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BOOK REVIEW

Hans van Ditmarsch, Barteld Kooi, Wiebe van der Hoek, *Dynamic Epistemic Logic*, Springer Publishing Company, Incorporated, 2007 Edition. ISBN-10: 1402069081, ISBN-13: 978-1402069086, 296 pp.

Alexandru DRAGOMIR*

The use of modal logics in the study of epistemic and doxastic concepts stems from Hintikka's „Knowledge and Belief" (see Hintikka 1962) and was limited to representing and reasoning with the knowledge of a single agent. Multiple agents and their interaction were considered in the literature after epistemic logic began being used by computer scientists and economists (see Fagin *et al.* 1995). But beliefs and knowledge are dynamic: our interaction with other people and the environment changes them. The way our set of known truths changes as a result of interaction is illustrated in the solution to the Muddy Children Puzzle. Suppose three children play outside and two of them get mud on their foreheads. Father comes and tells them that at least one of them is muddy and asks them to raise an arm if they know whether they're muddy or not. None of them raises an arm, so father asks them again. This time, all the muddy ones know their status. How is it possible? Suppose A and B are muddy and C is clean. A sees a clean C and a muddy B, and remarks that B doesn't know her status. She should've known her status if A were clean, because C is clean and at least one child is muddy. So A learns her status: muddy, and, by similar reasoning, so do all of them. In the setting of Hintikka's „static" epistemic logic, the dynamics of their knowledge could not be accounted for, whereas dynamic epistemic logics are able to describe the evolution of agents' knowledge as a result of communication between agents (like in the Muddy Children Puzzle). The common features of

* Alexandru DRAGOMIR, University of Bucharest. Email: alexdragomirs@gmail.com.

dynamic epistemic logics are: (1) creating semantics for dynamic operators in terms of model-transformers, functions that change the domain, accessibility relations and valuations of the traditional Kripke-models that are used to describe the knowledge of a group of agents, and (2) including „events" or „actions" in the syntax.

The first chapter offers a map of the philosophical and logical context in which dynamic epistemic logics appeared. They are introduced as tools for reasoning about information change, and the notions of information, knowledge and belief are succintly presented. An interesting part displays the interplay between logic, philosophy and computer science when dealing with the matters of defining epistemic and doxastic notions.

The second chapter introduces the reader to static epistemic logic with common and distributed knowledge. Both axiomatics (the S5 logical system with operators for common and distributed knowledge) and semantics (multi-agent Kripke models) are carefully introduced and the examples will certainly facilitate understanding.

Chapter three is an introduction to the AGM system of belief revision. In our interaction with nature and other agents we constantly change our belief sets. The AGM system proposes axioms that govern three possible actions on belief sets: expansions (adding a belief to our set, possibly making it inconsistent), contractions (removing beliefs) and revisions (as opposed to expansion, revision guarantees the consistency of the resulting belief set). The chapter ends with a short introduction to Dynamic Doxastic Logic.

The fourth chapter presents Public Announcement Logic, a logic discovered by J. Plaza (1989). This is the first logic to represent and reason with knowledge in the context of receiving new information. Its semantics is based on restricting the domain to the worlds that satisfy the publicly announced formula. Recall the Muddy Children Puzzle. The publicly observed fact that no child raises an arm after father's request is a public announcement of the epistemic formula that says that no agent knows whether she's muddy or not. After restricting the domain to the worlds at which it is true that no child knows her state, in the new model it becomes true that at least one child knows her status (see the details in the book). The use of model-transformers and the interaction between public announcements, knowledge and common knowledge are exemplified in formal solutions to the Muddy Children Puzzle and the Russian Cards Puzzle.

Chapters five and six offer introductions to H.P. van Ditmarsch's logic of epistemic actions and Baltag-Moss-Solecki Action Models (also called „event models" in the literature). These are logical tools that generalize the intuitions behind Public Announcement Logic: public announcements can be rendered as particular epistemic actions in these logics, but they can also represent and predict the evolution of knowledge after many other types of actions (like private announcements). What is interesting and innovative in Baltag-Moss-Solecki Action Models is that the changing in the knowledge

state of each agent after some acts of communication is modeled as the execution of an action in an epistemic model. Actions are represented as modal models with domains composed of actions, accessibility relations between actions and preconditions, i.e. functions from actions to formulas of the epistemic language, instead of valuations, i.e. functions from atoms to sets of possible worlds. The state of knowledge of each agent after the execution of an epistemic action is computed as the restricted modal product of an epistemic model and an action model. The restricted modal product is the modal product of the two models, from which the worlds that do not satisfy the precondition of the action are eliminated. The intuition behind this construction is that an action can be executed only if its preconditions are met: for example, in a game of cards a player cannot show the ace of spades if she does not have the ace of spades, or one cannot lie if one does not know the truth.

The seventh and the eighth chapters offer the completeness and expressivity results for the static and the dynamic epistemic logics presented. One interesting fact is that through the use of reduction axioms, every Public Announcement Logic (without common knowledge) formula can be translated into an Epistemic Logic formula, so its completeness is guaranteed by the completeness of S5. However, matters get complicated when the common knowledge operator is involved.

Being a highly prolific field, it recently expanded with technical and conceptual innovations that should be accounted for in a future edition: Public Announcement Logic with Protocols, its connection with Epistemic Temporal Logic (see Hoshi 2009), the effects of dynamically changing the protocols (see (Wang 2010)), public substitutions that change the valuations (see Kooi and van Ditmarsch 2008), plausibility models and conditional beliefs (see Baltag and Smets 2006; 2011).

The number of examples, exercises and solutions, and the clarity of the exposition make this book an excellent course material, both for undergraduate and graduate audience.

REFERENCES

Baltag, A. and S. Smets. 2006. Conditional doxastic models: A qualitative approach to dynamic belief revision. *Electron. Notes Theor. Comput. Sci.* 165: 5-21.

Baltag, A. and S. Smets. 2011. Keep changing your beliefs, aiming for the truth. *Erkenntnis* 75 (2): 255-270.

Groeneveld, W. and J. Gerbrandy. 1997. Reasoning about Information Change.

Journal of Logic, Language and Information 6 (2): 147-169.

Hintikka, J. 1962. *Knowledge and Belief*. Ithaca, N.Y., Cornell University Press.

Hoshi, T. 2009. Epistemic dynamics and protocol information. PhD thesis, Stanford, CA, USA, 2009. AAI3364501.

Plaza, J. 1989. Logics of public communcations. In M. L. Emrich, M. Z. Pfeifer, M. Hadzikadic, and Z. W. Ras (editors). *Proc. 4th Int. Symposium on Methodologies for Intelligent Systems*.

Kooi, B.P. and H.P. van Ditmarsch. 2008. Semantic results for ontic and epistemic change. In G. Bonanno, W. van der Hoek and M. Wooldridge (editors). *Logic and the Foundations of Game and Decision Theory (LOFT 7). Texts in Logic and Games 3*, Amsterdam University Press, Amsterdam.

Fagin, R., J.Y. Halpern, Y. Moses and M. Vardi. 1995. *Reasoning about Knowledge*. Cambridge, Massachusetts: The MIT Press 1995.

Wang, Y. 2010. Epistemic Modelling and Protocol Dynamics. PhD thesis, University of Amsterdam, 2010.