coupled dual representations, has much to commend it. It is consistent with, for example, research in cognitive science which may be taken to suggest that people frequently employ multiple representations. Arguing further in the system's favour is a chapter devoted to evaluation, in which Sun demonstrates how reasoning based on simple rules, analogies, default inheritance, and exceptions to inheritance, can be performed within the system. Issues of scaling are partially addressed with the presentation of results obtained from a moderate-sized rule base of geographical knowledge (though the precise number of rules employed is not mentioned).

Less convincing is Sun's attempt in the following chapter to present the coupled networks as a faithful implementation of Fuzzy Evidential Logic (FEL) a mathematico-logical theory of reasoning based on "fuzzifying" Shoham's causal theory. It is far from clear just what it should mean for a statement such as "necessarily" to have truth value of 0.1, or a statement such as "possibly q" to have a truth value of 0.9. Two further dubious chapters follow. In the first Sun considers issues arising from the interaction of the two subsystems. Inheritance in its many guises comes in here, and whilst much of the discussion is not problematic, the equation of intensionality, feature-based representations and semantics (and the equation of the complementary concepts, extensionality, holistic local representations, and syntax), is, from a formal perspective, disturbing. The incorporation of variables and variable binding considered in the following chapter is equally off-putting. In brief the proposed technique involves nodes within each network corresponding to distinct variables, with the activation values of those nodes mapping to instances. Thus, when the activation of a variable node is 0.41 that node might represent John, whereas when the activation of the node is 0.42 it might represent Mary. The difficulty with this approach is that the representation of an instance when it is bound to a variable bears no relation to, for example, the distributed representation of that instance as it occurs elsewhere in the system.

In the final chapters Sun attempts to review FEL and his reasoning system, placing them in relation to other work in reasoning. Special emphasis is given to the way that FEL treats all forms of inexactness in a uniform way. Whilst uniformity does have its advantages, it is far from clear that, for example, uncertain knowledge and incomplete knowledge should be treated in the same way. In the end, whether one is convinced by Sun's approach may well reduce to ones willingness to accept the uniform treatment.

To summarise, Sun's introduction of coupled networks with dual, interacting, representations may well be a profitable area, both within the field of reasoning and beyond. However, my personal impression is that Sun attempts to oversell his system. The treatment of several issues (such as the mathematical foundations of the system, and variable binding) is not convincing, and this leaves me with a number of reservations. Nevertheless, I do recommend the earlier chapters of the book to practitioners of Artificial Intelligence involved in the research and development of rule-based systems, and to cognitive scientists interested in the interface between distributed and localised representations.

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Cooperation in industrial multi-agent systems by Nick Jennings, World Scientific, Singapore, 1994, pp 177, £28, ISBN 981-02-1652-1.

This book describes the development of multi-agent systems for industrial applications, using a DAI shell that is based on a novel theoretical framework for cooperation and coordination in dynamic and unpredictable environments.

The introductory chapter explains various issues involved in coordination, such as global coherence, computational cost and communication bandwidth. Agent autonomy and partiality are considered to contribute to difficulties in coordinating social actions. Well-known coordination techniques are then introduced, including organisational structure, meta-level information

exchange and multi-agent planning. The need for communication and interaction in cooperative multi-agent communities is identified. Two examples of industrial applications are then introduced for use throughout the book: particle acceleration and electricity transportation.

Chapter 2 describes an initial agent architecture called GRATE, in which generic layers of knowledge for cooperation, situation assessment and control are incorporated. GRATE is interfaced to domain-specific systems via the control module. The situation assessment module decides whether activities are local or social, whether to honour a requested social activity and how to respond to new information. The cooperation module is only responsible for managing the agent's social activities and interacting with other agents. The GRATE architecture is then applied to the two industrial applications given in Chapter 1. The particle accelerator example is particularly interesting in that two real, stand alone expert systems are transformed into cooperating agents under the control of GRATE with few modifications to the expert systems and none to GRATE itself. Simulated domain systems are used in the electricity transportation application. Improvements in various aspects are reported in both cases.

Chapter 3 explains a theoretical model for joint social actions, called the Joint Responsibility model. A novel mechanism for coordination is first introduced based on the notions of commitments and conventions. Conventions are used for monitoring agent commitments, which may be withdrawn in a dynamic environment. These conventions define the conditions under which comments may be dropped and what actions to take in such circumstances. A formal language based on modal and dynamic logic is then described for the formal representation of beliefs, goals, actions and commitments from both individual and social points of view. A mental state of Joint Responsibility is finally proposed for coordinated actions together with an associated social convention, known as the Joint Responsibility Social Convention. The use of the Joint Responsibility model is demonstrated in the electricity transportation example.

Chapter 4 presents a computational architecture for the Joint Responsibility model. A specific realisation of the architecture is devised in a refined version of GRATE, called GRATE*. GRATE* overcomes the shortcomings of GRATE in that it can deal with unpredictable and dynamic changes in an agent community since it incorporates the Joint Responsibility Social Convention. GRATE* is finally evaluated against the original GRATE in terms of coherence, computational cost and communication cost.

Chapter 5 gives a summery of the book's contributions to the DAI community, discusses desirable enhancements to the GRATE systems and the Joint Responsibility model, and expresses a vision that the next generation of DAI systems shall have an explicit knowledge level for cooperation.

The book is extremely well-written in its clarity and structure. It offers a substantial amount of theoretically and practically valuable ideas, concepts and techniques for use in multi-agent systems. In addition, it covers general DAI material very well. Therefore the book is highly recommendable to DAI researchers, practitioners, as well as readers who have a general interest in multi-agent systems.

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Constraint-based reasoning by E. C. Freuder and A. K. Mackworth (Eds), MIT Press, Cambridge, MA, 1994, pp 403, £31.50/$47.25, ISBN 0-262-56075-5.

With the current explosion in the number of books being published it is important to be very selective about what you read. This book is a reprint of the 1992 issue of *Artificial Intelligence* (Vol. 58, Nos. 1–3). If you have not seen that issue, then this book is well worth reading.

The issue includes several very important papers, of which I will pick out three. "Partial Constraint Satisfaction" by Freuder and Wallace (no relation to myself!) is a thorough study of how to apply constraint satisfaction techniques embedded in a branch and bound algorithm to problems