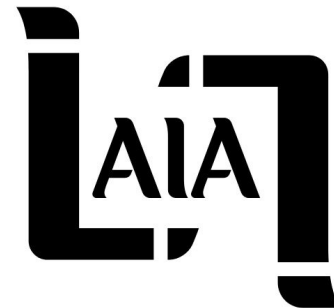


Argumentation in Multi-Agent Systems

Alison R. Panisson



Agenda

- Argumentation-Based Reasoning
- Argumentation-Based Dialogues
- Current directions:
 - Enthymemes,
 - Theory of Mind,
 - Neuro-Symbolic Approaches

Argumentation-Based Reasoning

- Construct arguments
- Identify conflicts between arguments
- Define which arguments are acceptable (semantics)

Argumentation-Based Reasoning

- Construct arguments
- Identify conflicts between arguments
- Define which arguments are acceptable (semantics)
- Knowledge base changes -> query-based approaches.

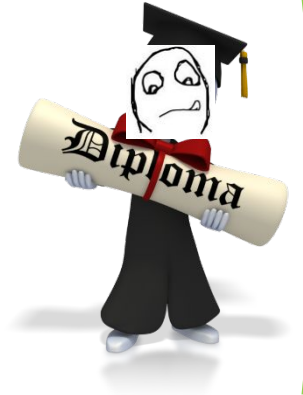
Argumentation-Based Reasoning



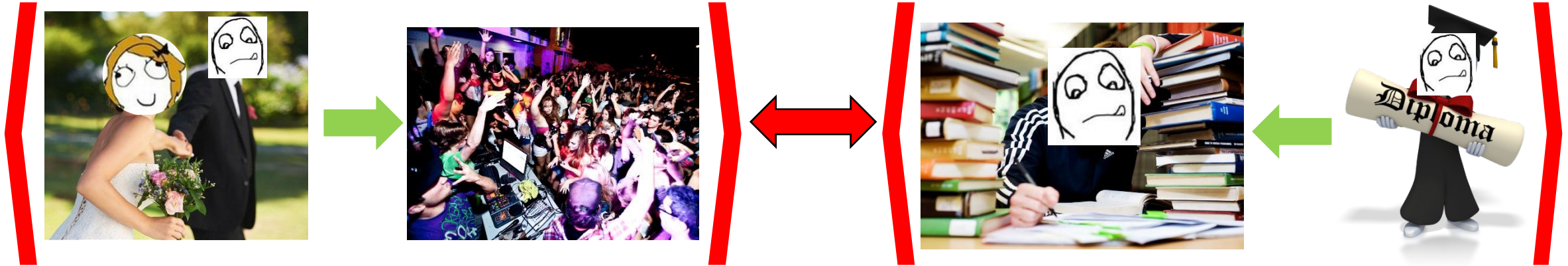
Argumentation-Based Reasoning



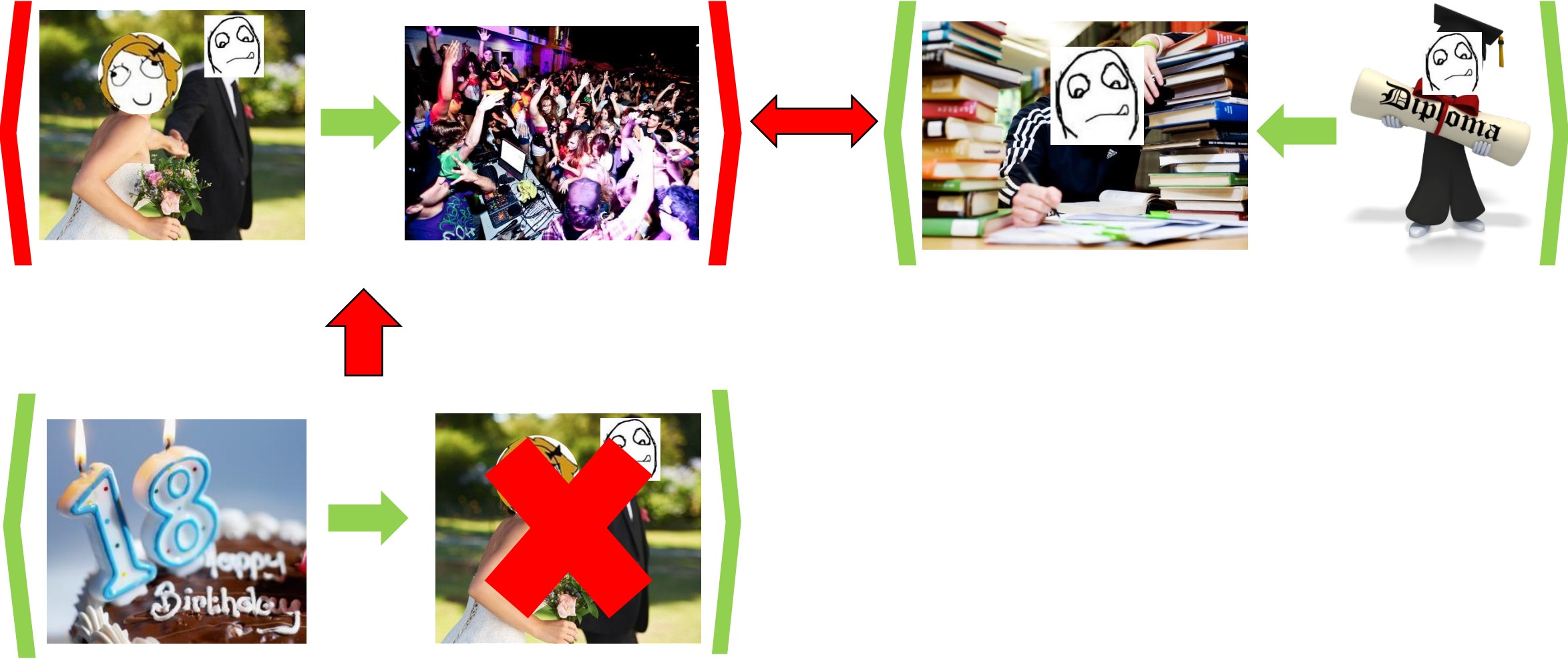
Argumentation-Based Reasoning



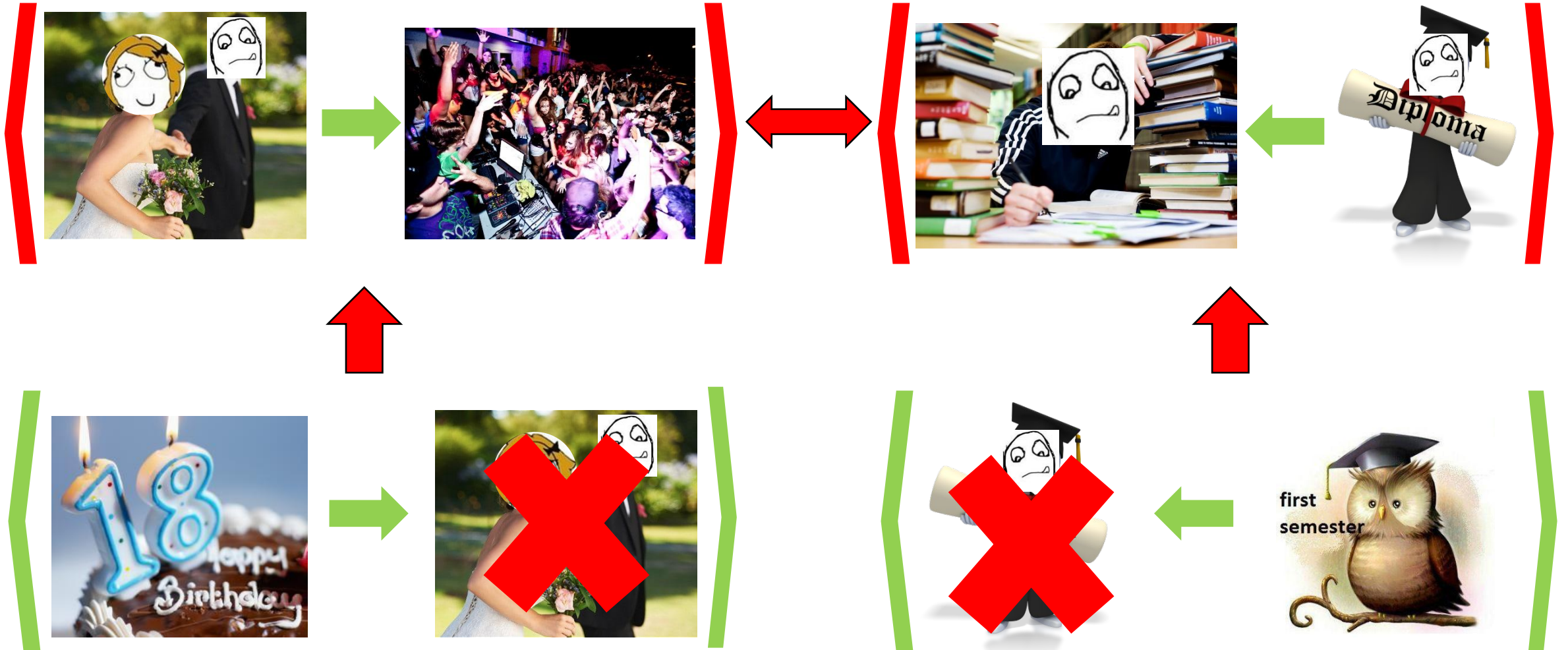
Argumentation-Based Reasoning



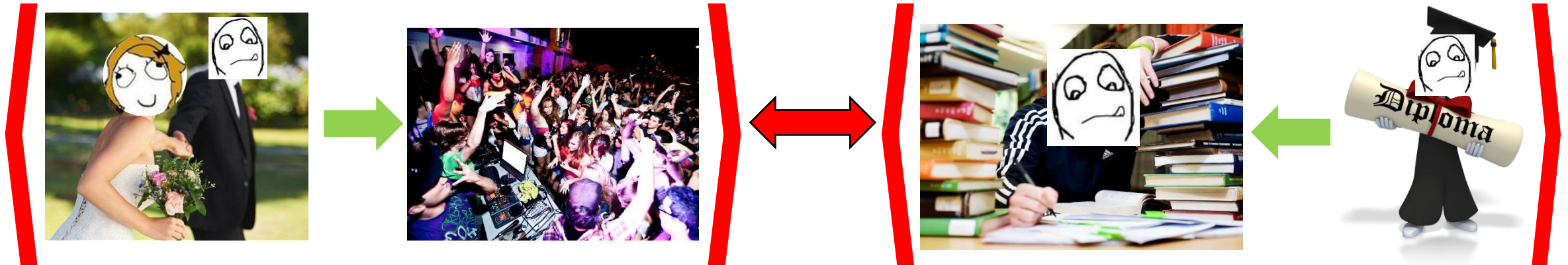
Argumentation-Based Reasoning



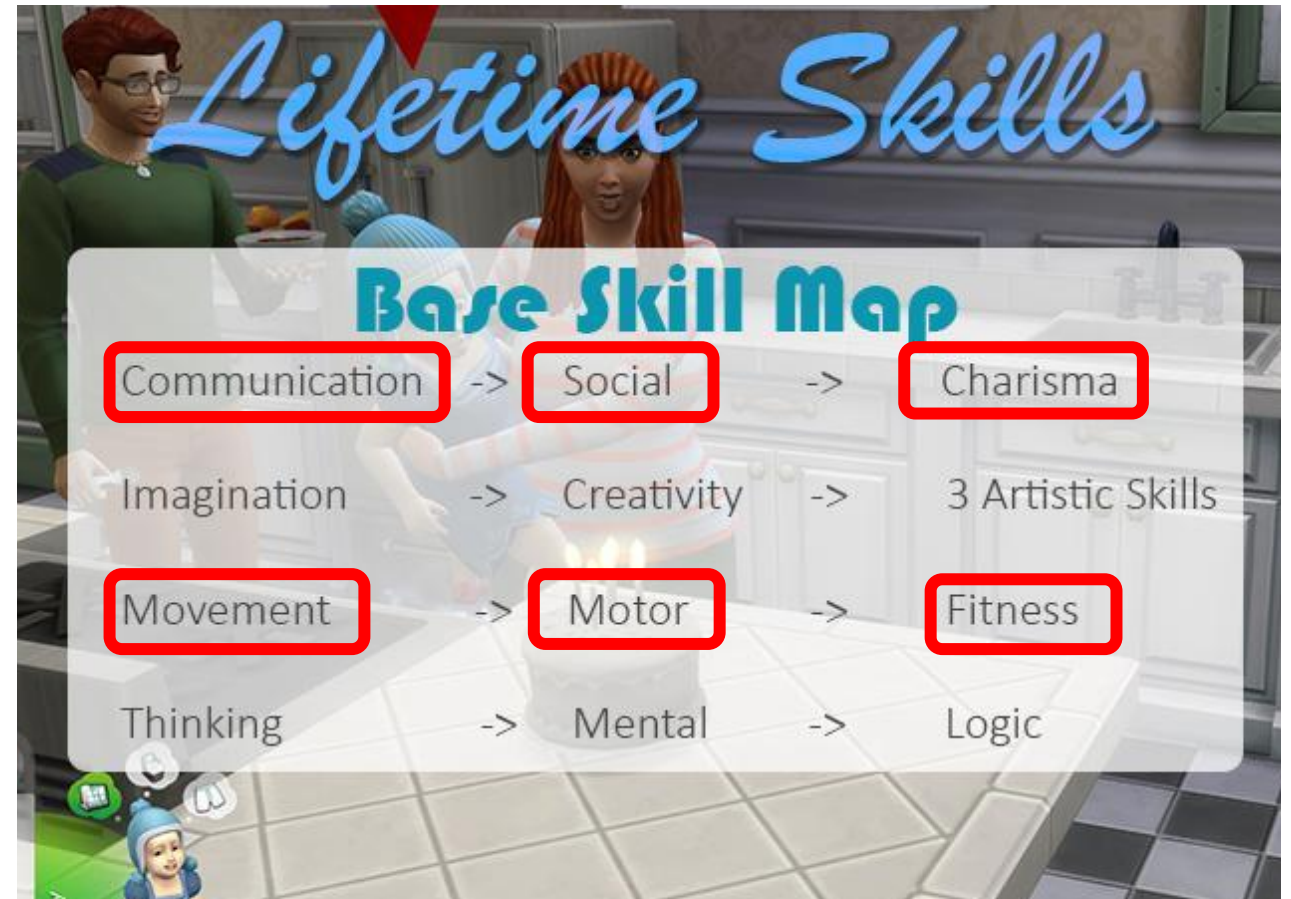
Argumentation-Based Reasoning



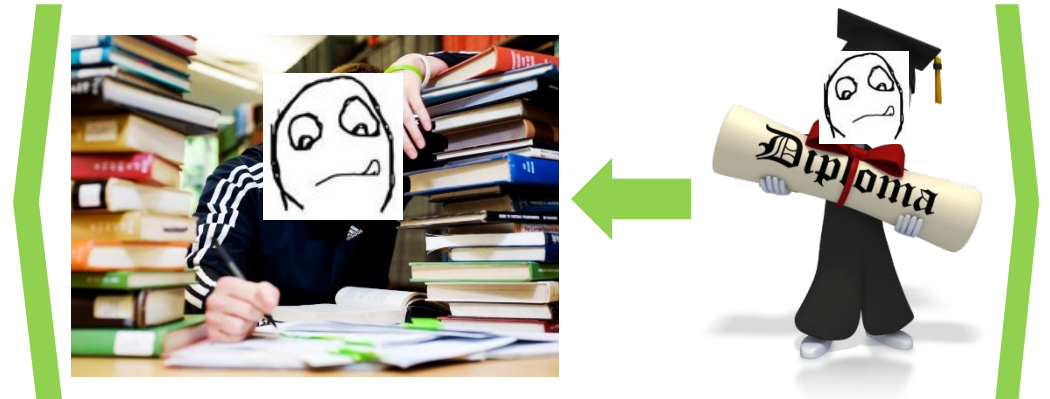
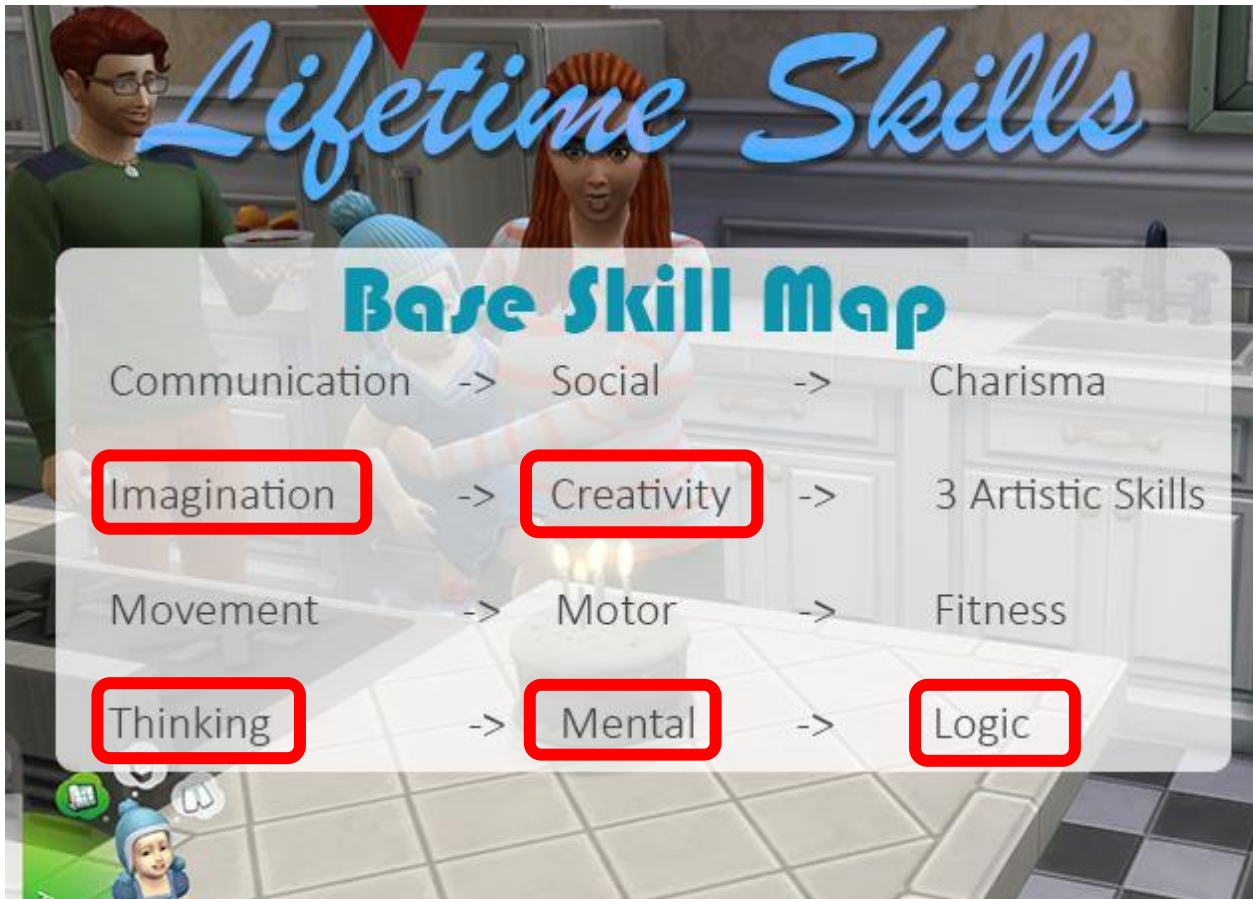
Argumentation-Based Reasoning



Argumentation-Based Reasoning



Argumentation-Based Reasoning





Argumentation-Based Reasoning in Multi-Agent Systems

Argumentation-Based Reasoning in Multi-Agent Systems

- Agent-Oriented Programming Language – Jason
 - Predicates – `colour(car,blue)`_[source(john)]

Argumentation-Based Reasoning in Multi-Agent Systems

- Agent-Oriented Programming Language – Jason
 - Predicates – `colour(car,blue)`_[source(john)]
 - Defeasible inferences – `defeasible_inference(H,[B])`

Argumentation-Based Reasoning in Multi-Agent Systems

- Agent-Oriented Programming Language – Jason
 - Predicates – `colour(car,blue)`_[source(john)]
 - Defeasible inferences – `defeasible_inference(H,[B])`
 - Prolog-like Rules – `father(X,Y):- man(X) & progenitor(X,Y).`

Argumentation-Based Reasoning in Multi-Agent Systems

- Agent-Oriented Programming Language – Jason
 - Predicates – `colour(car,blue)`_[source(john)]
 - Defeasible inferences – `defeasible_inference(H,[B])`
 - Prolog-like Rules – `father(X,Y):- man(X) & progenitor(X,Y).`

`argument(X) :- X.`

`argument(X) :- defeasible_inference(X,[B]) & argument(B).`

Argumentation-Based Reasoning in Multi-Agent Systems

- Agent-Oriented Programming Language – Jason
 - Predicates – `colour(car,blue)`_[source(john)]
 - Defeasible inferences – `defeasible_inference(H,[B])`
 - Prolog-like Rules – `father(X,Y):- man(X) & progenitor(X,Y).`

`argument(X) :- X.`

`argument(X) :- defeasible_inference(X,[B]) & argument(B).`

- Plan

`+!go_to(market): argument(go_to(market))`

`<- ... <steps towards X> ...`

Argumentation-Based Reasoning in Multi-Agent Systems

- Agent-Oriented Programming Language – Jason
 - Predicates – `colour(car,blue)`_[source(john)]
 - Defeasible inferences – `defeasible_inference(H,[B])`
 - Prolog-like Rules – `father(X,Y):- man(X) & progenitor(X,Y).`

`argument(X) :- X.`

`argument(X) :- defeasible_inference(X,[B]) & argument(B).`

- Plan

`+!go_to(market): argument(go_to(market),Arg)`

`<- .send(mother,explain,Arg) //explain why it needs do that`

`.send(mother,ask_permission,go_to(market))) //ask permission`

Argumentation-Based Reasoning in Multi-Agent Systems

- Agent-Oriented Programming Language – Jason
 - Predicates – `colour(car,blue)`_[source(john)]
 - Defeasible inferences – `defeasible_inference(H,[B])`
 - Prolog-like Rules – `father(X,Y):- man(X) & progenitor(X,Y).`

`argument(X) :- X.`

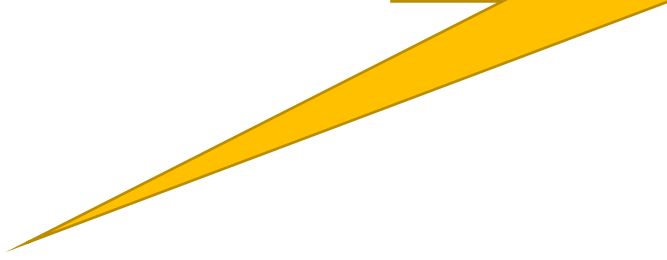
`argument(X) :- defeasible_inference(X,[B]) & argument(B).`

- Plan

`+!go_to(market): argument(go_to(market),Arg)`

`<- .send(mother,explain,Arg) //explain why it needs do that`

`.send(mother,ask_permission,go_to(market))) //ask permission`

- 
- Explain to other agents
 - Explain to humans

Argumentation-Based Reasoning in Multi-Agent Systems

- Plan

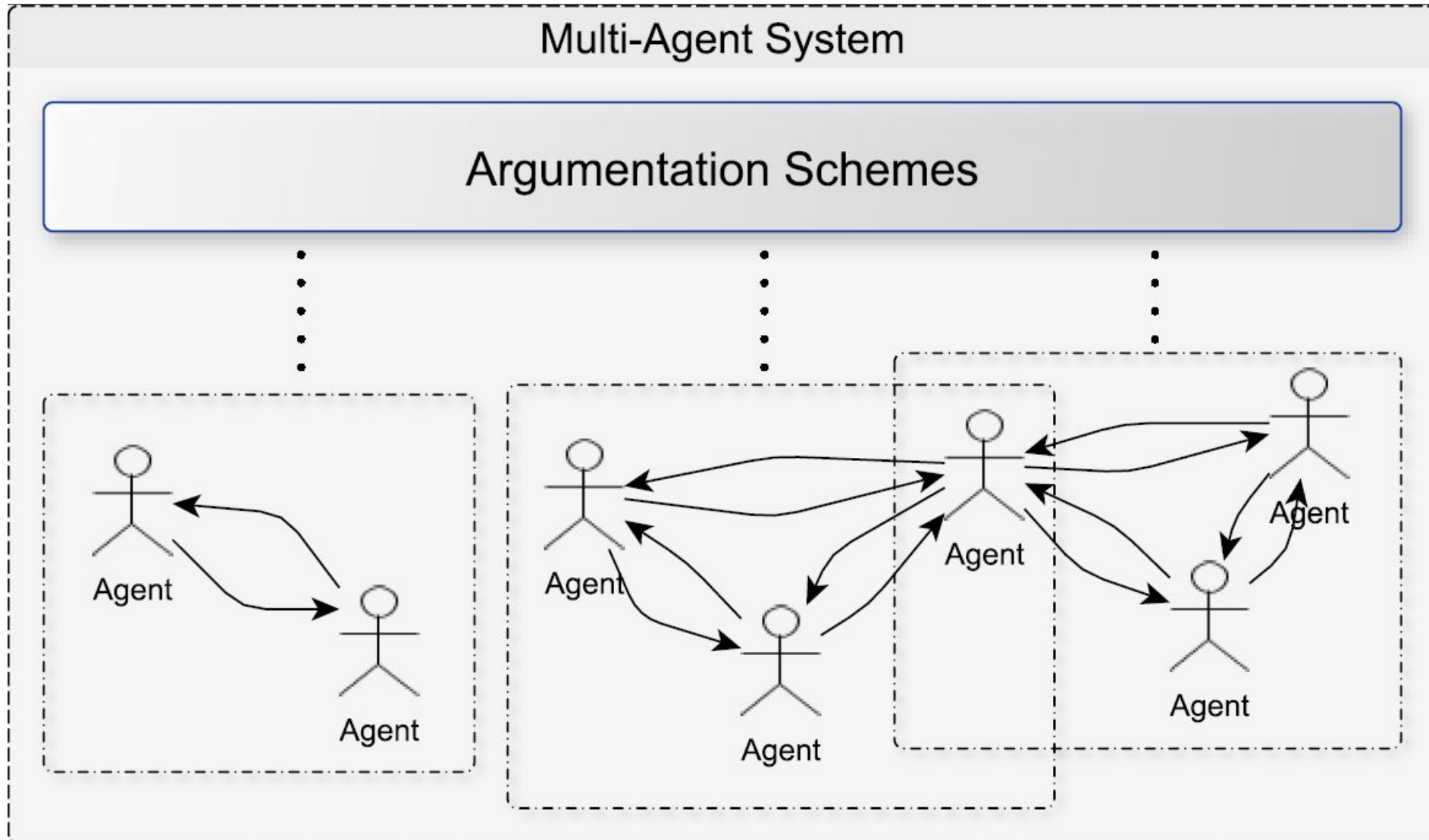
```
+!explain(X,Ag): argument(X,Arg)  
    <- .send(Ag,explain,Arg). //explain a belief/goal/intention
```

```
+!answer_why(X,Ag): argument(X,Arg)  
    <- .send(Ag,answer,Arg). //answer a why question
```

```
+!answer_why_not(Ag,X): ...
```

```
...
```

Argumentation Schemes in MAS



Communication in Multi-Agent Systems

- Argumentation:
 - Richer communication
 - Agents able to support their position
 - Agents able to explain their position



Communication in Multi-Agent Systems

- Speech acts theory

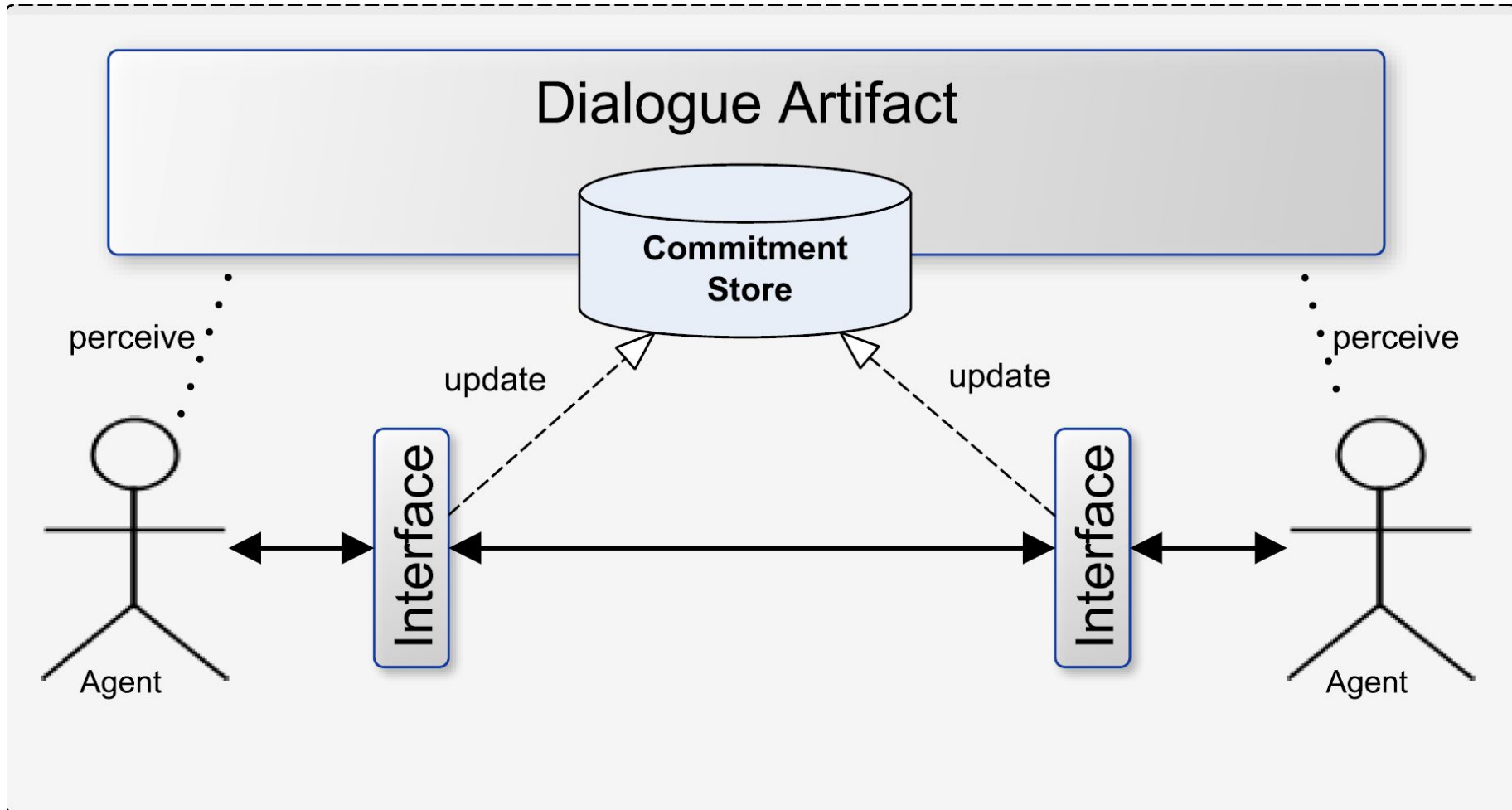
- Performatives – describing the intention of the sender
- Content

< john , tell , close(door) > - “John, the door is closed!”

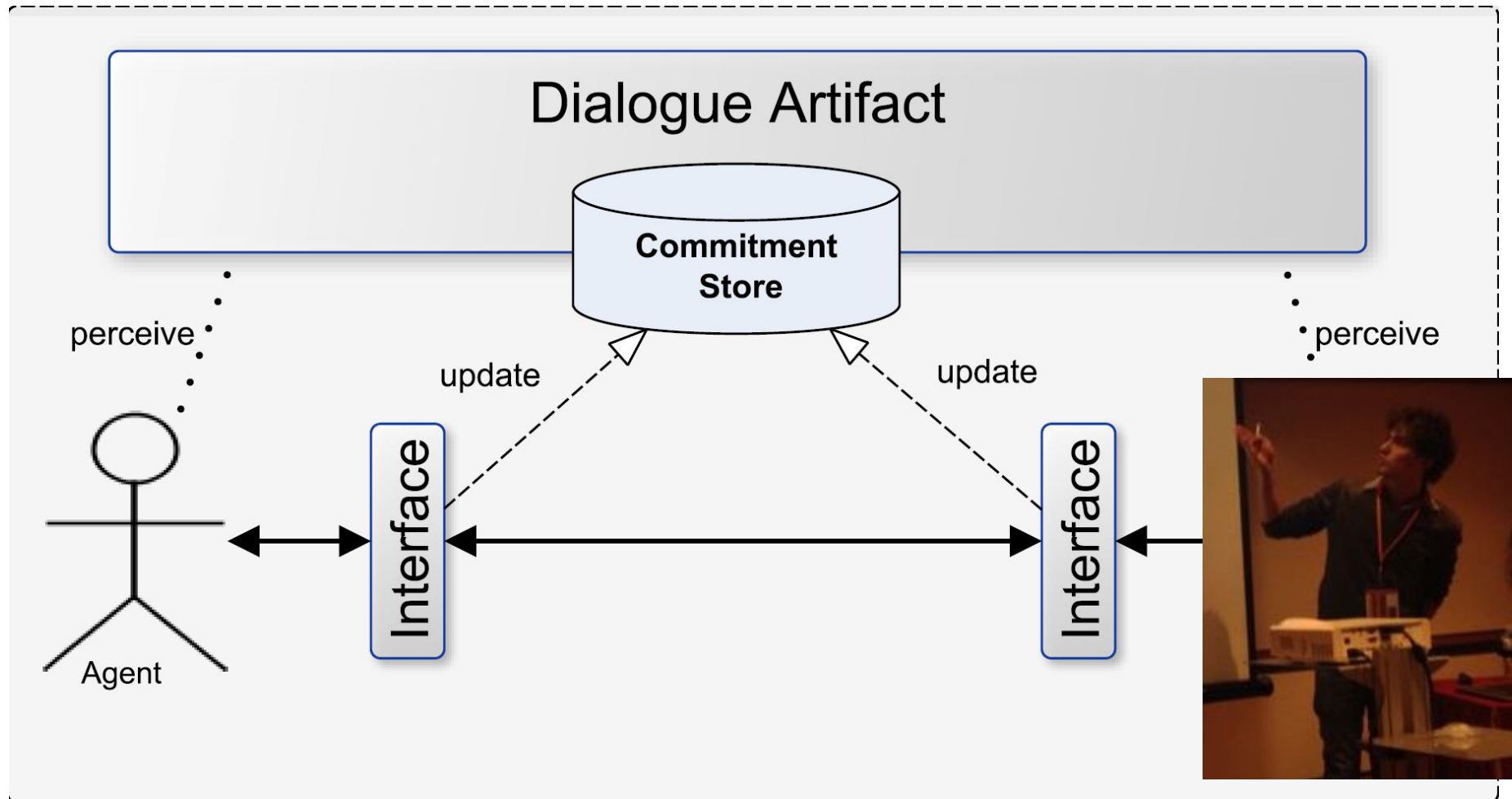
< john , ask , close(door) > - “John, is the door closed?”

< john , achieve , close(door) > - “John, close the door!”

Argumentation-Based Dialogues in Multi-Agent Systems

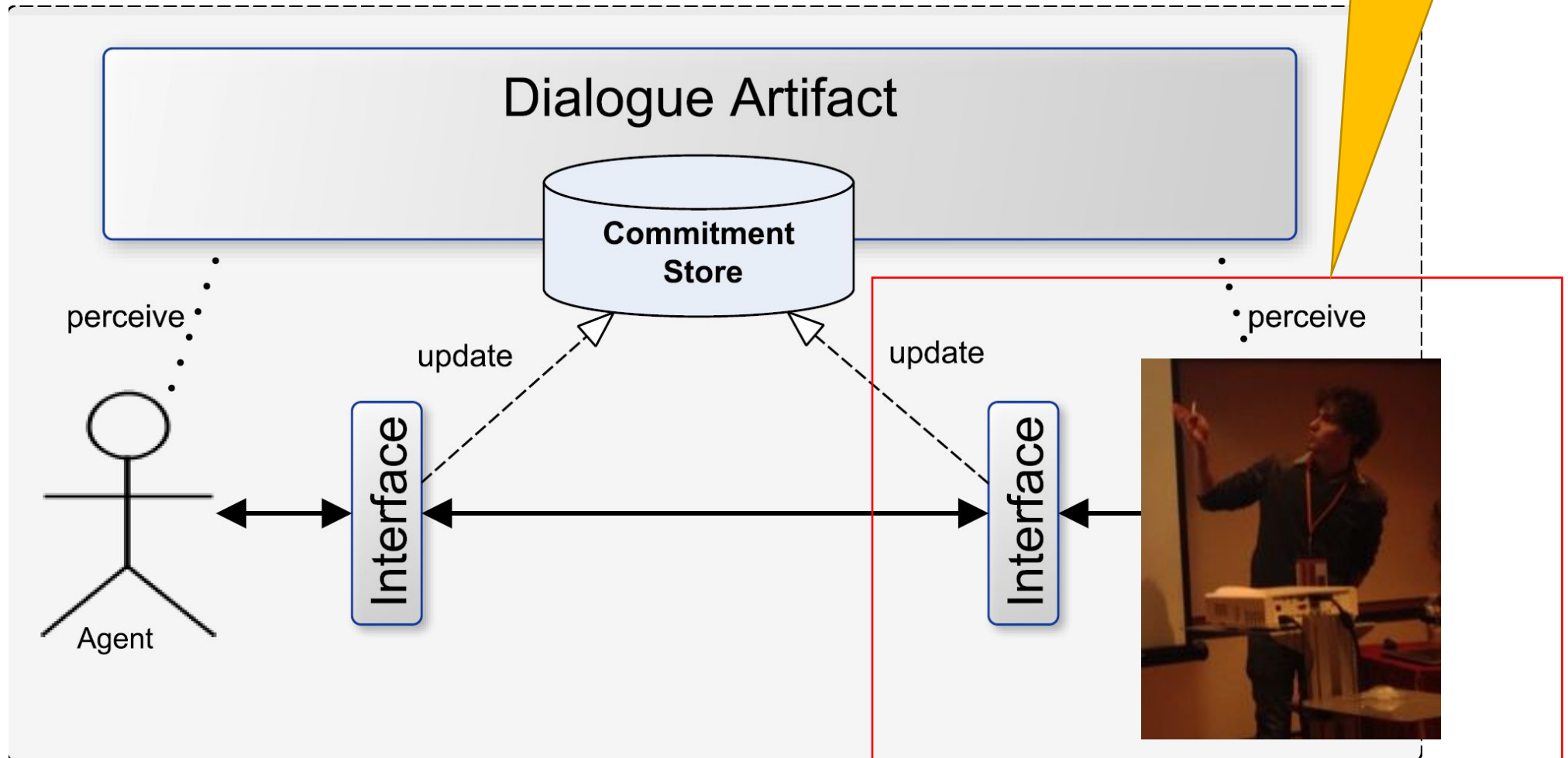


Argumentation-Based Dialogues in Multi-Agent Systems



Argumentation-Based Dialogues in Multi-Agent Systems

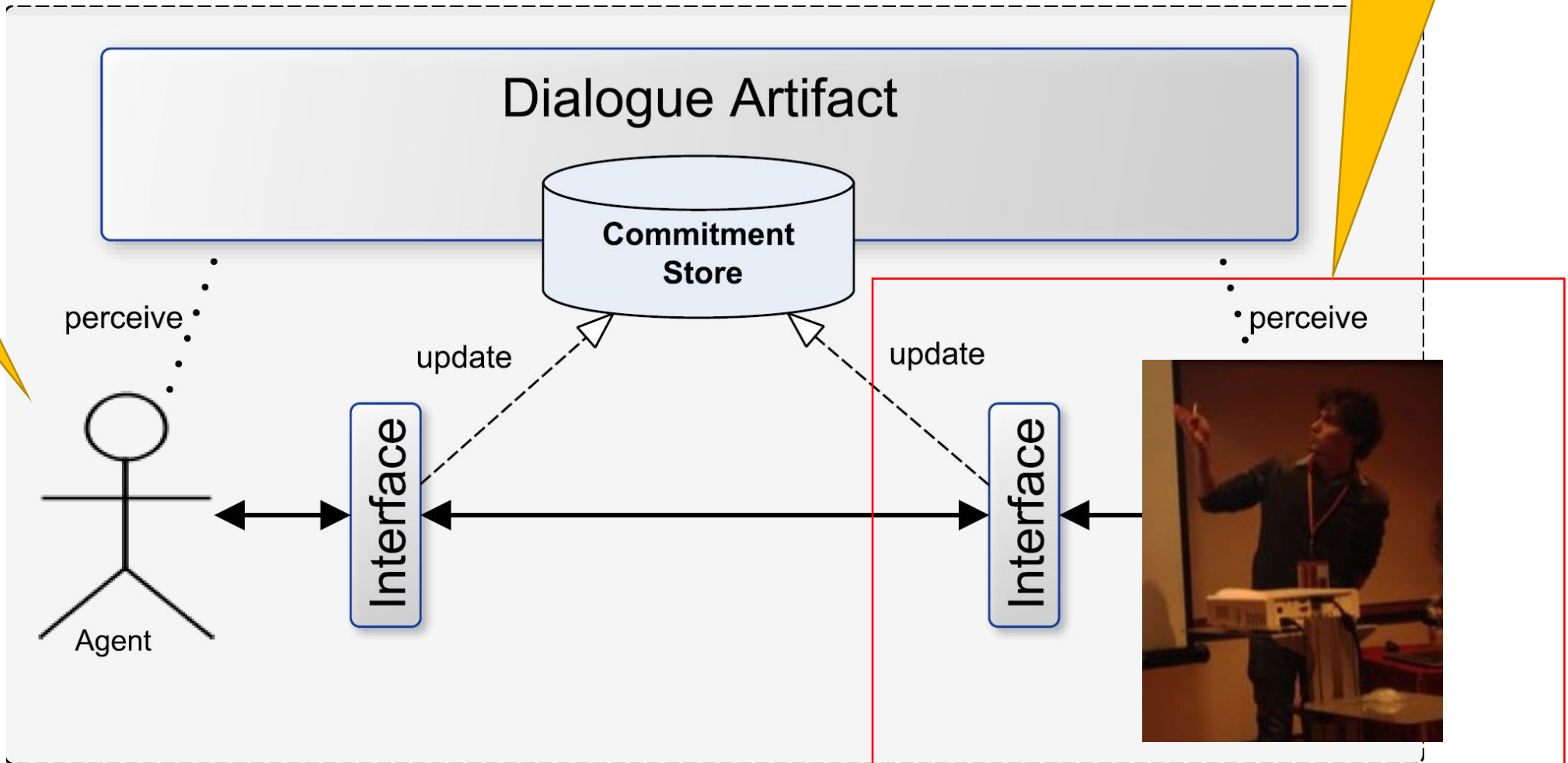
- NLP techniques
- Arg. Schemes



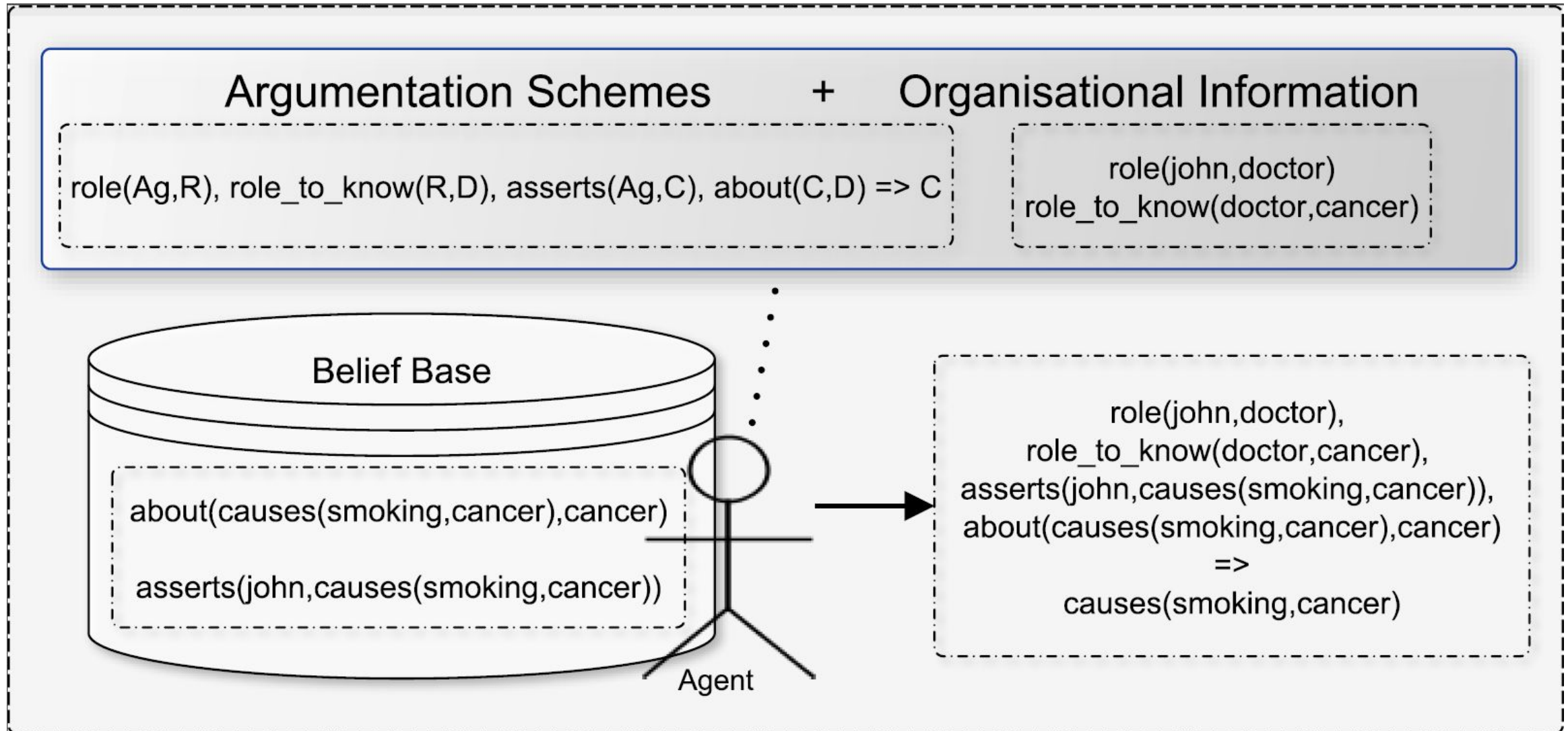
Argumentation-Based Dialogues in Multi-Agent Systems

- ToM
- Context

- NLP techniques
- Arg. Schemes



Enthymemes in MAS



Enthymemes in MAS

```
< {  role(john,doctor), role_to_know(doctor,cancer),  
asserts(john,causes(smoking,cancer)), about(causes(smoking,cancer),cancer),  
def_inf(C,[role(Ag,R),role_to_know(R,D),asserts(Ag,C),about(C,D)])  },  
  
causes(smoking,cancer) >
```

Enthymemes in MAS

```
< {  role(john,doctor), role_to_know(doctor,cancer),  
asserts(john,causes(smoking,cancer)), about(causes(smoking,cancer),cancer),  
def_inf(C,[role(Ag,R),role_to_know(R,D),asserts(Ag,C),about(C,D)])  },  
  
causes(smoking,cancer) >
```

Enthymemes in MAS

```
< {  role(john,doctor), role_to_know(doctor,cancer),  
asserts(john,causes(smoking,cancer)), about(causes(smoking,cancer),cancer),  
def_inf(C,[role(Ag,R),role_to_know(R,D),asserts(Ag,C),about(C,D)])  },  
  
causes(smoking,cancer) >
```

Enthymemes in MAS

```
< {  role(john,doctor), role_to_know(doctor,cancer),  
asserts(john,causes(smoking,cancer)), about(causes(smoking,cancer),cancer),  
def_inf(C,[role(Ag,R),role_to_know(R,D),asserts(Ag,C),about(C,D)])  },
```

```
causes(smoking,cancer) >
```

Enthymemes in MAS

```
< {  role(john,doctor), role_to_know(doctor,cancer),  
asserts(john,causes(smoking,cancer)), about(causes(smoking,cancer),cancer),  
def_inf(C,[role(Ag,R),role_to_know(R,D),asserts(Ag,C),about(C,D)])  },  
  
causes(smoking,cancer) >
```

Enthymemes in MAS

```
    < {   role_to_know(doctor,cancer),  
asserts(john,causes(smoking,cancer)), about(causes(smoking,cancer),cancer),  
    def_inf(C,[role(Ag,R),role_to_know(R,D),asserts(Ag,C),about(C,D)])   },
```

```
    causes(smoking,cancer) >
```

Enthymemes in MAS

```

                < {   role_to_know(doctor,cancer),
asserts(john,causes(smoking,cancer)), about(causes(smoking,cancer),cancer),
                def_inf(C,[role(Ag,R),role_to_know(R,D),asserts(Ag,C),about(C,D)])   },

                causes(smoking,cancer) >
```

Enthymemes in MAS

```
< {  asserts(john,causes(smoking,cancer)),  
      about(causes(smoking,cancer),cancer),  
def_inf(C,[role(Ag,R),role_to_know(R,D),asserts(Ag,C),about(C,D)])  },  
  
      causes(smoking,cancer) >
```

Enthymemes in MAS

```
< {  asserts(john,causes(smoking,cancer)),  
      about(causes(smoking,cancer),cancer),  
def_inf(C,[role(Ag,R),role_to_know(R,D),asserts(Ag,C),about(C,D)])  },  
  
      causes(smoking,cancer) >
```

Enthymemes in MAS

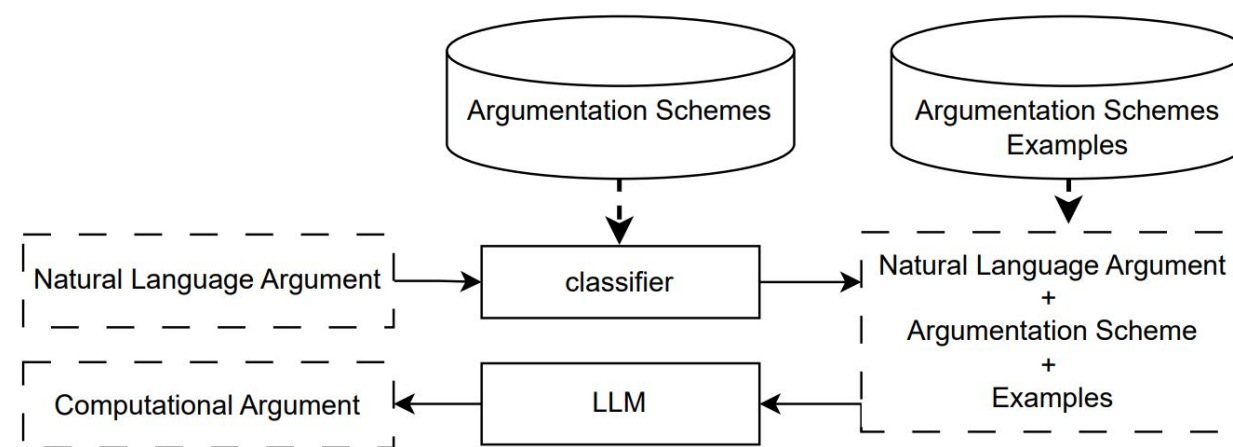
```
< { asserts(john,causes(smoking,cancer)),  
  about(causes(smoking,cancer),cancer) },
```

```
causes(smoking,cancer) >[role_to_know]
```

NL <> Symbolic Representation

Directions of Hybrid Intelligence. To build interfaces between Human and Symbolic Agents

(2022 - present) - LLMs to translate NL arguments into computational, symbolic arguments guided by Argumentation Schemes (and vice-versa). Also understand **enthymemes** (will talk about that in (4)).



[20] G. Trajano, D. C. Engelmann, R. H. Bordini, S. Sarkadi, J. Mumford, A. R. Panisson, Translating natural language arguments to computational arguments using llms, in: Computational Models of Argument (COMMA), IOS Press, 2024, pp. 289–300.

[26] G. Trajano, S. Hoffmann, S. Sarkadi, A. R. Panisson, Toward enthymeme reconstruction: A neurosymbolic interface, in: IEEE/WIC/ACM International Joint Conference on Web Intelligence and Intelligent Agent Technology (WI-IAT), 2025.

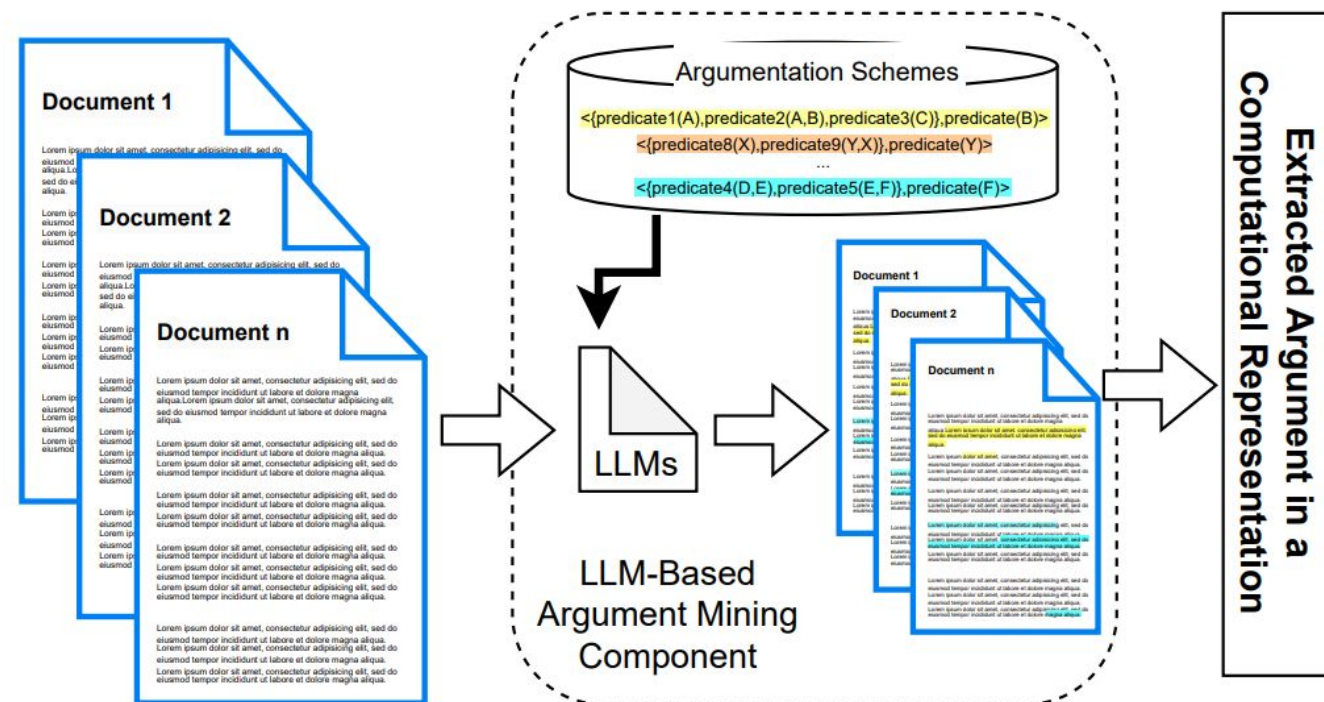
[22] A. R. Panisson, P. McBurney, R. H. Bordini, Towards an enthymeme-based communication framework in multi-agent systems, in: Proceedings of the 19th International Conference on Principles of Knowledge Representation and Reasoning, KR 2022, Haifa, Israel. July 31-August 5, 2022, 2022, Israel., 2022.

Neurosymbolic Argument Mining

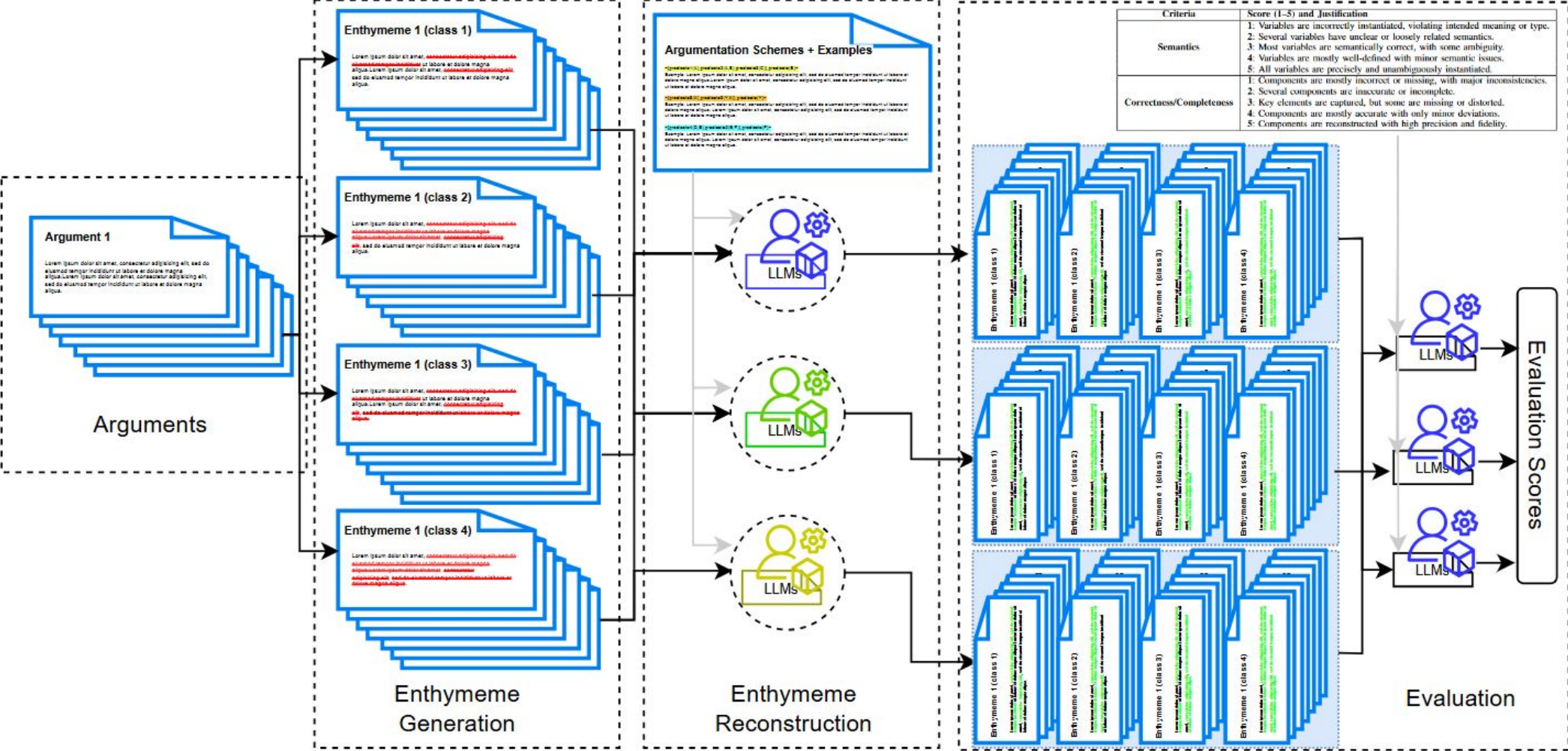
To leverage the NLU capabilities of LLMs, guided by the structural patterns of AS, to perform argument mining from unstructured texts (e.g., blog posts or documents).

Pipeline:

- (1) Text Pre-processing,
- (2) AS-Guided Extraction
- (3) Enthymeme Handling (Inference)
- (4) Symbolic Translation and Instantiation

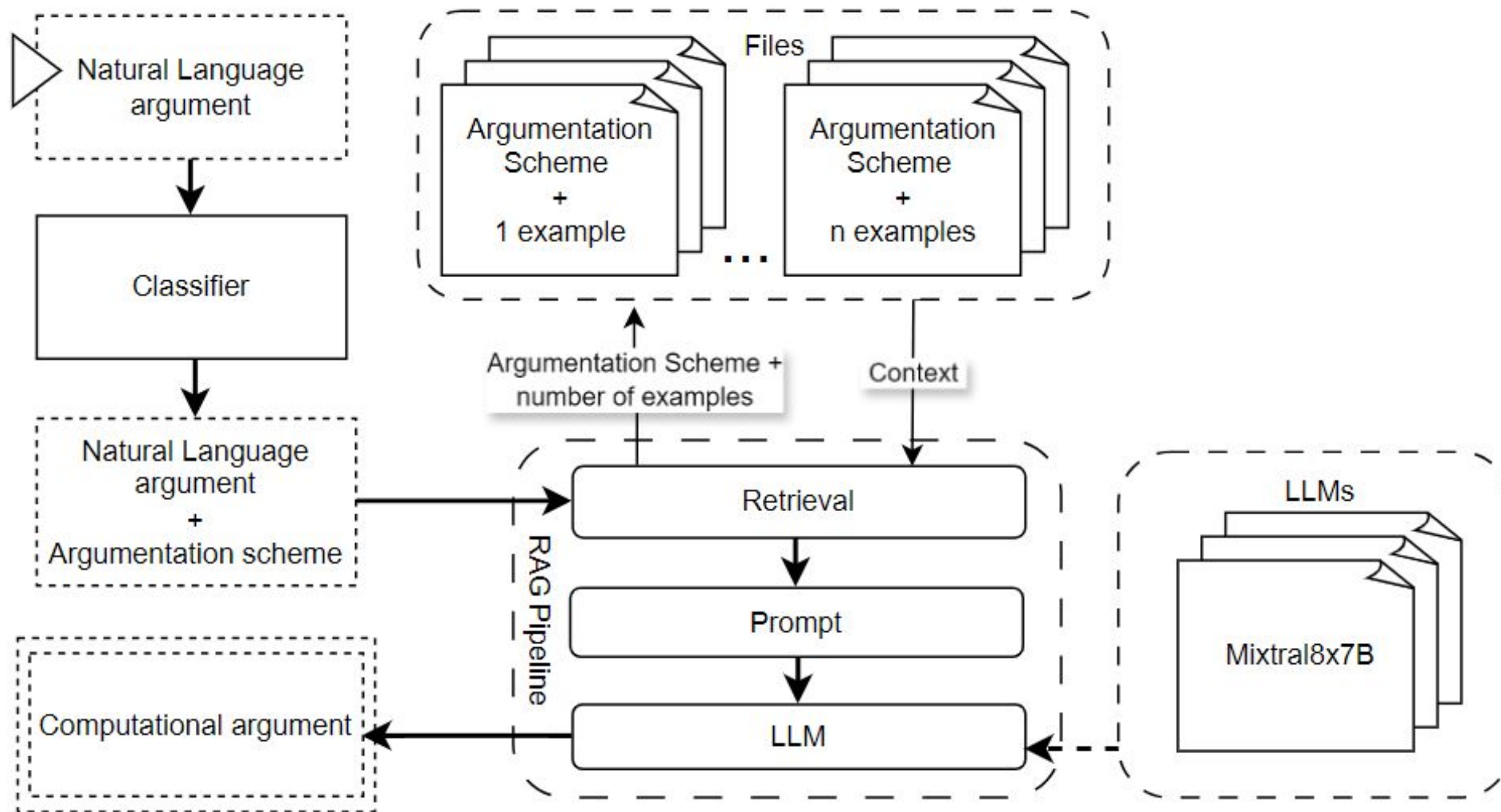


Neurosymbolic Enthymeme Reconstruction



[26] G. Trajano, S. Hoffmann, S. Sarkadi, A. R. Panisson, Toward enthymeme reconstruction: A neurosymbolic interface, in: IEEE/WIC/ACM International Joint Conference on Web Intelligence and Intelligent Agent Technology (WI-IAT), 2025.

Dataset



Joint work with



This research is partially funded by CNPq and CAPES.



Co-authors

[EDIT](#)

Rafael H. Bordini
School of Technology, PUCRS



Renata Vieira
Researcher at Évora University, ...



Felipe Meneguzzi
Professor of Computing Science, ...



Peter McBurney
King's College London



Simon Parsons
University of Lincoln, School of C...



Stefan Sarkadi
Lecturer & RAEng UK IC Resear...



Artur Freitas
PhD in Computer Science (PUC...



Daniela Schmidt
Professor at Évora University - D...



Viviana Mascardi
Associate Professor, University o...



Analúcia Schiaffino Morales
Federal University of Santa Cata...



Angelo Ferrando
Assistant Professor at the Univer...



Diana F. Adamatti
Universidade Federal do Rio Gra...



Cleo Zanella Billa
FURG



Tabajara Krausburg
PhD student, PUCRS



Martin Chapman
King's College London



Giovani Parente Farias
Estudante de doutorado em Ciên...



Asad Ali
Ofcom



Jomi Fred Hübner
Associate Professor of Federal U...



Milene Selbach Silveira
Professor of Computer Science, ...



Roberto Rodrigues-Filho
Assistant Professor, Federal Uni...



Alison R. Panisson

alison.panisson@ufsc.br



dblp
computer science bibliography



Thank you!

