Conversational Interactions Among Rational Agents

Philippe Lemoisson, Stefano A. Cerri, Jean Sallantin

Conversational Interactions among Rational Agents

Philippe LEMOISSON[a], Stefano A. CERRI[a], Jean SALLANTIN[a]

[a] *LIRMM, CNRS & University Montpellier II*
161, Rue Ada 34392 Montpellier Cedex 5, France
lemoisson@lirmm.fr, sallantin@lirmm.fr, cerri@lirmm.fr

Abstract. The new paradigm of "knowledge construction using experiential based and collaborative learning approaches" is an outstanding opportunity for interdisciplinary research. This document is an attempt to introduce and exemplify as much as possible using the lexicon of "social sciences", considerations and tools belonging to "artificial intelligence". In the paper we first draw a conceptual framework for rational agents in conversational interaction; then we use this framework for describing the processes of co-building ontologies, co-building theories, social interactive learning ... as examples of constructive interactions; finally we give a brief description of a conversational protocol aimed at putting a stone in the middle of the gap between human conversation and calculus.

Keywords. SocioConstructivist-Learning, Rational Agents, Ontology Construction, Conversational Protocol

Introduction

The intertwining of cultures in a Society with planetary extension, the progressive fragmentation of every one's daily life, the omnipresence of communication networks and computing machines have induced a radical paradigm shift with an impact on any aspect of today's personal, social, cultural and economic processes:
- people and computers meet through internet, therefore assuming the role of "agents" in conversational interactions;
- the idea of static knowledge which might be enclosed in universal encyclopedias before being delivered to the masses is progressively substituted by the notion of dynamic, interactive, social knowledge construction, based on a consensus reached by means of subsequent cycles of acceptance, refutation and refinement of shared knowledge inside any group;
- learning is therefore no longer considered as "knowledge transfer" – within a behavioristic or cognitive paradigm at choice – rather on "knowledge construction using experiential

based and collaborative learning approaches in a contextualized, personalized and ubiquitous way", as it appears in the ELeGI[1] project.

This paradigm shift is an outstanding opportunity for interdisciplinary research. Notions like "interaction", "collaboration" and "learning", that belong historically both to "social sciences" and "artificial intelligence" become central. However, it is yet quite unclear if and how there will be a convergence on meanings attributed to which appear as fundamental phenomena for the future of our societies.
This document is an attempt to introduce and exemplify as much as possible using the lexicon of "social sciences", considerations and tools belonging to "artificial intelligence" (e.g.: the machine learning tradition). By doing this, we wish to support the argument, hardly accepted by the general public, that current AI methods and tools, when they respect specific realistic constraints emerging from observing human communities engaged in the construction of shared meanings, indeed are of invaluable help to facilitate, if not enable the convergence of the process and therefore the achievement of important results, among which the learning of complex concepts and skills by humans. This approach may be synthesized by a view of human learning stimulated by doing: the actions being those necessary and sufficient for constructing shared meanings from real observations of experienced phenomena.

The position paper is organized in three parts:

1. an initial scenario introducing a few informal definitions;
2. a conceptual framework exemplified through the processes of co-building ontologies, co-building theories, social interactive learning ...
3. a brief description of a conversational protocol aimed at putting a stone in the middle of the gap between human conversation and calculus.

1 An Initial Scenario Introducing a few Informal Definitions

To start with an elementary scenario let us consider three "agents" looking at a collection of geometrically shaped colored objects. Assume the three agents are motivated and have indeed decided to build a language to describe them.

- "gf1" is a agent able to see shapes (and not colors). "gf1" will naturally classify the objects by shapes and give a name to the resulting classes. A possible classification by “gf1” is: SQUARE, TRIANGLE
- "gf2" is another agent, equally able to see shapes, and equally unable to see colors. She, or he produces the following class names : CARRÉ, TRIANGLE
- "rf" is a third agent who cannot see shapes, but can see colors. He identifies and names the following classes: RED, GREEN, BLUE

[1] http://www.elegi.org/

We wish to settle the basis of a "framework" where protocols can be formally defined, and where the following questions may be discussed in an unambiguous way:

a) will "gf1", "gf2" and "rf" be able to communicate through a language?
b) if YES will they be able to build together a theory concerning the objects (for instance the expression of a particular relation between color and shape)?
c) if YES will they be able to teach this theory to another agent, and how?

In order to start, we assume that:

- there is a "physical world", where REAL experiences take place. This allows us to say that "gf1", "gf2" and "rf" are looking at the same REAL objects, although they may see and therefore describe those in different ways.
- there are "intelligent entities", able to put these experiences in order, to link some experiences to others, and to build "meaning" upon all this. AI researchers use to call them "agents" independently from their human or artificial nature. We are going to adopt this habit, not because we have an anthropomorphic view of software (or a mechanistic view of human thought), but rather for simplicity. Agents and objects are of course part of the REAL WORLD.

This REAL or "physical" world is where interaction happens, WITH OR WITHOUT a communication language: agent "gf1" may select some objects and give them to "rf" without words. Whenever interaction inside a group through real experiences is submitted to a set of rules constraining the behaviors, we shall talk of PRAGMATIC PROTOCOLS.
But of course, everything becomes easier when the use of a shared communication language is allowed. Such languages have progressively emerged from interactions of intelligent entities; we shall address them from the point of view of SYNTAX which can be described:

- in "social sciences" as the "grammatical relationships among signs, independently of their interpretation or meaning"[2];
- in "artificial intelligence" as the level where "well formed expressions" are built and recognized ; when a program is seen as a set of expressions, the syntax is checked by the interpreter or the compiler.

The syntactic level includes almost the totality of "informatics", roughly described as the discipline consisting in defining, using and processing formal languages as abstract models of reality.

One of the powerful paradigms of Artificial Intelligence is "Multi Agents Systems" [1] in which "agents":

- exchange "messages" respecting the (public) rules of "communication languages", so that collaboration may be enjoyed;
- internally use "expressions" respecting the (private) rules of "description languages", so that abstraction may occur;

[2] translated from « Le Petit Robert : Dictionnaire de la Langue Française »

- for instance, SQUARE, TRIANGLE are concepts in a “description language” for “gf1”, and if "gf2" comes to the conclusion that " SQUARE = CARRÉ", then this correspondence may generate a concept belonging to a “communication language” between them.

In order to talk about "interpretation and meaning", we must evocate the SEMANTIC level. SEMANTICS put the focus on the signification of signs or symbols, as opposed to their formal relations. "gf1" interprets the objects as shapes, while «rf» interprets them as colors. One point we wish to outline is that the other agents have NO ACCESS to "gf1's" or "rf's" mind/semantic level, they are just allowed to guess with the help of protocols relying on PRAGMATICS and SYNTAX!
That is to say that agents are not allowed to have direct interaction at the SEMANTIC level, they need the mediation of both the REAL and the SYNTAX levels.

In the simplified framework we need for the purpose of this paper, a RATIONAL AGENT is:

- able to act and react within the REAL world through the mediation of interfaces (eyes, mouth, keyboard, monitor) … perceptions and actions are the basis for “interaction” between agents;
- able to deal with descriptions of the objects of the real world, as well as to interact inside groups through messages, using structured languages the SYNTAX of which is independent from what is described or exchanged;
- able to keep record of the descriptions of private experiences (perceptions and actions), to classify them, and therefore to develop evolving internal SEMANTICS.

2 A Conceptual Framework for Rational Agents in Interaction

2.1 Analyzing two Simplified Situations

Let us first come back to our initial scenario, and split it in the two simplified situations illustrated in Figure 1 and Figure 2:

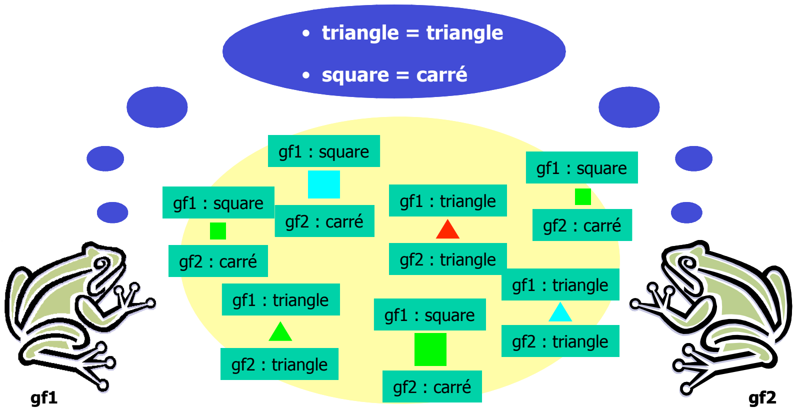


Figure 1. « gf1 » and « gf2 » have identical classifiers

In **Figure 1**, "gf1" is a frog able to see shapes and give them English names, while "gf2" is another frog able to see shapes but who gives them French names.

We imagine a protocol where these two agents are watching the same objects, and sticking labels at them, so that each one can simultaneously see the objects and their associated labels. Because they basically classify the objects in the same way, according to their shapes, we may hope that they are going to understand each other. More precisely, we bet that they will be able to build at the SEMANTIC level a correspondence between English and French labels, which can be described at the SYNTAX level as the first step for sharing an ontology[3].

[3] In order to give an informal definition of "ontology", we shall refer to [2] : "In general, an ontology describes formally a domain of discourse. Typically, an ontology consists of a finite list of terms and the relationships between these terms. The terms denote important concepts (classes of objects) of the domain. For example, in a university setting, staff members, students, courses, lecture theaters, and disciplines are some important concepts.
The relationships typically include hierarchies of classes. A hierarchy specifies a class C to be a subclass of another class C0 if every object in C is also included in C0. For example, all faculty are staff members. "

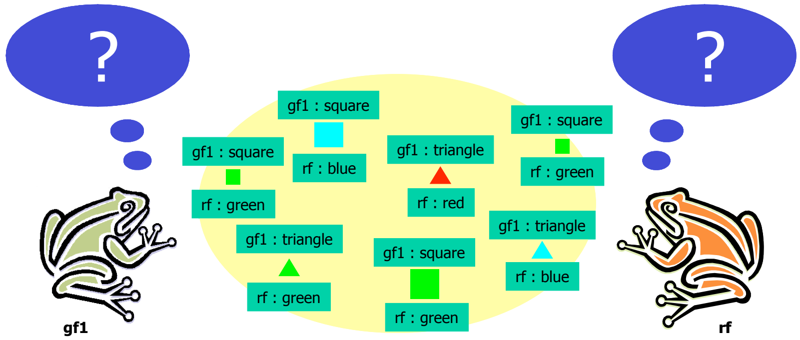
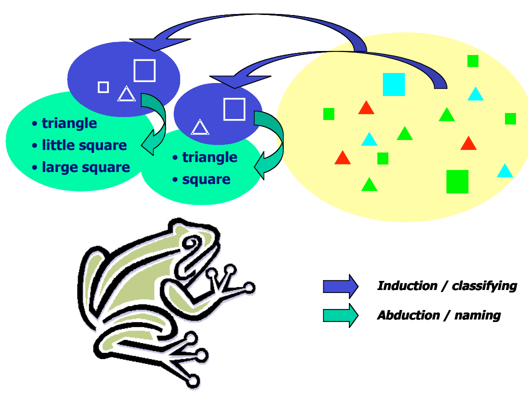


Figure 2. « gf1 » and « rf » have different classifiers

In **Figure 2**, "gf1" is a frog able to see shapes; while "rf" is a frog able to see colors ... then the mutual understanding is much more difficult, simply because classification of the couples (object, label given by other agent) doesn't work here!

We are not intending to give a full discussion of those two cases, but we wish to outline a few points:

- sharing "description languages" and turning them into "communication languages" is the ultimate aim of "ontology building"; the result will belong to the SYNTAX LEVEL, but the "checking" as well as the co-building of ontologies imply PRAGMATIC PROTOCOLS, as illustrated in [3].



- two basic "operations", both implying the SEMANTIC LEVEL, occur in the building of ontologies; these are CLASSIFYING and NAMING:

Figure 3. classifying and naming

- CLASSIFYING happens in biological brains through the cross-activation of neural networks [4]; it happens in the case of symbolic machine learning through algorithmical analysis of Galois lattice [5]. While human agents classify REAL experiences, software agents classify only SYNTACTIC descriptions, but in both cases, the input is a set of experiences / examples which constitute the local private memory of the agent who classifies; and the output classes keep on transforming as long as this input is fed by new experiences. The logicians call this operation INDUCTION[4], because it basically consists in generalizing from peculiar examples. Induction reoccurs as soon as new examples are available; and it may happen than a given object is classified in two different ways at two different moments.

- NAMING makes a classification visible to other agents, otherwise it would remain confined inside each agent's SEMANTICS. Naming is subject to evolution in accordance with the reoccurring induction. In the example given **Figure 3** naming the objects "square " or "triangle" is a shortcut for asserting "*objects O1, O5, O6, O7, O9 are equivalent and will be referred to as square* ; *objects O2, O3, O4 are equivalent and will be referred to as triangle*". And this can be reconsidered by the agent into "*objects O1, O5, O6 are equivalent and will be referred to as little square; objects O7, O9 are equivalent and will be referred to as large square* ; *objects O2, O3, O4 are equivalent and will be referred to as triangle*". So that naming appears as a major step in building a set of logical predicates aimed at describing the REAL world in the frame of a "theory"[5]. For logicians, the "emission of a set of hypothesis needing validation through further experience" is an ABDUCTION. Therefore the basic cycle connecting the private sphere of semantics to the public sphere of syntax is the INDUCTION/ABDUCTION CYCLE as illustrated in [6] and [7] through the collaborative construction of a theory by a group of agents.

- the definition of an interaction PROTOCOL between a group of rational agents relies on a set of options taken in respect with the following questions :

  ✓ the question of horizon : has each agent a local horizon (can access to only partial information) or a global horizon (can access to complete information)?

  ✓ the question of memory : are all the examples simultaneously given, or are they sequential events which have to be stored by the agent, and for how long?

  ✓ the question of the starting point : do the agents of the group already share a language, is it a formal language derivation rules ?

2.2 A More Ambitious Case: Co-Building a Theory

We are now able to put the focus on situations in which a given protocol allows a group to develop a common knowledge, i.e. to build and stabilize a new syntactic corpus through a conversational process involving each agent's semantics. In the following example

[4] Induction is an inference drawn from all the particulars. [Sir W. Hamilton]

[5] The word "theory" here should be understood as a coherent set of logical assertions

developed in **Figure 4** and **Figure 5**, two agents are co-building a theory, following a protocol defined by:

✓ local horizons : "gf1" and "gf2" are not looking at the same objects;

✓ simultaneous examples : all objects are given at once;

✓ starting point : "gf1" and "gf2" share an ontology in which the objects are depicted by shapes and colors, and a formal language including epistemic logics.

We consider two steps:

- step1: each agent makes his own abduction, according to his local horizon **(Figure 4)**

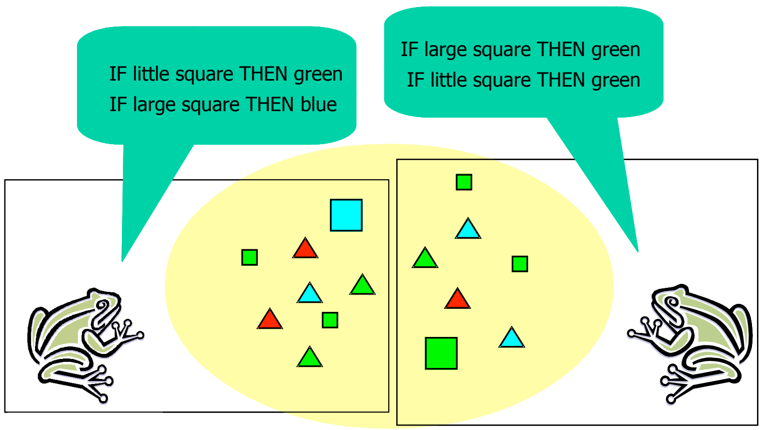


Figure 4. each agent makes his own abduction, according to his local horizon

- step2: each agent takes into account the other's abduction and proceeds to a revision of one's own theory **(Figure 5),** since the assertion of the other is not coherent with his own abduction.

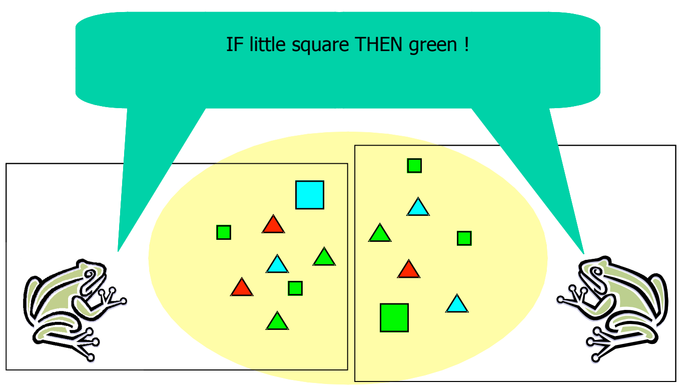


Figure 5. each agent takes into account the other's abduction and proceeds to a revision of one's theory

Here again, the aim of this paper is not to give a full discussion of the example, which would lead us to the introduction of epistemic logics [8] [9], but rather to give an introduction to the general framework where AI methods and tools can be compared and combined.
In this framework, social supervised learning basically follows the same protocol as co-building of ontologies, the particular point is that the group feeds the learner with examples in order to let him make the correct abductions. A more extensive discussion of this kind of learning can be found in [10] [11].

We could follow the two steps of our "co-building of a theory" through a mock up dialog:

- *[gf1] My own induction about the objects I can see makes me formulate the following hypothesis (abduction): "all little squares are green" & "all large squares are blue"*
- *[gf2] From my own point of view: "all little squares are green" & "all large squares are green"*
- *[gf1] If we consider simultaneously our beliefs, and apply the formal rules of the syntax we share, the only valid hypothesis is "all little squares are green"*
- *[gf2] I agree.*

2.3 A General Framework

The diagram **Figure 6** is a simplified representation of our framework:

- rational agents classify real experiences through INDUCTION
- then they corroborate their interpretations through ABDUCTION

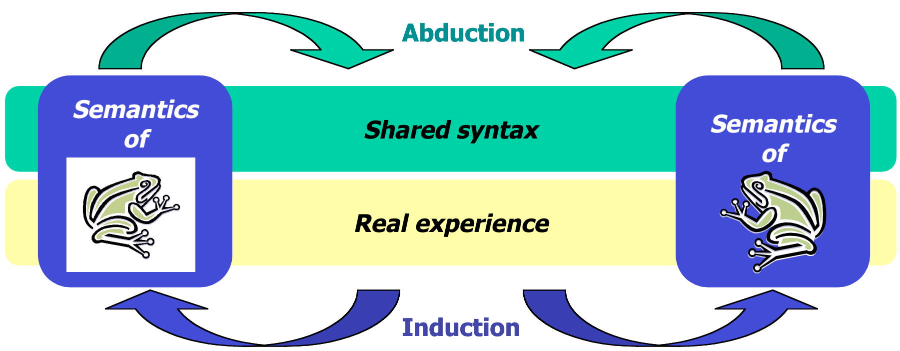


Figure 6. major flows in conceptual framework

This framework example can apply to more complex scenarios, and then IA tools may become necessary …

For instance, if we try and build a theory about Organic Chemistry instead of geometrically shaped colored objects, we may find it difficult to find out regularities "by hand", that is why we would like to mention here "machine learning", considered as a help for a human learner. [5] directly addresses the induction/abduction cycle through research work on structural machine learning with Galois lattice and graphs.

Moreover, if we want conversational processes to be effective, they have to generate services that help humans to learn facts, rules and ... languages. In [12], artificial agents are able to learn dynamically facts, rules and languages. As a resulting side effect, those artificial agents "learn by being told" during conversations with other artificial agents, and thus show a dynamic behavior that adapts to the context. The STROBE model [13] allows artificial agents to modify dynamically their interpreters at the SYNTAX level of our general diagram.

3 E-talk: a Conversational Protocol between Human Conversation and Calculus

3.1 Applying the Framework to Conversations between Humans and Machines

Language based communication happens through conversations in the case of humans, and the metaphor has been kept for communication between a human and a machine, or between two machines; we may therefore talk about "conversations" between rational agents (human or artificial), although "the discourse competences of artificial agents are only a dim shadow of those of humans" [14]. Conversations are always ruled by protocols, but whereas in the case of artificial agents those protocols are "wired", they are merely guidelines in the case of humans.

Referring to our framework:

- a conversation between humans is the creative and unpredictable intertwining of individual INDUCTION/ABDUCTION CYCLES relying on a shared SYNTAX but also on private SEMANTICS…
- … while a conversation between artificial agents is totally immerged in the world of syntax, and is PURELY DEDUCTIVE, from the viewpoint of an appropriate logic.

The main purpose of the "e-talk protocol" [15] is to implement the metaphor of a collaborative conversation between rational agents in such a way that:

- each agent is allowed to perform his own INDUCTION/ABDUCTION CYCLES
- IF each agent is PURELY DEDUCTIVE, THEN the global conversation is PURELY DEDUCTIVE.

An "e-talk interaction" looks like a conversation between human agents inside a room (nobody is allowed to enter after the conversation has started):

- each agent is allowed to formulate questions and assertions in a language using a very expressive syntax, we shall call those: "statements";

- turn-taking in the conversation is automatically controlled in respect with what has been said or asked;
- parallel interactions are allowed;
- each agent is allowed to ask any number of questions before producing his own statements; those are organized in steps so that step $^{N+1}$ can start as soon as all the questions asked during step ^{N} have found an answer;
- each agent has its own privacy: the internal behavior in reacting to a question or to an answer is ignored by the others; in particular, each agent is allowed to choose by abduction one possibility among several when no deterministic algorithm is available.

Yet, it remains a calculus[6]:

- the turn-taking rule, as well as the algorithm giving answers to questions, do not depend on the semantics of the conversation, they only rely on syntactic comparisons between statements;
- the conversation will end in finite time, under some syntactically checkable conditions;
- the issue of the conversation depends only of the initial state (agents including their abduction capability + initial statements);

The purpose of this article is not to enter the technical details of the e-talk protocol; we shall just provide some clues concerning the way we have conciliated the two above viewpoints, and this is by putting two constraints on the agents:

1. "<u>forward specialization</u>" : before interaction starts, agents emit "general statements", and all further statements must be "reductions" or specializations of those, according to a partial order defined on statements ;
2. "<u>no back-tracking on real statements</u>" : as soon as a statement is fully "reduced", it becomes "real" and cannot be withdrawn.

In the following, we shall briefly demonstrate "e-talk" through the example of agenda synchronization between humans assisted by artificial rational agents; we shall see that the artificial agents (that we supposed incorporated in communicating PDAs) interconnect their deductive potentials in order to settle a meeting … but eventually ask humans to arbitrate when no solution is directly computable.

[6] A "calculus" here is an algorithm giving a result for any argument value inside the domain in a finite number of steps.

3.2 A Multi-Agents Conversation Aimed at Organizing a Meeting

The following case has been run on a Java prototype implementing the "e-talk protocol" as well as the language for statements; the behavior of the artificial agents is embedded in Python scripts.

3.2.1 The case

Clement, Jean, Pascal, Philippe and Stefano are possessing PDAs which keep their respective agendas by codifying of each day of the week with a color:

- *"green" means "free for meeting"*
- *"red" means already booked*
- *"orange" means "not willing, but with no major impossibility"*

Besides keeping its owner's agenda, each PDA is programmed in order to negotiate in case of "orange availability"; for instance:

- *in case of "orange", Clement's PDA lets Clement arbitrate if he wishes to shift to "green"*
- *in case of "orange", Jean's PDA waits until Stefano has answered, and will shift to "green" if Stefano is "green"*
- *in case of "orange", Stefano's PDA waits until all have answered and will shift to "green" if two others come at least*

As soon as somebody wishes a meeting for one particular day on a particular subject, the PDAs start a conversation, moderated by another artificial agent called "Palm synchronizer". A meeting will happen only if half the concerned persons at least are present.

In order to illustrate our protocol, we are going to follow the conversation through the "e-talk" interface, which has two mains zones :

- the upper zone, labeled "Pentominos/Invocations", shows the agents. Each of them may be invoked in parallel in several contexts and each invocation will appear as a "child" of the agent. An hourglass appears whenever an invocation is waiting for answers to the questions it has emitted in a previous step of its computation.
- the lower zone, labeled "Syntagmes", displays the statements:
  - questions, ending by: ";?)"
  - assertions, ending by: ";)"

3.2.2 Initial state of the conversation: **Figure 7**

6 agents appear in the upper zone, having not yet started to talk:

- ✓ *the first 5 are the PDAs : Clements's PDA; Jean's PDA; Pascal's PDA; Philippe's PDA; Stefano's PDA*
- ✓ *the 6th is the Palm Synchronizer which moderates the conversation*

- *by computing the different meeting propositions in parallel (if several demands meet on the same day, then their order of emission gives priority)*
- *by asking the concerned persons (PDAs) for availability*
- *by summarizing the answers*

The initial statements appear in the lower zone:

- ✓ *everybody is orange on the 16/09/2008 (lines 1 to 5)*
- ✓ *Stefano, Philippe, Pascal and Clement are concerned by "Social Informatics" (lines 6 to 9); Stefano, Philippe, and Jean are concerned by "Machine Learning" (lines 10 to 12)*
- ✓ *a proposition of meeting on the 16/09/2008 about "Social Informatics" has been emitted at time "1.0", (line 15); another one on the 16/09/2008 about "Machine Learning" has been emitted at time "2.0", (line 16)*

3.2.3 Intermediate state of the conversation: **Figure 8**

The upper zone shows the parallel invocations of each agent, who have all started to talk:

- ✓ *Clement is only concerned by Social Informatics; so his PDA has been invoked once only. This PDA has finished "talking" after Clement has arbitrated: "red"*
- ✓ *Jean is only concerned by Machine Learning; so his PDA has been invoked once only. His PDA is waiting for Stefano's answer*
- ✓ *Pascal is only concerned by Social Informatics; so his PDA has been invoked once only. His PDA is waiting for Pascal to arbitrate through a dedicated window where the information concerning the other attendants is displayed*
- ✓ *Philippe is concerned by both subjects; so his PDA has been invoked twice. His PDA has already shifted to "green" for "Social Informatics" and has not yet been asked for "Machine Learning", because if the first meeting did not happen, he could free himself for the second*
- ✓ *Stefano's PDA has also been invoked twice, waiting for the others' answers about "Social Informatics" (step 2/3) and having not yet enquired for the others' answers about "Machine Learning" (step 1/3)*
- ✓ *"Palm synchronizer" is moderating in parallel the two conversations, and is more advanced about "Social Informatics" (step 3/4) then about "Machine Learning" (step 2/4, for priority reasons*

3.2.4 Final state of the conversation: **Figure 9**

The upper part of the window shows that all invocations have finished talking.

The lower part shows the final statements:

- ✓ *Stefano, Philippe and Pascal have arbitrated "green" for Social Informatics (lines 6, 7, 8) and then turned to "red"(line 1 to 3) to indicate that are not free for other meetings on the same day*

- ✓ *The meeting about " Social Informatics" has been successfully organized (line4) because 3 persons were available out of 5 invited*
- ✓ *The meeting about "Machine Learning" could not be organized because of no participants at all (even Jean would not have come since Stefano had turned to red)*

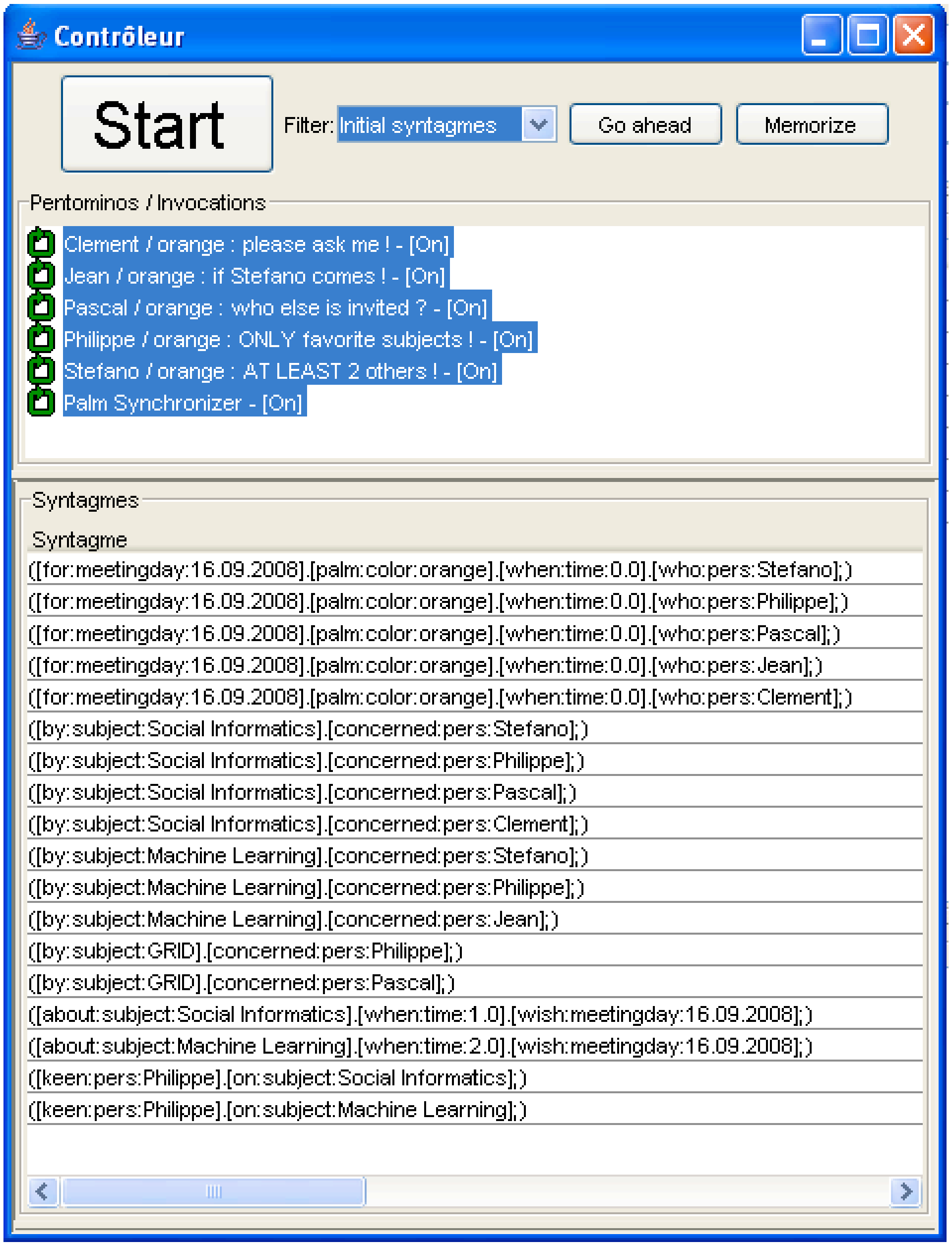


Figure 7. initial state before conversation

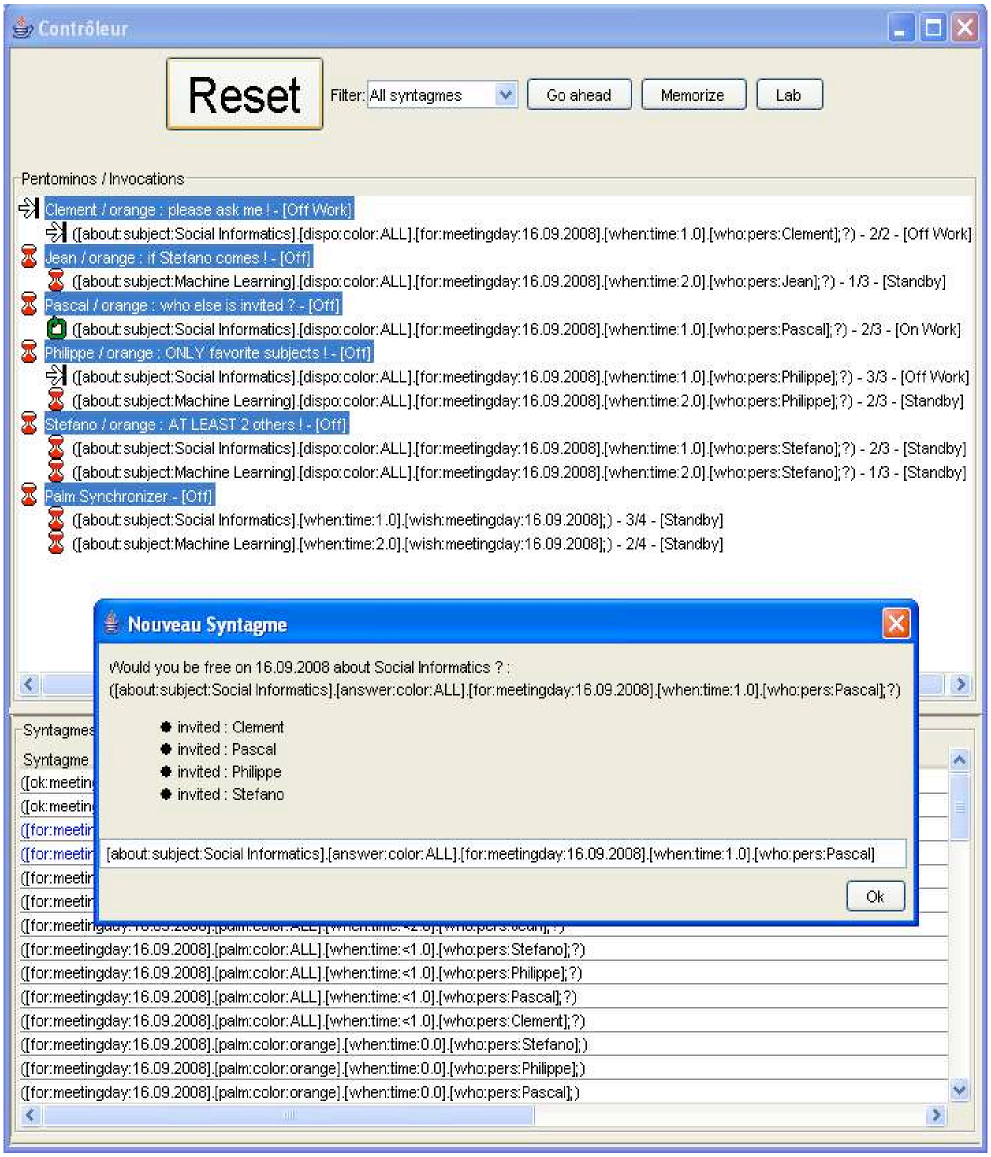


Figure 8. intermediate state

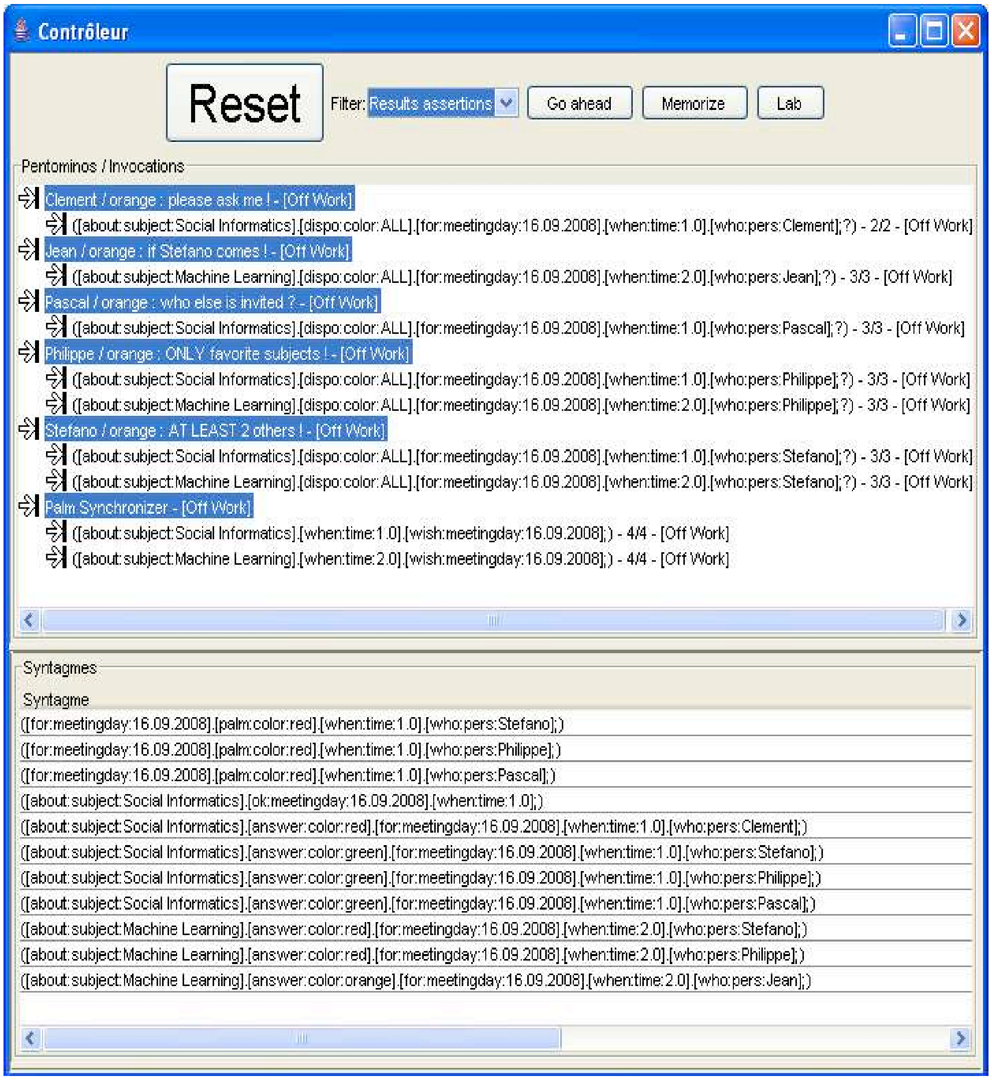


Figure 9. final state after conversation

3.3 Discussion

Being a distributed algorithm, the global conversation is SYNTACTICALLY controlled through comparisons between the statements:

- ✓ Control of question answering: “does statement *x* answer to statement *y*?” relies on the syntactical comparison: “is *x* a specialization of *y*?”
- ✓ Control of turn taking: “does statement *z* invoke agent *A*?” relies on the syntactical comparison: “is *z* a specialization of *A*’s trigger?”

But it is the meaning of statements which governs those SYNTACTICAL expression above which are computed turn-taking and questions answering, therefore the conversation is in fact SEMANTICALLY synchronized!

This also means that the global conversation is subject to eventual SEMANTIC “dead-locks”, a well known phenomenon in multi-agents interactions, when several wait for each other in a loop.
For instance, if in the previous case “Machine Learning” had been proposed before “Social Informatics”, Jean and Stefano would have endlessly waited for each other... not because of a computational problem, but because of a conceptual problem embedded in the semantics of the case!
Of course the constraint of “waiting endlessly for pertinent answers” could be released … but then the issue of the global conversation would depend on the resulting turn-taking, and could not be qualified of PURELY DEDUCTIVE any longer!
Whenever a dead-lock occurs, the constructive attitude is to make the system evolve; meaning that at least one of the agents has to update his behavior; this is highly facilitated by “e-talk”:

- the SYNTACTICAL loop is automatically put out by the protocol;
- its highly expressive syntax allows easy SEMANTIC interpretation.

The other point to outline is that such a protocol allows Clement as well as Pascal to freely arbitrate whether they will come or not, yet the way they arbitrate does not interfere with the computational properties of the conversation! As it has been said before, although each agent is allowed to perform his own INDUCTION/ABDUCTION CYCLES, their conversation remains a calculus.

Conclusion

The conceptual framework we have drawn for rational agents in interaction has allowed us to represent some of the major ingredients of social interactive learning:

- co-building ontologies
- co-building theories
- collaboration in problem solving

As we have pointed out, these constructive interactions inside groups rely on protocols allowing dynamic consensus by means of subsequent cycles of acceptance, refutation and refinement of shared knowledge.

An experimental protocol has been presented; it allows conversational interactions between human and artificial agents, and the synchronization of their conversations is guided by semantic coherence, not just by the syntactic respect of a classical protocol.

Acknowledgements

This work was partially supported by the European Community under the Innovation Society Technologies (IST) programme of the 6th Framework Programme for RTD - project ELeGI, contract IST-002205. This document does not represent the opinion of the European Community, and the European Community is not responsible for any use that might be made of data appearing therein.

References

[1] J. Ferber "Multi Agents Systems: an introduction to distributed artificial intelligence". Addison-Wesley
[2] G. Antoniou & F. van Harmelen. « A Semantic Web Primer ». Technical Report 03009, The MIT Press, 2005.
[3] J. Sallantin, J. Divol and P. Duroux. "Conceptual Framework for interactive ontology building". In Second IEEE International Conference on Cognitive Informatic ICCI 2003 London 18-20 August 2003 pp 179-186
[4] G. M. Edelman "Neural Darwinism: The Theory of Neuronal Group Selection». Basic Books, 1988
[5] M. Liquière and J. Sallantin. "Structural machine learning with gallois lattice and graphs". In 5th International Conference on Machine Learning, pages 305–313, Madison, Wisconsin (USA),1998. Morgan Kaufmann.
[6] G. M. da Nóbrega, S. A. Cerri, and J. Sallantin. "A contradiction-driven approach to theory formation: Conceptual isssues pragmatics in human learning". In Journal of the Brazilian Computer Society November 2003 Volume 9 Number 2 pp 37-55
[7] S. Charron « Un protocole pour l'étude d'un processus social de découverte : le jeu Nobel-Eleusis » Mémoire de DEA, université de Montpellier II, 2004
[8] R. Fagin, J. Y. Halpern, Y. Moses, and M. Y. Vardi. "Reasoning About Knowledge". MIT-Press, 1995.
[9] J. Gerbrandy. "Bisimulations on Planet Kripke». PhD thesis, Institute of Logic, Language and Computation, University of Amsterdam, Amsterdam, The Netherlands, 1999
[10] G. M. da Nóbrega, S. A. Cerri, and J. Sallantin. "On the Social Rational Mirror: learning e-commerce in a Web-served Learning Environment". In S.A. Cerri, G. Gouardères, and F. Paraguaçu, editors, Intelligent Tutoring Systems 6th International Conference - ITS 2002, Biarritz (France), June 5-8 2002. LNCS 2363, pp. 41-50. Springer-Verlag Berlin Heidelberg 2002
[11] L. F. Martins, E. Ferneda, G. M. da Nóbrega, and J. Sallantin. "A discovery support system based on Interactive Asynchronous Reasoning Advances in intelligent system and robotic" LAPTEC 2003 Edited by Germano Lambert Torres, Jair Minoro Abe Marcos Luiz Mucheroni Paulo Estevao Cruvinel IOS Press 2003 pp87 –95
[12] S. A. Cerri, M. Eisenstadt, C. Jonquet. "Learning Agents and Enhanced Presence for Generation of Services on the Grid". THIS BOOK
[13] S. A. Cerri. "Shifting the focus from control to communication: the STReams Objects environments model of communicating agents". In Padget, J.A. (ed.) Collaboration between Human and Artificial Societies, pages 74–101, Berlin, Heidelberg, 1999. New York: Springer-Verlag, Lecture Notes in Artificial Intelligence.
[14] J. Breuker. « Towards a conceptual framework for conversation and services». ELeGI Technical Report D12 : Preliminary version of Grid Service Architecture for conversational and collaboration processes / 2.3., Internal Deliverable on http://portal.sema.es/ October 2004
[15] P. Lemoisson. « E-talk : un protocole de résolution distribuée ». Technical Report 03009, université de Montpellier II, www.lirmm.fr/bibli/DocumentPrint. htm?numrec=031974857915660 , Juin 2003.