STSM application:
Planning in Dynamic Epistemic Logic for Argumentation-based Negotiation
Pere Pardo (IIIA - CSIC)
Host: Oxford Computing Lab July-October 2011

1 Motivation

Applicant:	Pere Pardo Ventura, IIIA-CSIC, Bellaterra, Barcelona, Spain
Host:	Dr. Mehrnoosh Sadrzadeh, Oxford Computing Lab, Oxford, UK

The objective of this visit is to start a collaboration with Dr. Sadrzadeh and Dr Panangaden on the topics of Dynamic Epistemic Logics (DEL) and Partial Order Planning (POP), with applications to Argumentation-based Negotiation (ABN). Argumentation frameworks have been devised as an alternative foundation for logical approaches to applications in AI, and in particular to support negotiation processes. These negotiations are not just about the price to pay for some item-with-given-attributes, but also about the propositions that are to be made true in exchange for this price.

Most proposals in the literature on ABN, though, cannot support representation, reasoning and -hence- negotiation in dynamic or temporal environments in the general case. Thus, in most proposed frameworks one cannot reason or negotiate with world-changing services, understood as actions in the sense of (1) planning or (2) dynamic operators in some modal logic or (3) temporal propositions in some logic. (Consider e.g. a service whose execution turns a proposition φ into its negation $\neg\varphi$. If dynamicity or temporality is not made explicit in the logic, the standard representation of (the execution of) this service as an implication would collapse the agent's logical theory into an inconsistent set.) For planning-based approaches, though, it is known that standard planning systems have strong restrictions on the propositional language and hence on its inference capabilities. (Classical planning for instance, only represents literals and has no inference at all.)

These two representation problems (no dynamicity in argumentation, no inference in planning) were addressed in the paper: Garcí, García and Simari

Defeasible Reasoning and Partial Order Planning, (FoIKS 2008), where the authors proposed a combination of defeasible logic programming DeLP with POP planning, for a planner agent who is also able to reason defeasibly, using an argumentation-based procedure. That this argumentative procedure (which defines the notion of logical consequence in DeLP) supplies a planner-reasoner agent with a good deal of argumentative capabilities was illustrated in our paper (6), for the cooperative case of a set of planner agents who dialogue to reach an agreement upon a joint plan. In these multi-agent argumentative planning domains, a cooperative joint plan is a solution if the property of *being a solution plan* could not be defeated (successfully counterargued) by agents in the group.

The step from cooperative scenarios to complex (dynamic) negotiation scenarios extends the argumentative capabilities as follows. Instead of group joint plan, here agents try to obtain maximally beneficial offers from the other agents that turn into successful plans for their sets of goals. An offer here is a (possibly incomplete) plan describing a list of world-changing services at some price. On the one hand, negotiating agents can still make use of this previous descriptive argumentation: a vendor may counter-argue a complex offer (made by a rival vendor to the customer agent) by pointing out its flaws as a plan (in order to ultimately show the impossibility of refining this plan up to a solution plan). On the other hand, a new kind of arguments exist in this selfish scenarios: rival offers. The existence of an (arguably) better rival offer is in itself a practical argument against the previous offer. The dialogues for ABN taking place in some logic-based planning framework, then, take into account both types of argumentation.

This planning-reasoning approach to ABN was explored in a recent paper (9); this is based on a logic-based planning framework extending the paper mentioned above (García-García-Simari 2009). In (7) we proposed a temporal extension of DeLP, called t-DeLP and studied its logical properties. In (8) we combined t-DeLP with POP, in a similar way to the combination of. We showed how can this proposal t-DeLP-POP be used to solve the Ramification problem and search for physically correct plans. Finally, in (9) we considered multi-agent negotiation scenarios where agents sell or buy (dynamic) services. In these scenarios, dialogues can be defined that make use of the two kinds of negotiating arguments described above. Classical examples in the literature were analyzed in this framework (The papers (6)-(9) can be accessed through the webpage of the IIIA-CSIC institute: www.iiia.csic.es).

Despite the work in (9) is still preliminary and we plan to work more on it in the future, we would like also to explore other logical formalisms to be combine with POP planning. Modal logics may help in defining (dynamic) practical argumentation system that address other key aspects of negotiation, mainly those taking into account the other agents' knowledge about the world, services and other agents. Our previous proposal (9) is somehow limited in this sense.

Dynamic Epistemic Logic (DEL) has been used to reason with epistemic aspects of communicative actions, which are of utmost importance in negotiation scenarios, reasoning about other's knowledge under changes due to (epistemic or communicative) actions. Several examples involving communication in key application areas in AI and logic (security, games, multi-agent systems) have been analyzed, including the Coordinated Attack problem, some Eavesdropping scenarios and variants of the Muddy Children problem.

Since Dr. Sadrzadeh is a leading scientist in the area of DEL, my stay at Oxford would be profitable for the theoretical task proposed and its applications to ABN.

2 Detailed Work Plan

The main goals of our visit are to transform DEL logic into a DEL-based POP practical reasoning mechanism when agents are given some goals G to achieve, and apply this practical reasoning in negotiation scenarios.

The reason for this approach is that the naive purely logical procedure is not feasible. Typically, logics are designed with a theoretical aim in mind, namely to reason about *what should an agent believe* given her knowledge base. For practical reasoning (i.e. *what an agent is to do*), though, a logic containing dynamic modalities for actions (or temporal encodings of actions executions, preconditions and effects) will describe the result of the execution of some plan, but this tells us nothing about how to build a plan for a set of goals, or how good a plan is in terms of cost (i.e. the economic cost of actions involved in the plan). Moreover, there do not exist reasonable algorithms that transform a logic into a tool for practical reasoning in the language of this logic.

This naive approach would consist in testing whether a random sequence of actions (dynamic operators) [a][b]...[z] constitute a proof for the set of goals G, i.e. testing whether the theory T representing the agent's mental state is such that: T proves [a][b]...[z] G. Observe this naive approach cannot exploit partial order search of plans [a][b]...[z] due to logical constraints, hence the flexible POP-style search cannot be implemented logically (at least for non-paraconsistent logics) and thus would be committed to an unprincipled sequential plan search. In contrast, it is known that for some logic-based planning algorithms, an A* search (or best first search) procedure can be applied that takes into account the cost of the plan during construction.

The work plan can be summarized as follows:

1) Define a translation function from the language of DEL into a (deterministic) planning language. Translate sets of user axioms into planning domains: given a set of formulas representing the user axioms for her belief state, this function must faithfully translate information about an action modality into the corresponding planning action (in the planning domain of the corresponding agent). Non-modal formulas translate into the initial state. Epistemic formulas translate. Introduce a second set of formulas for goals, in the language of Epistemic Logic or DEL logic itself (this depends on whether it is an admissible goal that an action has some effect). This translation function defines the planning domain (S, A, G) corresponding to the set of user axioms, where S contains information about the initial

state, A information about actions (its effects and preconditions) and G is the set of goals.

2) Use this translation function to define a Partial order plan as a set of (dynamic) action-steps and (non-dynamic) proof-steps when building a plan. This planning system has also to take into account valid DEL-proofs (i.e. valid at some step within some linear ordering the plan) that pose a threat to other proof-steps that are part of the plan.

3) Study a non-deterministic plan search algorithm for the defined planning system (as well as constraints concerning goal or threat selection on this basic algorithm). Prove that relative to the plan space, the algorithm is correct (any successful output is actually a solution in the plan space) and complete (if a solution exists eventually the algorithm terminates with some such solution. Study applicability of heuristic search, e.g. A*, for optimal planning, so that the corresponding plan search algorithm terminates in an optimal solution, if a solution exists.

4) Define a translation function back from plans to proofs. That is, given a (sequential) solution plan ¡a,b,...,z¿ for a planning domain (S, A, G), show that ”[a][b]...[z]G” is provable in DEL from the sets of formulas S-plus-A:

5) Study how does planning applies to the examples in the different application domains studied by DEL.

6) Application to Argumentation-based Negotiation. Compute succesful moves in negotiation dialogues in terms of (the desirability of) its expected epistemic effects for the other agents. Case Study: analyze negotiation scenarios involving the negotiation of an information exchange.

3 Expected Costs

Travel Costs	200 eur.
Subsistence Costs	2300 eur.

(Here we include the Bench Fees at Univ. of Oxford: £1400 (£100 per week plus £200 for setup costs)

4 Bio

Name:	Pere Pardo Ventura
D.O.B.:	March 5th, 1977

5 Academic Degrees:

B.A. in Philosophy, Universitat de Barcelona (1999)

M.D. in Logic and Foundations of Mathematics, Universitat de Barcelona (2001)

6 Work:

Institut d'Investigació en Intel.ligència Artificial (IIIA - CSIC) (Institute for Research in Artificial Intelligence - National Research Council) April 13th, 2008

7 Current Projects:

Consolider *Agreement Technologies* CSD2007-022, Ingenio 2010. Funded by the Spanish Ministry of Science and Innovation. Participant institutions: IIIA - CSIC, Univ. Rey Juan Carlos (Madrid), Univ. Politècnica de València (València)

LoMoReVI (Logical Models of Reasoning with Vague Information) FFI2008-03126- E/FILO (FP006) EuroCORES. Participant institutions: IIIA - CSIC, Institute of Computer Science, Academy of Sciences (Prague, Czech Rep.), Institut für Computersprachen, TU Wien (Wien, Austria)

8 Languages Spoken:

English (fluent)

Spanish (fluent)

Catalan (fluent)

9 Publication List:

(2009)

(1) Pere Pardo *Base Belief Revision for finitary monotonic logics*, ESSLLI 2009 (Student Session), Bordeaux, France, 20/07/2009.

(2) Pere Pardo, Pilar Dellunde, Lluís Godo *Secure and Optimal Base Contraction in Graded Lukasiewicz Logics*, Artificial Intelligence Research and Development. Proceedings of the 12th International Conference of the Catalan Association fo Artificial Intelligence. Frontiers in Aritficial Intelligence and Applications, vol. 202, Cardona, Catalonia, Spain, IOS Press, pp. 265-274, 21/10/2009

(3) Pere Pardo *Aggregation of Trust for Iterated Belief Revision in Probabilistic Logics*, Third International Conference on Scalable Uncertainty Management (SUM 2009). Godo and Pugliese (eds.)Lecture Notes in Artificial Intelligence, vol. 5785, University of Maryland, Washington DC, USA, Sringer-Verlag, pp. 165179, 28/09/2009

(4) (2010)

(5) Pere Pardo, Pilar Dellunde, Lluís Godo *Base Belief Change for finitary monotonic logics*, Current Topics in Artificial Intelligence. Lecture Notes in Artificial Intelligence, no. 5988: Springer, pp. 82-92, 2010

(2011)

(6) Pere Pardo, Sergio Pajares, Eva Onaindía; Lluís Godo; Pilar Dellunde "Multi-agent argumentation for cooperative planning in DeLP-POP", 10th Int. Conf. on Autonomous Agents and Multiagent Systems (AAMAS 2011), Tumer, Yolum, Sonenberg and Stone (eds.) , Taipei (Taiwan), pp. 971-978, 02/05/2011.

(7) Pere Pardo, Lluís Godo *t-DeLP: a temporal extension of the defeasible logic programming argumentative framework*, To appear in: Proc. of SUM 2011 Conference on Scalable Uncertainty Management, Dayton, Ohio (2011).

(8) Pere Pardo *Temporal Defeasible Logic-based POP for physically correct plans*, to be presented at the GenPlan Workshop, during the AAAI 2011 Conference, San Francisco, CA.

(9) Pere Pardo, Pilar Dellunde, Lluís Godo *Argumentation-based Negotiation in t-DeLP*, Submitted.

(10) Marco Cerami, Pere Pardo *Many-valued semantics for vague counterfactuals* To appear in: Understanding Vagueness - Logical, Philosophical and Linguistic Perspectives. (In press)

10 Conferences, Schools, Workshops and Meetings attended:

- COMMA 2008 Computational Models of Argumentation, Toulouse (France), May 2008
- ESSLLI 2009 (Student Session) Summer School in Logic, Language and Computation, Bordeaux (France), July 2009

- Conference on Logical Models of Reasoning with Vague Information (LoMoReVI Meeting), Cejkovice (Czech Rep.), September 2009
- WUPES Workshop on Uncertainty Processing, Liblice (Czech Rep.), September 2009
- SUM 2009 Third International Conf. on Scalable Uncertainty Management, Washington (USA), September 2009
- CCIA 2009 Conf. of the Catalan Association for Artificial Intelligence, Cardona (Spain), October 2009
- CAEPIA 2009 Conf. of the Spanish Association for Artificial Intelligence, Sevilla (Spain), November 2009
- LATD Logic, Algebra and Truth-Degrees, Prague (Czech Rep.), September 2010
- EAMVL 2010 Epistemic Aspects of Many-Valued Logics, Prague (Czech Rep.), September 2010
- DIP-LEAP 2010 Workshop on Dialogues, Inference and Proof - Logical and Empirical Perspectives, Wien (Austria), November 2010
- SELLC Sino-European Winter School in Language, Logic and Information, Guangzhou (China), December 2010,
- AAMAS 2011 Autonomous Agents and Multi Agent Systems. May 2011, Taipei (Taiwan)