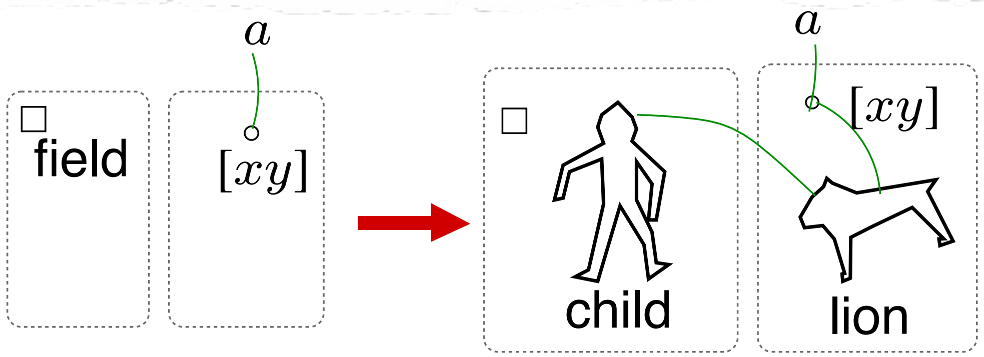
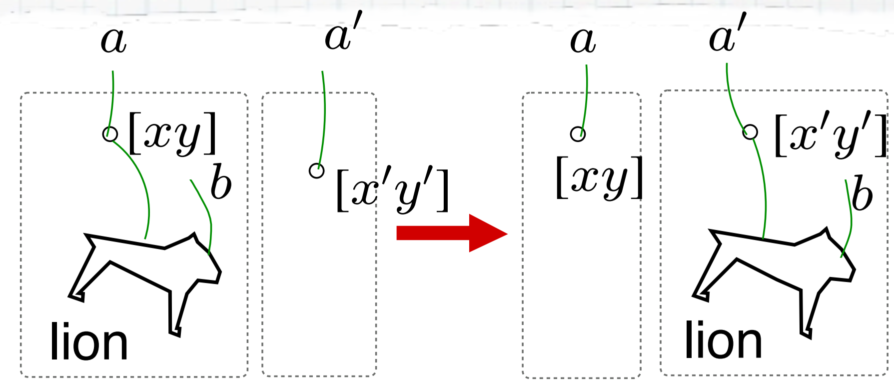
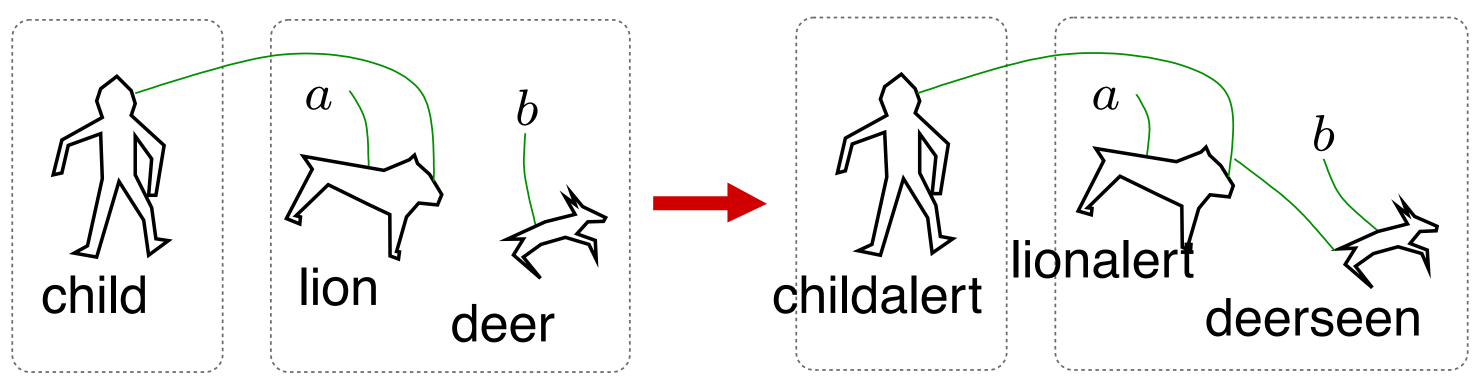




$(|x - x'| + |y - y'| = 1)$

A child/lion enters the game at spot $[xy]$ (similarly for a deer)

A virtual lion moves to another spot (similarly for a deer)



A child/lion becomes alert to a deer in its locale

$$/c\,(\mathsf{child}_c \parallel (\mathsf{lion}_{ac} \mid \mathsf{deer}_b)) \longrightarrow /c\,(\mathsf{childalert}_c \parallel (\mathsf{lionalert}_{ac} \mid \mathsf{deerseen}_{bc}))$$

Expertise issue

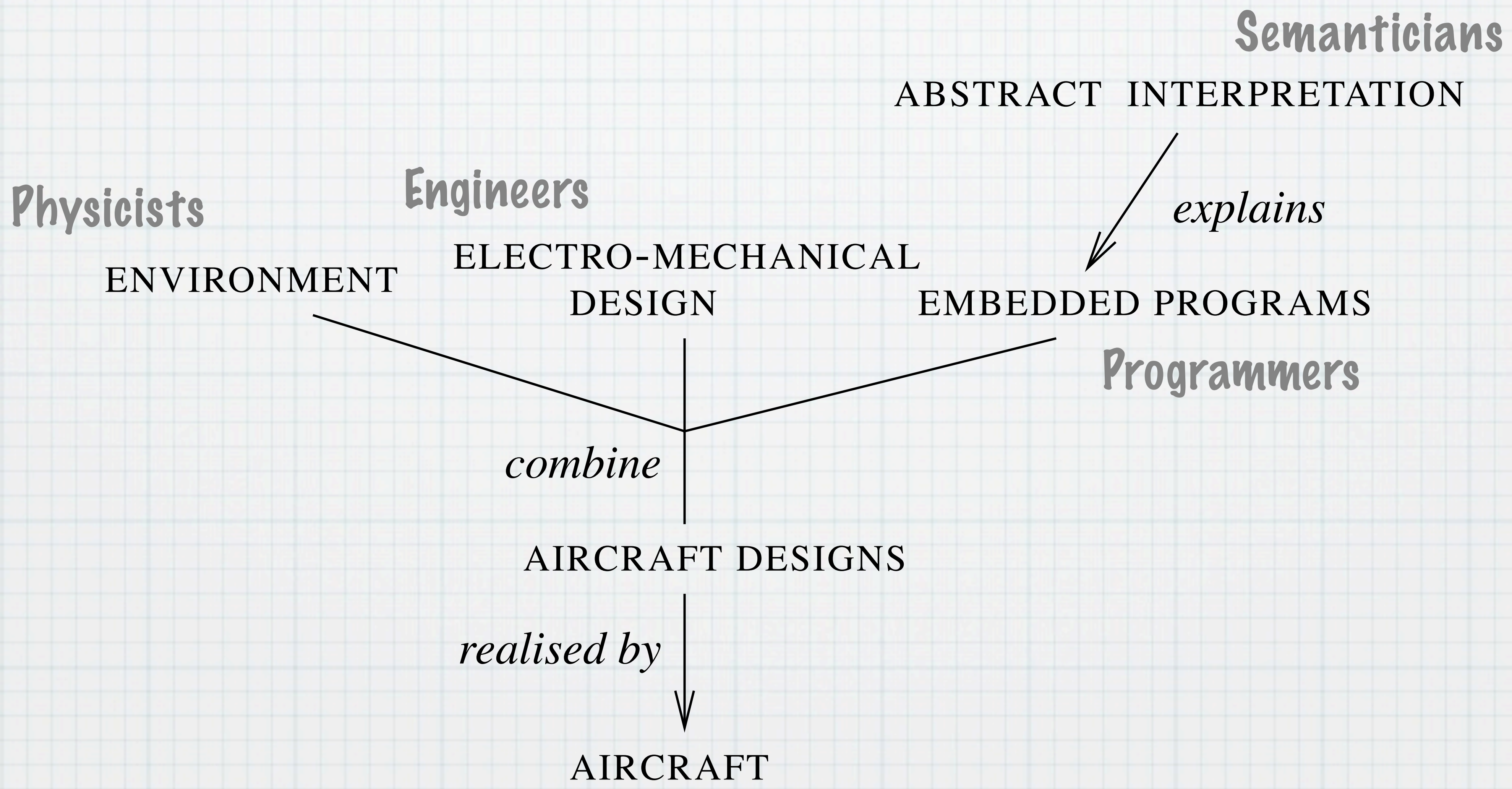


Figure 4: A simplified model tower for aircraft construction

Expertise issue

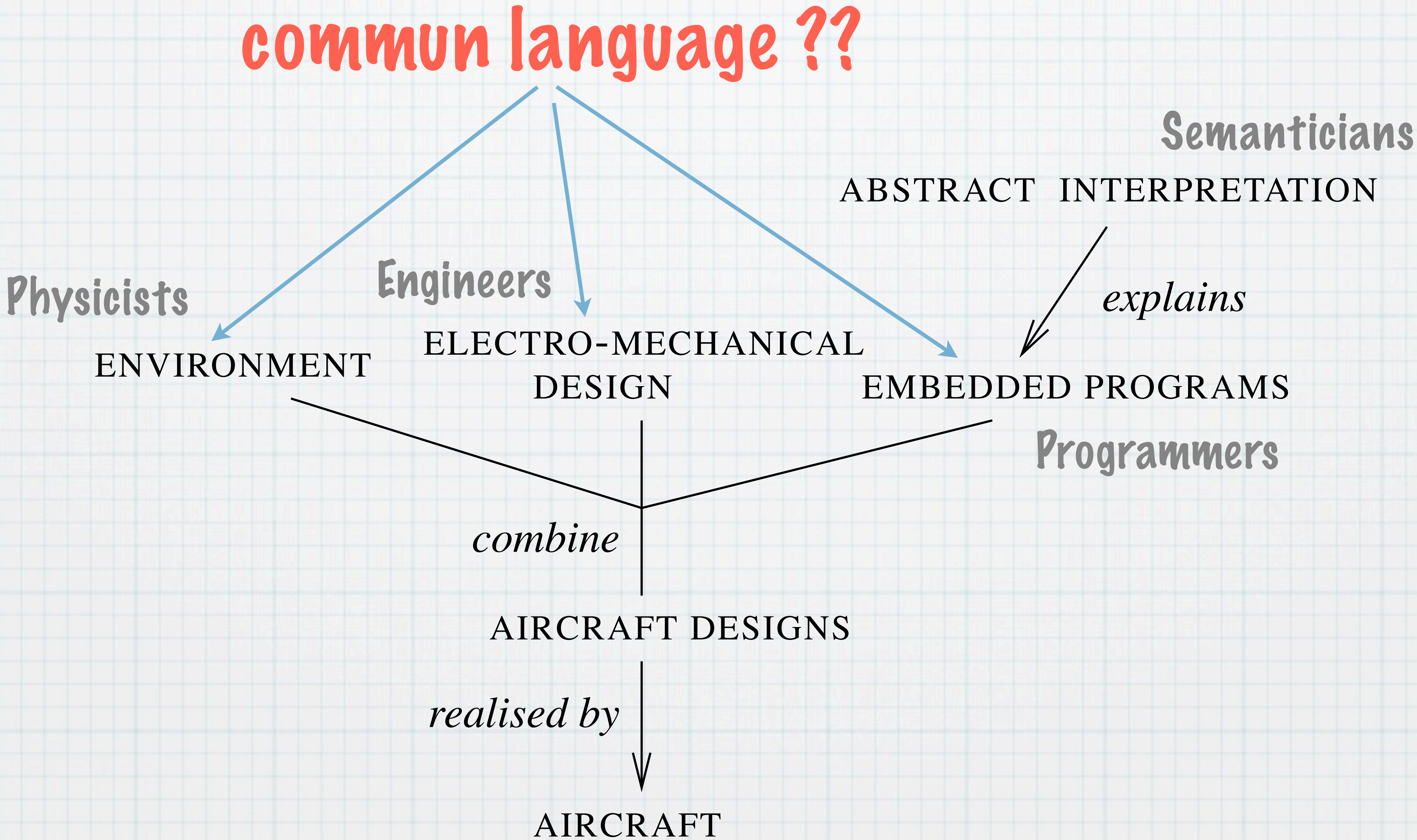
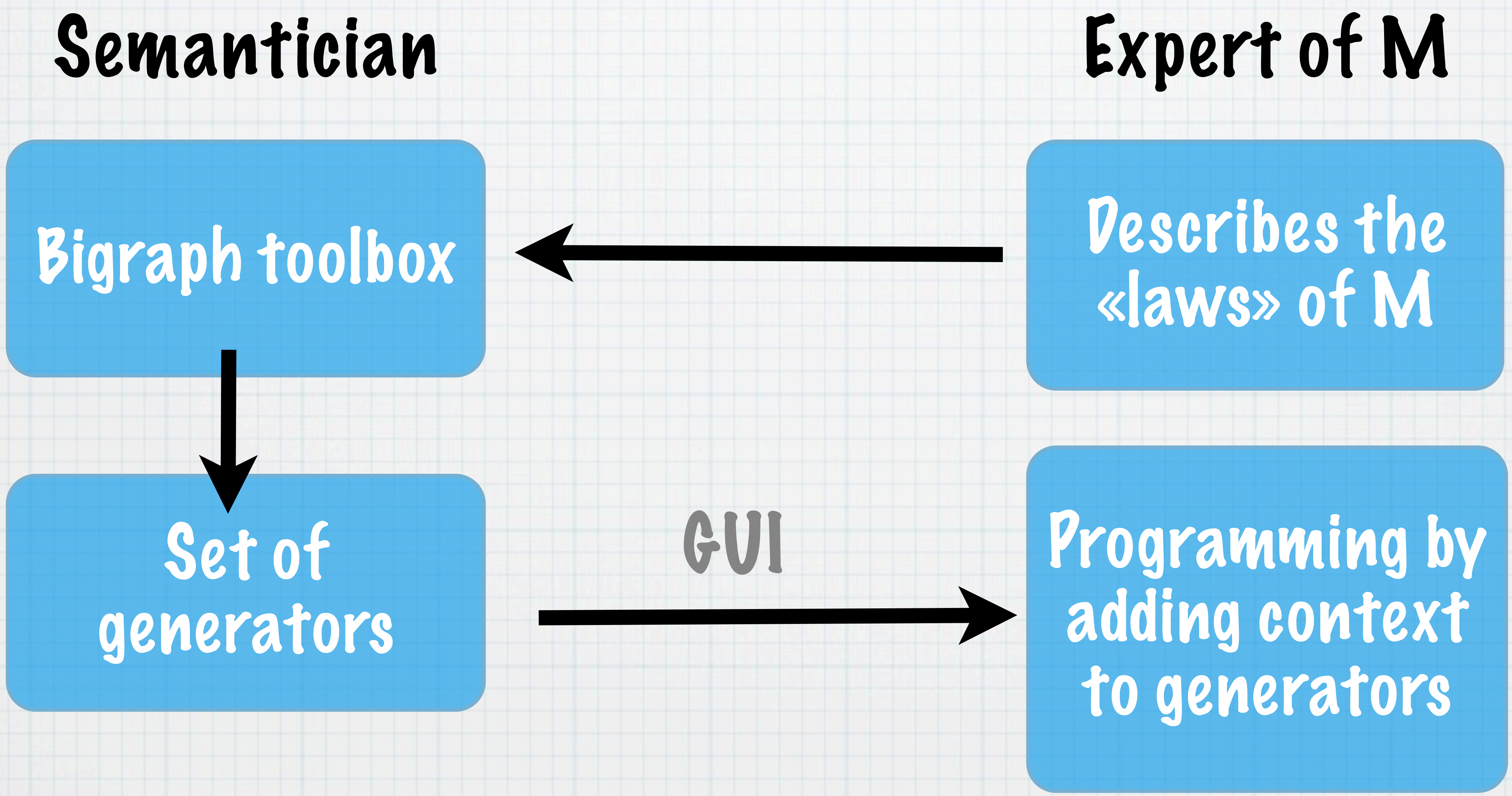


Figure 4: A simplified model tower for aircraft construction

Where should we be?



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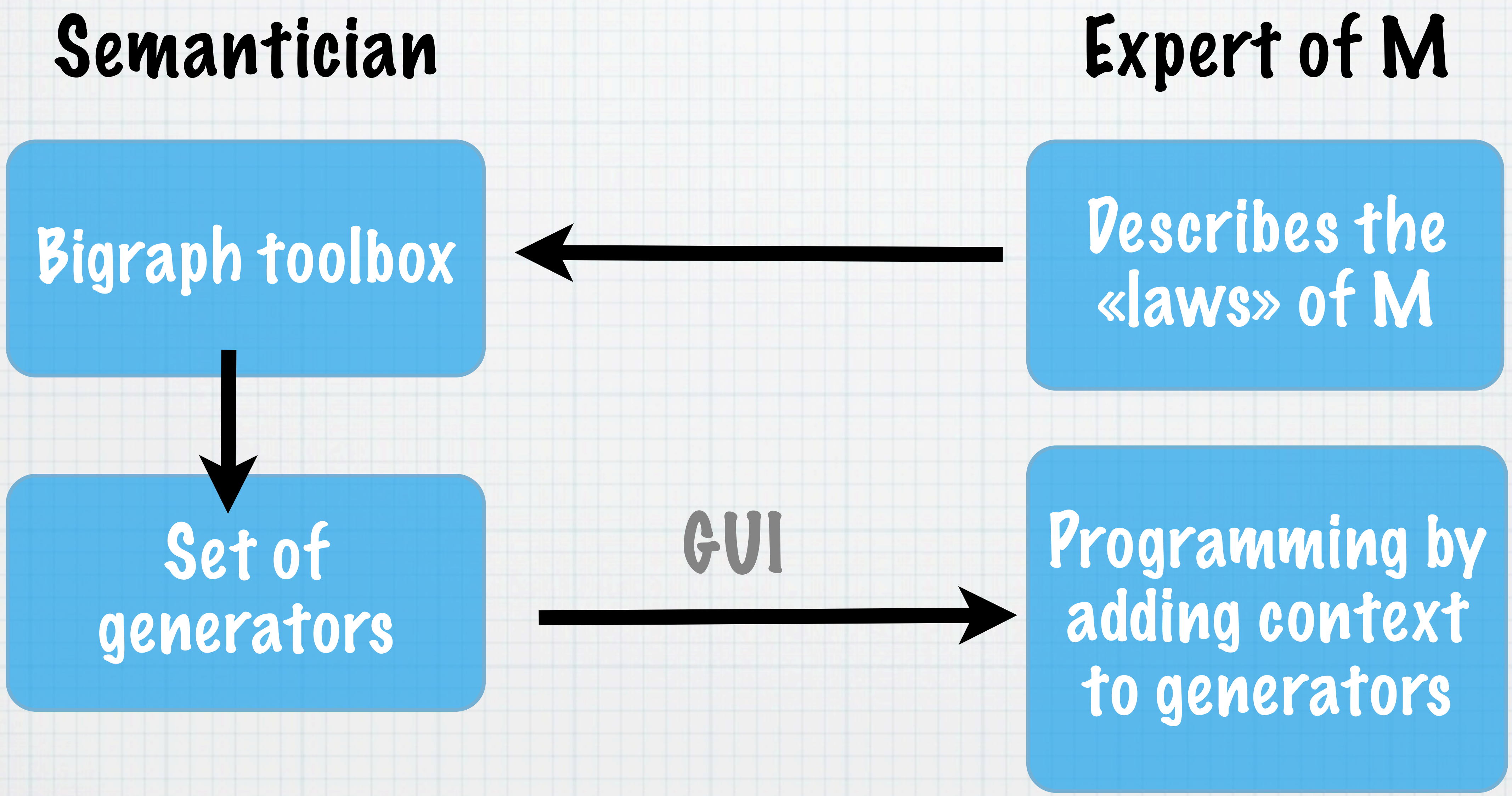


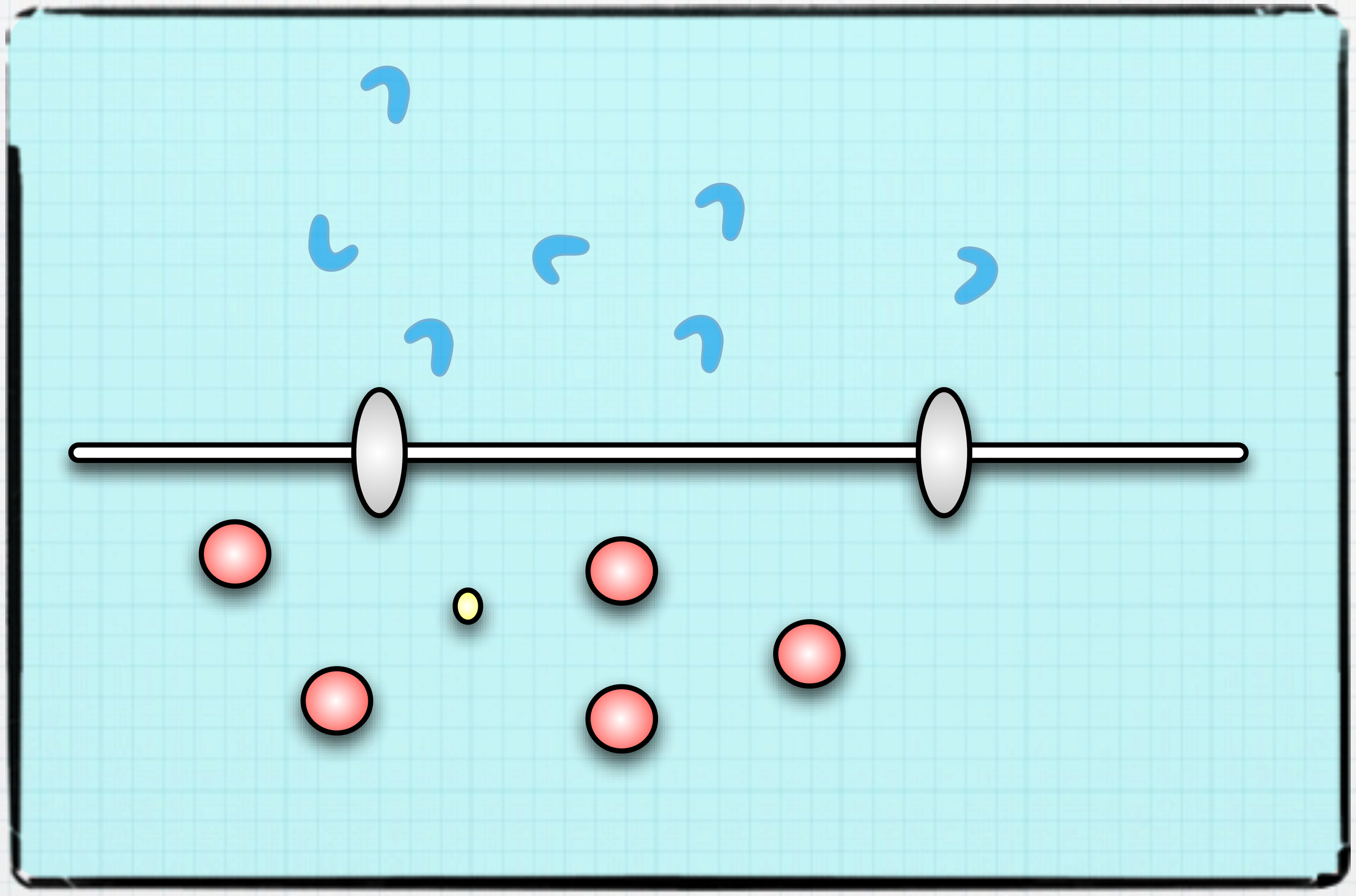
eyebrow scratching...

OK let me show you...

Laws

Can we provide a language that biologists can use describing these facts ?

Laws



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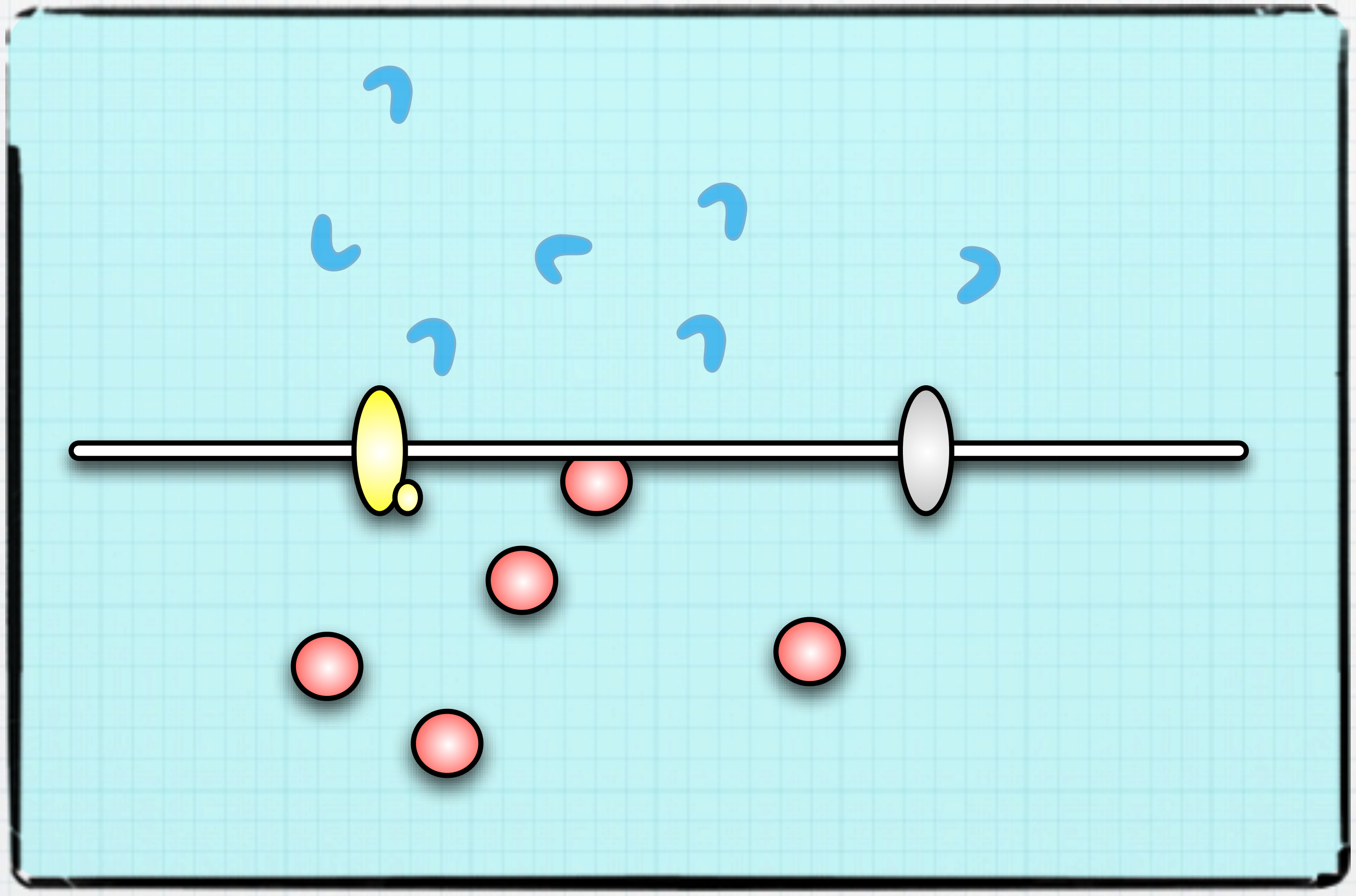
Laws



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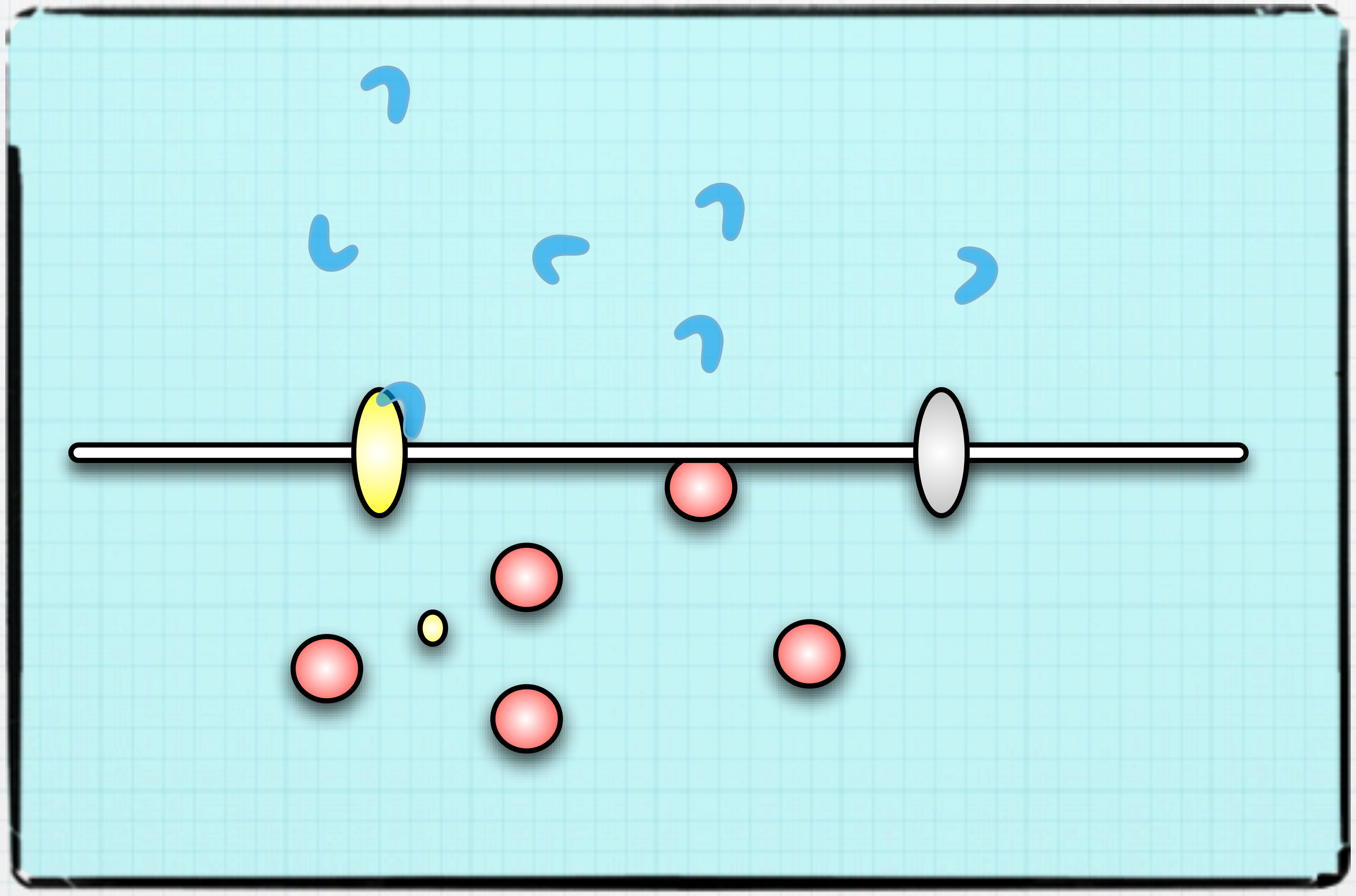

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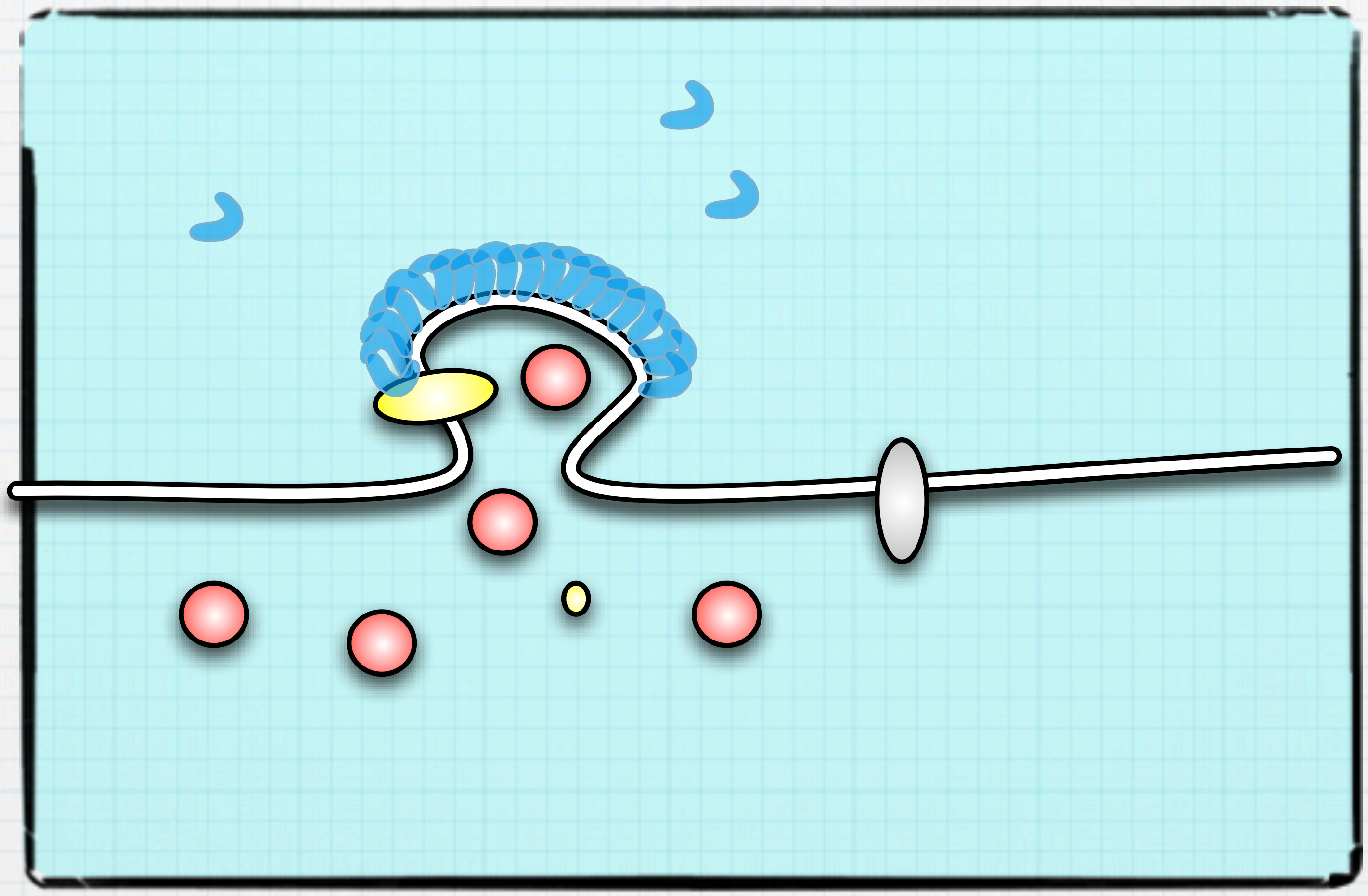

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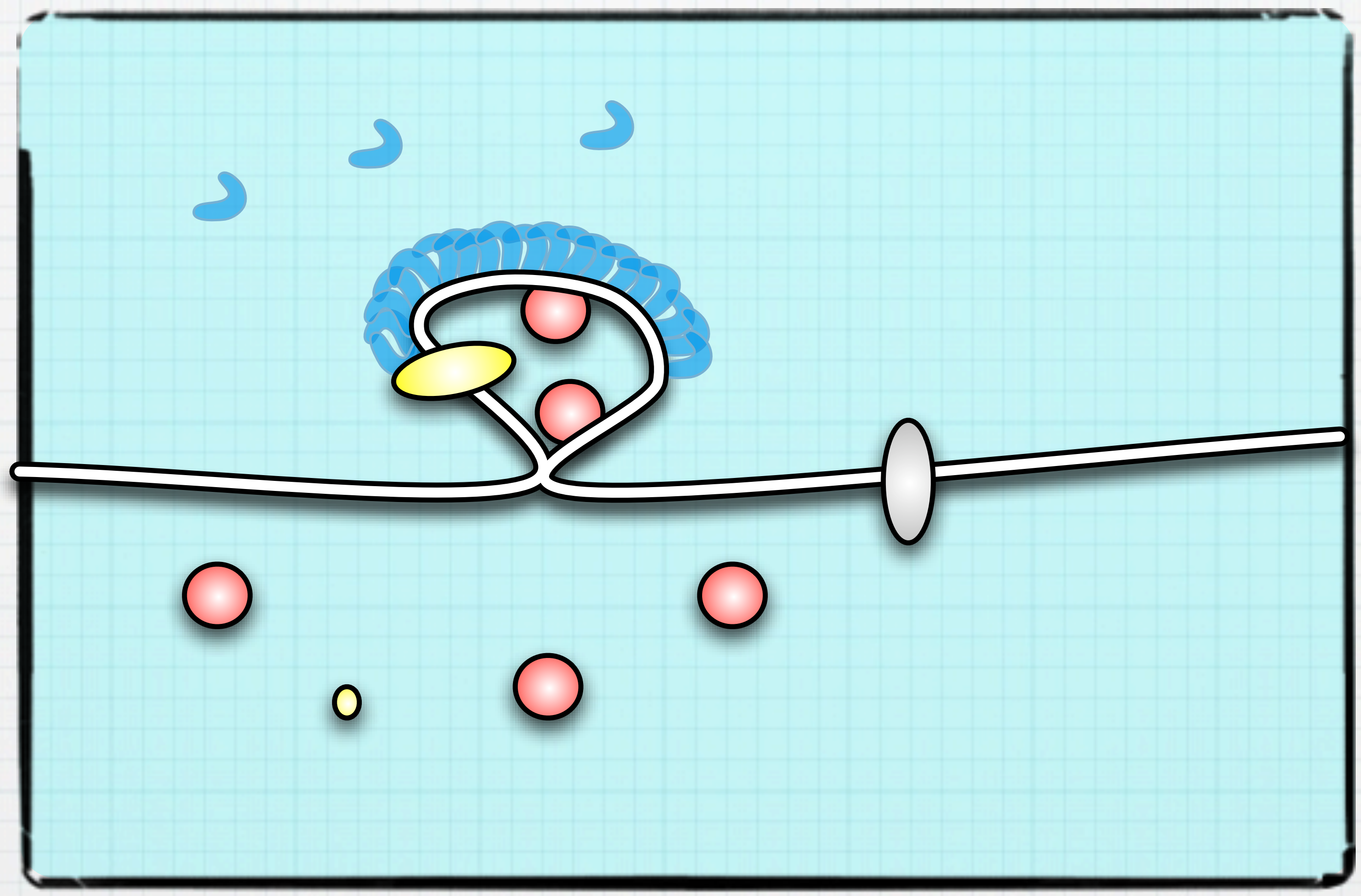

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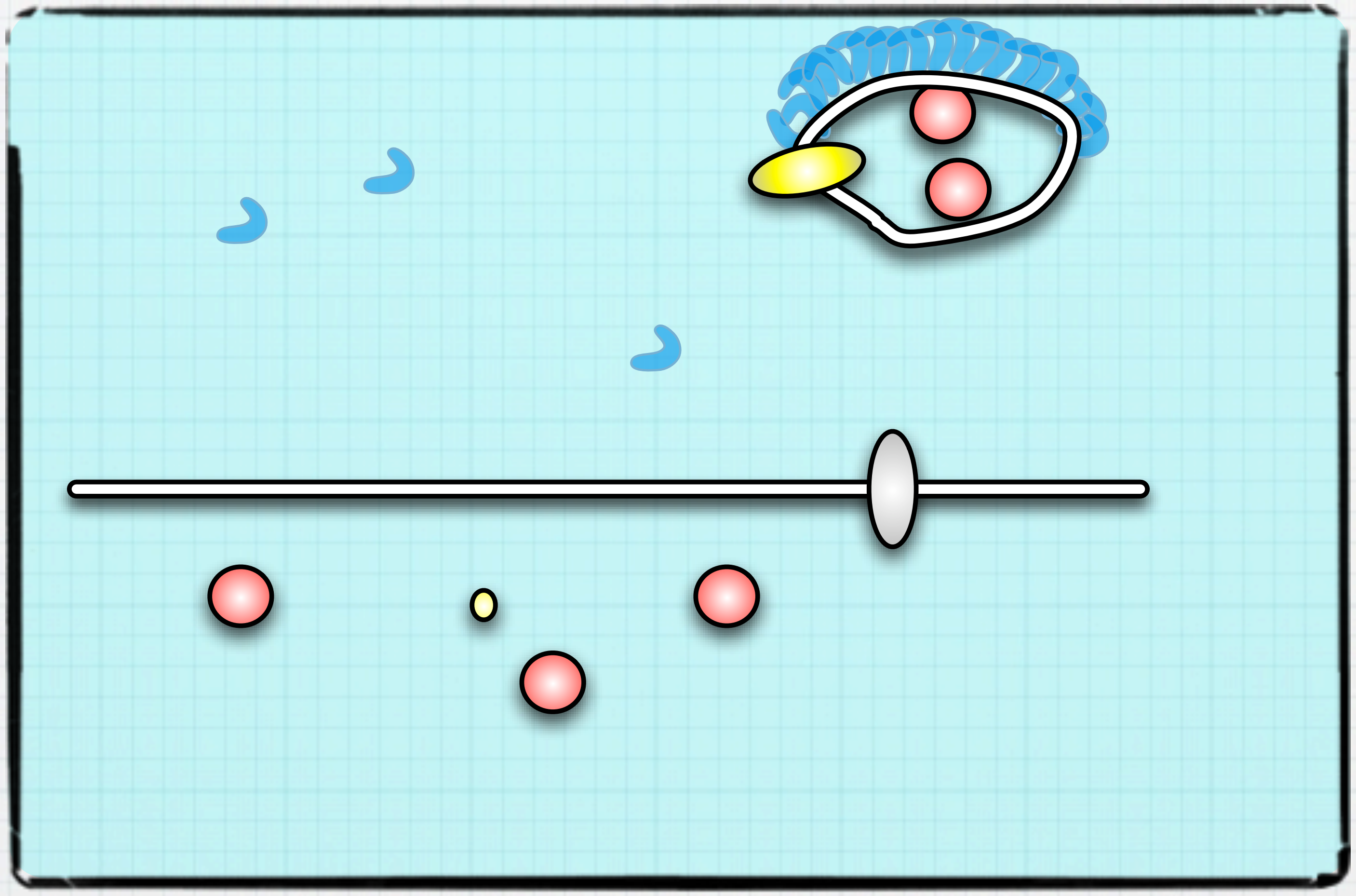


Can we provide a language that biologists can use describing these facts ?

Generators for PPI

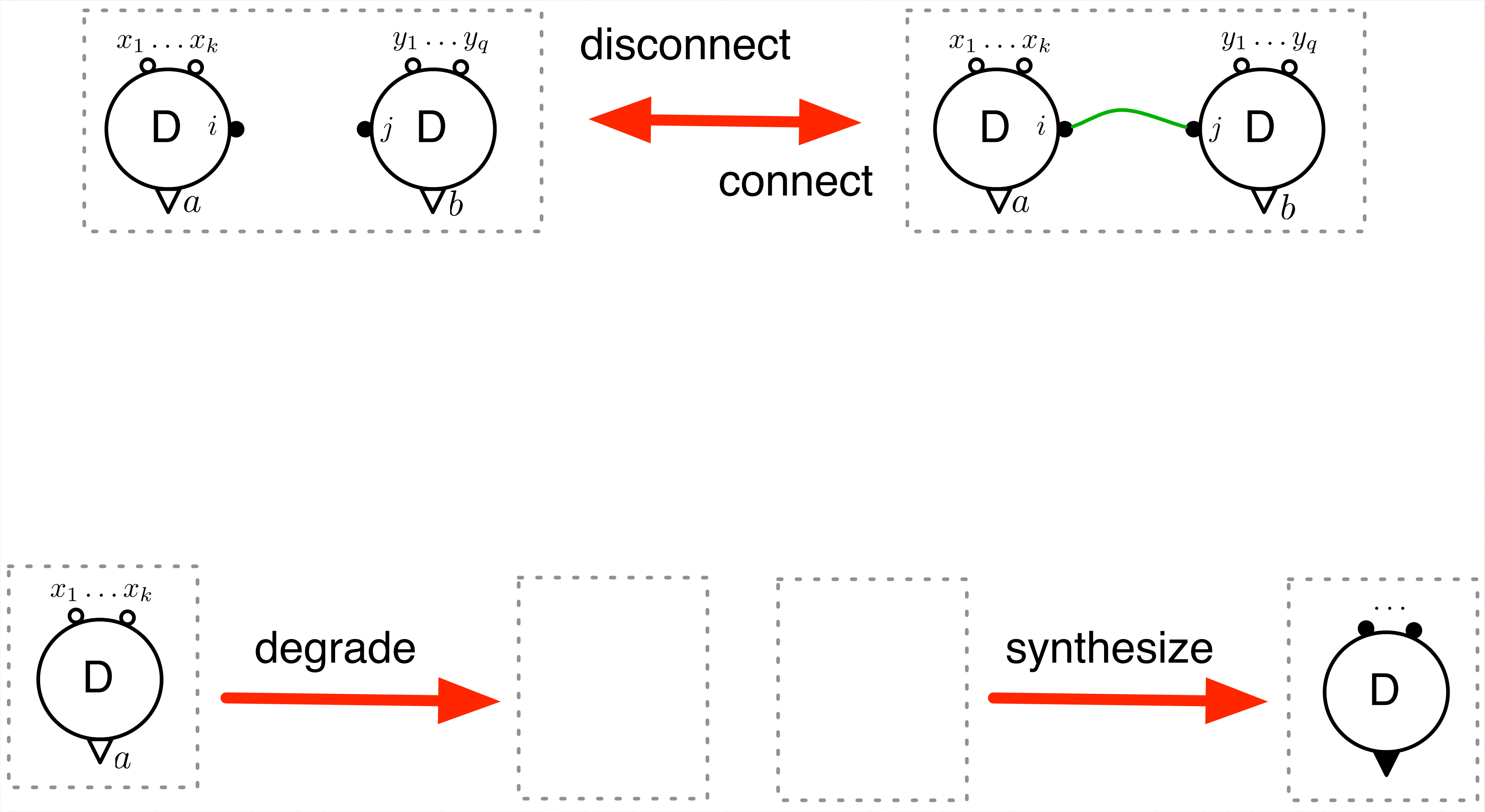
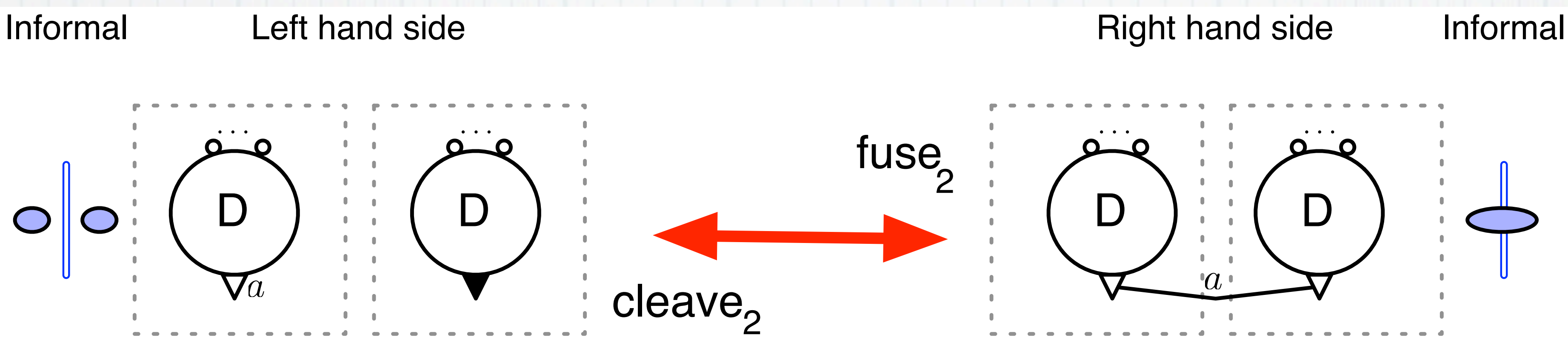
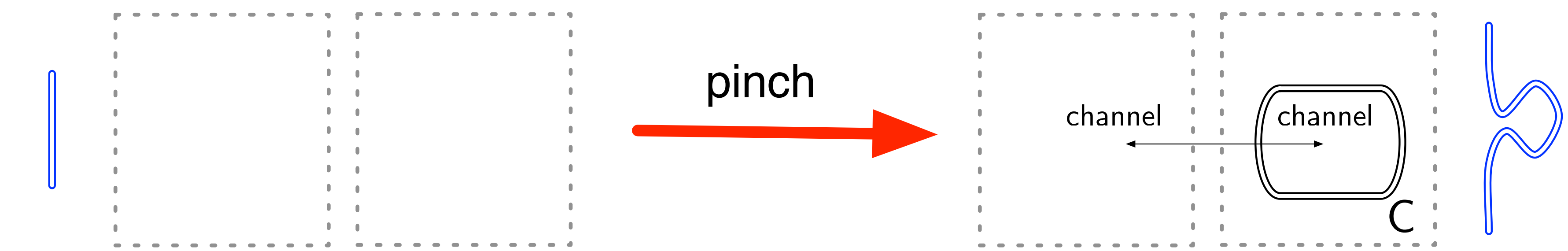


Fig. 1: Generators for $\mathcal{C}_0$.

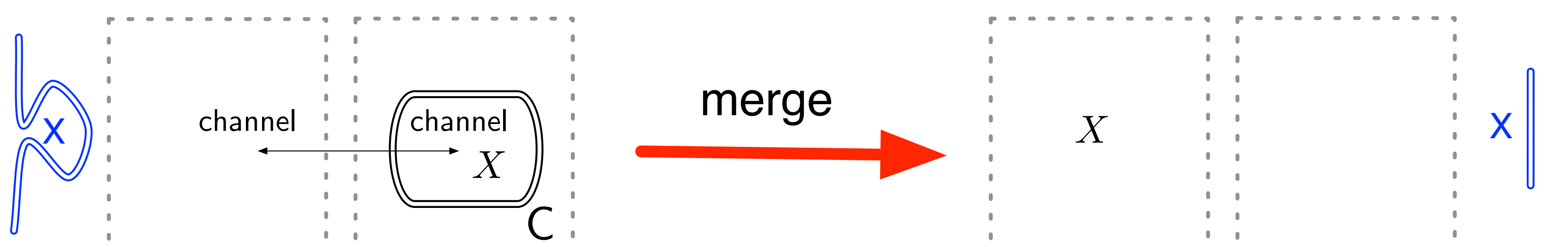
Generators for membrane



$$\mathsf{D}^a(x_1,\ldots,x_k) \parallel \mathsf{D}^b(y_1,\ldots,y_q)\backslash b \to \mathsf{D}^a(x_1,\ldots,x_k) \parallel \mathsf{D}^a(y_1,\ldots,y_q)$$

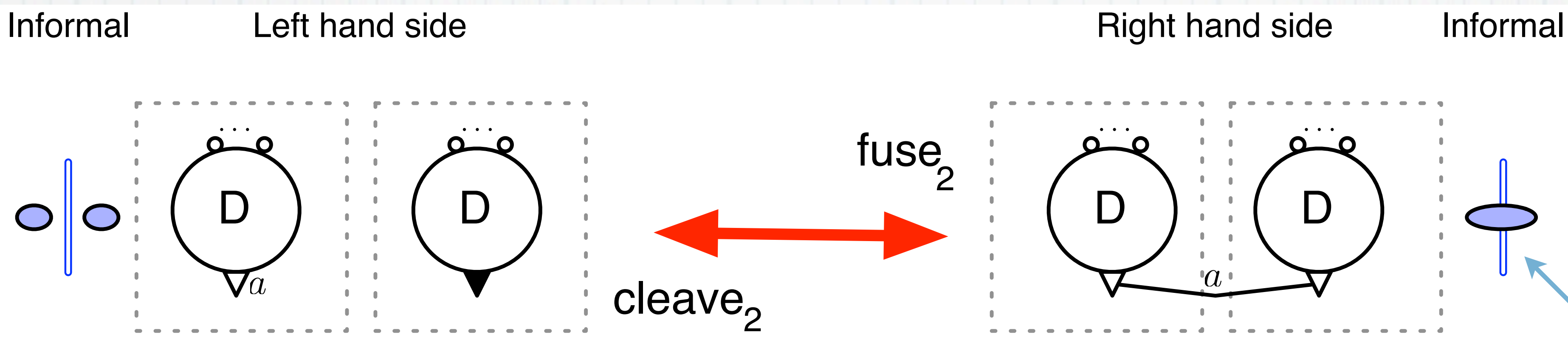


$$0 \parallel 0 \to (\mathsf{channel}_m \parallel \mathsf{C}(\mathsf{channel}_m))\backslash m$$



$$(\mathsf{channel}_m \parallel \mathsf{C}(\mathsf{channel}_m, X))\backslash m \to X \parallel 0$$

Generators for membrane



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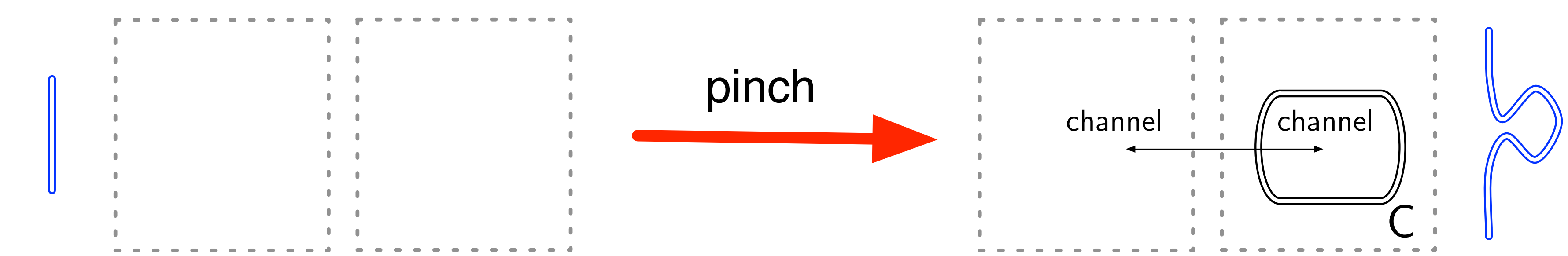

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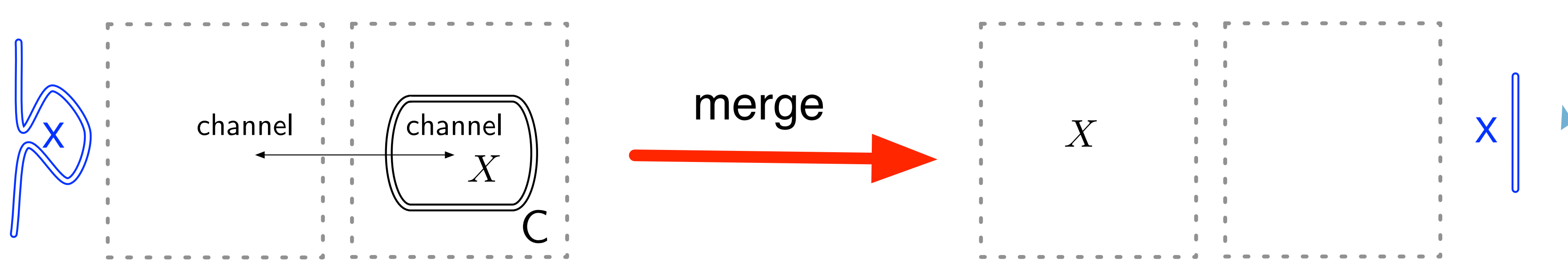
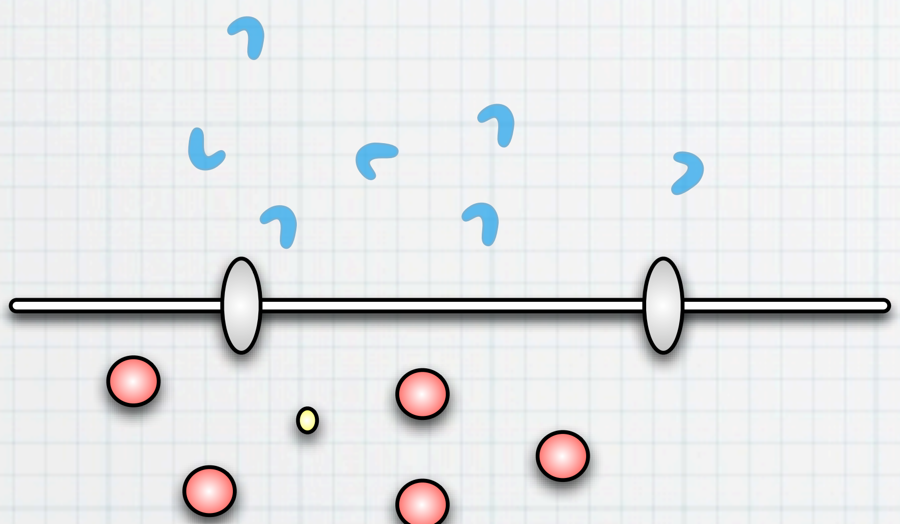


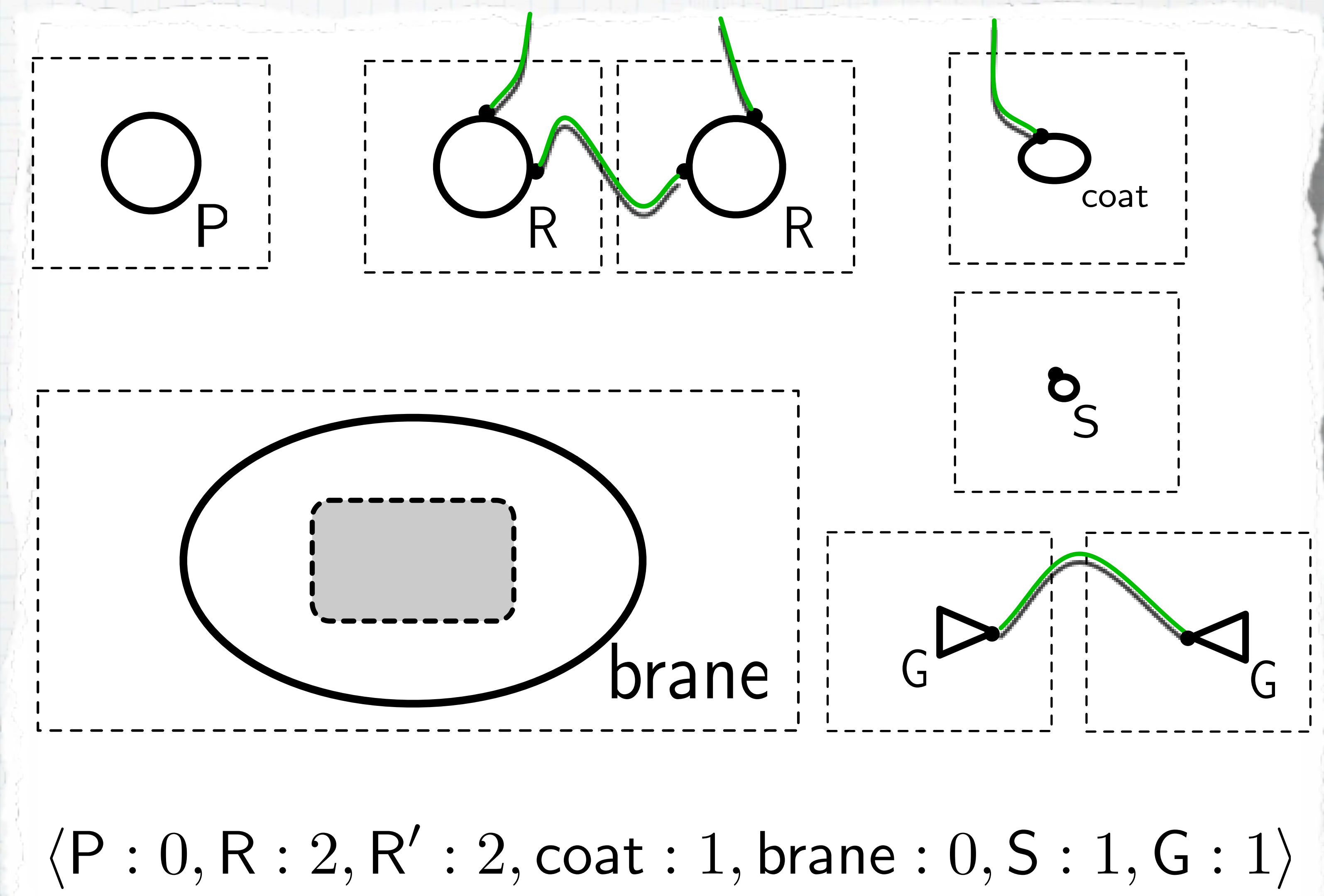
$$(\mathsf{channel}_m \parallel \mathsf{C}(\mathsf{channel}_m, X))\backslash m \to X \parallel 0$$

GUI !

Model entities

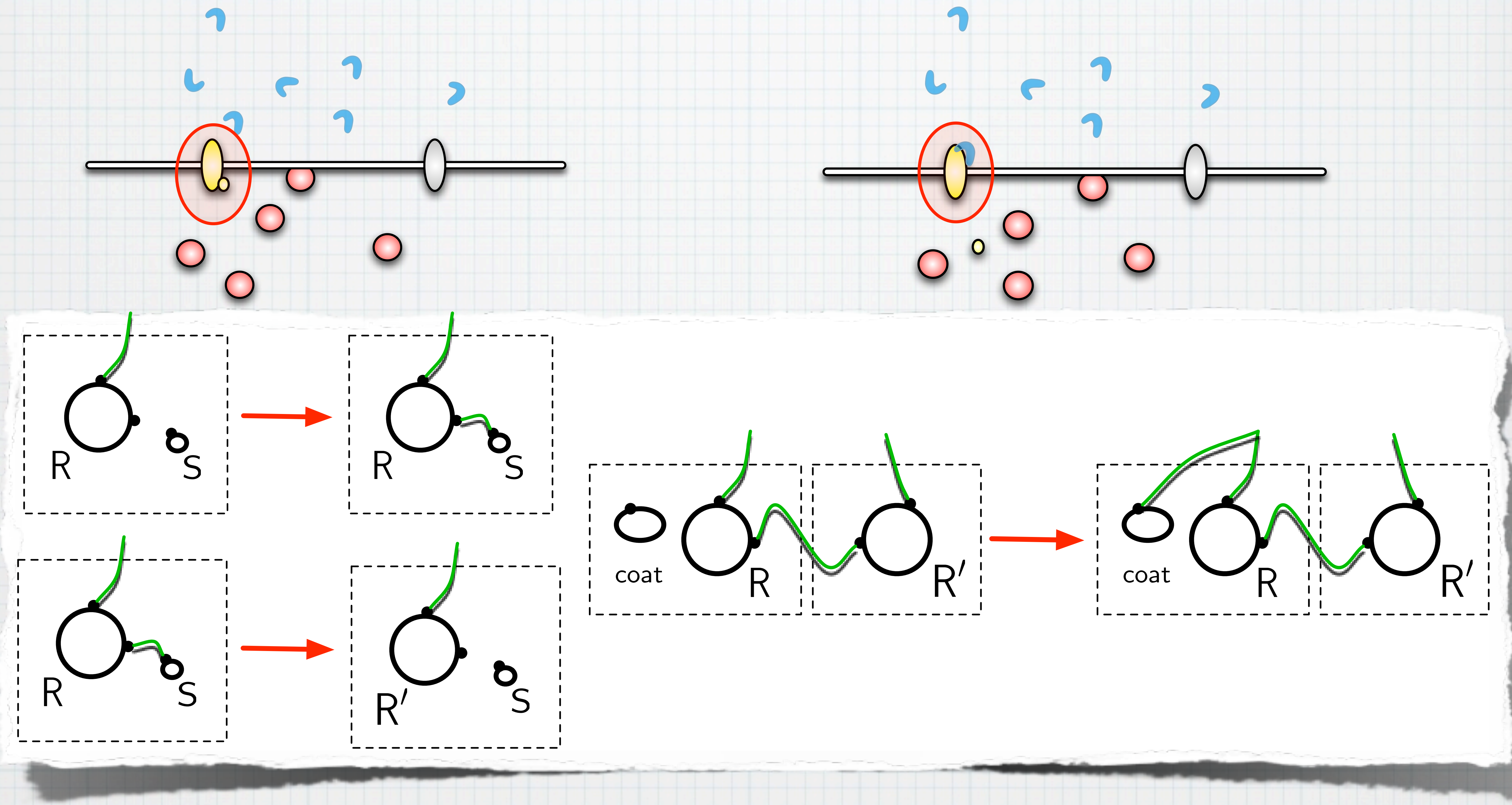


Systems biologist names the biological entities



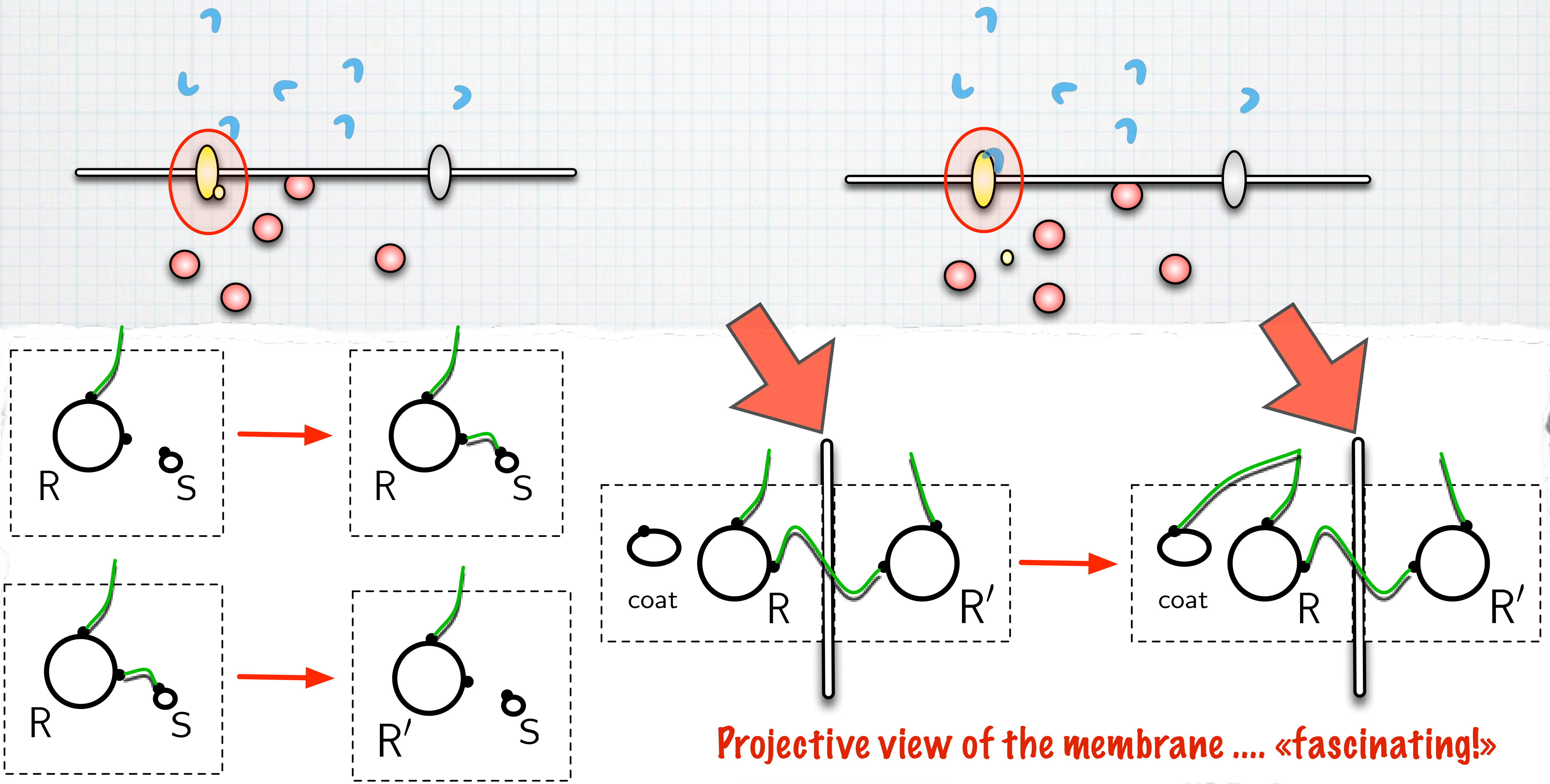
which become particular instances of the entities of the generators

Refinements



Refinements of the PPI generators

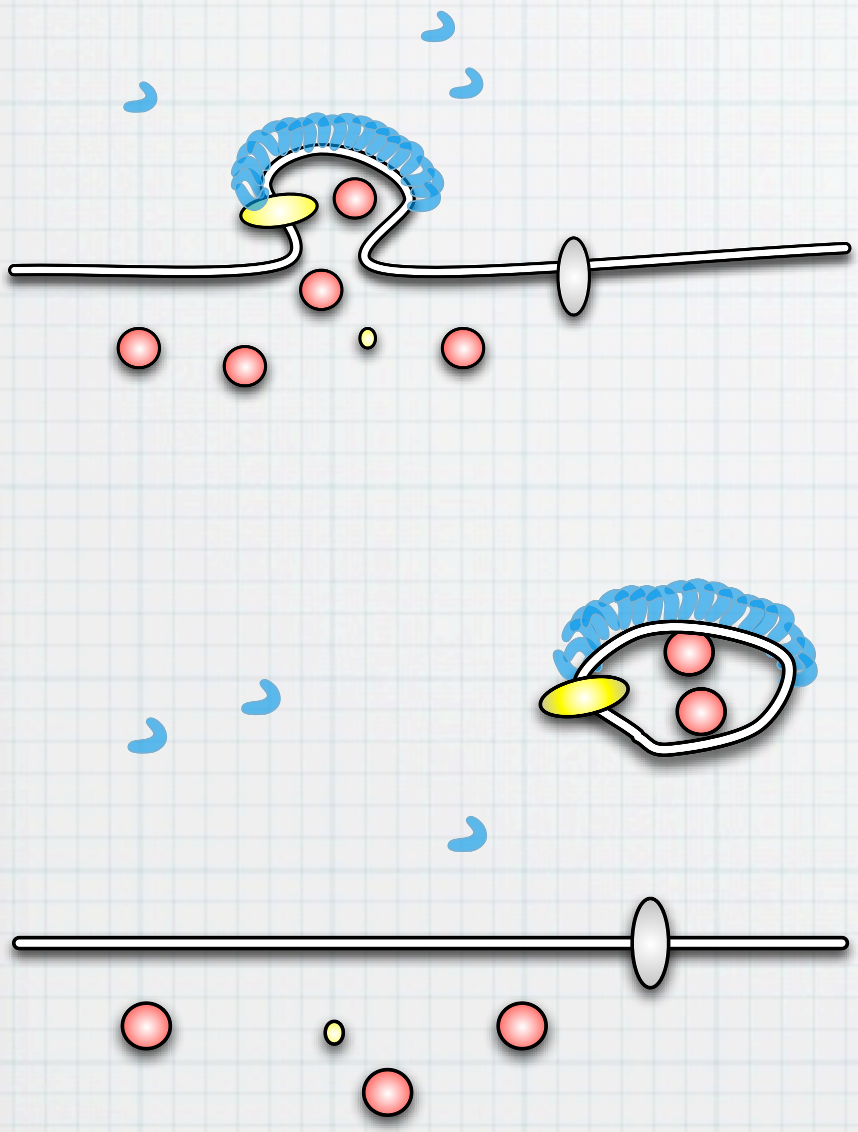
Refinements

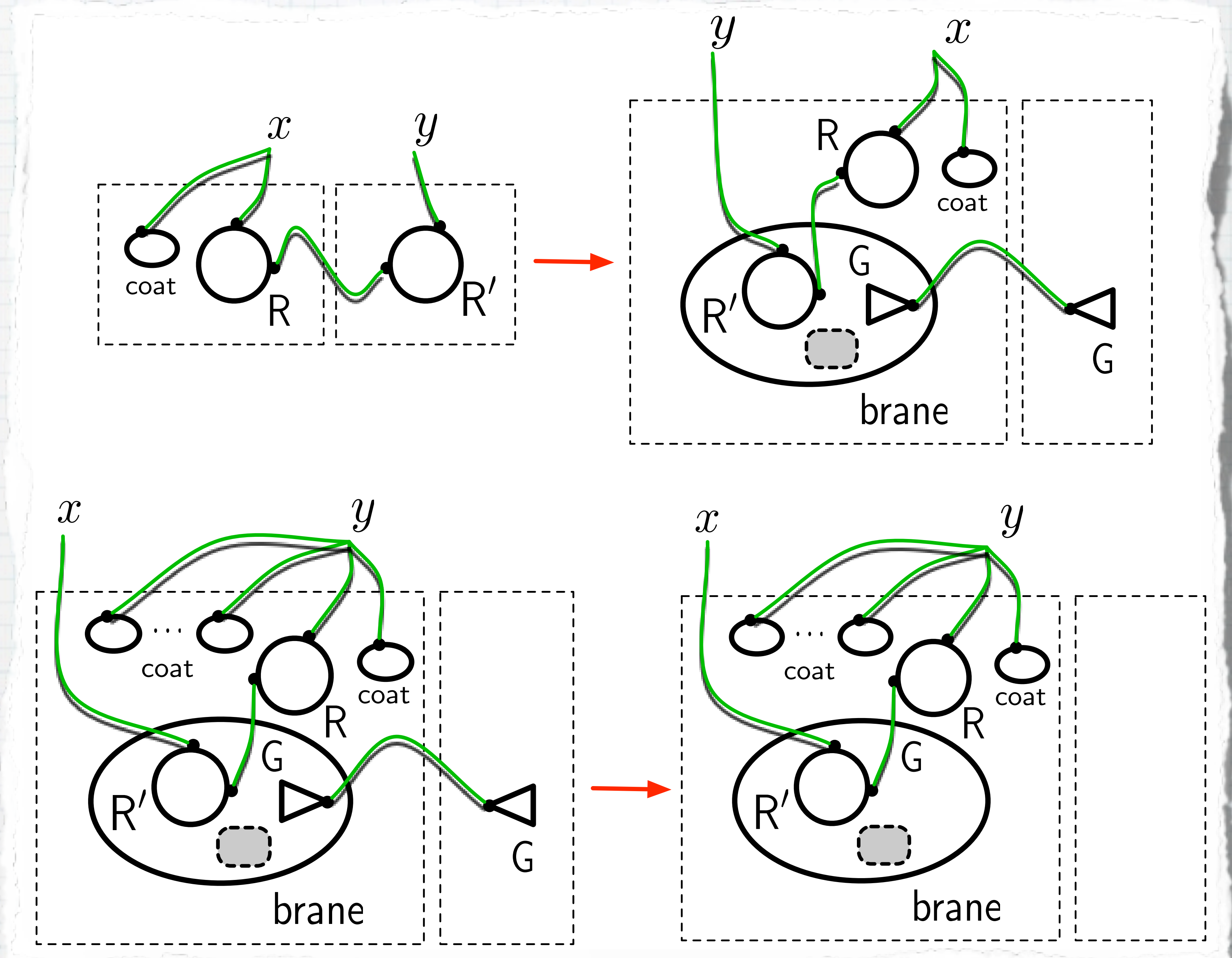


Projective view of the membrane .... «fascinating!»

Refinements of the PPI generators

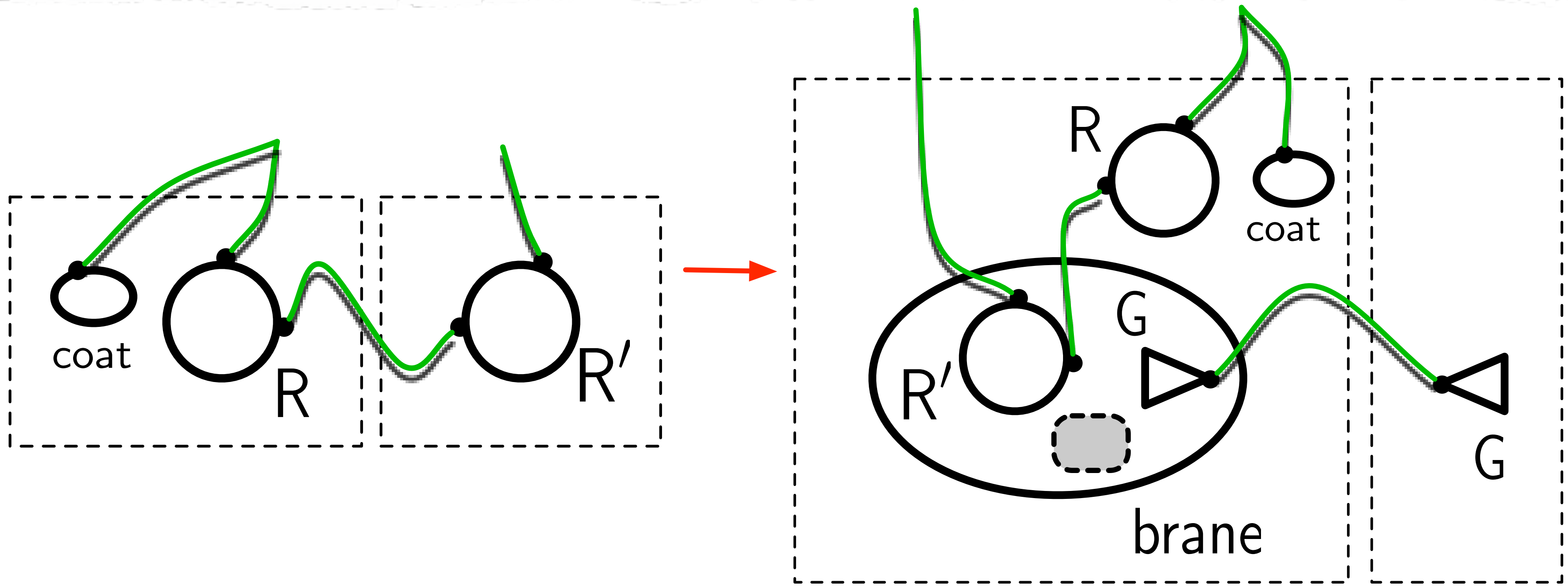
Budding



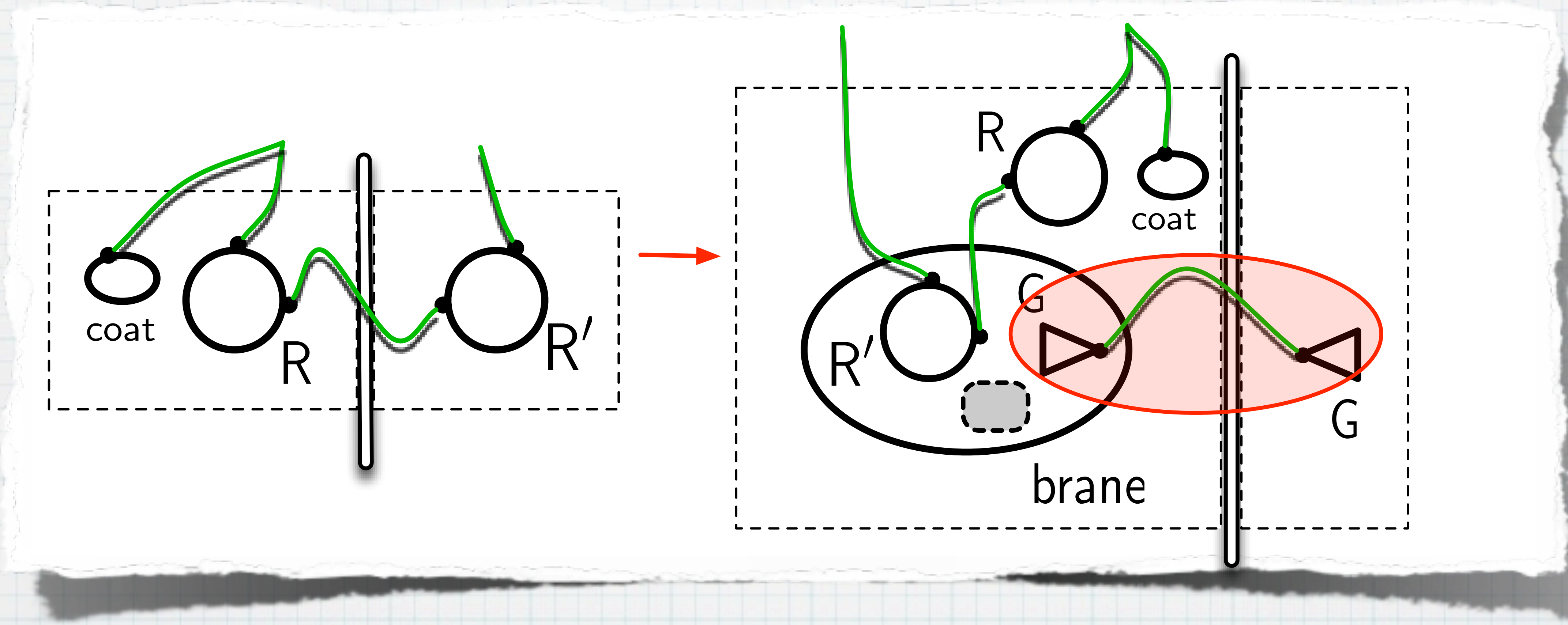


Refinements of the membrane generators

Space and motion

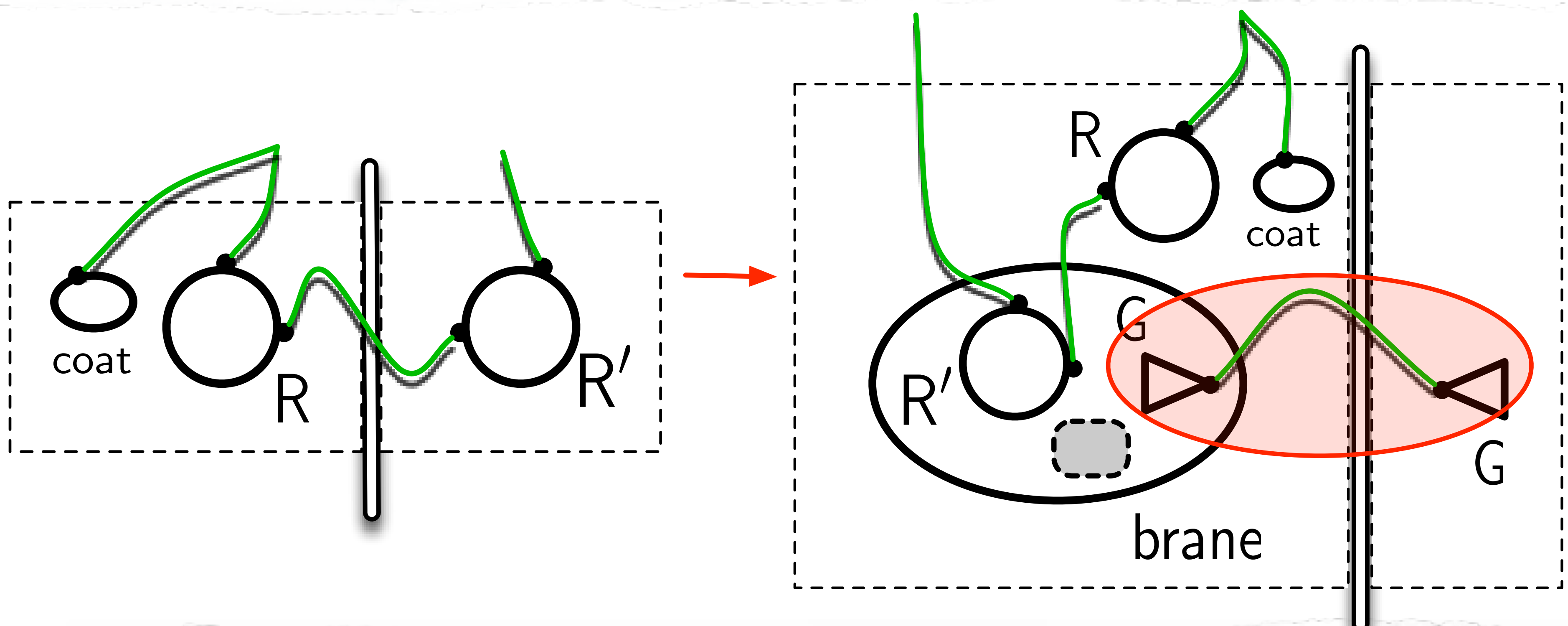


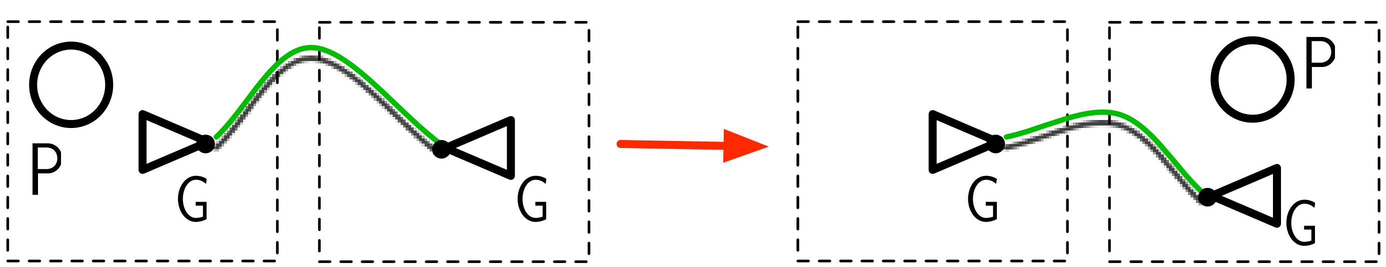
Space and motion



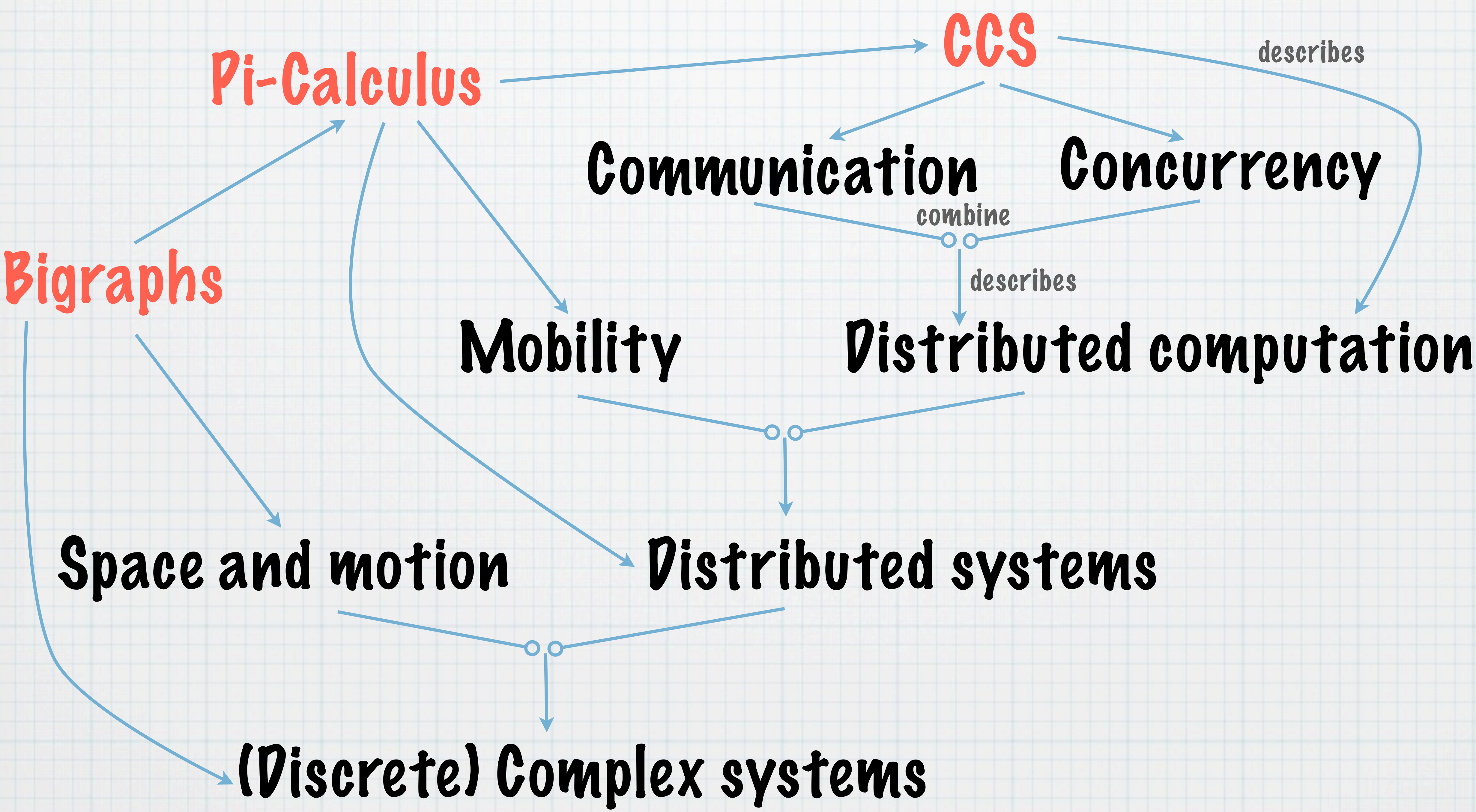
Diffusion is a consequence of the «diffuse» generator

Space and motion





Conclusion



CCS
describes
Pi-Calculus
Communication
Concurrency
combine
Bigraphs
describes
Mobility
Distributed computation
Space and motion
Distributed systems
(Discrete) Complex systems

Conclusion

Higher, Deeper, broader

continuum

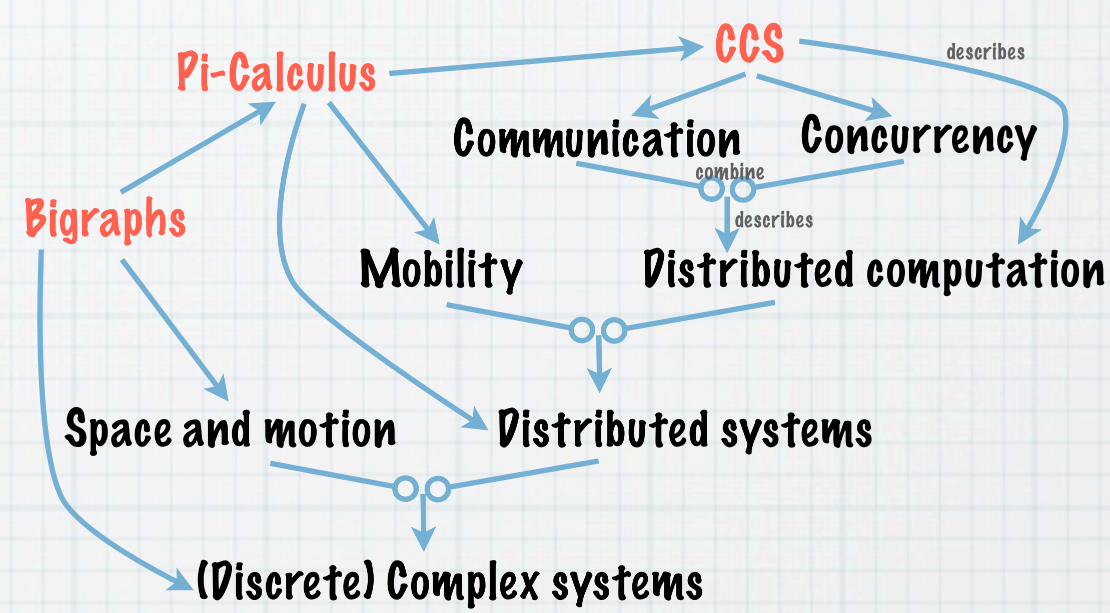
recursion

Stronger foundations

combination

morphisms

Abstract machine



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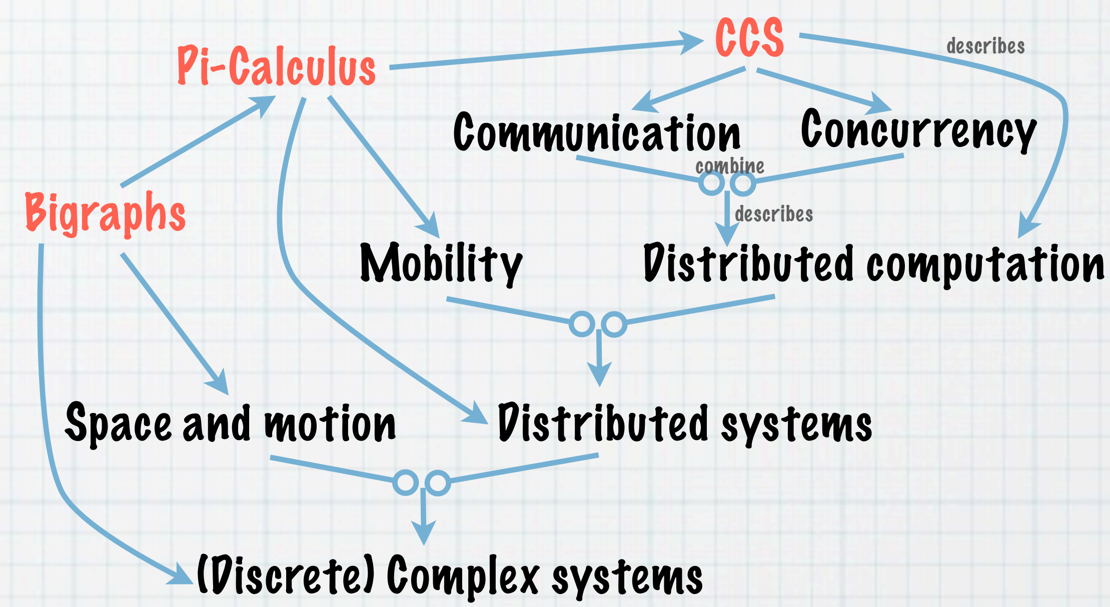

The bigraph model is not canonical —variants and alternatives can be imagined— but it has at least enough power and flexibility to serve as a case study for a theory to underpin future systems engineering.

There is a lot of work to do, and we are hiring!

Thanks!