Chapter 7

Results and conclusions

In chapter 1, sextion 7, we discussed the research questions and goals of the thesis. In this final chapter, we summarize the results and conclusions. We do this in three parts: rules and reasons (section 1), legal reasoning (section 2), and dialectical argumentation (section 3). We close with some suggestions for future research (section 4).

1 Rules and reasons

Our first group of research questions (chapter 1, section 7) was the following:

- What is the role of rules and reasons in argumentation with defeasible arguments? What properties of rules and reasons are relevant for argumentation and defeat? How do these properties relate?

In order to answer these questions, we have presented a formal model of rules and reasons as they are used in argumentation: Reason-Based Logic. The formalism is a formal semantics of rules and reasons; it focuses on the types of facts relevant for argumentation with defeasible arguments, and the relations between these facts.

We established the following types of facts concerning rules and reasons that are relevant for argumentation with defeasible arguments:

- The state of affairs $\textit{state-of-affairs}_1$ is a reason for the state of affairs $\textit{state-of-affairs}_2$.
- There is a valid rule with condition *condition* and conclusion *conclusion*.
- The rule with condition *condition* and conclusion *conclusion* is excluded for the instance *fact* of its condition.
- The rule with condition *condition* and conclusion *conclusion* is made applicable by the fact expressed by the instance *fact* of its condition.
- The rule with condition *condition* and conclusion *conclusion* applies on the basis the fact expressed by the instance *fact* of its condition.
- The reasons *reasons-pro* for the conclusion *conclusion* outweigh thr reasons *reasons-con* against it.

In chapter 2, the relations between these types of facts are elaborated in the formalism Reason-Based Logic.

In Reason-Based Logic, there are three main mechanisms that lead to defeat:

1. An exclusionary reason makes a rule inapplicable (cf. Raz, 1990).
2. Reasons for a conclusion do not lead to that conclusion if the reasons against the conclusion outweigh the reasons for it (cf. Naess, 1978).
3. A rule does not apply if the reasons against applying the rule outweigh the reasons for applying it.

In chapter 2, these are worked out in detail. The use of exclusionary reasons is closely related to the use of exception predicates, well-known in the research on nonmonotonic reasoning (cf., e.g., Prakken, 1993). Although there are several formalisms that model some form of weighing of reasons, Reason-Based Logic is, as far as we know, the first in which weighing is treated qualitatively instead of quantitatively. We know of no other formalism that models reasons for and against applying a rule.

Once again we stress that there is no single generally agreed upon interpretation of the notions ‘rule’ and ‘reason’. As the many versions of Reason-Based Logic[1] show, this is not even the case if one restricts oneself to the rules and reasons of argumentation with defeasible arguments.

Therefore our formalism is accompanied by many examples in order to make the interpretation of the notions rule and reason as clear as possible (cf. our method of research, described in chapter 1, section 7).

Apart from the particular form of Reason-Based Logic as presented in this thesis, we have made three general contributions to the research on the formalization of rules and reasons:

1. We have separated the semantics of rules and reasons, as used in argumentation with defeasible arguments, from the definition of a defeasible consequence relation. Although this is similar to the preferential-model semantics for nonmonotonic consequence relations (Shoham, 1988; Kraus *et al.*, 1990; Makinson, 1994), there is a difference: in Reason-Based Logic, the facts concerning rules and reasons related to defeat are explicitly represented in the logical language, while the preference relation (that determines nonmonotonicity) of a preferential-model semantics is separated from the logical language. In this way, the definition of defeasible reasoning in Reason-Based Logic becomes less ad hoc, and is based on explicit standards (cf. chapter 2, section 6).
2. We have shown that it is advantageous to consider rules as special objects and to use a translation from sentences to terms (cf. chapter 2, section 4). In this

[1] E.g., Hage (1991, 1993, 1995), Hage and Verheij (1994a, b), Hage *et al.* (1993), Verheij (1994, 1995e), Verheij and Hage (1994).

way, it becomes possible to represent facts about rules, and to reason with them. As a result, we could keep the merits of two competing approaches: the use of rule identifiers and the use of special-purpose conditionals. Our approach enhances the ad hoc use of rule identifiers, which was introduced in order to represent facts about rules. At the same time, our approach can represent the validity of rules, which is an advantage of the use of special-purpose conditionals in contrast with the use of rule identifiers (cf. chapter 4).

3. We have separated the generation of a reason and the generation of a conclusion, which can both occur when the condition of a rule is satisfied. First, this clarifies the relation of rules and reasons, and second, this allows different levels where defeasibility can occur (cf. chapter 3, sections 5 and 6).

2 Legal reasoning

Legal reasoning has been an important inspiration during the development of Reason-Based Logic. Legal reasoning provides good examples for Reason-Based Logic, since in the law several pragmatic solutions have been developed to dealing with exceptions to rules, dealing with rule conflicts, and reasoning about rules. As a result, the usefulness of Reason-Based Logic can be shown using examples from the field of law.

In chapter 3, we have formalized several examples of legal reasoning in Reason-Based Logic. Apart from different ways of dealing with exceptions to rules and rule conflicts, which are specific for Reason-Based Logic, we have given two applications of Reason-Based Logic to the theory of legal reasoning, namely to integrating rules and principles, and to reasoning by analogy:

1. We have presented an integrated view on rules and principles, and have shown that rules and principles can be regarded as the extremes of a spectrum of hybrid rules/principles. This integrated view is in contrast with Dworkin's strict distinction between rules and principles (cf. Dworkin, 1978).
2. We have given three different ways of reconstructing reasoning by analogy: (1) application of principles that underlie the original rule, (2) application of an analogous rule/principle that has the same underlying principles as the original rule, and (3) analogous application of the original rule, i.e., the application of the rule with non-standard justification. The first of these ways of reconstruction of reasoning by analogy follows directly from the integrated view on rules and principles. The second is a familiar interpretation of analogy, except that we have made the nature and justification of the analogy explicit in terms of underlying principles. The third is typical for Reason-Based Logic.

Since we have given formal elaborations in Reason-Based Logic, the insights can be applied to the use of computers as tools in the field of law (cf. Van den Herik, 1991).

3 Dialectical argumentation

The second group of research questions (chapter 1, section 7) was the following:

- What is the role of process in argumentation with defeasible arguments? How is the defeat of an argument determined by its structure, counterarguments and the argumentation stage?

In order to answer these questions, we developed a formal model of dialectical argumentation, CumulA, in chapter 5.

We have focused on the process of taking arguments into account, and on the defeasibility of arguments. CumulA is a model in which the defeat status of an argument, either undefeated or defeated, depends on:

1. the structure of the argument;
2. counterarguments;
3. the argumentation stage.

We discuss each below.

In CumulA, the structure of arguments is modeled as in, e.g., the argumentation theory of Van Eemeren *et al.* (1981, 1987). Both the subordination and the coordination of arguments are possible. In CumulA, it is explored how the structure of arguments can lead to their defeat. To our knowledge, CumulA is the only formalism that explores how the coordination of arguments influences defeat (cf. the definitions of the narrowings of arguments in chapter 5, section 2.4, and of defeat status assignments in chapter 5, section 4.4).

In CumulA, the influence of counterarguments on defeat is modeled using defeaters. Defeaters indicate when arguments can defeat other arguments. We have shown that defeaters can be used to represent a wide range of types of defeat: undercutting and rebutting defeat, as distinguished by, e.g., Pollock (1987), defeat by sequential weakening and by parallel strengthening, as distinguished by Verheij (1995c), and collective and indeterministic defeat, related to the well-known skeptical and credulous approaches in nonmonotonic reasoning (cf. Ginsberg, 1987). However, these types of defeat were not previously integrated in one formalism (cf. chapter 5, section 3).

Argumentation stages represent the arguments taken into account and the status of these arguments, either defeated or undefeated. CumulA's lines of argumentation, formally sequences of stages, give insight into the influence that the process of taking arguments into account has on the status of arguments. For instance, by means of argumentation diagrams, which give an overview of possible lines of argumentation, phenomena that are characteristic for argumentation with defeasible arguments, such as the reinstatement of arguments, are explicitly depicted.

In chapter 6, we have analyzed a number of existing argumentation models. First, we made several formal distinctions between argumentation theories.

- Four types of arguments were distinguished in CumulA by their structure: statements, single-step arguments, arguments that are constructed by subordination, and arguments that are constructed by subordination and coordination.
- Four types of defeat were distinguished by the structure of the challenging and challenged arguments involved: no defeat, sentence-type defeat (with, as a special case, assumption-type defeat), step-type defeat, and composite-type defeat.
- Five types of defeat were distinguished by the number of challenging and challenged arguments involved: no defeat, self-defeat, simple defeat, left-compound defeat, and right-compound defeat.
- Two types of defeat were distinguished by different ways in which defeat is triggered: inconsistency-triggered and counterargument-triggered defeat.
- Four types of direction of argumentation were distinguished: static argumentation, forward argumentation, backward argumentation, and bi-directional argumentation.

Second, we have shown the generality of CumulA by capturing elements of selected argumentation models in CumulA. Previously, Lin and Shoham (Lin and Shoham, 1989; Lin, 1993) and Dung (1995) have captured other selections of argumentation models in their formalisms. However, we have not proven formal relations, in contrast with Lin and Shoham and Dung.

Third, we have shown similarities and differences between the argumentation theories capturing argumentation models by applying the distinctions above. Previously, Lin (1993) made a distinction related to our distinction of sentence-type and composite-type defeat. However, his distinction was based on intuition, while ours is based on formal grounds. Moreover, we have made several other distinctions.

To conclude, CumulA has shown that

1. it is advantageous to consider arguments structured both by subordination and by coordination if argumentation with defeasible arguments is modeled;
2. the defeat of arguments can be described in terms of their structure, counterarguments, and the stage of the argumentation process;
3. both forward and backward argumentation can be formalized in one model.

4 Future research

A first direction of future research will be the integratation of the ideas behind Reason-Based Logic and CumulA. Whereas Reason-Based Logic lacks a process model of argumentation, like that of CumulA, CumulA lacks a rich language, like that of Reason-Based Logic. Because of the already existing connections between the two models, e.g., the admission of the accrual of reasons, this direction of research could be fruitful, and could lead to a better understanding of argumentation with defeasible arguments.

A second direction of future research will be the implementation of Reason-Based Logic and CumulA. Early versions of Reason-Based Logic have been implemented in Prolog (Hage, 1993; Verheij, 1993, 1995e), but have become outdated by the later theoretical enhancements. CumulA has not been implemented, but seems to be well-suited, due to its process-orientation. Moreover, it is promising that Dung (1995) has shown close connections between argumentation and logic programming.

A third direction of future research will be the practical assessment of the mostly theoretically motivated ideas on legal reasoning, as presented in this thesis. Probably, the actual legal practice will necessitate several adjustments and compromises. There is a detailed plan to test the theoretical ideas against the actual practice in the legal domain of tort.[2]

[2] The Dutch National Program for Information Technology and Law (ITeR) has recently provided funding for this project, that will be carried out at the Department of Metajuridica of the Universiteit Maastricht.

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