



PROMOTING THE
SCIENTIFIC EXPLORATION
OF COMPUTATIONAL
CREATIVITY

Computational Approaches to Conceptual Blending (part I)

Amílcar Cardoso

Autumn School on Computational Creativity

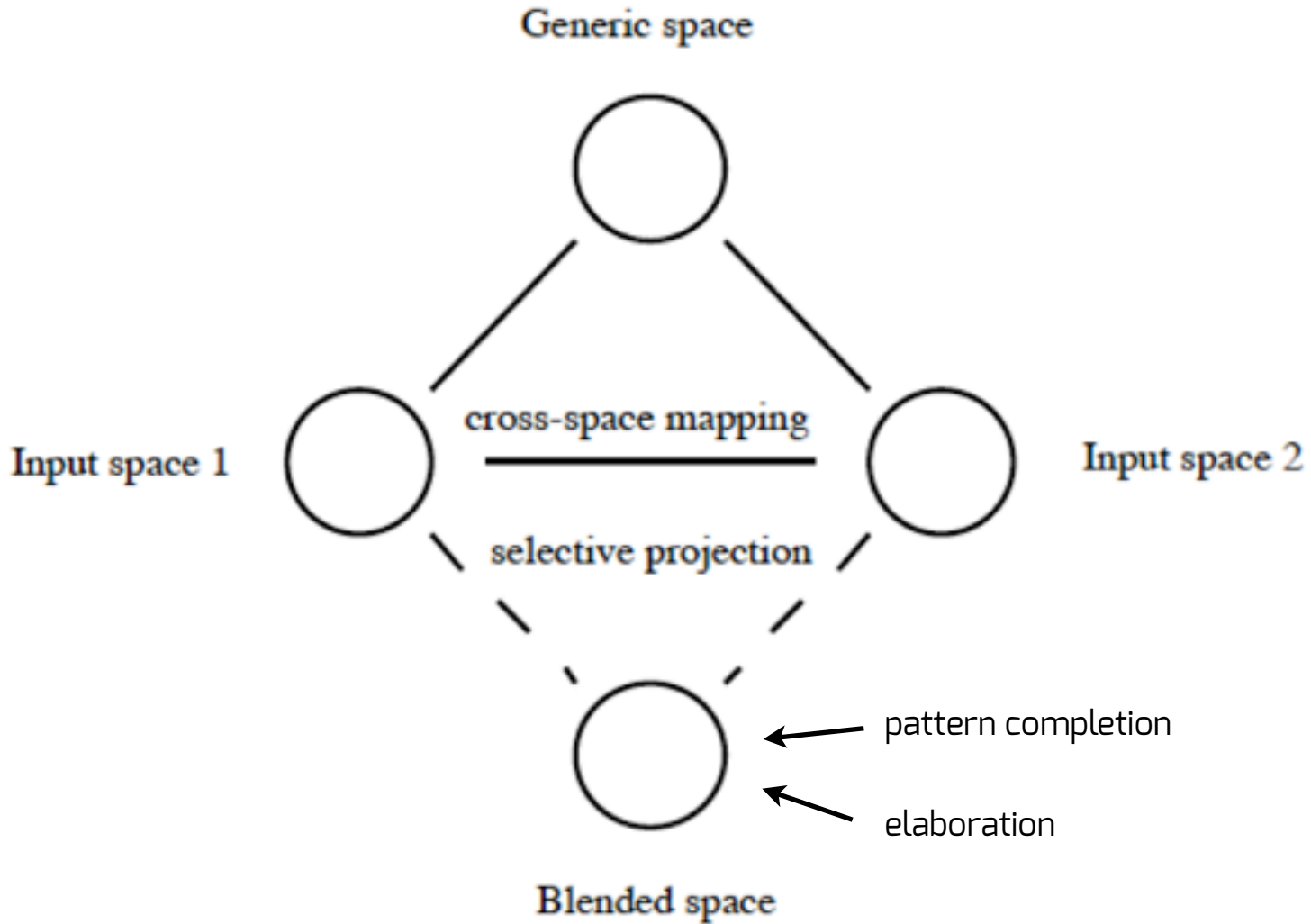
Porvoo, Finland, November 2013

Conceptual Blending

- Fauconnier and Turner [1998, 2002, 2003]
- *“Basic mental operation that leads to new meaning, global insight, and conceptual compressions useful for memory and manipulation of otherwise diffuse ranges of meaning”.*
- Blend: a concept (or web of concepts) whose existence and identity, although attached to the pieces of knowledge that participated in its generation (the inputs), acquires gradual independence through use.
- Ex: Pegasus, Pokemon, Computer Desktop

Conceptual Blending

- Fauconnier and Turner [1998, 2002, 2003]
- *“Basic mental operation that leads to new meaning, global insight, and conceptual compressions useful for memory and manipulation of otherwise diffuse ranges of meaning”.*
- *“Plays a fundamental role in the construction of meaning in everyday life”*

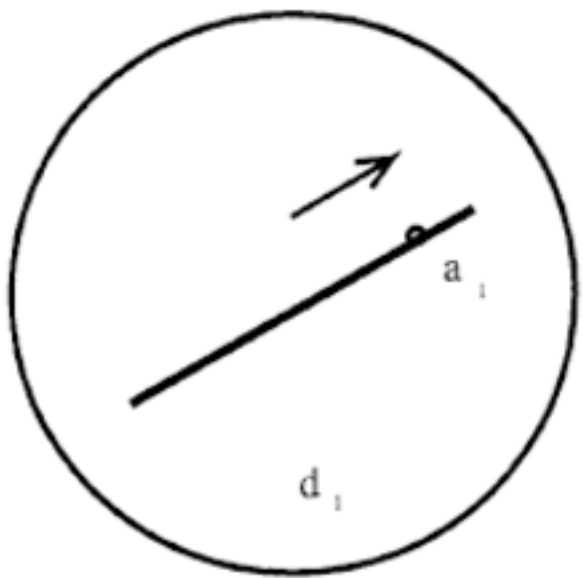


Conceptual Blending

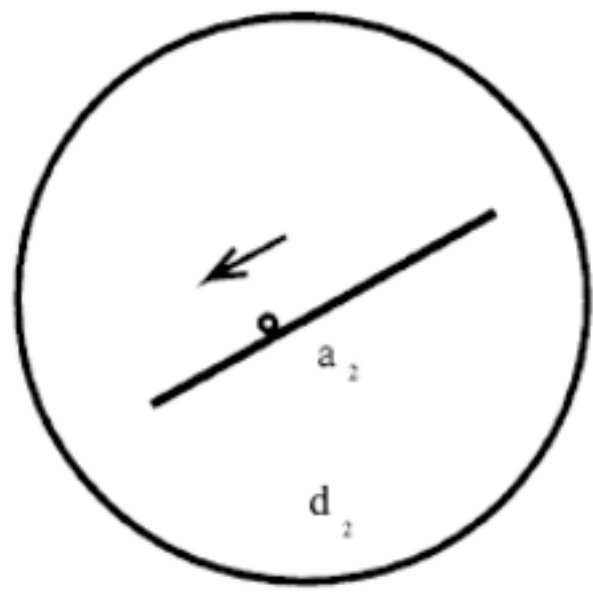
- Not a creative mechanism in itself...
- ... but the framework models cognitive processes involved in creativity
- ... thus it may be worth to explore it for computational creativity

Riddle of the Buddhist Monk (Koestler, 1964)

- *A Buddhist Monk begins at dawn one day walking up a mountain, reaches the top at sunset, meditates at the top for several days until one dawn when he begins to walk back to the foot of the mountain, which he reaches at sunset. Make no assumptions about his starting or stopping or about his pace during the trips.*
- Riddle: Is there a place on the path that the monk occupies at the same hour of the day on the two separate journeys?

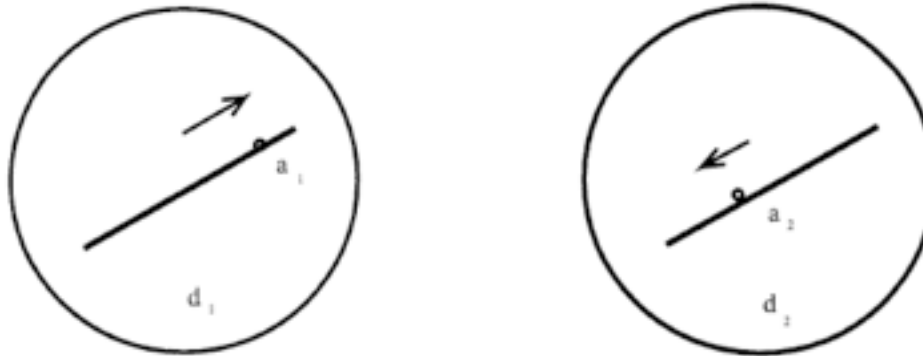


Input Space 1
(time $t = d_1$)



Input Space 2
(time $t = d_2$)

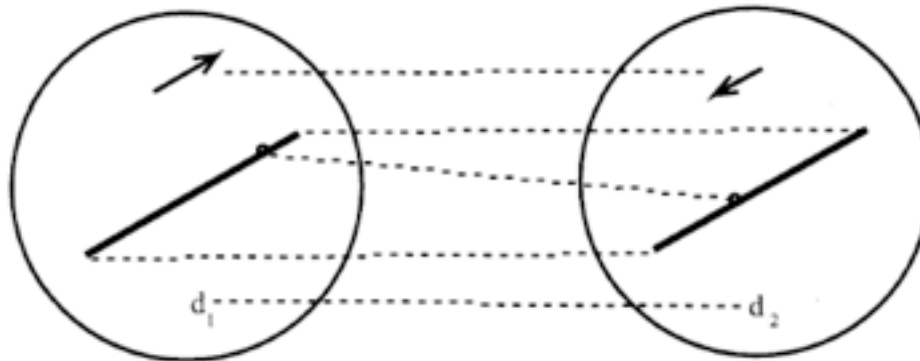
Input Mental Spaces



Input Space 1

Input Mental Spaces

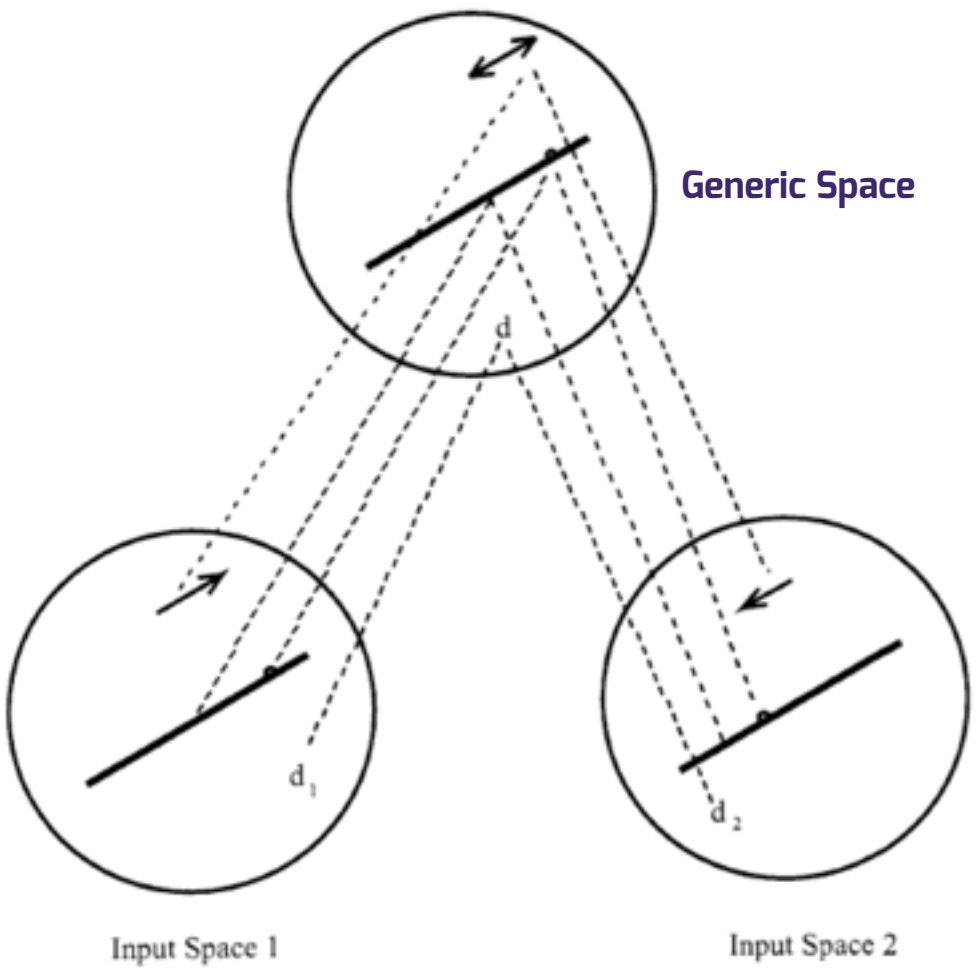
Input Space 2

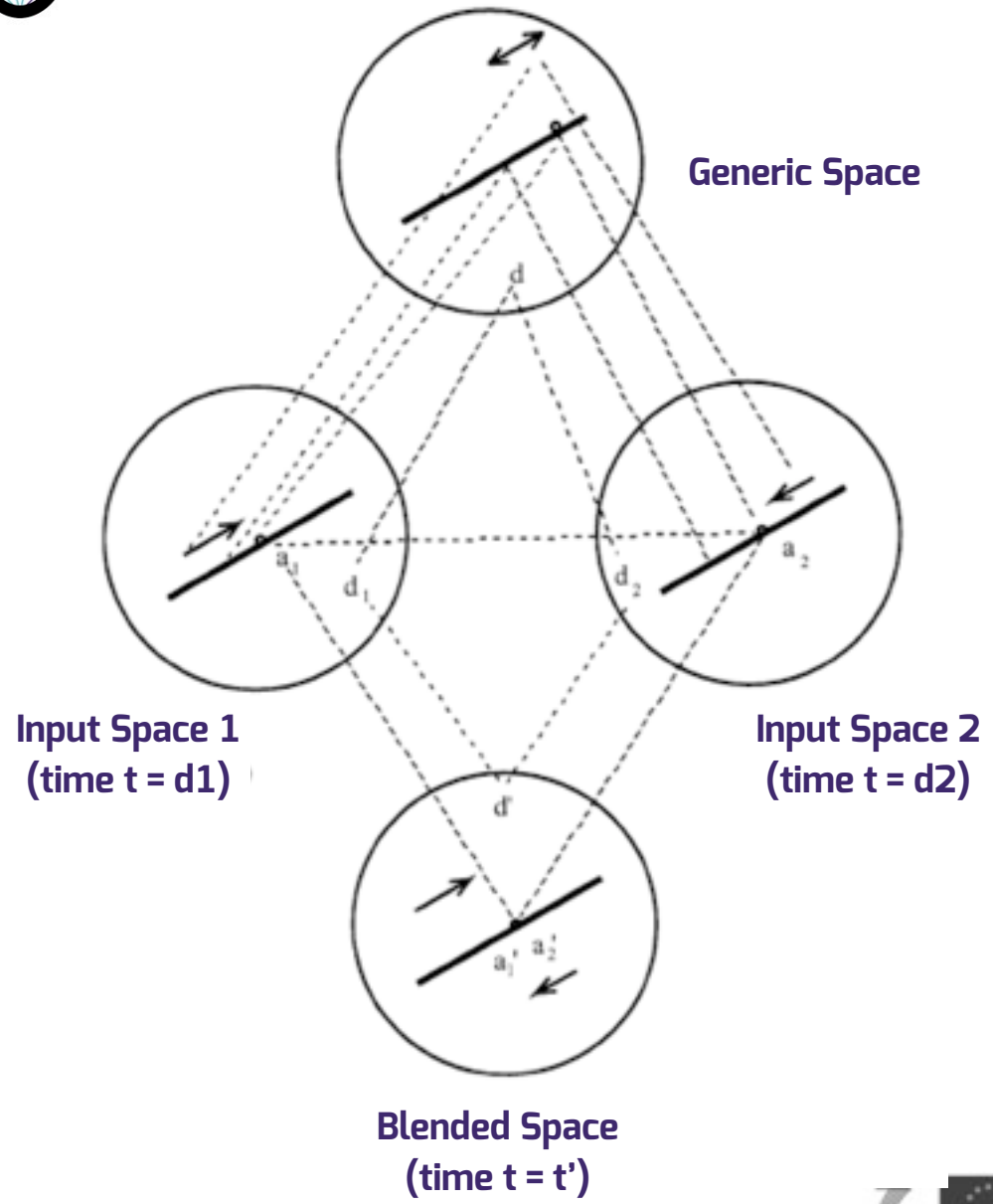


Input Space 1

Cross-Space Mapping

Input Space 2

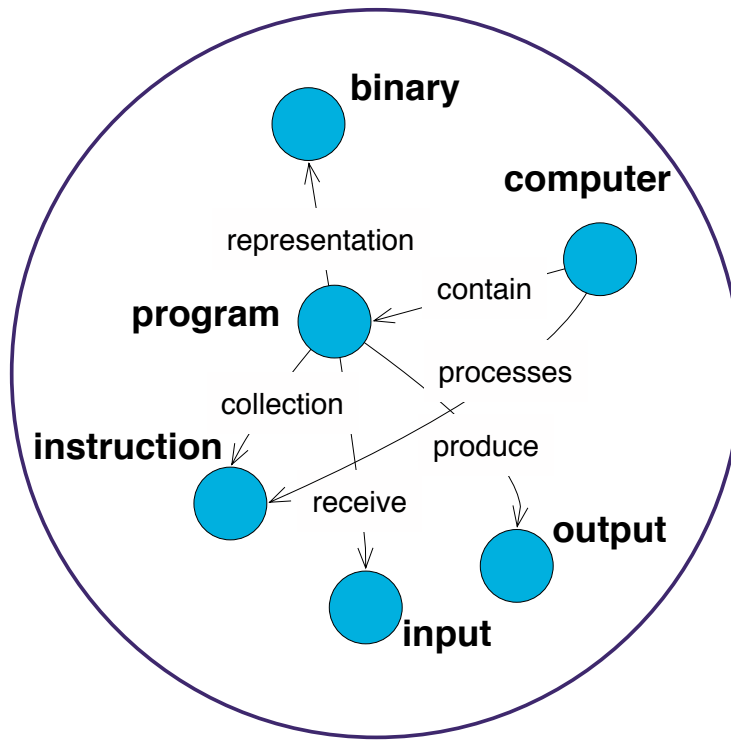




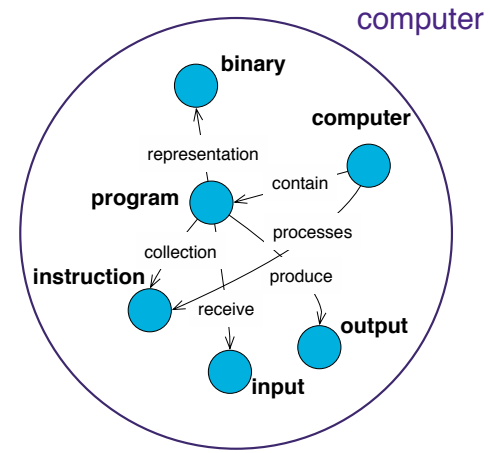
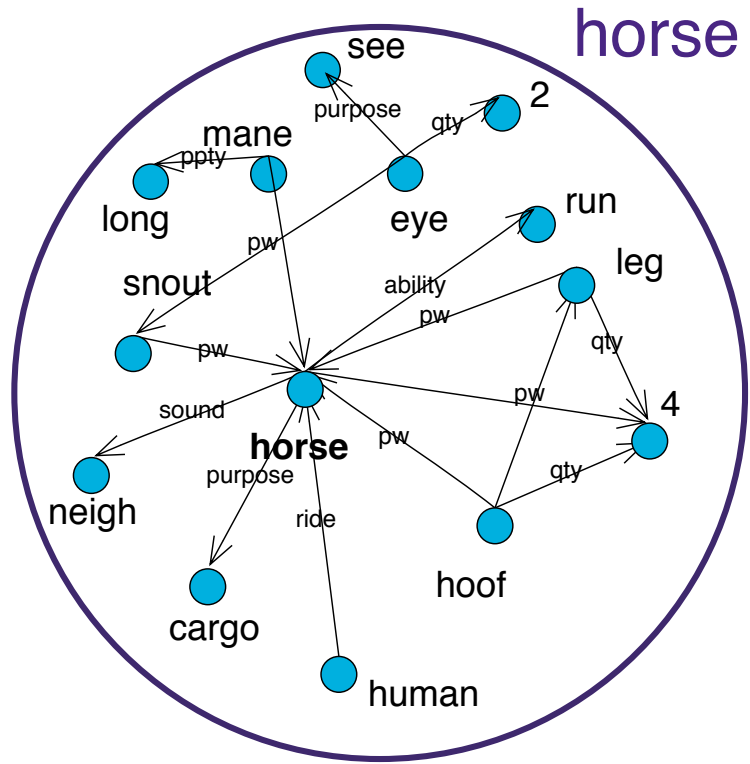
Mental spaces

- “Small conceptual packets constructed as we think and talk, for purposes of local understanding and action” (F&T)
- “They are interconnected, and can be modified as thought and discourse unfold” (idem)
- “can be used generally to model dynamic mappings in thought and language” (idem)

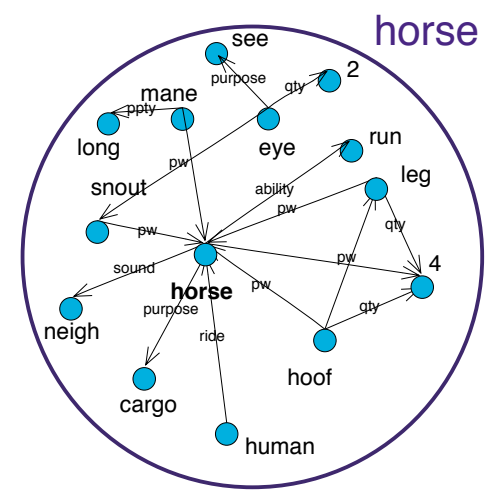
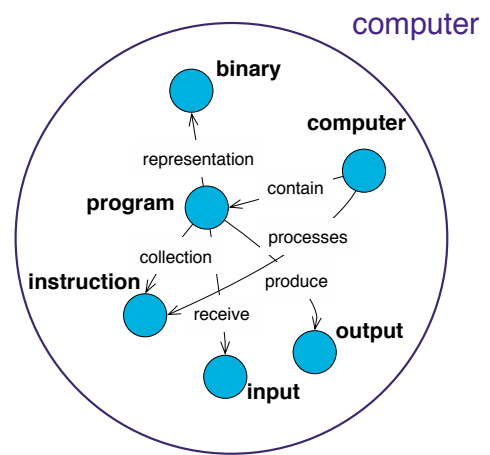
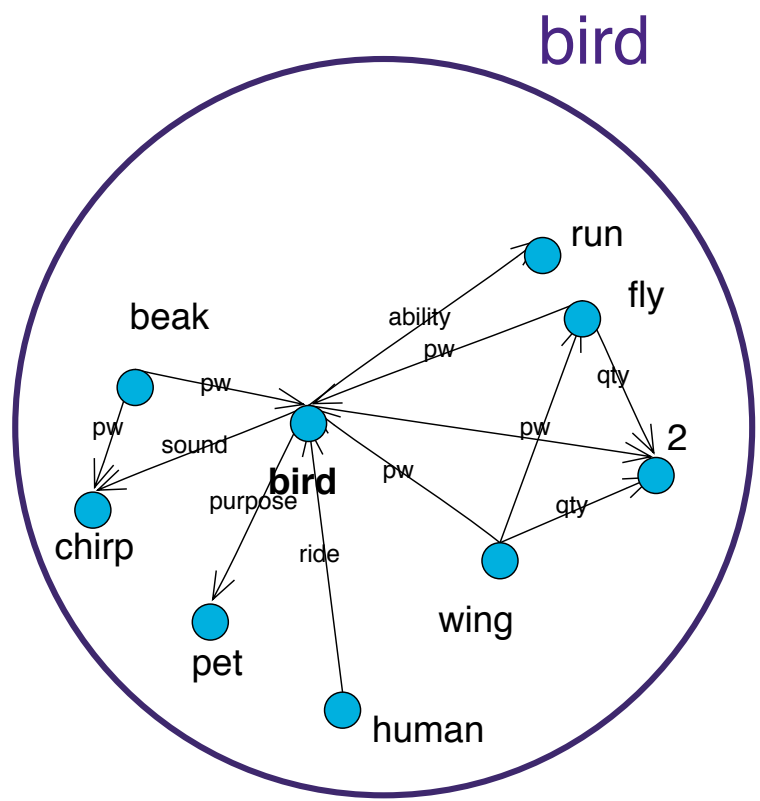
Mental spaces



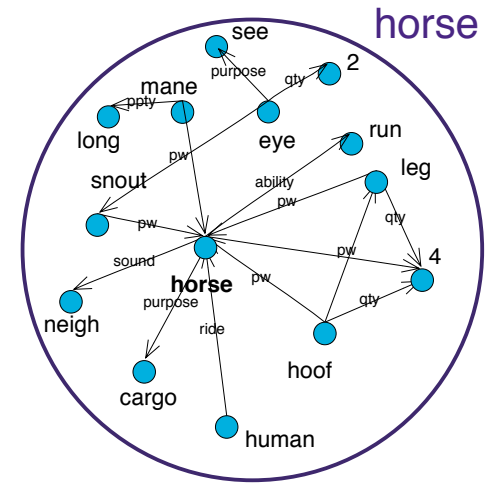
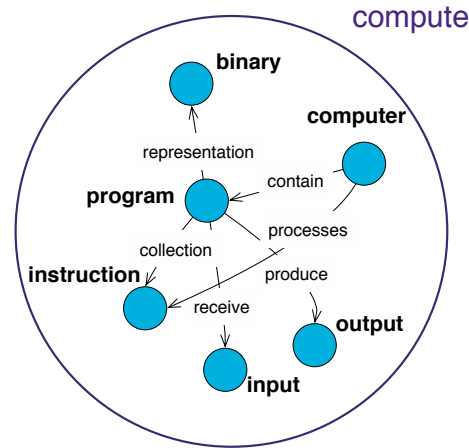
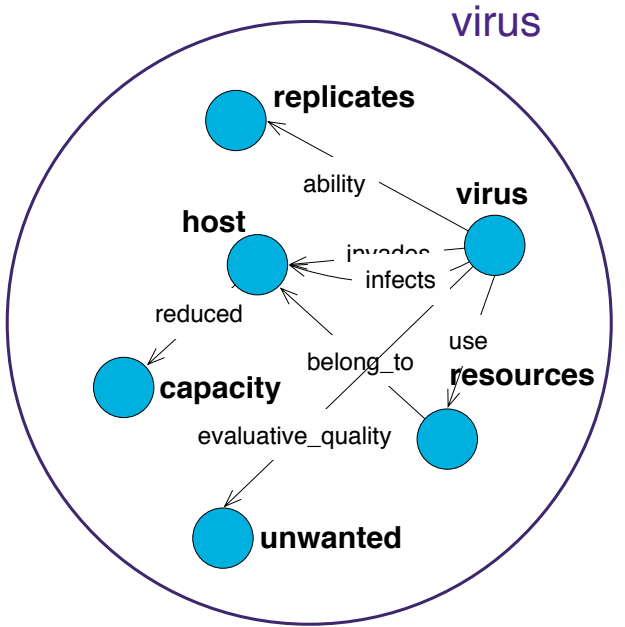
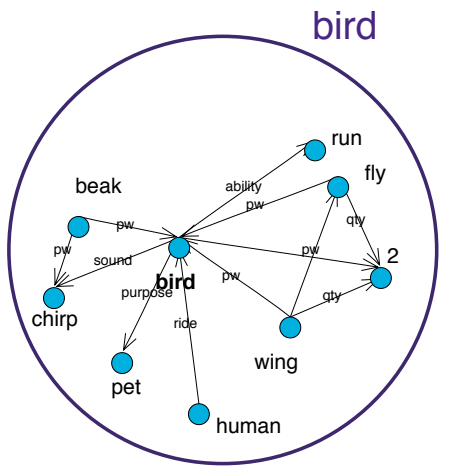
Mental spaces



Mental spaces



Mental spaces



Boat race

As we went to press, Rich Wilson and Bill Biewenga were barely maintaining a 4.5 day lead over the ghost of the clipper *Northern Light*, whose record run from San Francisco to Boston they're trying to beat. In 1853, the clipper made the passage in 76 days, 8 hours¹.

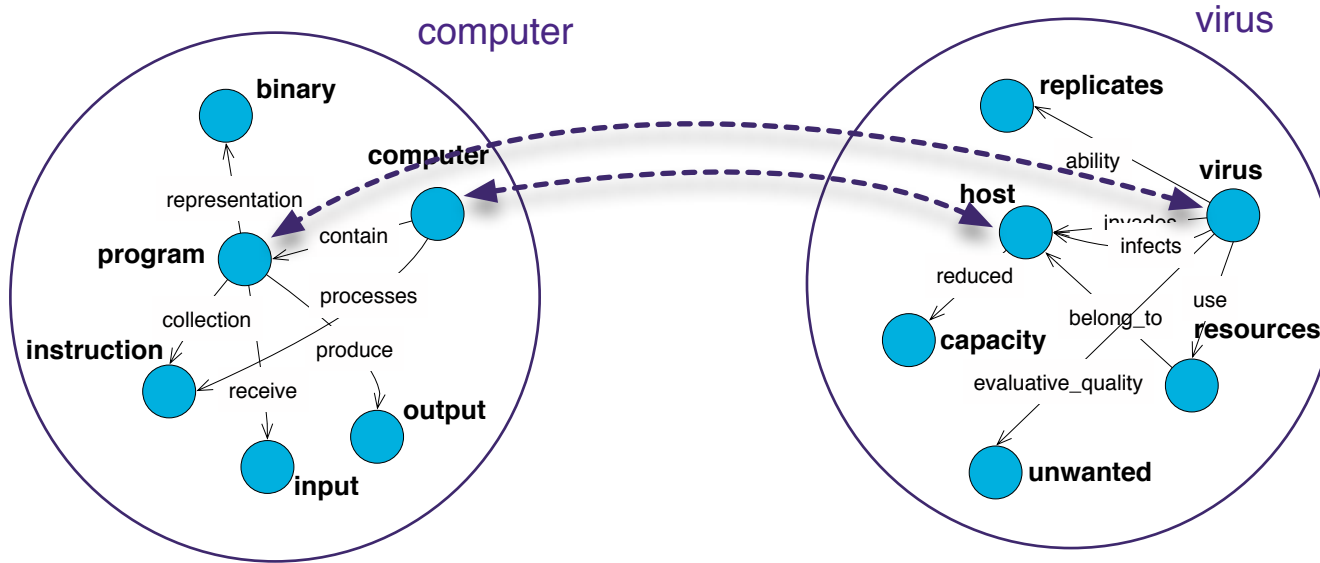
- Two input spaces: clipper in 1853, catamaran in 1993
- Generic space: sailing from S. Francisco to Boston
- Blend: single event, two boats, 1993
 - pattern completion: “race” frame imported from background
 - elaboration: we imagine relative positions and dynamics

Boat race

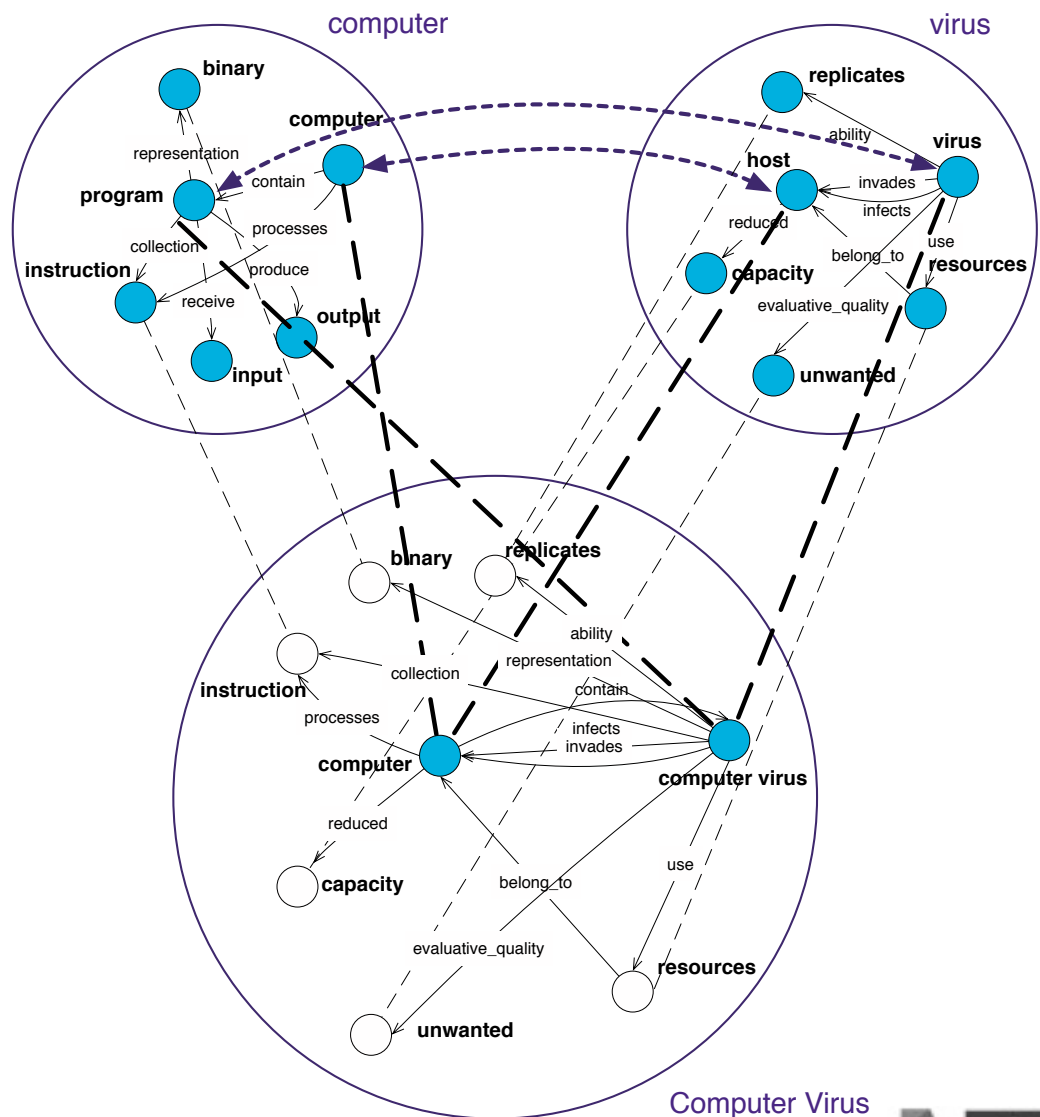
As we went to press, Rich Wilson and Bill Biewenga were barely maintaining a 4.5 day lead over the ghost of the clipper *Northern Light*, whose record run from San Francisco to Boston they're trying to beat. In 1853, the clipper made the passage in 76 days, 8 hours¹.

- Blend: single event, two boats, 1993
 - pattern completion: “race” frame imported from background
 - elaboration: we imagine relative positions and dynamics
- The blended space remains connected to the inputs by the mappings:
 - the catamaran is going faster than the clipper, and how much

Cross-space Mappings



- Process: identity, structure alignment, slot-filling, analogy, ...



Computer Virus

Principles

- Constitutive principles:
 - Partial cross-space mappings, selective projection, completion, elaboration
- Governing principles:
 - strategies for optimising emergent structure
 - competing pressures
 - 8 principles in original theory, later on distilled to 4

Governing Principles

- Topology:
 - Other things being equal, set up the blend and the inputs so that useful topology in the inputs and their outer-space relations is reflected by inner-space relations in the blend.
- Unpacking:
 - Other things being equal, the blend all by itself should prompt for the reconstruction of the entire network.

Governing Principles

- Web:
 - Other things being equal, manipulating the blend as a unit must maintain the web of appropriate connections to the input spaces easily and without additional surveillance or computation.
- Integration:
 - achieve an integrated blend.

Integration networks

- Four main types of integration networks:
 - Simplex: one input consists of a frame and the other consists of specific elements.
 - Mirror: a common organising frame is shared by all spaces in the network
 - Single-Scope: the organising frames of the inputs are different, and the blend inherits only one of those frames.
 - Double-Scope: essential frame and identity properties are brought in from both inputs (Frame Blending)

Integration networks

- Four main types of integration networks:
 - Simplex: one input consists of a frame and the other consists of specific elements.
 - example: “James is the father of John”
 - Mirror: a common organising frame is shared by all spaces in the network
 - Buddhist Monk, Regatta

Integration networks

- Examples:
 - Single-Scope: the organising frames of the inputs are different, and the blend inherits only one of those frames.
 - “Presidential shoot-out”
 - Double-Scope: essential frame and identity properties are brought in from both inputs (Frame Blending)
 - “The president is snatching the rice bowl out of the child's hands”
 - Two frames: one for "snatching", another for “political decision”



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Computational Approaches to Conceptual Blending (part II)

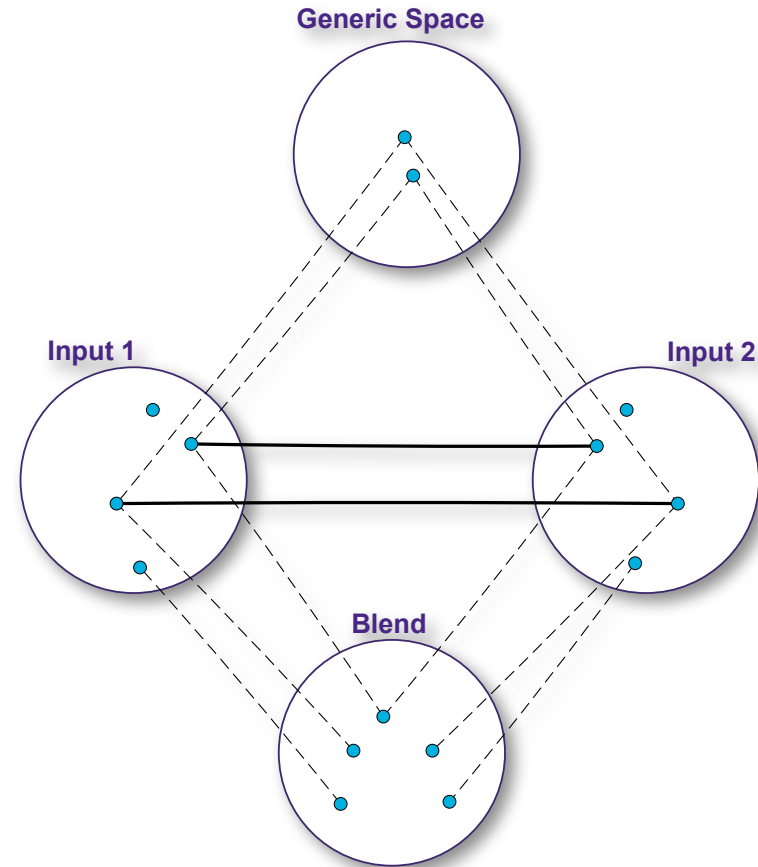
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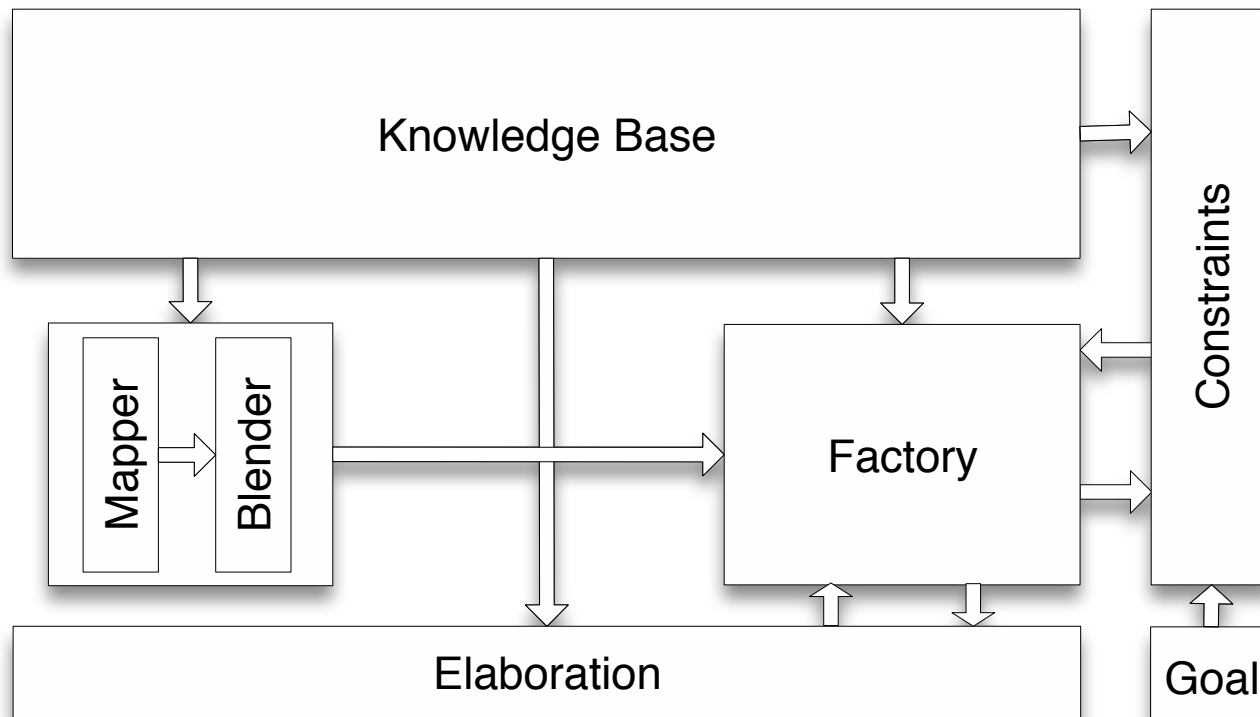
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Divago

- Given:
 - Two input Domains (Mental Spaces)
 - One Generic Space Domain
- Produces:
 - Blend Domain

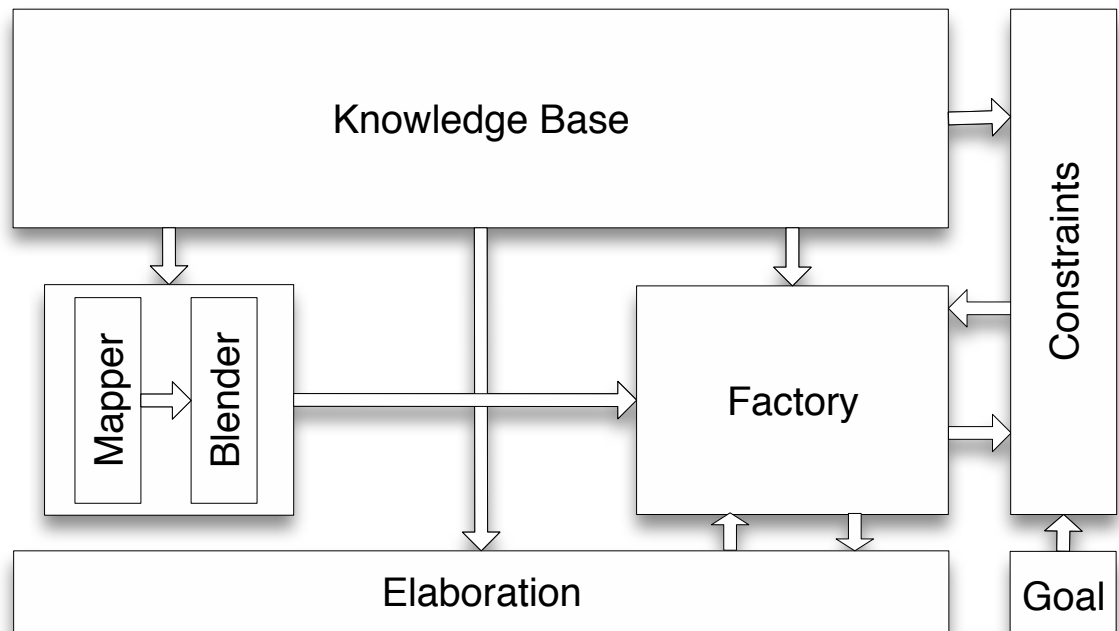


Divago Architecture



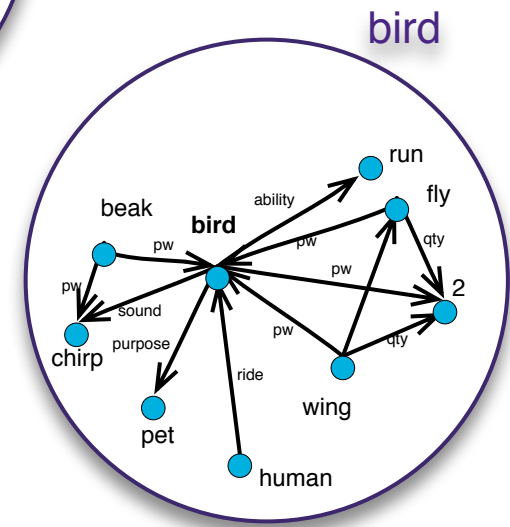
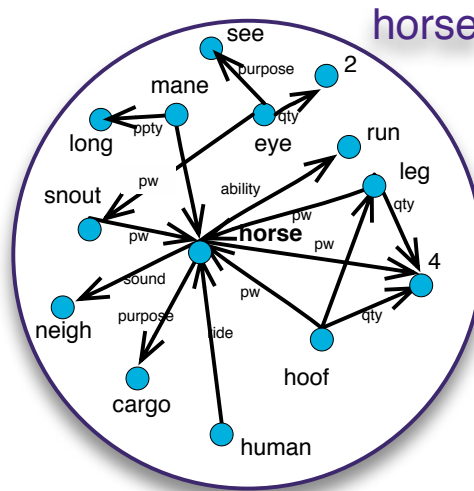
Knowledge Base

- Composed by *Domains*
- Domain:
 - Concept Map
 - set of Instances
 - set of Rules
 - set of Frames
 - set of Integrity Constraints



Knowledge Base

- Composed by *Domains*
- Domain:
 - **Concept Map**
 - set of Instances
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Knowledge Base

- Composed by *Domains*
- Domain:
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 - set of Instances
 - set of Rules
 - **set of Frames**
 - set of Integrity Constraints

```

frame(transport_means(X)) :
carrier(X, people) ← have(X, container) ∧ have(X, Y) ∧
                    purpose(Y, locomotion) ∧ drive(−, X)
    
```

Knowledge Base

- Composed by *Domains*
- Domain:
 - Concept Map
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 - **set of Frames**
 - set of Integrity Constraints

```

frame(new_ability(d1)) :
    new_ability(X, A) ← ability(X, A) ∧ not rel(d1, ability(X, A)) ∧
                        purpose(P, A) ∧ pw(P, X) ∧
                        projection(blend, d1, X, X) ∧
                        projection(blend, d2, A, A)
    
```

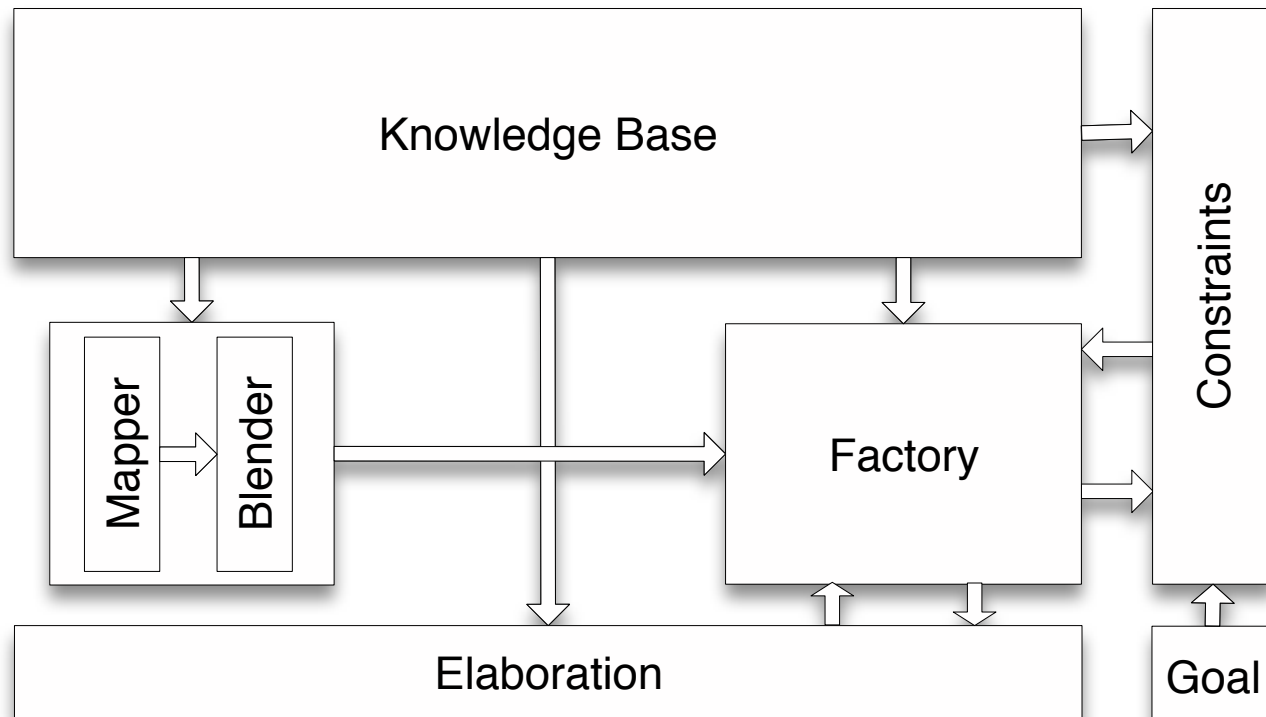
Transforming Frame

Knowledge Base

- Composed by *Domains*
- Domain:
 - Concept Map
 - set of Instances
 - set of Rules
 - set of Frames
 - **set of Integrity Constraints**

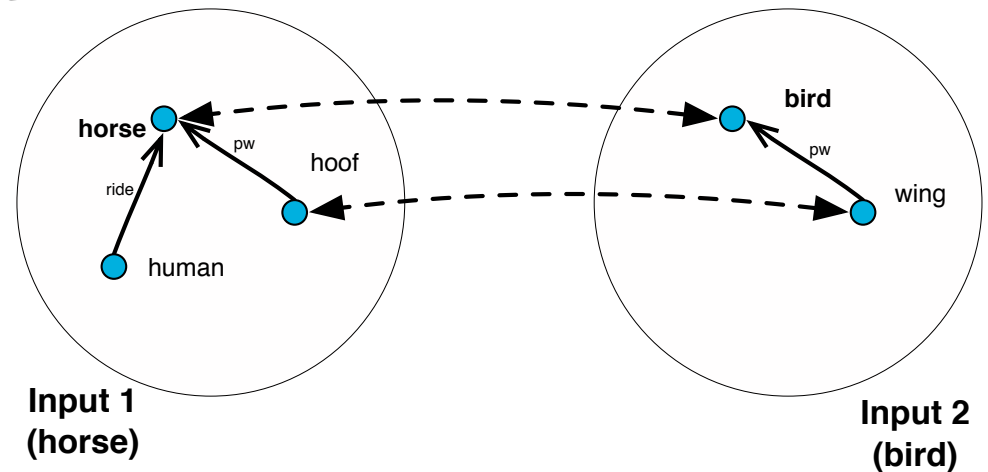
$$false \leftarrow state(X, dead) \wedge state(X, alive)$$
$$false \leftarrow pw(X, X)$$

Mapping Engine



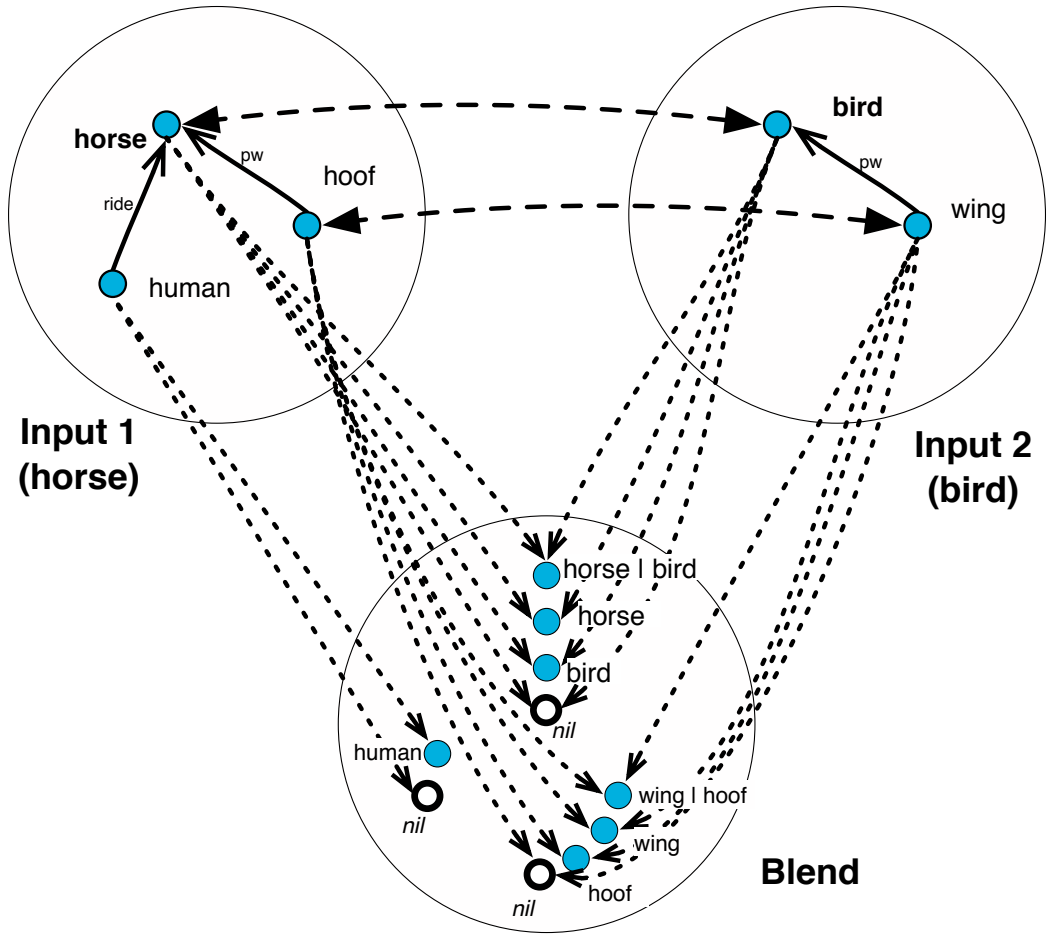
Mapping Engine

- Structure alignment + Spreading activation
 - Similar to Sapper [Veale 93], but simpler
- Mapping: largest isomorphic pair of subgraphs
- Returns set of all possible mappings



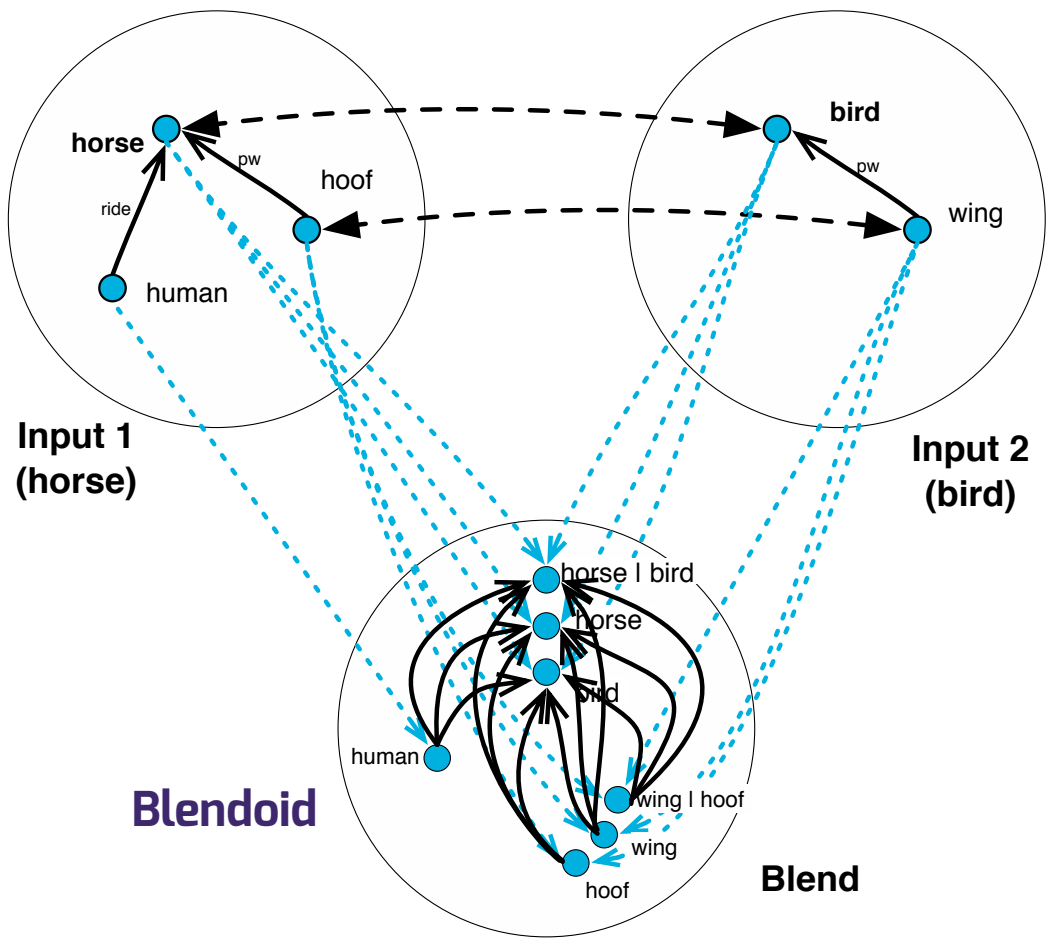
Blender

- For each mapping m, makes a blending projection

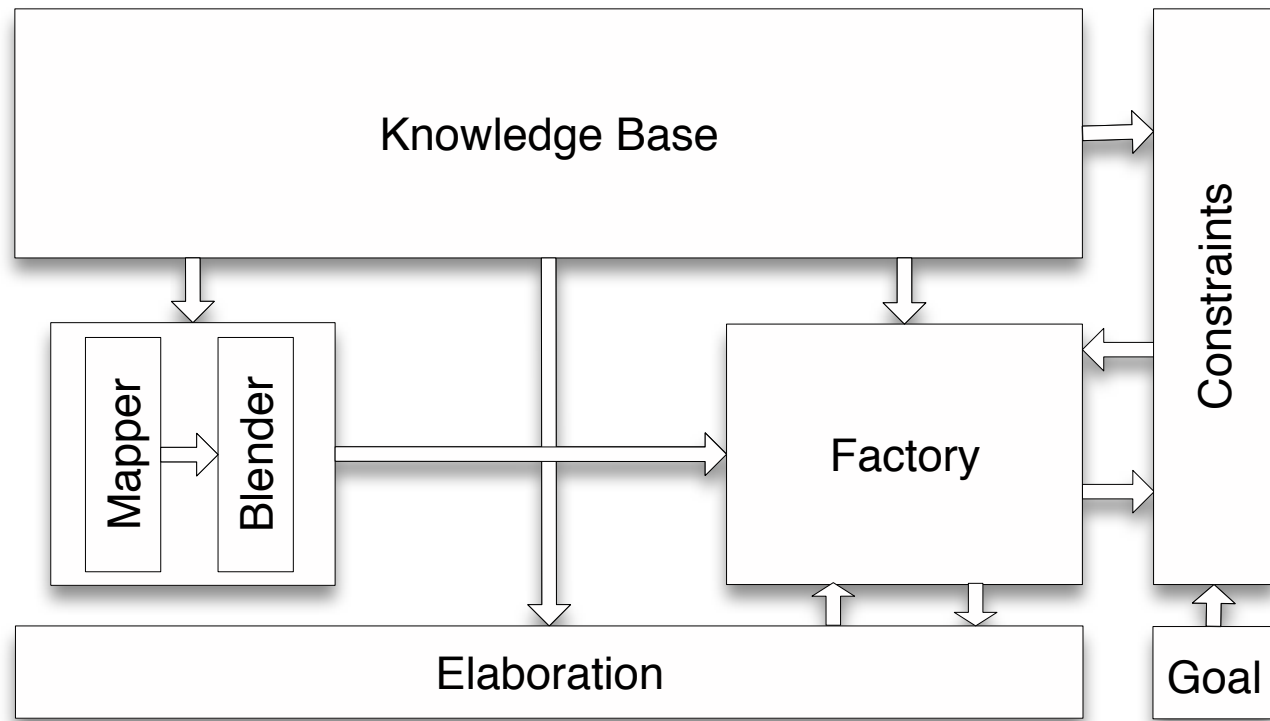


Blender

- For each mapping m , makes a blending projection
- Then, projects remaining elements in the Blend

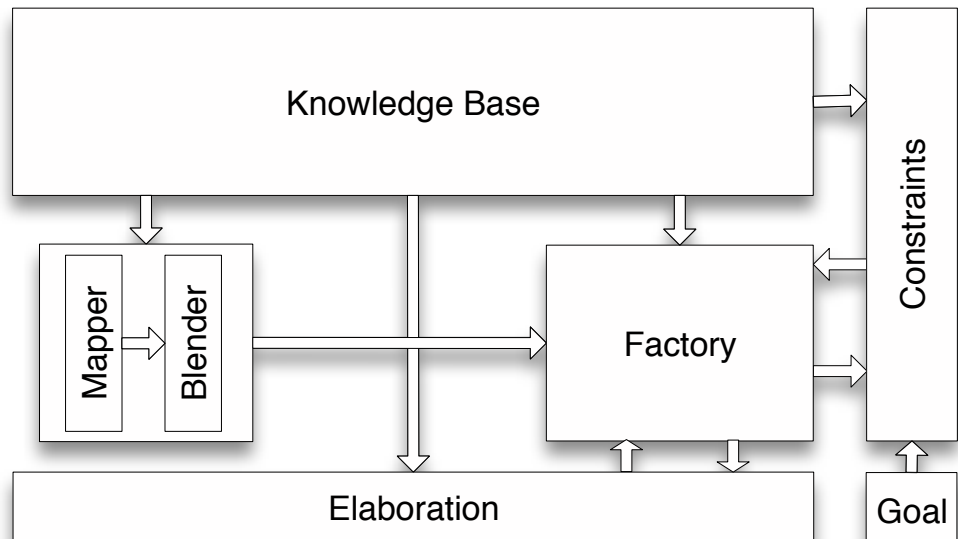


Factory



Factory

- Explores the space of all possible combinations of projections
- Divergent Strategy: GA
- Convergent Strategy
- Stopping condition



Factory

- Evolve projections:
 - individual = set of projections for each node of input domains
 - Paralell search for best blend
- Compute Blend:
 - for each individual
- Fitness function:
 - weighted sum of optimality constraints
 - 8 optimality principles (from F&T 2002)

Optimality Constraints (F&T 2002)

- Integration
- Topology
- Maximization of Vital Relations
- Unpacking
- Relevance
- Web
- Pattern Completion
- Intensification of Vital Relations

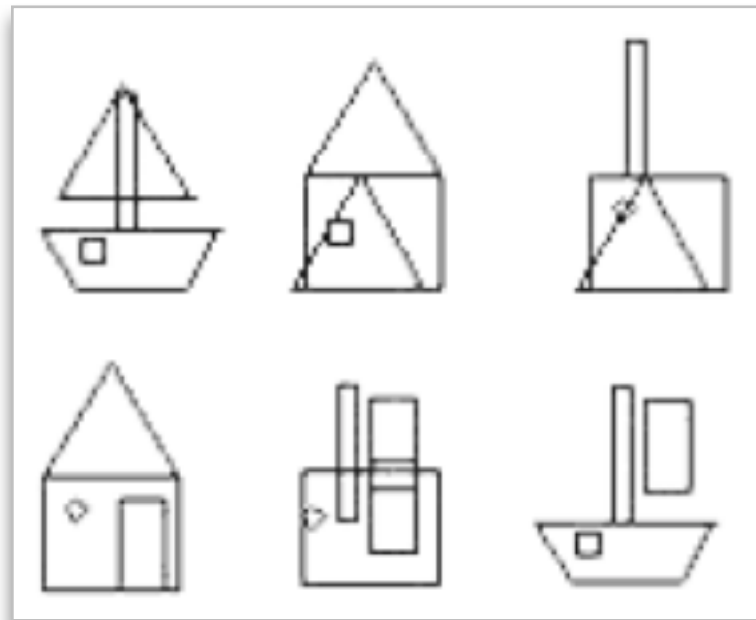
Elaboration

- Completion + Elaboration
- Run Frames, run rules

Boat-House experiment

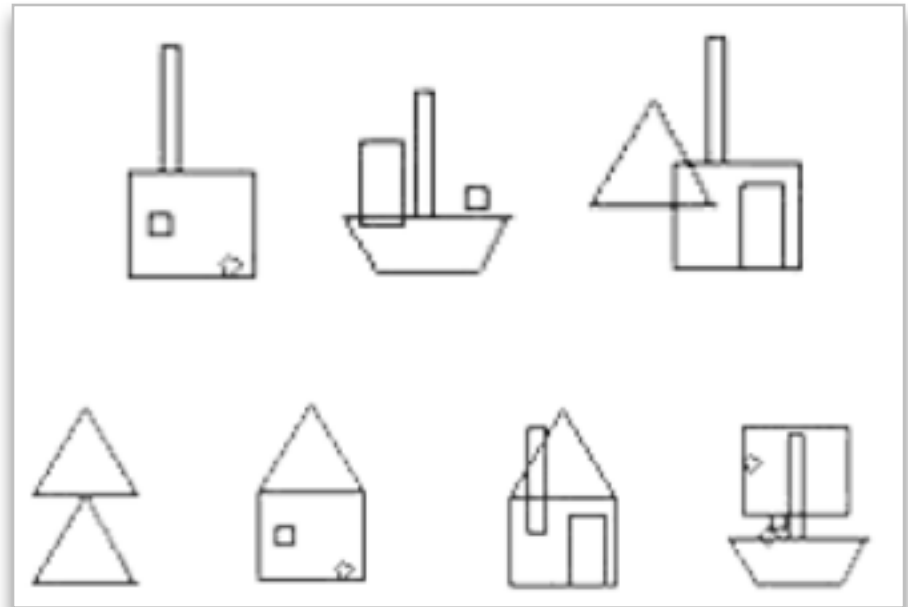
- Only Concept Maps + Instances

entrance	↔	movement
task	↔	task
protection	↔	support
roof	↔	mast
door	↔	sail
house	↔	sailing_boat
physical_		
structure	↔	boat
window	↔	hatch
body	↔	vessel
water_proof	↔	slow
container	↔	container
observation	↔	observation



Boat-House experiment

body	↔	sail
container	↔	movement
door	↔	hatch
entrance	↔	observation
house	↔	sailing_boat
physical_		
structure	↔	boat
window	↔	mast
roof	↔	vessel
water_proof	↔	slow
protection	↔	container
observation	↔	support



Creatures experiment

- Input creatures



Creatures experiment - outputs



- horse|dragon (nov=0.25), horse|werewolf (0.56) and werewolf|dragon (0.62)

Creatures experiment - outputs



- horse|dragon (0.37), horse|werewolf (0.86) and werewolf|dragon (0.65)

Recent approaches

- Li, B., Zook, A., Davis, N., and Riedl, M. (2012). Goal-Driven Conceptual Blending: A Computational Approach for Creativity (ICCC12)
 - address the efficiency issues by constructing blends in a goal-driven and context-driven manner.
- Veale, T. (2012). From Conceptual “Mash-ups” to “Bad-ass” Blends: A Robust Computational Model of Conceptual Blending. (ICCC12)
 - constrained notion of Blend for creative reuse and extend existing common-sense knowledge of a topic