Wiebe van der Hoek
Michael Wooldridge

Preface

The use of mathematical logic for reasoning about knowledge and belief is by now a well-documented and widely accepted field of research. Originally, of course, the topic was of interest primarily to philosophers, with the work of Hintikka seminal in this respect. More recently, however, epistemic logic has become an important and well-respected topic of study in computer science and economics. Computer scientists are interested in what computer processes can be said to know. Their reason for this interest is not mere curiosity; they want to design communication protocols, which govern the interaction between computer processes, and in so doing, they need to prove epistemic properties of these processes. A typical requirement in such a protocol might be that "process i does not send message m_{u+1} to process j until it knows that process j received message m_u". In order to formally – mathematically – express such requirements, epistemic logic seems a useful tool.

Of course, as this example suggests, computer scientists are not generally interested in just the *static* aspects of knowledge: when one computer process sends a message to another, it is *performing an action*, and this action may change the epistemic state of the system in many subtle ways. This motivates the development of dynamic epistemic logics and temporal epistemic logics, which make it possible to formally explore the interplay between action, time, and knowledge. This interplay is complex and intriguing, and trying to find a suitable logical framework within which to represent and explore these subtleties has been a major ongoing area of work since Moore first formulated dynamic epistemic logic in the late 1970s.

In January 2002, we organised a Dagstuhl seminar with the title *Towards a Logic of Rational Agency*, which attracted about 35 participants, from the economics, computer science, logic, and linguistics communities. A recurrent theme in many of the presentations and discussions at this workshop was the dynamics of knowledge. This motivated us to put together the present special issue, which brings together papers primarily from computer science and economics.

In *Memory of Past Beliefs and Actions*, Giacomo Bonanno combines the notions of belief, time, and actions, and addresses the question what it means that an agent remembers what he knew, or what he did, and how these interact. Memory is defined as the recollection of past epistemic states, and

Studia Logica **75**: 3–5, 2003.

it is claimed that correctness of beliefs is not a property that is inherent to the notion of memory. By carefully adding more properties to the semantic structures, he distinguishes several axioms regarding memory of past beliefs and memory of past actions. This coincides with the observation in game theory that the restriction to a property such as perfect recall (if the agent believes that after doing a, property φ will be the case, then after doing a, he believes that indeed φ) is not always realistic, but also, that relaxation of this principle leads to problems of, for instance, dynamic inconsistency of choices.

The Russian Cards Problem by Hans van Ditmarsch deals with making announcements in a strategic way: how can two agents publicly exchange information without a third party deriving any significant knowledge from their exchange? Here, the knowledge of the agents changes as a result of some well defined speech acts that the agents can perform. Clearly, multi-agent attitudes during such announcements are crucial: the two agents have to learn something, while the third must remain ignorant. And the latter should not be 'accidentally' the case but rather, should be common knowledge among all. In this contribution, dynamic epistemic logic is put forward as a means to analyze or even generate cryptographic protocols.

Alessio Lomuscio and Marek Sergot combine informational and normative attitudes in their paper *Deontic Interpreted Systems*. Their starting point is the claim that the commonly used Kripke semantics for modeling Multi Agent Systems may be a precise tool to specify and reason about complex systems, but that software engineers feel the lack of constructive methodologies provided by such specifications for actually building them. So they shift to a semantics that is more 'computationally grounded', that of so-called interpreted systems. They then propose an extension of this semantics, giving a model that allows for the representation and reasoning about states of correct and incorrect functioning behaviour of the agents, and of the system as a whole. Since they also incorporate knowledge, it is possible to give a semantics to concepts like 'the knowledge that an agent is permitted to have', and 'the knowledge he has assuming that the other components of the system are functioning correctly'.

Interpreted systems are also employed in *Complete Axiomatizations for Reasoning about Knowledge and Branching Time*, a paper by Ron van der Meyden and Ka-shu Wong. While several axiomatisations for knowledge in multi-agent systems are known for linear time, this paper systematically surveys frameworks for branching time and knowledge, providing a family of tools to specify multi-agent knowledge over time. In such a framework, one can express properties such as 'there is a branch in which in the next state every body knows φ' (a formulation that would be allowed in the fragment based on Computation Tree Logic (CTL)), but the operators may be used in arbitrary ways (the temporal analogue is called CTL^*), like in 'in the next state, agent i knows that in every branch, φ'. The paper distinguishes logics with or without the following operators or assumptions: common knowledge, unique initial state, synchrony, and perfect recall.

Finally, in *Cooperation, Knowledge, and Time: Alternating-time Temporal Epistemic Logic and its Applications*, Wiebe van der Hoek and Michael Wooldridge, rather than studying epistemic logic in the context of branching time, add epistemic operators to what is called 'Alternating-time Temporal Logic' (ATL). In ATL, path quantifiers are replaced by *cooperation modalities* for representing 'social powers' — what groups of agents can achieve. Thus, it becomes possible to express properties such as 'agents i and j can cooperate to achieve that eventually, it will be common knowledge in the group $\{i, j, k\}$ that φ'. Similarly, it is possible to capture the epistemic preconditions that are required to perform an action, as in 'if i knows the key to the safe, he will be able to open it until this key changes'. After investigating various axioms of the logic, they show that verifying properties of their system by means of model checking is tractable, and they also provide a case study to illustrate the approach.

We thank the authors for their work and the anonymous referees for their valuable suggestions.

Liverpool, 16 January 2003.

WIEBE VAN DER HOEK
Department of Computer Science
University of Liverpool
Liverpool L69 7ZF
Liverpool, United Kingdom
`wiebe@csc.liv.ac.uk`

MICHAEL WOOLDRIDGE
Department of Computer Science
University of Liverpool
Liverpool L69 7ZF
Liverpool, United Kingdom
`m.j.wooldridge@csc.liv.ac.uk`