Research Statement

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In the 1990s, I was mainly active in academic teaching. I have been an active researcher since the year 2000. This overview basically covers the period 2000-2006, with incidental backreferences to the 1990s. For each topic except the PhD, the overview of accomplishments is followed by the main relevant publication(s) and concluded by plans for the future.

PhD

I started my PhD in 1996 and completed it in 2000. It focussed on the logical dynamics of games. I studied card games named knowledge games. The 'murder mystery' game Cluedo is an example. The results of these investigations were an analysis of questions and answers in games, the characterization of initial game states in knowledge games (in the precise sense of providing a logical theory that has the Kripke structure for the intitial game state as its unique model, up to bisimilarity), and a dynamic epistemic language to describe knowledge changes in multiagent systems, such as game actions. Precursors of this work in dynamic epistemics are mainly Jelle Gerbrandy and Alexandru Baltag.

H.P. van Ditmarsch. *Knowledge games*. PhD thesis, University of Groningen, 2000. ILLC Dissertation Series DS-2000-06.

Dynamic Epistemics

My work in this area can be seen as the continuation of my PhD research. For example, the publication *Description of Game Actions* below is based on a chapter of the PhD thesis. New work resulted in a language for concurrent epistemic actions, such as players simultaneously handing cards, and a more detailed description of dynamics in the muddy children problem. This partly involved close collaboration with Wiebe van der Hoek (Liverpool) and Barteld Kooi (Groningen).

H.P. van Ditmarsch. Descriptions of game actions. *Journal of Logic, Language and Information*, 11:349–365, 2002.

H.P. van Ditmarsch, W. van der Hoek, and B.P. Kooi. Concurrent dynamic epistemic logic. In V.F. Hendricks, K.F. Jørgensen, and S.A. Pedersen, editors, *Knowledge Contributors*, pages 45–82, Dordrecht, 2003. Kluwer Academic Publishers. Synthese Library Volume 322.

A different direction for generalization is towards the dynamics of non-$S5$ systems (so in particular, systems that are *not* interpreted systems). A main open question is the axiomatization of these dynamic epistemic languages. Their descriptive power in relation to other frameworks, such as by Baltag and by Gerbrandy, is also unknown. Yet another direction for generalization is the integration of epistemic and factual change. An open question is which fragment of public announcement logic (one such dynamic epistemic language) consists of formulas that remain true after their announcement. A recent new line of research involves collaboration with Andreas Herzig and Philippe Balbiani on 'plan operators', a generalization of announcement operators. Again, the open question concerns the axiomatization given a proposed semantics.

Some research interests are in non-dynamic epistemics. The thesis work on characterizing game states started my interest in multi-agent frame characterization. This involved (still not concluded) interactions with Alessio Lomuscio and, independently, with Paul Harrenstein.

I am also interested in theorem proving and model checking for (epistemic) modal logics. Such tools will be clearly indispensable for efficient reasoning about realistic multi-agent systems. My experiences with epistemic model checkers, in 2005, are promising, but pencil and paper still provide faster results.

Information-based Cryptography

This line of research got started by so-called 'card cryptography' and in particular by the 'Russian Cards Problem', wherein seven cards are distributed over three players, and two players (a 'sender' and 'receiver') are required to communicate to each other their hand of cards by public communication, without the third player ('eavesdropper') learning a single card. The results appear generalizable to protocol analysis and design for computationally unlimited agents. The research has been supported by an AOARD grant in 2004.

H.P. van Ditmarsch. The russian cards problem. *Studia Logica*, 75:31–62, 2003.

On my wishlist is the design of a protocol of length strictly larger than two, that is (therefore) irreducible to a length-two protocol. For the setting of card deals, it is unclear whether such protocols exist. On information-theoretic grounds (see work by Fischer & Wright) it is conceivable that they exist. It is even unclear if such protocols exist for the case of seven cards.

Game Theory

I am very interested in interactions between logic and game theory. The precise description of game actions in card games is a prerequisite to computing a preference relation among the various requests a player can make in such a question-answer game, and thus to computing optimal strategies for playing such games – 'doing its game theory' so to speak. I have a minor result for one such card game, namely the Pit game. This is simulation of the stock market trading pit.

H.P. van Ditmarsch. Some game theory of pit. In C. Zhang, H.W. Guesgen, and W.K. Yeap, editors, *Proceedings of PRICAI 2004 (Eighth Pacific Rim International Conference on*

Artificial Intelligence), pages 946–947. Springer, 2004. LNAI 3157.

H.P. van Ditmarsch. The logic of pit. *Knowledge, Rationality & Action (Synthese)*, volume 149(2), pages 343–374. Springer, 2006.

I wish to investigate the game theory of different Pit simplifications – and specifically, to determine optimal strategies for playing Pit. On the long term, I would like to apply possible results to other knowledge games, such as Cluedo. The general setting is that of computing equilibria for multiplayer imperfect information games.

Belief Revision

Interactions with my Otago colleague Willem Labuschagne, in 2002 and beyond, resulted in a new interest, namely the 'redescription' of results in classical belief revision ('AGM' belief revision) in a modal logical setting. This resulted in sharing the supervision of MSc student Guillaume Aucher with Johan van Benthem. Guillaume has since become my PhD student, in co-supervision with Andreas Herzig, and continues to work in that area. The main results in dynamic belief revision are a convenient semantic setting for iterated, higher-order, and multi-agent belief revision. Not all of the 'classical' postulates can be (or even deserve to be) retained, e.g., one has to reinterpret 'minimal change' and also 'success'.

H.P. van Ditmarsch. Prolegomena to dynamic logic for belief revision. *Synthese (Knowledge, Rationality & Action)*, 147:229–275, 2005.

Some of these logics have not been axiomatized. Different iterated revision operators, definable by certain frame properties, will have corresponding logical axioms. The relation with conditional modal logics is unclear.

Combinatorial Mathematics

The Otago Computer Science Theory Group investigates permutation patterns (regularities of subsequences of permutations), permutation machines, stack machines, and various other matters of combinatorial interest. I have been involved in this group after my arrival in Otago, even though this research topic was initially less central to my interests and expertise. More information is found on `http://www.cs.otago.ac.nz/staffpriv/mike/TheoryPages/`. The research overlaps with the information-based cryptography for card deals: the first publication mentioned below provides a partial characterization of length-two protocols for deals of cards over three players – of which the seven-card Russian Cards Problem was an example.

M.H. Albert, R.E.L. Aldred, M.D. Atkinson, H.P. van Ditmarsch, and C.C. Handley. Safe communication for card players by combinatorial designs for two-step protocols. *Australasian Journal of Combinatorics*, 33:33–46, 2005.

R. E. L. Aldred, M. D. Atkinson, H. P. van Ditmarsch, C. C. Handley, D. A. Holton, and D. J. McCaughan. Permuting machines and priority queues. *Theoretical Computer Science*, 349:309–317, 2005.

Computer Science Education

Prior to and in the initial phase of the research that culminated in my thesis, I did some investigations in the area of logic education. This research grew out of my commitment to course development and teaching. Until a fairly recently the overview of software for teaching natural deduction below was my most cited publication. *Logic for computer science* is an undergraduate textbook, currently in its third edition, that has been a classic (i.e., at some stage used at the majority of Dutch universities) since its first appearance in 1989. The list of educational logic software has been maintained since 1996 – in 2006 I am involved in two conferences on that topic, European Conference on Computing and Philosohy (ECAP '06, Trondheim, Norway), and Second International Congress on Tools for Teaching Logic (Salamanca, Spain). *Dynamic Epistemic Logic* is a graduate textbook, to appear March 2007.

H.P. van Ditmarsch. User interfaces in natural deduction programs. In R.C. Backhouse, editor, *Proceedings of UITP 98*, pages 87–95, Technical University of Eindhoven, Netherlands, 1998. TUE CS report 98-08.

J.F.A.K. van Benthem, H.P. van Ditmarsch, J. Ketting, J.S. Lodder, and W.P.M. Meyer-Viol. *Logica voor informatica (Logic for Computer Science)*. Addison-Wesley, Amsterdam, 2003. Third revised edition. (Fourth unrevised edition to appear 2007.)

`http://www.cs.otago.ac.nz/staffpriv/hans/logiccourseware.html`

H.P. van Ditmarsch, W. van der Hoek, and B.P. Kooi. *Dynamic epistemic logic*. Springer Synthese Library, volume 337, 2007. See `http://www.cs.otago.ac.nz/staffpriv/hans/del.html`