

# NOVAMENTE

A Practical Architecture for Artificial General Intelligence

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# The Novamente Project

- **Long-term goal:**
  - creating "artificial general intelligence" approaching and then exceeding the human level
  - to be approached via a series of incremental phases
    - Learning programme inspired by human developmental psychology
    - The system is taught via its embodiment in a 3D simulation world
- **Novamente AI Engine: an integrative AI architecture**
  - Overall architecture inspired by cognitive science
  - a "weighted labeled hypergraph" knowledge representation
    - smoothly spans perception, cognition and action
    - Aspects in common with semantic nets and attractor neural nets
  - Learning via computer science algorithms:
    - **evolutionary programming** (a special kind of EDA)
    - **probabilistic inference** (Probabilistic Logic Networks)
  - efficient, scalable C++/Linux implementation
- Currently parts of the Novamente codebase are being **used for commercial projects**
  - natural language processing
  - biological data analysis



# Overview Papers

- *The Novamente AI Engine*
  - IJCAI Workshop on Intelligent Control of Agents, Acapulco, August 2003
- *Novamente: An Integrative Architecture for Artificial General Intelligence*
  - AAI Symposium on Achieving Human-Level Intelligence Through Integrated Systems and Research, Washington DC, October 2004
- *Patterns, Hypergraphs and General Intelligence*
  - World Congress on Computational Intelligence, Vancouver CA, July 2006
- Chapter on Novamente in
  - *Artificial General Intelligence* volume, Springer Verlag, 2006

# Novamente-Related Books-in-Progress

- *The Hidden Pattern*
  - *Related philosophy of mind*
  - *In press; to appear 2006*
- *Probabilistic Term Logic*
  - In final editing stage; to be submitted 2006*
- *Engineering General Intelligence*
  - In final editing stage*
  - Reviews the overall NM design*
  - May or may not be submitted (AI Safety concerns)*
- *Artificial Cognitive Development*
  - Developmental psychology for Novamente and other AGIs*
  - In preparation*



## The Grand Vision

- Conceptual Background
- Teaching Approach
- Knowledge Representation
- Software Architecture
- Learning Dynamics

## The Current Reality

- Implemented Components
- AGISim Experiments
- NLP Experiments

## The Path Ahead

# Novamente: The Grand Vision



# Conceptual Background: Probabilistic Patternism

- Founded on a “patternist philosophy of mind”
- An intelligent system is conceived as a system for recognizing patterns in the world and in itself
- Probability theory is used as a language for quantifying and relating patterns
- Logic (term, predicate, combinatory) is used as a base-level language for expressing patterns
- Self-analysis allows the system to recognize and utilize patterns existing emergently among numerous logical expressions

# Conceptual Background: Novamente Learning Dynamics

- Evolutionary learning is used to generate speculative new patterns
- Logical inference is used to systematically extrapolate known patterns
  - Accounting appropriately for uncertainty in inference is critical
- Simpler, statistical pattern mining algorithms are also incorporated





# Conceptual Background: Definition of Intelligence

- Intelligence is considered as the ability to achieve complex goals in a complex environment
- Goals are achieved via recognizing probabilistic patterns of the form “Carrying out procedure  $P$  in context  $C$  will achieve goal  $G$ .”

*The Structure of Intelligence*, Springer-Verlag, 1993

*The Evolving Mind*, Gordon and Breach, 2003

*Chaotic Logic*, Plenum Press, 1994

*From Complexity to Creativity*, Plenum Press, 1997

*Creating Internet Intelligence*, Kluwer Academic, 2001

*The Hidden Pattern*, Brown Walker Press, 2006

Page Count = 472; Spine = 0.951 "

*The Hidden Pattern* presents a novel philosophy of mind, intended to form a coherent conceptual framework within which it is possible to understand the diverse aspects of mind and intelligence in a unified way. The central concept of the philosophy presented is the concept of "pattern": minds and the world they live in and co-create are viewed as patterned systems of patterns, evolving over time, and various aspects of subjective experience and individual and social intelligence are analyzed in detail in this light.

Many of the ideas presented are motivated by recent research in artificial intelligence and cognitive science, and the author's own AI research is discussed in moderate detail in one chapter. However, the scope of the book is broader than this, incorporating insights from sources as diverse as Vedantic philosophy, psychedelic psychotherapy, Nietzschean and Peircean metaphysics and quantum theory. One of the unique aspects of the patternist approach is the way it seamlessly fuses the mechanistic, engineering-oriented approach to intelligence and the introspective, experiential approach to intelligence.



THE HIDDEN PATTERN  
A Patternist Philosophy of Mind

GOERTZEL

# THE HIDDEN PATTERN

A Patternist Philosophy of Mind



BEN GOERTZEL

# *The Hidden Pattern:*

## Contents

1. Meta-Philosophy
2. Kinds of Minds
3. Universal Mind
4. Intelligence
5. Experience
6. Four Levels of Mind
7. Complexity
8. Quantum Reality and Mind
9. Free Will
10. Emotion
11. Autopoiesis
12. Evolution
13. Science
14. Language
15. Toward Artificial Minds
16. Post-Embodied AI
17. Causation
18. Belief and Self Systems
19. Creative Intuition
20. Mindfulness and Evil
21. Immortality
22. Compassion and Ethics

### Appendices

- A1. Toward a Mathematical Theory of Pattern
- A2. Toward a Mathematical Theory of Mind
- A3. Notes on the Formalization of Causal Inference



# AI Teaching Methodology

- Embodiment
- Post-embodiment
- Developmental Stages

# The Power of Embodiment

## **Embodiment (real or virtual) provides a would-be AGI with**

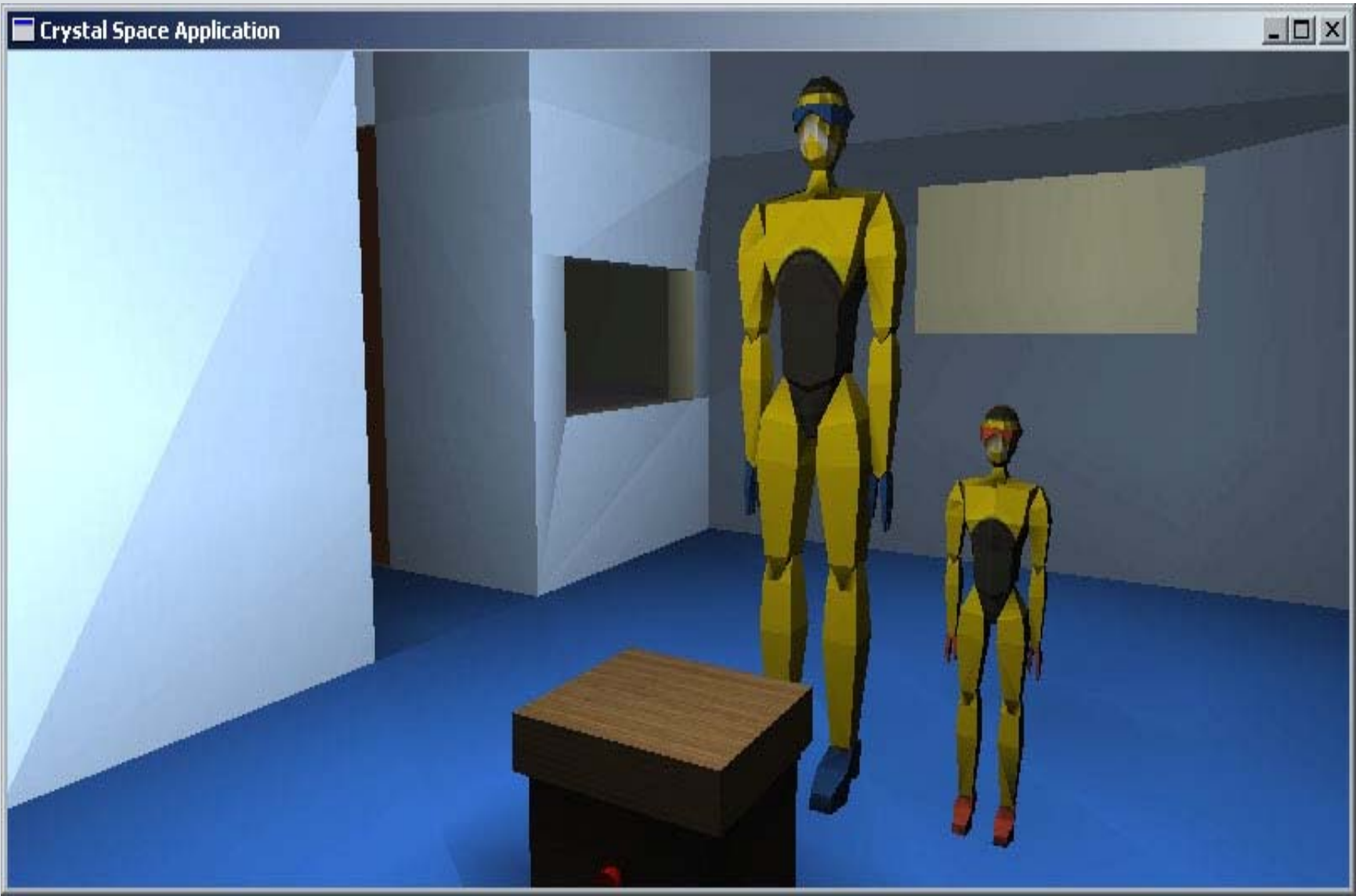
- Symbol grounding
  - Most crucially: grounding of subtle words like prepositions
- An effective medium for learning complex cognitive skills
  - attention allocation
  - procedure-learning
  - inference control
- A sense of self
  - Critical for cognition as well as mental health
- Empathy with humans



# AGISim:

## An Open-Source Simulation Environment for AGI

- AI systems can sense and act in real-time via embodiment in a 3D virtual world
- Uses CrystalSpace (open-source game engine) for visualization
- Provides AI systems with multisensory inputs
  - visual inputs at varying levels of granularity: pixels, polygons or objects
  - hearing, touch, proprioception, ...
- Integration with natural language interface for fluid, situated communication
- Suitable for teaching/learning based on a developmental-psychology-based methodology
- Compatible with Novamente but usable by any AI system via a simple sockets-based protocol






Novamente - AGI Sim

**Goals**

- Notice novelty 0.5
- Gather knowledge 0.5
- Create and consolidate abstract knowledge 0.5

**Simulation**




**Resources**

- 45% - Goal-driven Inference
- 35% - Sensor Processing
- 20% - Background Inference

**Log**

Submit ?

Reward

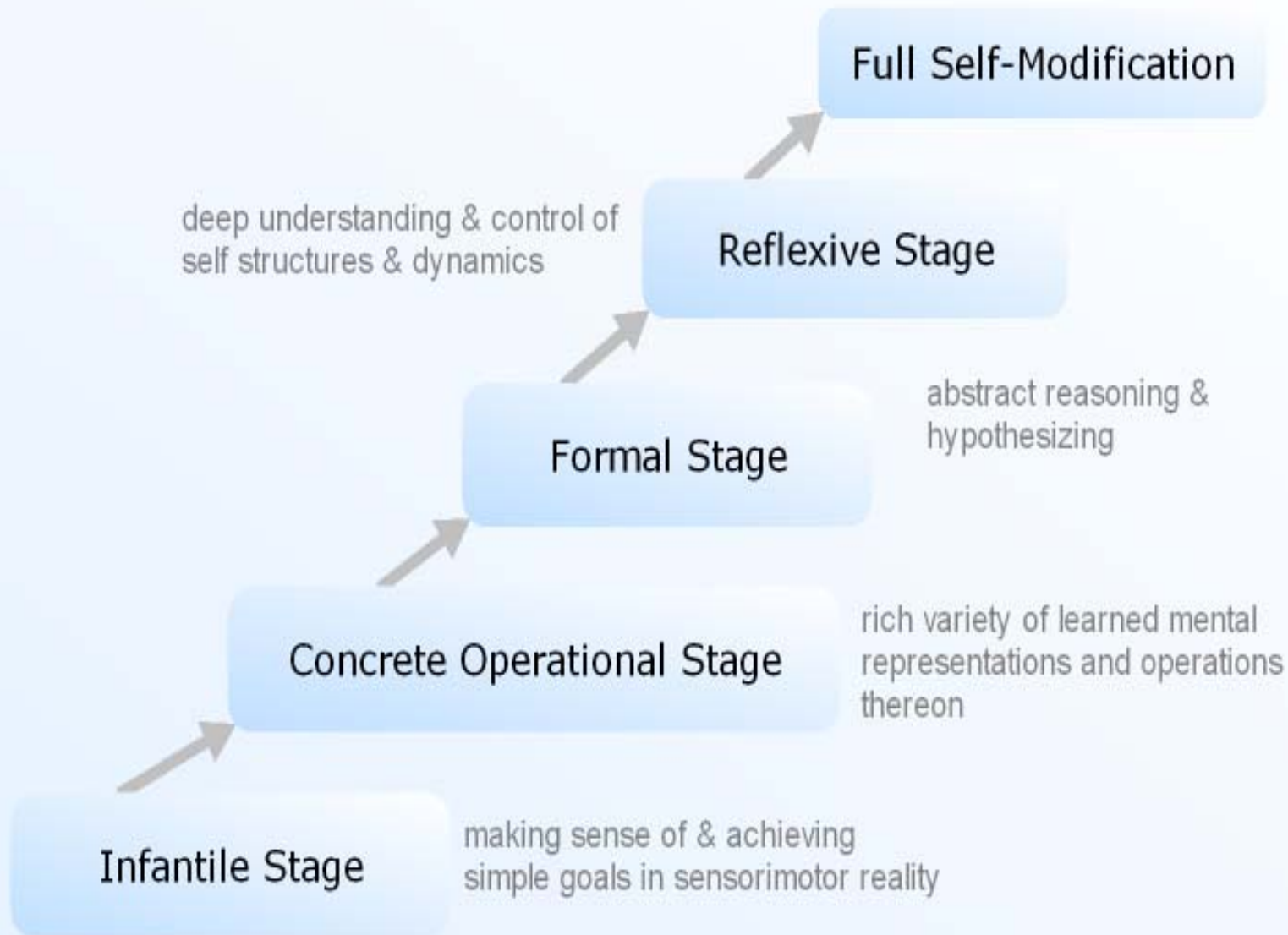


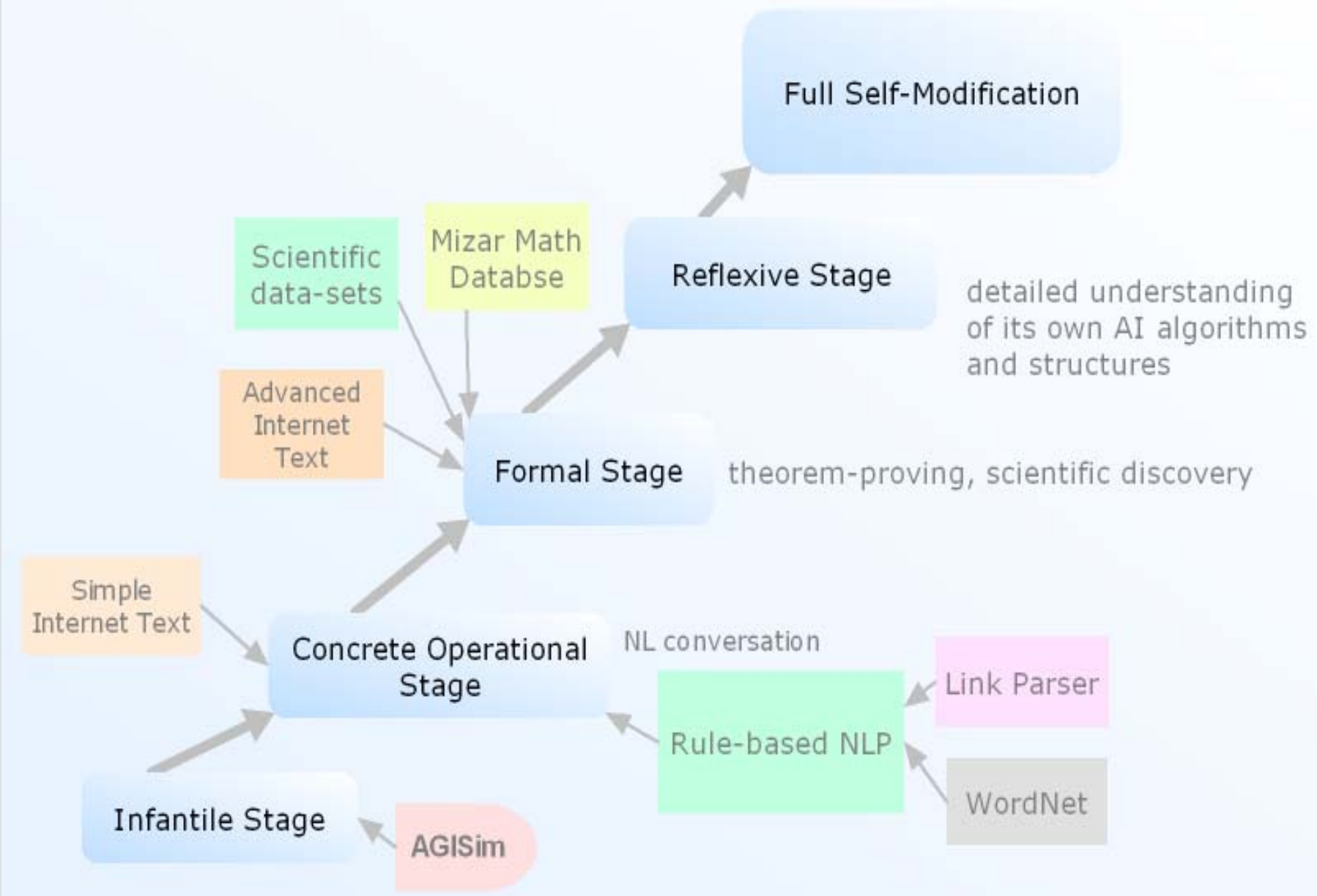
Correct

# Post-Embodied AI

## **AI systems may viably synthesize knowledge gained via various means**

- virtually embodied experience
  - AGISim
- physically embodied experience
  - Robotics
- explicit encoding of knowledge in natural language
- ingestion of databases
  - WordNet, FrameNet, Cyc, etc.
  - quantitative scientific data





# *Artificial Cognitive Development :*

## Contents

*(with Stephan Vladimir Bugaj, Ari Heljakka. ??)*

1. Cognitive Development from a Systems Theory Perspective
2. Human versus Artificial Developmental Psychology
3. Object Recognition and Object Permanence
4. Grounding Semantic Primitives
5. Building the Phenomenal Self
6. Experiential Language Learning
7. Learning “Theory of Mind”
8. Learning Conservation Laws
9. Learning Ethical Behavior



# Knowledge Representation

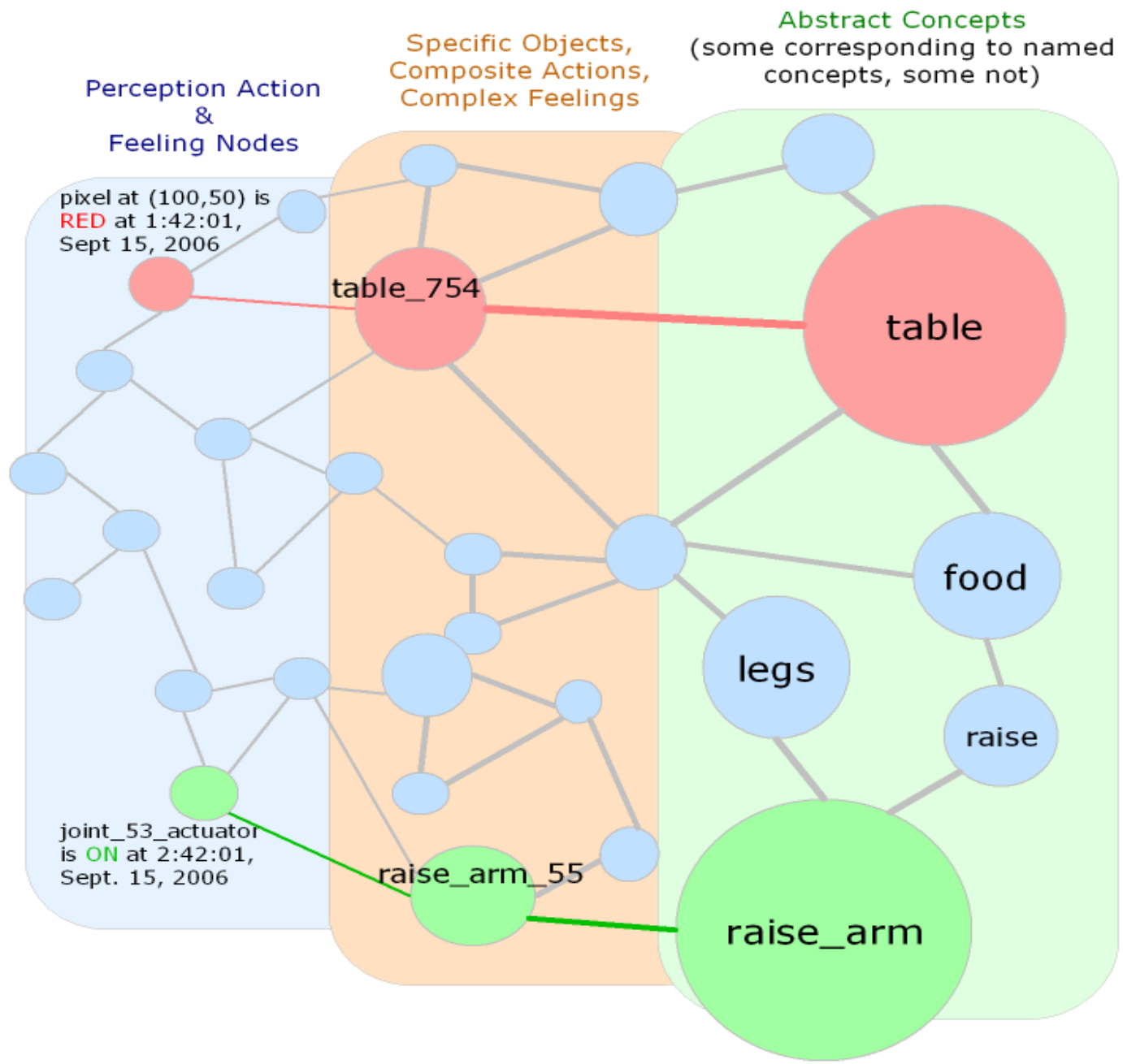
# Novamente's "Atom Space"

- Atoms = Nodes or Links
- Atoms have
  - Truth values (probability + weight of evidence)
  - Attention values (short and long term importance)
- The Atomspace is a weighted, labeled hypergraph

# Novamente's "Atom Space"

- Not a neural net
  - No activation values, no attempt at low-level brain modeling
- Not a semantic net
  - Atoms may represent percepts, procedures, or parts of concepts
  - Most Nodes do not correspond to any simple English label

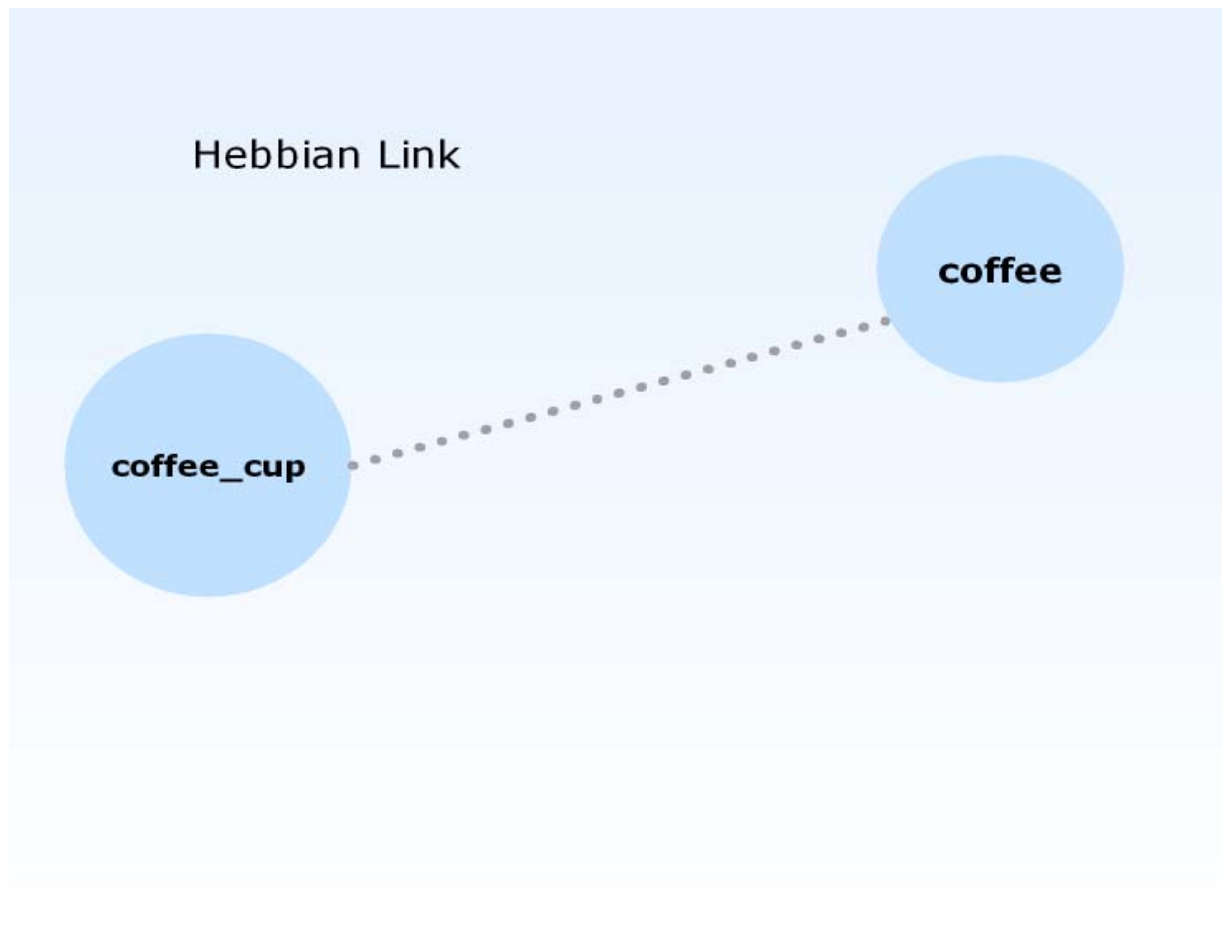




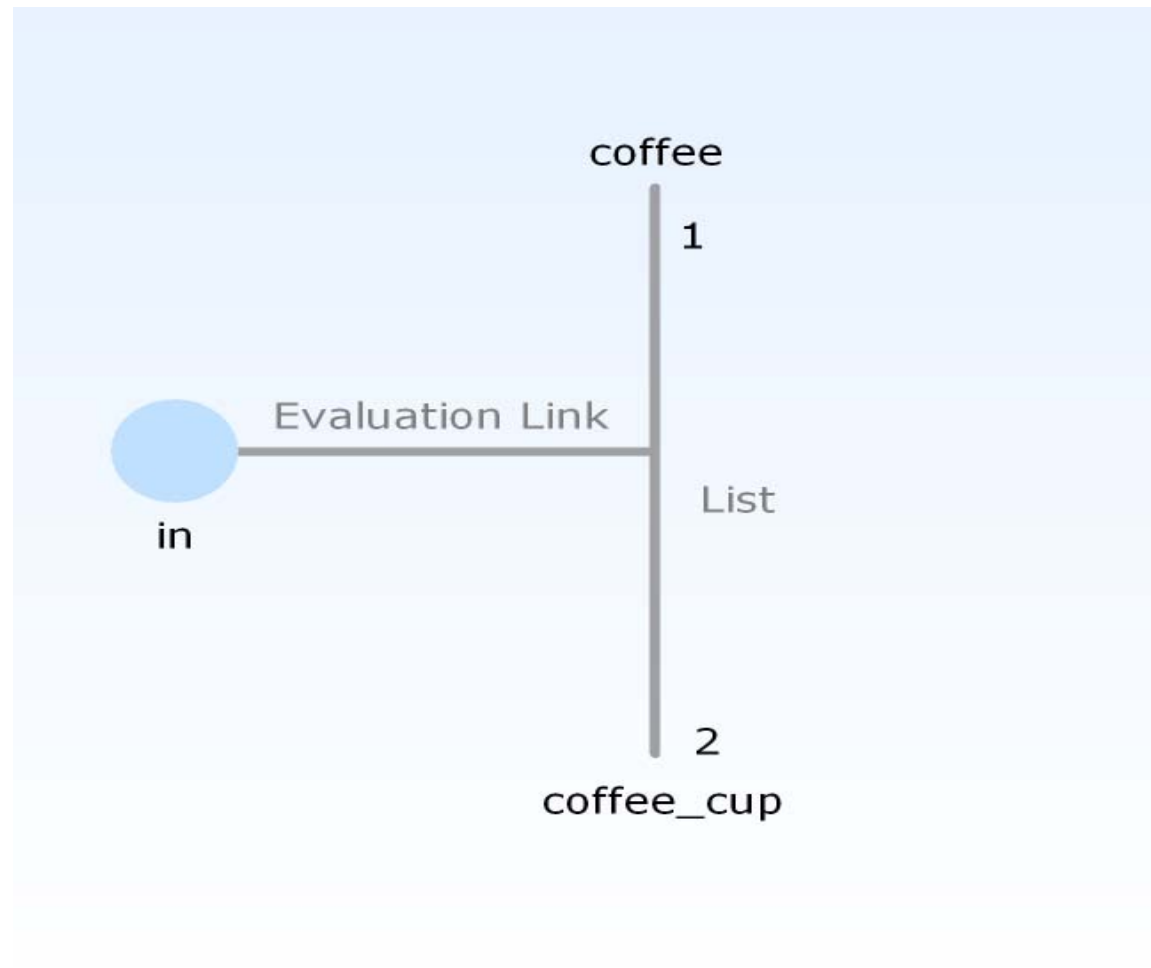
Node Variety	Description
<b>Perceptual Nodes</b>	These correspond to perceived items, like WordInstanceNode, CharacterInstanceNode, NumberInstanceNode, PixelInstanceNode
<b>Procedure Nodes</b>	These contain small programs called "schema," and are called SchemaNodes. Action Nodes that carry out logical evaluations are called PredicateNodes.
<b>ConceptNodes</b>	This is a "generic Node" used for two purposes. An individual ConceptNode may represent a category of Nodes. Or, a Map of ConceptNodes may represent a concept.
<b>Psyche Nodes</b>	These are GoalNodes and FeelingNodes, which are special PredicateNodes that play a special role in overall system control, in terms of monitoring system health, and orienting overall system behavior.

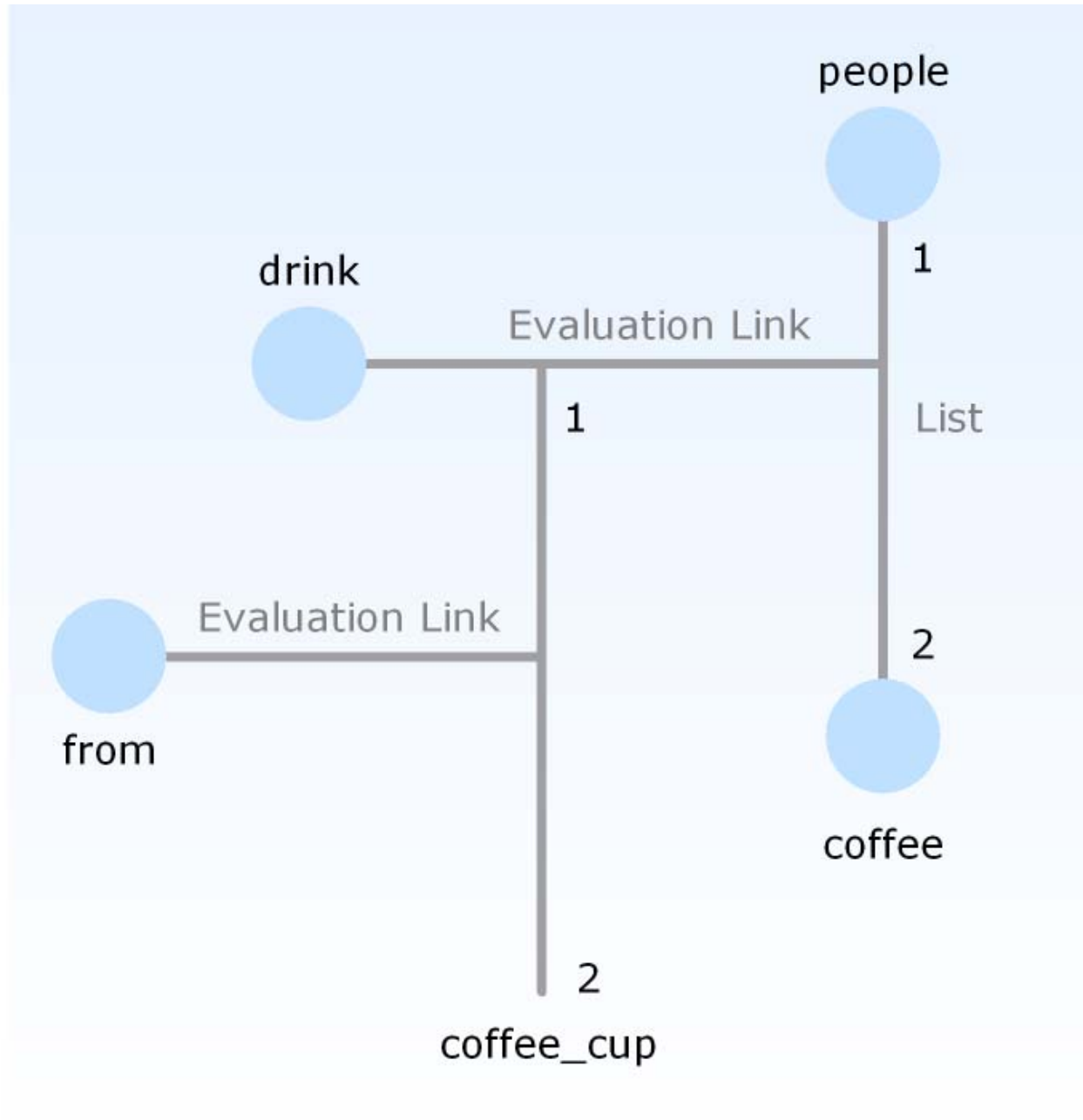
Link Variety	Description
<b>Logical links</b>	These represent symmetric or asymmetric logical relationships , either among Nodes (InheritanceLink, SimilarityLink), or among links and PredicateNodes (e.g. ImplicationLink, EquivalenceLink) .
<b>MemberLink</b>	These denote fuzzy set membership .
<b>Associative links</b>	These denote generic relatedness, including HebbianLink learned via Hebbian learning, and a simple AssociativeLink representing relationships derived from natural language or from databases.
<b>ExecutionOutput Link</b>	These indicate input-output relationships among SchemaNodes and PredicateNodes and their arguments.
<b>Action-Concept links</b>	Called ExecutionLinks and EvaluationLinks, these form a conceptual record of the actions taken by SchemaNodes or PredicateNodes .
<b>ListLink and concatListLink</b>	These represent internally -created or externally -observed lists, respectively .

Links may denote generic association ...



...or precisely specified relationships





# Attention Values

Low Long-term Importance

High Long-term Importance

Low Short-term  
Importance

Useless

Remembered but not  
currently used (e.g.  
mother's phone #)

High Short-term  
Importance

Used then forgotten  
(e.g. most precepts)

Used and remembered

# Truth Values

Strength low

Strength high

Weight of  
evidence low

Weakly suspected to be  
false

Weakly suspected to be  
true

Weight of  
evidence high

Firmly known to be false

Firmly known to be true

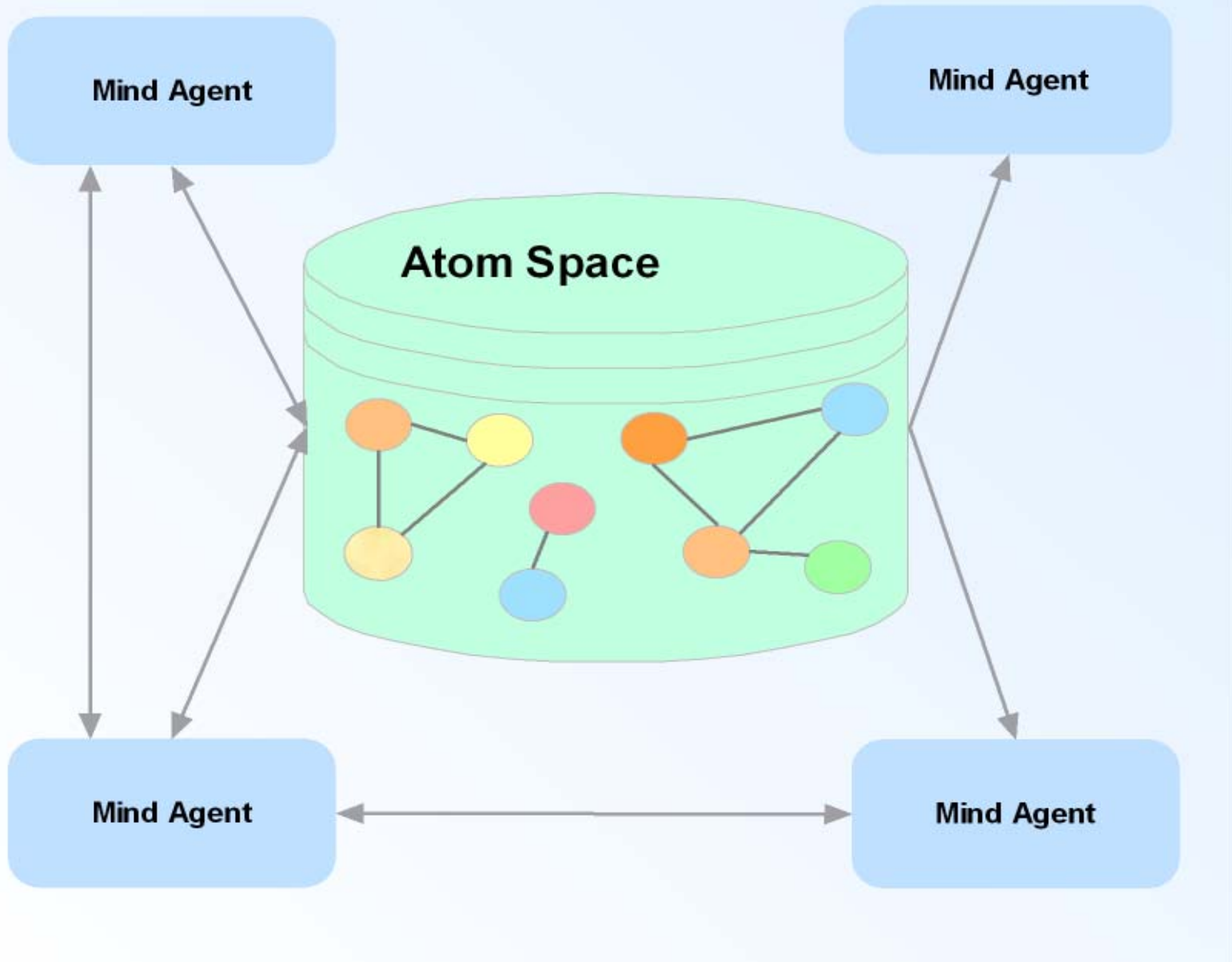
Weight of evidence low	Weakly suspected to be false	Weakly suspected to be true
Weight of evidence high	Firmly known to be false	Firmly known to be true



# Software Architecture

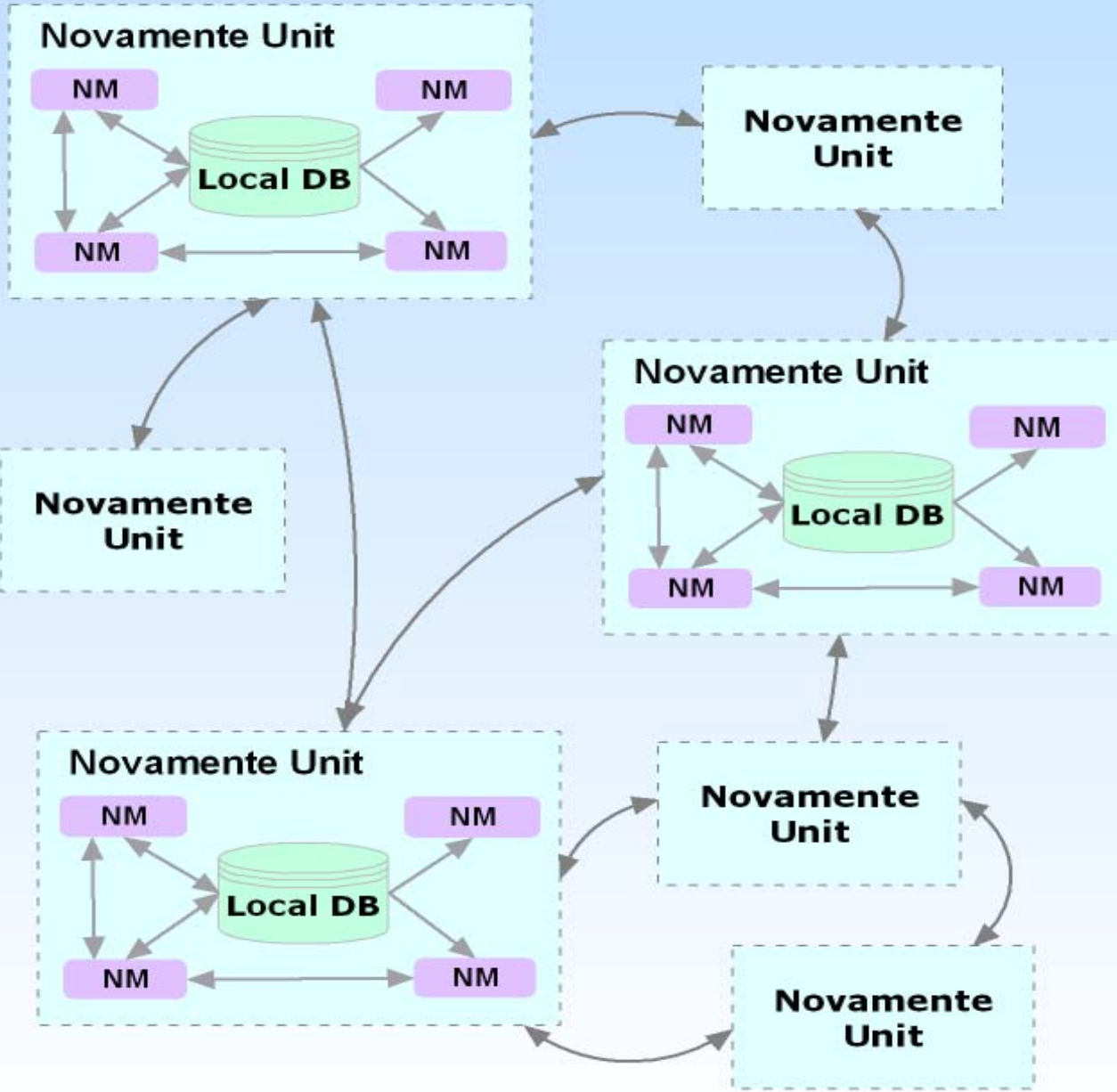


# Novamente Machine

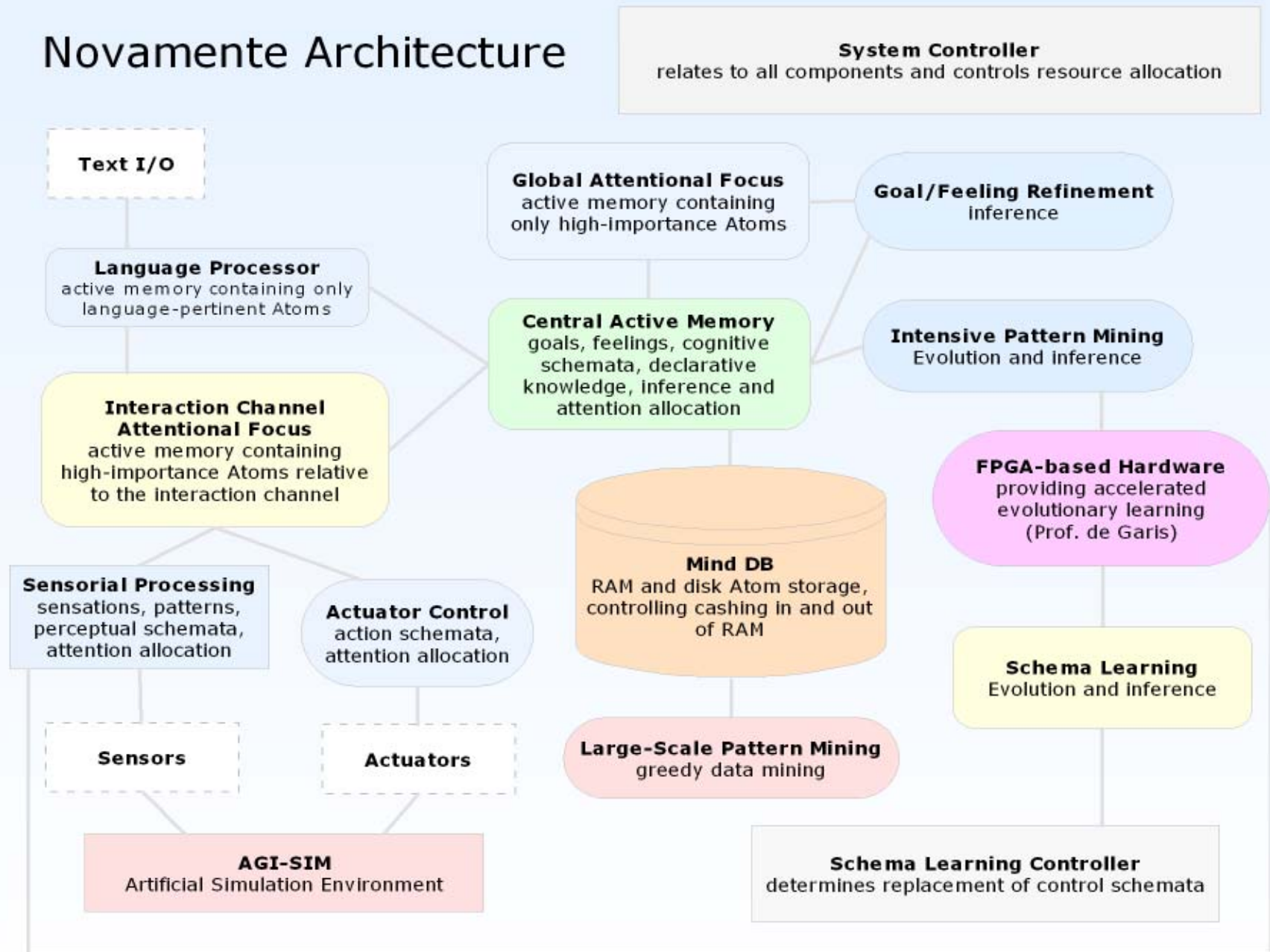


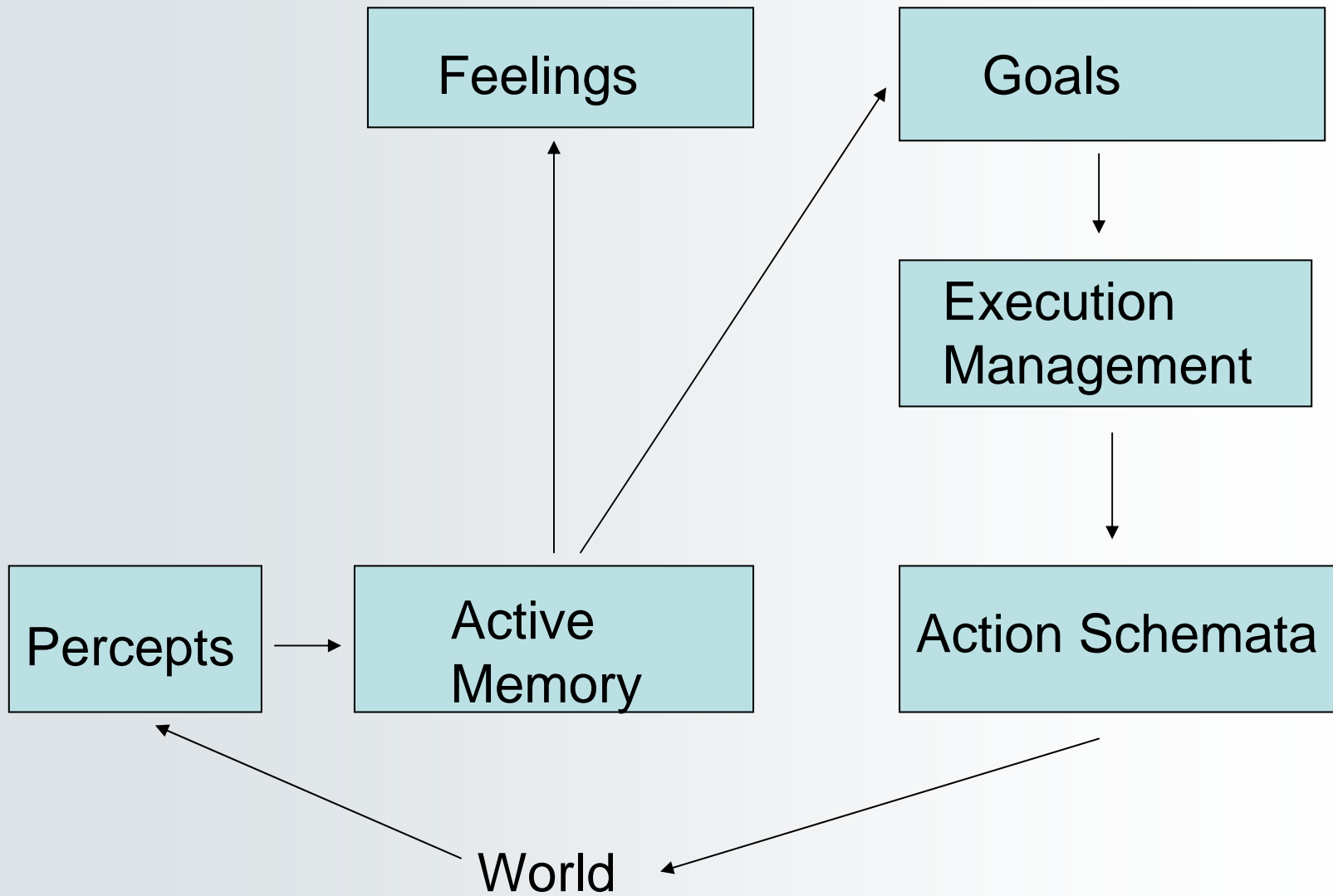
MindAgent	Function
<b>Spontaneous Inference</b>	Uses PLN inference to infer new links from existing ones, driven by a general "fitness function" that aims to create surprising or useful information
<b>Goal-Directed Inference</b>	Uses PLN inference to figure out how to achieve current goals
<b>Goal Refinement</b>	Uses PLN inference and heuristics to create new goals refining existing ones
<b>Predicate Schematization</b>	Transforms logical knowledge regarding goal achievement into schemata that can be executed to achieve goals
<b>LogicalLinkMining</b>	Creates logical links out of nonlogical links (a form of pattern recognition)
<b>Evolutionary Predicate Learning</b>	Creates PredicateNodes containing predicates that predict membership in ConceptNodes
<b>Clustering</b>	Creates ConceptNodes representing clusters of existing ConceptNodes
<b>Importance Updating</b>	Updates Atom "importance" variables and other related quantities
<b>Hebbian Association Formation</b>	Builds and modifies HebbianLinks between Atoms, based on a PLN-derived Hebbian reinforcement learning rule
<b>Evolutionary Schema Learning</b>	Creates SchemaNodes that fulfill criteria, e.g. that are expected to satisfy given GoalNodes
<b>Concept Formation</b>	Creates speculative, potentially interesting new ConceptNodes via blending existing ones

MindAgent	Function (Table Continued)
<b>Predicate/Schema Formation</b>	Creates speculative, potentially interesting new SchemaNodes and PredicateNodes by blending existing ones
<b>Schema Execution</b>	Enacts active SchemaNodes, allowing the system to carry out coordinated trains of action
<b>Map Encapsulation</b>	Scans the AtomTable for patterns and creates new Atoms embodying these patterns
<b>Map Expansion</b>	Takes schemata and predicates embodied in nodes, and expands them into multiple Nodes and links in the AtomTable (thus transforming complex Atoms into Maps of simple Atoms)
<b>Homeostatic Parameter Adaptation</b>	Applies evolutionary programming to adaptively tune the parameters of the system



# Novamente Architecture





# Learning Dynamics



# *Engineering General Intelligence:*

## Contents

1. Patterns, Hypergraphs and General Intelligence
2. Atoms and Atomspaces
3. Denoting Atoms
4. Combo Trees and the Combo Language
5. The Mind OS
6. Embodied Goal-Oriented Cognition
7. Procedure Execution
8. Dimensional Embedding
9. Evolutionary Procedure Learning
10. Speculative Concept Formation
11. Integrative Procedure and Predicate Learning
12. Attention Allocation
13. Map Encapsulation and Expansion



# *Probabilistic Logic Networks:*

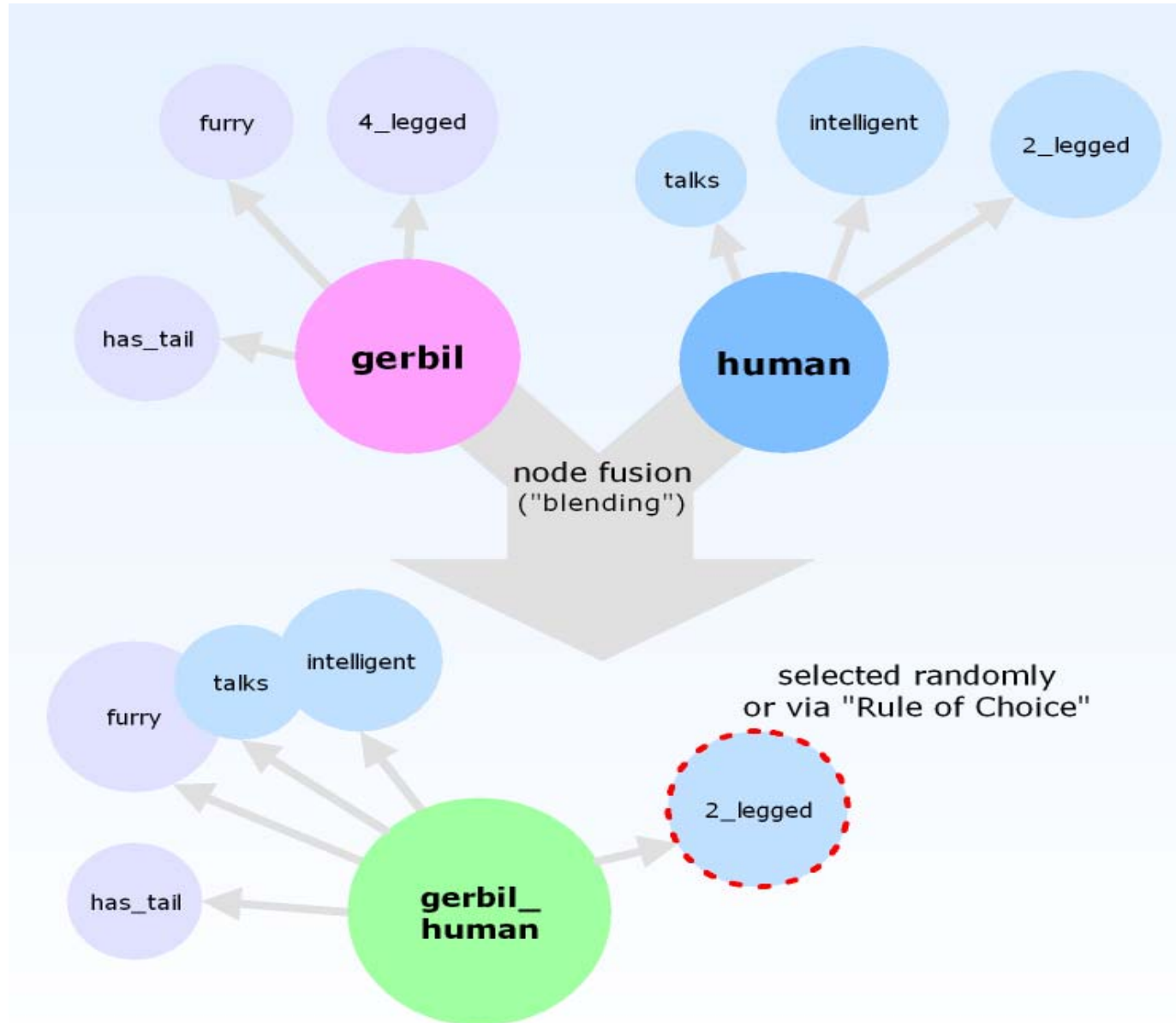
## Contents

*(with Matt Ikle', Izabela Freire Goertzel, Ari Heljakka)*

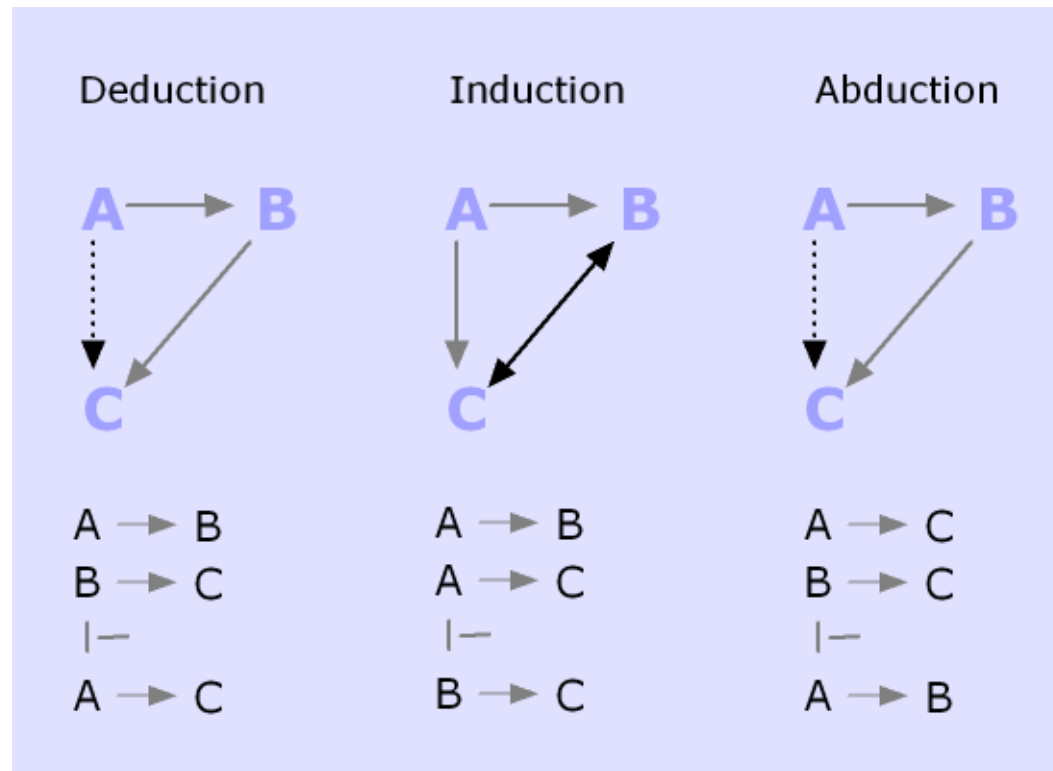
1. Introduction
2. Knowledge Representation
3. Experiential Semantics
4. First-Order Extensional Inference: Rules and Strength Formulas
5. Specialized Approaches for Large-Scale Inference
6. The Inference Metric
7. Error Magnification in Inference Formulas
8. Inference with Distributional Truth Values
9. Higher-Order Extensional Inference: Rules and Strength Formulas
10. Intensional Inference
11. Weight of Evidence
12. Temporal and Causal Inference
13. Applying Probabilistic Logic Networks



Novamente contains multiple heuristics for Atom creation, including “blending” of existing Atoms



## Example PLN Rules Acting on ExtensionalInheritanceLinks



## Unification:

```
Imp <1.00, 0.95>
  AND
    Inh($t,toy)
    Inh($b,bucket)
    Eval placed_under($t,$b)
    Eval found_under($t,$b)
  Inh (toy_6,toy)
  Inh (red_bucket_6,bucket)
  Eval placed_under(toy_6,red_bucket_6)
  AND <1.00, 0.98>
    Inh (toy_6,toy)
    Inh (red_bucket_6,bucket)
    Eval placed_under(toy_6,red_bucket_6)
```

|-

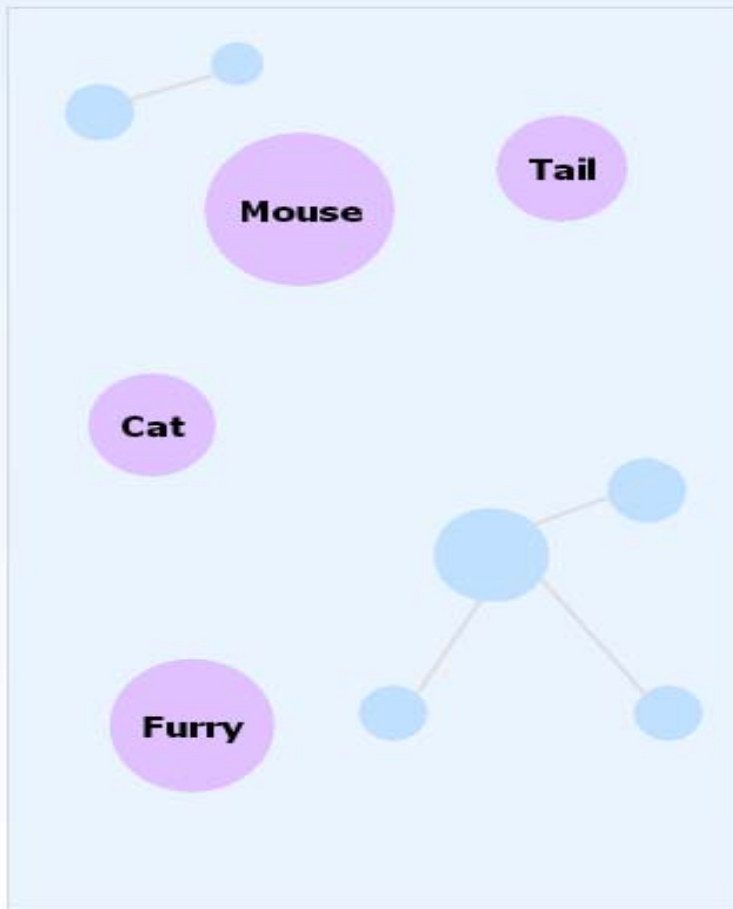
```
Imp <1.00, 0.95>
  AND <1.00, 0.98>
    Inh (toy_6,toy)
    Inh (red_bucket_6,bucket)
    Eval placed_under(toy_6,red_bucket_6)
  Eval found_under(toy_6,red_bucket_6)
```

Higher-order PLN inference handles complex inferences with variables, quantifiers, etc.

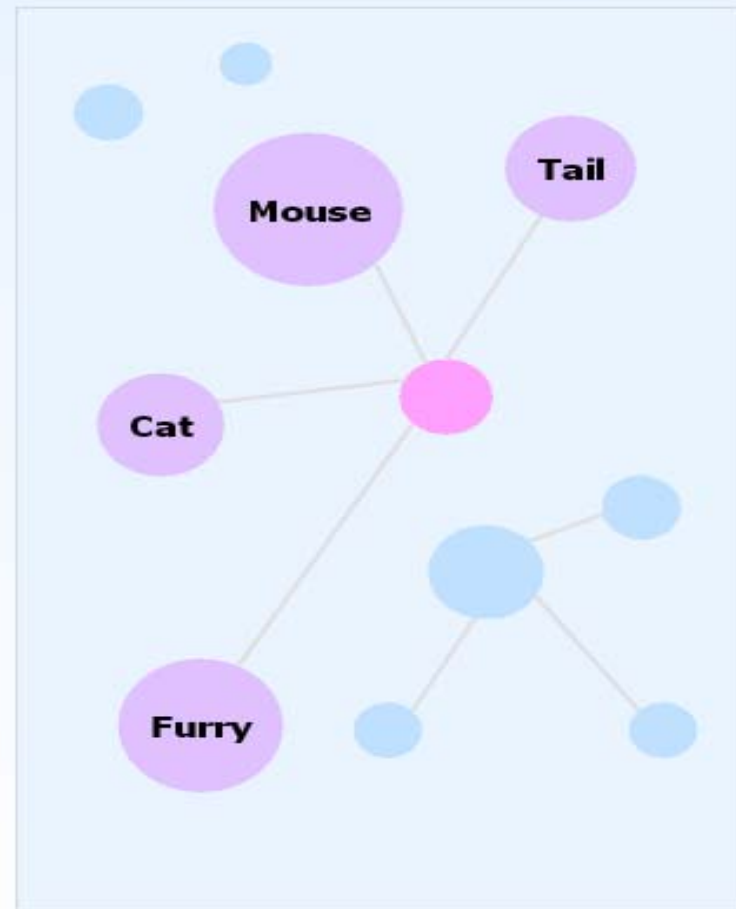


Atoms associated in a dynamic “map” may be grouped to form new Atoms: the Atomspace hence *explicitly representing patterns in itself*

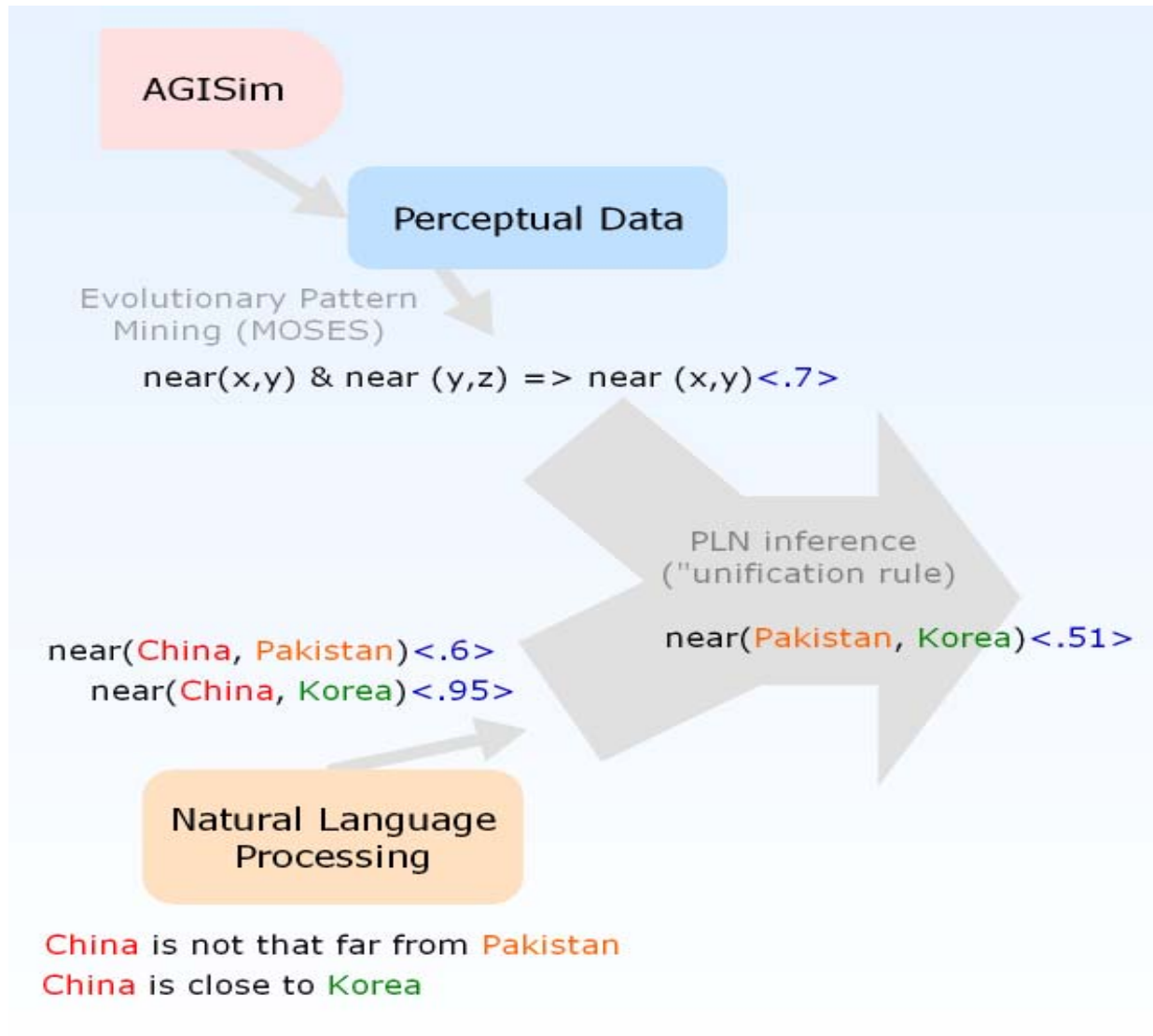
Atom Table Before  
Map Encapsulation



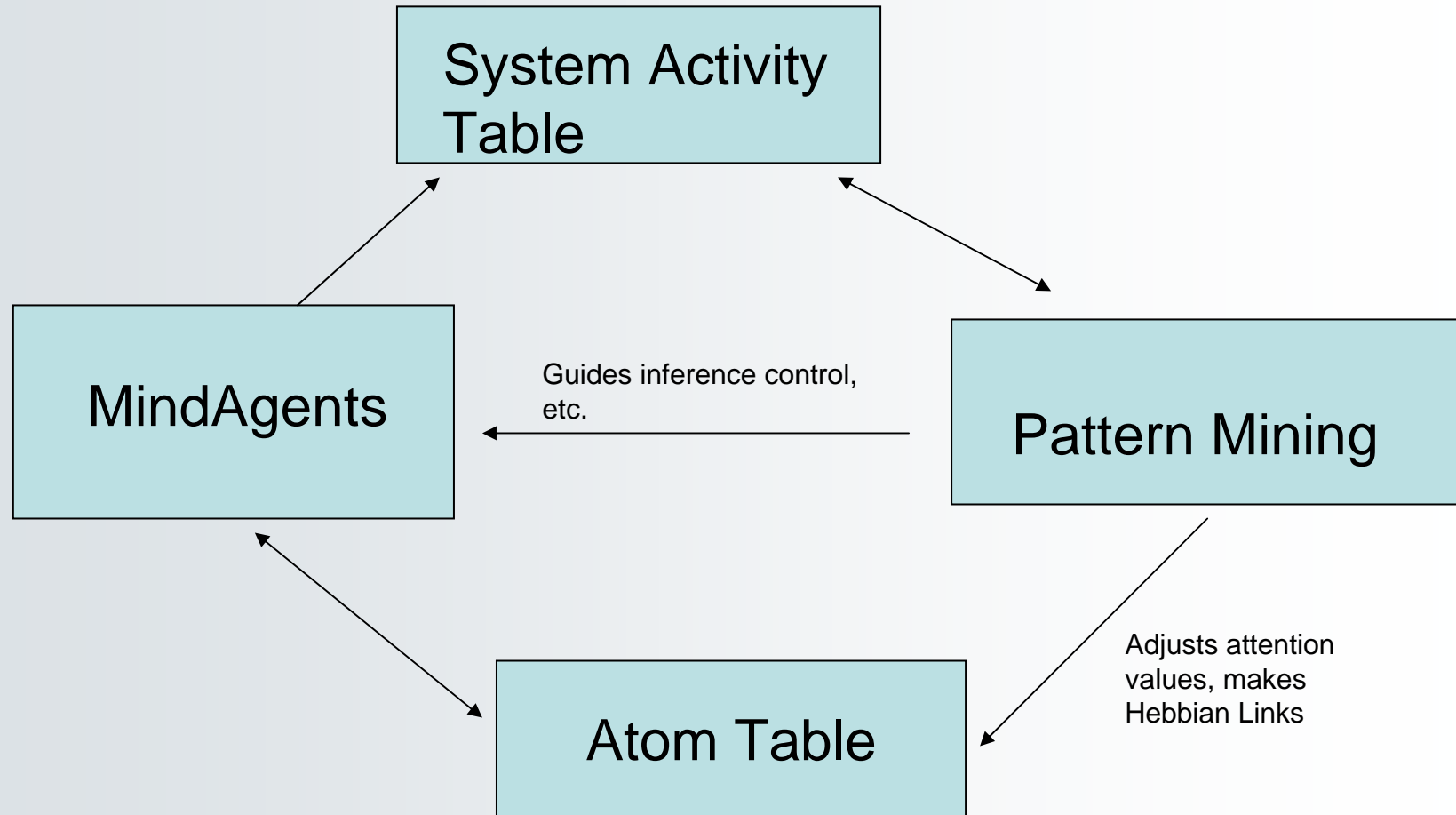
Atom Table After  
Map Encapsulation



Grounding of natural language constructs is provided via inferential integration of data gathered from linguistic and perceptual inputs



# Attention Allocation





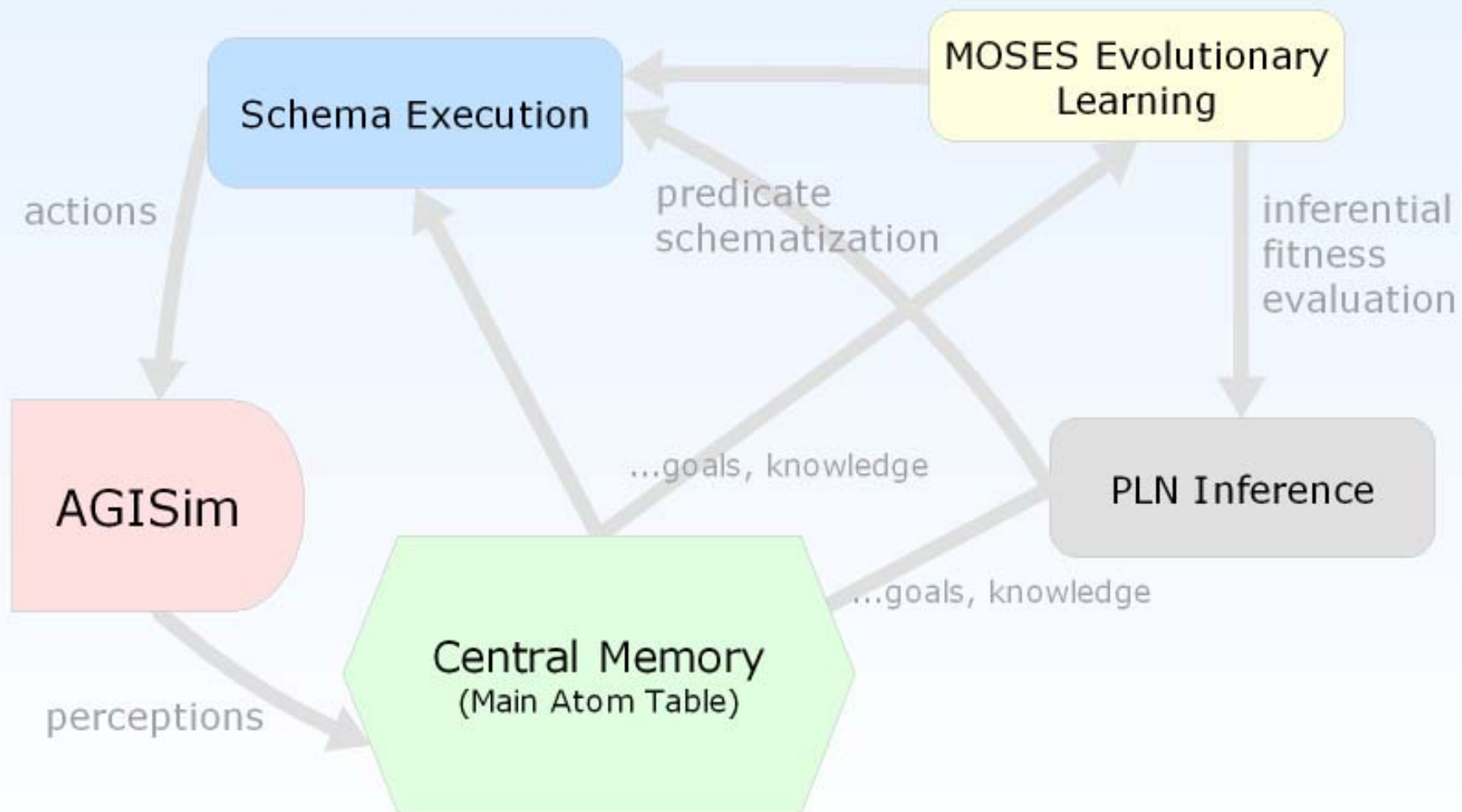
# Novamente: The Current Reality



# Implemented Components

- **Novamente core system**
  - AtomTable, MindAgents, Scheduler, etc.
  - Now runs on one machine; designed for distributed processing
- **PLN**
  - Relatively crude inference control heuristics
  - Simplistic predicate schematization
- **MOSES**
  - Little experimentation has been done evolving procedures with complex control structures
- **Schema execution framework**
  - Enacts learned procedures
- **AGISim**
  - And proxy for communication with NM core
- **NLP front end**
  - External NLP system for “cheating” style knowledge ingestion

# Current AGISim Learning Architecture



# Simple, Initial AGISim Experiments

- Fetch
- Tag
- Piagetan A-not-B experiment
- Word-object association

Goals

- Notice novelty  
0.5
- Gather knowledge  
0.5
- Create and consolidate abstract knowledge  
0.5

Simulation



Resources

- 45% - Goal-driven Inference
- 35% - Sensor Processing
- 20% - Background Inference

Log

Teacher: Where is the toy?  
Teacher: Open it  
Teacher: Good! The toy is there!

Reward



Correct

Submit



# Inference Trajectory for A-not-B

**Target:**

Eval found\_under(toy\_6,\$1)

**Step 1**

**ANDRule:**

Inh (toy\_6,toy)

Inh (red\_bucket\_6,bucket)

Eval placed\_under(toy\_6,red\_bucket\_6)

|-

AND <1.00, 0.98>

Inh (toy\_6,toy)

Inh (red\_bucket\_6,bucket)

Eval placed\_under(toy\_6,red\_bucket\_6)

**Step 2**

**Unification:**

Imp <1.00, 0.95>

AND

Inh(\$t,toy)

Inh(\$b,bucket)

Eval placed\_under(\$t,\$b)

Eval found\_under(\$t,\$b)

AND

Inh (toy\_6,toy)

Inh (red\_bucket\_6,bucket)

Eval placed\_under(toy\_6,red\_bucket\_6)

|-

Imp <1.00, 0.94>

AND

Inh (toy\_6,toy)

Inh (red\_bucket\_6,bucket)

Eval placed\_under(toy\_6,red\_bucket\_6)

Eval found\_under(toy\_6,red\_bucket\_6)

**Step 3**

**Modus Ponens**

Imp <1.00, 0.94>

AND

Inh (toy\_6,toy)

Inh (red\_bucket\_6,bucket)

Eval placed\_under(toy\_6,red\_bucket\_6)

Eval found\_under(toy\_6, red\_bucket\_6)

AND <1.00, 0.98>

Inh (toy\_6,toy)

Inh (red\_bucket\_6,bucket)

Eval placed\_under(toy\_6,red\_bucket\_6)

|-

Eval found\_under(toy\_6, red\_bucket\_6) <1.00, 0.93>

# Predicate Schematization

Logical knowledge

EvPredImp <0.95, 0.3>  
Execution try(goto box)  
Eval near box

SimultaneousImplication  
Eval near box  
Eval can\_do(push box)

EvPredImp <0.6,0.4>  
And  
Eval can\_do(push box)  
Execution try(push box)  
Evaluation Reward



Predicate schematization

Executable procedure

repeat  
goto box  
near box  
repeat  
push box  
Reward

# NLP Subsystem

- RelEx (Relationship Extractor)
  - Developed under subcontract to INSCOM
  - Based on Carnegie-Mellon link parser
  - Add hand-crafted semantic mapping rules
  - Add statistical methods for disambiguation and reference resolution
  - Designed to allow easy feeding of NL knowledge into Novamente
  - Can be modified to enable simple language generation
- INLINK
  - Interactive system for NL knowledge entry
  - Allows user to correct RelEx's mistakes prior to submission of knowledge into Novamente



# NLP Subsystem

Viewed as “scaffolding” from an AGI perspective

Using it, we may feed Novamente semantic information that will help guide its experiential, embodied language learning process

Knowledge Entry | Queries

Mugniyah is a senior member of Hizbullah.  
 He is one of the founders of Hizbullah.  
 He is the head of security for Hizbullah.  
 The members of Hizbullah are Shi'ite Muslims.  
 He was responsible for the bombing of the U.S. embassy in Beirut in 1983.  
 63 people died in the bombing of the U.S. embassy in Beirut in 1983.  
 He was also responsible for the truck bombing of the U.S. Marine barracks in Beirut in 1983.

Sentence

he was also responsible for the truck bombing of the U.S. Marine barracks in Beirut .

Process | Submit | New | Next imported

Selected parse: parse1

Context

dave[Imad\_Mugniyah]

New | Rename | Load | Import

SubCategorization Frames | All Relations | Sense Disambiguation | Reference Resolution | Entity Categorization | Sentence Generation

```

    subj-rDESCRIPTEE
    also = [ responsible also ]
           %past

    subjAGENT      for
    responsible = [ he responsible bombing ]
                  singular %past uncountable

    subj-nFOCUS
    truck = [ bombing truck ]
            uncountable

    in[2] of
    bombing = [ bombing 1983 barrack ]
              uncountable plural

    subj-nFOCUS
    U.S._Marine = [ barrack U.S._Marine ]
                 plural singular

    in[1]
    barrack = [ barrack Beirut ]
    
```

Logon | Logout | Change password | User administration | Exit

Knowledge Entry | Queries

Mugniyah is a senior member of Hizbullah.  
He is one of the founders of Hizbullah.  
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Sentence

he was also responsible for the truck bombing of the U.S. Marine barracks in Beirut in 1983 .

Process | Submit | New | Next imported

Selected parse: parse1

Context

dave[Imad\_Mugniyah]

New | Rename | Load | Import

SubCategorization Frames | All Relations | Sense Disambiguation | Reference Resolution | Entity Categorization | Sentence Generation

Disambiguated words:

he was also responsible for the truck bombing of the U.S. Marine barracks in Beirut in 1983 .

Disambiguated SARs (Syntatic Argument Relations):

subj-n (truck , bombing)  
subj-r (also , responsible)

Below, you can select the correct sense for each word or SAR:

he	N*Male_pronoun [he] : Refers to a male.
also	R*00048649 [as_well, besides, too, also, likewise] : in addition; "he has a Mercedes, too"
responsible	A*00321319 [responsible, responsible_for(p)] : being the agent or cause; "determined who was the responsible party"; "termites were responsible for the dan
for	forFOCUS [for] : For all his large size, he moves gracefully. (in spite of)
truck	forFOCUS [for] : For all his large size, he moves gracefully. (in spite of) forSUITABILITY [for] : Our men are ready for action. It is not for you. (suitability) forEXCHANGE [for] : He paid ten for a hat. He received a ball for a table. (Used to express equality or equivalence in exchange, number or quantity.) forFOCUS2 [for] : For one thing, the price is too high. For example, this sentence is fairly boring and slightly annoying. (implied selection) forEXCHANGE2 [for] : Go to the store for me. (in place of)

Create/modify senses...

Logon Logout Change password User administration Exit

Knowledge Entry Queries

Mugniyah is a senior member of Hizbullah.  
He is one of the founders of Hizbullah.  
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He was also responsible for the truck bombing of the U.S. Marine barracks in Beirut in 1983.

Sentence

he was also responsible for the truck bombing of the U.S. Marine barracks in Beirut in 1983 .

Process Submit New Next imported

Selected parse: parse 1

Context

dave[Imad\_Mugniyah]

New Rename Load Import

SubCategorization Frames All Relations Sense Disambiguation Reference Resolution Entity Categorization Sentence Generation

Inheritance(3,1983)  
Inheritance(A,also)  
subj-rDESCRIPTEE(A,R)  
Inheritance(B,bombing)  
NounNumber(B,uncountable)  
in[2](B,3)  
of(B,B1)  
Inheritance(B1,barrack)  
NounNumber(B1,plural)  
in[1](B1,B2)  
Inheritance(B2,Beirut)  
NounNumber(B2,singular)  
Inheritance(H,he)  
NounNumber(H,singular)  
Inheritance(R,responsible)  
Tense(R,%past)  
for(R,B)  
subjAGENT(R,H)  
Inheritance(T,truck)  
subj-nFOCUS(T,B)  
Inheritance(U,U.S.\_Marine)  
NounNumber(U,singular)  
subj-nFOCUS(U,B1)

Mugniyah is a senior member of Hizbullah.  
He is one of the founders of Hizbullah.  
He is the head of security for Hizbullah.  
The members of Hizbullah are Shi'ite Muslims.  
He was responsible for the bombing of the U.S. embassy in Beirut in 1983.  
63 people died in the bombing of the U.S. embassy in Beirut in 1983.  
He was also responsible for the truck bombing of the U.S. Marine barracks in Beirut in 1983.

Sentence

he was also responsible for the truck bombing of the U.S. Marine barracks in Beirut in 1983 .

Process | Submit | New | Next imported

Selected parse: parse1

Context

dave[Imad\_Mugniyah]

New | Rename | Load | Import

Disambiguated words:

he was also responsible for the truck bombing of the U.S. Marine barracks in Beirut in 1983 .

Disambiguated SARs (Syntatic Argument Relations):

subj-n (truck , bombing)  
subj-r (also , responsible)

Below, you can select the correct sense for each word or SAR:

he	N*Male_pronoun [he] : Refers to a male.
also	R*00048649 [as_well, besides, too, also, likewise] : in addition; "he has a Mercedes, too"
responsible	A*00321319 [responsible, responsible_for(p)] : being the agent or cause; "determined who was the responsible party"; "termites were responsible for the dan
for	forFOCUS [for] : For all his large size, he moves gracefully. (in spite of)
truck	forFOCUS [for] : For all his large size, he moves gracefully. (in spite of) forSUITABILITY [for] : Our men are ready for action. It is not for you. (suitability) forEXCHANGE [for] : He paid ten for a hat. He received a ball for a table. (Used to express equality or equivalence in exchange, number or quantity.) forFOCUS2 [for] : For one thing, the price is too high. For example, this sentence is fairly boring and slightly annoying. (implied selection) forEXCHANGE2 [for] : Go to the store for me. (in place of)

Create/modify senses...

# Novamente: The Path Ahead



# Hypothetical Timeline

## 2006-2007:

- Complete “infantile” stage behaviors in AGISim
- Initial integration of existing NLP system

## 2007-2019:

- Enter concrete-operational stage
- Integration of NLP code with learning mechanisms
- Implement distributed processing infrastructure

## 2008-2012:

- Powerful natural-language question-answering
- Focus on embodied language learning

## 2009-2014:

- Formal stage?
- Integration of Mizar DB?



# Credits

## Novamente:

- Cassio Pennachin
- Moshe Looks
- Ari Heljakka
- Andre Senna
- Izabela Freire Goertzel
- Welter Silva
- Michael Ross
- Hugo Pinto

## AGISim:

- Ari Heljakka
- Welter Silva

