

Precedential Constraint: The Role of Issues

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ABSTRACT

Horty, Rigoni and Prakken have developed formal characterisations of precedential constraint based on dimensions and factors as introduced in HYPO and CATO. We discuss the relation between dimensions and factors and also describe the current models of precedential constraint based on factors, along with some criticisms of them. We argue that problems arise from ignoring the structure of legal cases that is provided by the notion of issues, and that seeing precedential constraint in terms of issues rather than whole cases provides a more effective approach and better reflects legal practice. The advantages of the issue based approach are illustrated with a concrete example. We then discuss how dimensions should be accommodated, suggesting that this is best done by seeing reasoning with legal cases as a two stage process: first factors are ascribed to cases and then factor based reasoning can be used to arrive at a decision. Thus precedential constraint can be described in terms of factors, dimensions being handled at the first stage. Both stages are constrained, in different ways, by precedents: we identify three types of precedent: *framework* precedents which structure cases into issues, *preference* precedents which resolve conflicts between opposing sets of factors within these issues, and *ascription* precedents which constrain the mapping from facts to factors.

CCS CONCEPTS

• Applied computing → Law.

KEYWORDS

reasoning with precedents, factors, dimensions, issues

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1 INTRODUCTION

Reasoning with precedent cases has been a central concern of AI and Law since the very beginning. At least three questions can be posed in relation to reasoning with precedent cases: (1) *how do people reason with precedents?* (2) *can we use precedents to predict*

the outcome of new cases? and (3) *can we formally characterise how precedents constrain future cases?*

An early project addressing precedential reasoning was the HYPO project of Rissland and Ashley, introduced at the first ICAIL [43] and most fully described in [6]. HYPO modelled reasoning with precedents in the US Trade Secrets domain. It influenced a great deal of research by a number of different researchers, as discussed in [10], including the CATO system of Ashley and Aleven, introduced in [4] and most fully described in [3]. CATO also addressed US Trade Secrets. Both HYPO and CATO were concerned with the first of our questions: their goal was to show how arguments concerning new cases can be constructed on the basis of precedent cases, and how such arguments can be challenged by distinguishing the cited precedents. These systems presented arguments for and against particular decisions, but did not attempt to *choose* between them: that was left to the judgement of the user.

In contrast, systems based on rules, whether based on expert knowledge [49], or on a formalisation of legislation [47], or a combination of the two [8], were able to predict the outcome of a new case entered into the system, answering our second question. It was therefore a natural development to adapt systems such as CATO to offer predictions based on reasoning with precedents. This was done in the Issue Based Prediction system (IBP) [21], in which arguments generated from CATO were organised and evaluated so as to predict an outcome. Subsequently Grabmair further developed this approach to accommodate his value judgement formalism [24]. Predictions based on precedent continue to be implemented in both symbolic systems [2] and machine learning (ML) systems such as [35] which base their predictions on large collections of case decisions. Factor based reasoning is acquiring an important new role in explaining the predictions of ML systems (e.g. [19] and [38]).

The reasoning in HYPO and CATO was embodied in algorithms rather than expressed declaratively and so was not readily amenable to formalisation to address the third question. This situation was changed when Prakken and Sartor provided a means of expressing a case base of precedents as a set of rules and priorities between them [39]. The resulting rule base could then be deployed to predict the outcome of a new case. Further, this laid the foundations for the provision of a formal account of precedential constraint¹. The work was begun by Horty [26], using a factor based representation taken from [6] and [3]. His approach was developed in [30] and extended by Rigoni in [41]. However, it became recognised that factors were not sufficient to capture all the necessary nuances of precedents: some aspects of cases can favour a party to different extents. The need to address dimensions was argued in [15] and

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¹These formal accounts consider that a decision is constrained if any other decision would be inconsistent with past decisions. In practice this constraint may not be respected in given judicial settings. For a jurisprudential discussion see [46].

addressed by Horty in [27], [28] and [29] and by Rigoni in [42]. A comparison of the approaches of Horty and Rigoni is given in [37].

In this paper we will address the question of how precedents constrain decisions in new cases, and in particular identify how domain knowledge can complement the purely formal characterisations. Section 2 reviews the use of dimensions and factors in HYPO and CATO to clarify their different roles: whereas dimensions identify the aspects of cases which must be considered, factors record their legal significance in the particular case by identifying the party favoured by that aspect. Section 3 gives an overview of the formalisations of precedential constraint using factors. In Section 4 we show how these approaches can be improved by exploiting the structure found in legal cases. Section 5 considers how to accommodate dimensions, by considering precedential reasoning as a two stage process. First factors are ascribed on the basis of dimensional facts and then these factors supply the reasons to resolve the issues, and hence constrain the overall decision. Different precedents are relevant at each stage: some constrain the ascription of factors while others constrain the preferences between sets of factors.

The contributions of the paper are: improvement in the formal characterisation of precedential constraint, both in terms of effectiveness and in reflecting actual decisions, by applying it to *issues* rather than *whole cases*; clarification of the role of dimensions by articulating the reasoning process into two *distinct* stages; and identifying the need to recognise that precedents operate differently at the two stages. Throughout the paper we use examples from US Trade Secrets cases, the most widely discussed domain for reasoning with precedents in AI and Law: as well as HYPO and CATO it has been used in [21], [22], [2], [24], [13], [36], [50] and [38], among many others.

2 DIMENSIONS AND FACTORS

To relate formal work on precedential constraint to actual legal cases, it is important to have a clear understanding of factors and dimensions and the relationship between them. The terms have been used in different ways, but we will consider dimensions as used in HYPO and factors as used in CATO, discussed by Rissland and Ashley in [44]. This is the most common use, and HYPO and CATO were explicitly identified by Horty in [26] and [30] as the source of the factors used in his formal account of precedential constraint, which is the starting point for subsequent discussions of this topic. Moreover both HYPO dimensions and CATO factors resulted from thorough domain analyses. Most of the many systems addressing US Trade Secrets have taken both the analysis of the domain and the ascription of factors to cases from CATO [3].

In HYPO cases are represented as collections of facts (see Appendix B of [6]). There are thirteen implemented dimensions (Appendix F of [6]) which may be applicable to a case on the basis of these facts. In general a dimension can take a range of values, but in fact ten of the thirteen were two-valued. A list of HYPO's dimensions, summarising Appendix F of [6], is given in Table 1.

Dimensions identify the aspects of cases which need to be considered to see if they are applicable:

Each dimension has prerequisites that must be satisfied in order for the dimension to be applicable. For example, the dimension Secrets-Voluntarily-Disclosed

has as one of its prerequisites that the plaintiff made disclosures of confidential information to outsiders. ([44], p 67)).

Although disclosures to outsiders may be a reason to find for the defendant, the lack of disclosures was never found to be used as a reason to find for the plaintiff in the analysed cases [44]: because the plaintiff is expected to take measures to protect the secret, simply refraining from disclosure seems not to strengthen the plaintiff's case. Thus this dimension is not applicable if no disclosures were made. Typically only a few dimensions will be applicable in any given case: in HYPO four or five is typical.

2.1 From Dimensions to Factors

Even if applicable, the value on the dimension may be such that it does not favour either party; the dimension may be neutral in the particular case. Applicable dimensions must be assessed for their legal significance for the particular case, that is whether they favour a party, and if so, which one. This significance is shown by ascribing a factor to the case. A factor is present if the case lies within a range on a dimension which favours a particular side. At one end the dimension will either be inapplicable because it does not affect the strength of a side's case, or it will favour a particular side. Moving along the dimension we may enter a neutral area favouring neither side, and then an area which favours the other side. In practice many dimensions have only two points and either favour a particular side or are inapplicable. For a many-valued dimension, such as D3d, if sufficient disclosures to provide a reason for the defendant were made, then the corresponding factor (F10d) applies. It may be, however, that too few disclosures were made to favour the defendant (e.g. *Emery v Marcan* "Even though parts drawings may on occasion have been shown to a limited number of outsiders for a particular purpose, this did not in itself necessarily destroy the secrecy which protected them."). Here no factor will apply (although the dimension remains applicable if *any* disclosures were made, because whether the factor should be ascribed needs to be considered). The point about neutrality is made in [44]

Note that CATO does not automatically treat the fact that a factor does not apply to a case as a strength for the opponent. ([44], pp 68-9).

As can be seen from Table 1, only one dimension, D13b, *Security Measures*, was seen as capable of favouring both sides.

[...] the Security-Measures dimension was broken into two factors: Security-Measures [F6p], favoring the plaintiff, and No-Security-Measures [F19d], favoring the defendant. This was done because judges explicitly said that the fact that plaintiff had taken no security measures was a positive strength for the opponent. By contrast, Ashley and Aleven did not create a "No-Secrets-Disclosed-Outsiders" factor because they found no cases where judges had said that the absence of any disclosures to outsiders was a positive strength for the plaintiff. ([44], p 69).

Thus the security measures dimension is always applicable, although it is possible that neither F6p nor F19d is present: the plaintiff may have taken sufficient measures to prevent the lack of concern

Table 1: Dimensions in HYPO and their corresponding CATO factors. Dimension and Factor IDs are D or F for dimension or factor (factor numbers are those in CATO) followed by p, d, or b to indicate whether it can favour plaintiff, defendant or both.

ID	Dimension	Values	Number of Values	Plaintiff Factors in CATO	Defendant Factors in CATO
D1p	Competitive Advantage Gained	Computed from development time and cost	Many	F8p	
D2d	Vertical Knowledge	Vertical or technical	2		F11d
D3d	Secrets Voluntarily Disclosed	Number of Disclosures	Many		F10d F27d
D4d	Disclosures Subject to Restriction	Yes or No	2	F12p	
D5p	Agreement Supported by Consideration	Something or Nothing	2		
D6p	Common Employee Paid to Change Employers	Something or Nothing	2		F2d
D7p	Exists Express Noncompetition Agreement	Yes or No	2	F13p	
D8p	Common Employee Transferred Product Tools	Something or Nothing	2	F7p	
D9p	Non-Disclosure Agreement Re Defendant Access	Yes or No	2	F4p	
D10d	Common Employee Sole Developer	Yes or No	2		F3d
D11d	Non-disclosure Agreement Specific	Yes or No	2		F5d
D12d	Disclosure in Negotiations with Defendant	Yes or No	2		F1d
D13b	Security Measures	Range of possible measures	8	F6p	F19d

being a strength for the defendant, but without sufficient rigour to be a reason to find for the plaintiff. Thus, although it is always relevant to consider the security measures taken, in many cases there will be no legal significance. Indeed many cases in CATO [3] do not have either F6p or F19d. Of the thirteen dimensions in HYPO, ten, the two-valued dimensions, are either inapplicable or favour a particular side. Of the three multi-valued dimensions, two are considered, if applicable, to be either neutral or capable of favouring only one party (defendant for disclosures, and plaintiff for competitive advantage). Only *security measures* is capable of favouring either side, or being neutral.

Note, however, that in one case, *disclosures to outsiders*, there are two *pro-defendant* factors associated with the dimension. As well as F10d, *SecretsDisclosedOutsiders*, we also have F27d *DisclosureInPublicForum*. This is because F27d provides a much stronger reason for the defendant than F10d, so that it might be that a plaintiff factor such as F12p *OutsiderDisclosuresRestricted* would defeat F10d but not F27d. Thus a dimension may give rise to multiple factors favouring the same side.

This understanding of dimensions and factors shows why it is a mistake to speak of the “negations” of base level factors, as in some recent formally oriented approaches (e.g. [50], [37]). CATO used two distinct factors for the rare case where a dimension could favour either side. Moreover, if a factor is absent, a different factor favouring that side may be present, as with disclosures. Thus the absence of F10d might mean that no disclosures had been made, so that the dimension was inapplicable; that too few disclosures had been made, meaning that the dimension was not legally significant in this case; or that disclosures had been made in a public forum, so that the stronger F27d was present. There seems little sense in wrapping these three quite different notions under the “negation” of F10d. Nor is negation needed to distinguish cases where a base level factor is known absent from those where there is no information about that factor. If a *base level* factor is not mentioned in

the opinion, it played no role in the decision, and hence can safely be considered absent. The absence of a base level factor does not provide a reason for the other side, and so its absence will be mentioned only when its presence was considered but rejected because the case fell into a neutral area on an applicable dimension.

In addition to the fourteen factors derived from the HYPO dimensions in Table 1, CATO introduced another twelve factors. This is because CATO analysed considerably more cases than HYPO and seems to have included more cases questioning whether the information was a trade secret rather than whether there was a confidential relationship. In Table 2 we have related these additional factors to dimensions in the manner of Table 1. These additional factors can be accommodated in seven dimensions, only one of which, D14b, has both plaintiff and defendant factors. Three have multiple factors for the same side. Four are two-valued. The mix is similar to that found in HYPO, and so may be considered typical.

That the additional cases analysed by CATO led to additional factors and dimensions is an indication of how precedent cases are the source of dimensions and factors. The opinions in precedents show what aspects of the cases judges thought relevant, and what, if any, significance they accorded to them in that case. Any given case will only have a few applicable dimensions, and so will only contain a small subset of possible factors. Therefore as we analyse more cases we are likely to encounter more dimensions and more distinctions and hence more factors.

2.2 Arguing with Factors

HYPO and CATO were not concerned with determining or predicting outcomes, but rather the identification of arguments for the two parties. These arguments were organised in the “three ply” structure common in law (e.g. US Supreme Court Oral Argument and witness testimony which follows the initial questions with a cross examination and a redirect). In this structure an outcome is

Table 2: Factors Introduced in CATO Organised into Dimensions. See Table 3 for factor names.

ID	Dimension	Values	Number of Values	Plaintiff Factors in CATO	Defendant Factors in CATO
D14b	Use Of Available Information	Various types of use	Many	F14p	F16d F25d F17d
D15p	Similarity Of Products	Degrees of similarity	Many	F15p F18p	
D16d	Availability Of Information	Various forms of availability	Many		F20d F24d
D17p	Invasive Techniques	Yes or No	2	F22p	
D18p	Obtained by Deception	Yes or No	2	F26p	
D19d	Confidentiality Waived	Yes or No	2		F23d
D20p	Knew Confidential	Yes or No	2	F21p	

proposed, a response made by the other side followed by a rebuttal from the original side. For reasoning with precedents with the proponent arguing for the plaintiff, these three plies in CATO are:

- (1) Cite the precedent case with a decision for the desired side which has the most factors in common and fewest distinguishing factors compared with the current case. The side favoured by the factors does not matter.
- (2) The opponent may distinguish the cited case. Typically the new case will not contain exactly the same factors as the precedent. Some of these differences will make the case stronger for the plaintiff: plaintiff factors in the current case but not the precedent, and defendant factors in the precedent but not the current case. The defence will be wise to remain silent as to these differences. If, however, the precedent contains plaintiff factors not in the current case, or defendant factors in the current case but not the precedent, the differences may be significant and so provide an argument not to follow the cited precedent².
- (3) The proponent may now attempt a rebuttal: downplaying distinctions by citing factors favouring the plaintiff (the differences the defendant could not use in the second ply).

Assuming that the opponent was able to make some distinctions in the second ply, it is now up to the user to decide whether, given the rebuttal, the distinctions are of sufficient weight to merit an outcome different from the precedent case.

This method of arguing with precedents is the basis of the formal characterisations of precedential cases discussed in the next section. Precedents are converted into sets of rules with conjunctions of factors as antecedents. These rules constrain a new case if there is a rule applicable to the new case which finds for a particular side (ply 1) which cannot be distinguished (ply 2), and which is preferred to any applicable rule favouring the other side (ply 3).

3 MODELS OF PRECEDENTIAL CONSTRAINT

HYP0 and CATO were realised as programs, with the knowledge represented as particular data structures (e.g. *case frames* in HYP0), and the operation of the reasoning defined in terms of algorithms manipulating these structures (the algorithms for CATO are given in Appendix 3 of [3]). As such, reasoning with cases was not readily amenable to logical analysis until Prakken and Sartor provided a

means of expressing precedent cases as a sets of rules [39]. Since the factors for the plaintiff provide a reason to find for the plaintiff and the factors favouring the defendant a reason to find for the defendant, the decision in the case can be seen as expressing a preference for one of these reasons. The conjunction of all the factors for a side is the strongest reason for that side, so the precedent can be modelled as a set of three rules expressing that the strongest reason for the winner was preferred to the strongest reason for the loser. Where the case comprises a set of factors $P \cup D$ where P is the set of plaintiff factors and D the set of defendant factors, the three rules are:

- $$\begin{aligned} r1: P &\rightarrow \text{plaintiff}; & r2: D &\rightarrow \text{defendant}; \\ r3: r2 < r1 &\text{ if the decision was for the plaintiff and } r1 < r2 &\text{ if} \\ &\text{the decision was for the defendant.} \end{aligned}$$

If we represent all the precedents in the domain using this technique we can build a logical theory representing our case base of precedents. If we are given a new case, we can see whether the rules apply to it, and if so whether an outcome is determined by the current theory. A distinction will mean that the winner's rule does not apply or that the loser may have a stronger rule. This representation was used in [9] in which the possible sets of plaintiff factors were represented as a partial order, the possible sets of defendant factors were represented as a partial order, and the precedents as ordering relations *between* these two partial orders. The nodes contain all the possible antecedents for plaintiff and defendant rules and the arcs show the priorities between particular rules. The example from [9] is shown in Figure 1. Deciding a new case is now a matter of adding an arc between the two relevant nodes representing the factors in the new case and deciding which way the arrow should point. The constraint is that the arrow should not introduce a cycle since this would introduce an inconsistency to the case base. Thus a case which could introduce a cycle is constrained, but if no cycle can result, the judge is free to decide either way.

This idea was refined and presented in a more rigorous way by Horty in [26] and further refined in [30]. Horty was interested in modelling two different accounts of precedential constraint from the jurisprudence literature. One is a very strict version, for which Horty cites [5]. Here any distinction between the precedent and the current case is enough to allow the judge to come to a different decision. This version, which corresponds to Figure 1, is now normally termed the *results model* in AI and Law [37]. This model encodes precedents as rules in the same way as [39] and [9]. Any weakening

²In HYP0 and CATO the opponent can also cite counter examples in this ply, but we will not discuss counter examples in this paper.

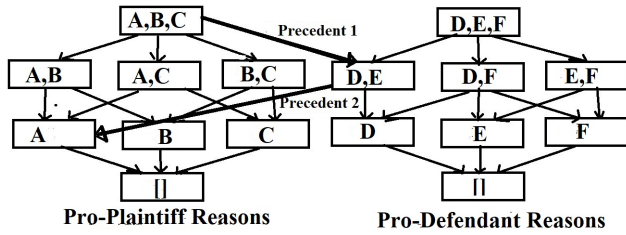


Figure 1: Plaintiff and Defendant lattices with two precedents from [9]. Precedent 1 was [A,B,C,D,E] found for plaintiff and Precedent 2 was [A,D,E] found for defendant.

of the plaintiff’s case or strengthening of the defendant’s case is enough to prevent a precedent for the plaintiff from being followed (and *vice versa*). Although this model provides an unchallengeable constraint when the rule is applicable, the standard required for the rule to be applicable is rather high. Even with only 3 factors for each side we have 64 possible comparisons, and if we have the 13 factors for each side from CATO we have 2^{26} (67,108,864) comparisons of sets of plaintiff factors with sets of defendant factors [1]. Of course, an example of every comparison is not needed, but still, given the number of possible distinctions, expecting enough precedents to provide significant guidance is unrealistic. This suggests that the result model does not offer us enough constraints from the precedents: rarely will the match be exact enough to constrain the decision. Horthy therefore used an alternative model, which he termed the *reason model* and attributed to [31]. Horthy noted that although the full set of factors for the plaintiff represented the *best* reason to decide for the plaintiff, a subset of these factors may well have been *sufficient* to defeat the defendant reason without the additional factors. Thus instead of representing the winner’s rule by the full set of factors favouring the winner, the winner could be represented by a subset of these factors, which can be seen as the *reason* for the case. Thus in the first precedent of Figure 1, we could see the reason for deciding the first case for the plaintiff as $B \rightarrow \text{plaintiff}$ ³, so that future cases containing [A, B, D, E] and [B, C, D, E] will also be constrained for the plaintiff, without being distinguished by the absence of C and A respectively as was the case with the results model shown in Figure 1. Horthy formalised this reason model in [26]. For a formal comparison of the result and reason models of factor based precedential constraint see [37].

3.1 Criticisms of the Reason Model of Precedential Constraint with Factors

Horthy’s formalisation of the reason model provides an effective way of characterising precedential constraint using factors. But there have been several questions raised about it.

Rigoni advanced two criticisms in [41]. First, he pointed to cases with multiple rationales:

³Of course, identifying the reason in practice is not a straightforward task: it requires close analysis of the decision and there may be different interpretations of the decision. The problem is avoided by the more conservative results model, at the expense of constraining far fewer cases

The first problematic sort of cases are those in which the court makes a decision on the basis of multiple legal rules, each of which would be sufficient for the decision. These are sometimes known as cases with alternative holdings” [34] ... Consider *Newport Yacht Basin Ass’n* ... the defendant prevailed and was awarded attorney’s fees “based upon a prevailing party provision of a purchase and sale agreement, a contractual indemnity provision, and principles of equitable indemnity” (NYBA 2012, p. 75). According to the trial court judge, each of these was sufficient to justify the awarding of attorney’s fees. ([41], p 141).

In such cases it is impossible to choose between the alternative holdings to give the rule to represent the case in the theory. This, however, is not an insurmountable problem: we can simply include all of these rules in our theory, each with a preference over the rule for the other side in the case.

Rigoni’s second observation is that not all precedents can be seen as expressing a preference between reasons. Some cases instead lay out a method for considering cases of a particular type. Rigoni termed these *framework* precedents, and used *Lemon v. Kurtzman* (1971) as his example:

In that case the US Supreme Court addressed the question of whether Pennsylvania’s and Rhode Island’s statutes that provided money to religious primary schools subject to state oversight violated the Establishment Clause of the First Amendment. The court **introduced a three-pronged test** and ultimately ruled that both programs did violate the Establishment Clause. ([41], p 142. **Emphasis ours**).

In *Lemon* it is not the balance of factors that led to the decision that are instructive, but the tests themselves. These tests will be applied in future cases, providing a set of *issues* that give a framework for deciding future cases. Framework precedents did not arise in CATO because the Restatements of Torts⁴ provides just such a framework of issues, which formed the basis of the factor hierarchy in CATO, rendering framework precedents unnecessary.

Another problem arises from the possibility of there being several factors for the same side with different strengths on a dimension. Consider the following example:

Example 1. Consider a case in which the plaintiff had a unique product (F15p), but made disclosures to outsiders (F10d), which was found for the defendant. This gives the three rules:

- r1: F15p \rightarrow plaintiff; r2: F10d \rightarrow defendant
- r3: r1 < r2

Now consider a case where the plaintiff had made the disclosures in a public forum, so that F27d applies rather than F10d. Now r2 does not match, and so the theory does not constrain the new case. But since F27d is stronger on the dimension than F10d, the new case should, *a fortiori*, be decided for the defendant on the basis of the precedent.

This problem has a simple pragmatic fix: where a factor is included in a case, include also all weaker factors on that dimension.

⁴The relevant section, section 757, *Liability for disclosure or use of another’s Trade Secret*, can be found at <https://www.lrdc.pitt.edu/ashley/restatem.htm>.

So the new case becomes [F15p, F10d, F27d] and r2 will match. This will work from a logical perspective, although care must be taken to use the factor actually present in any explanation.

The fourth criticism is simply that even the reason model does not constrain enough cases. This is because no account is taken of whether the distinction is sufficient to overturn the rule. The reason model as formalised above accepts any distinction, whereas in CATO distinctions can be rejected through downplaying through substitution and cancellation [40] of factors. The point is clear in the following example.

Example 2. Here we have two cases, both found for the plaintiff. In case 1 the plaintiff took security measures (F6p) and, although the defendant claimed the information was reverse engineerable (F16d), the plaintiff won⁵. In the second case we have the plaintiff making disclosures (F10d), but restricting these disclosures (F12p). Here the preference for the plaintiff is clear. We therefore have the following rules:

r1: F6p → plaintiff	r4 F12p → plaintiff
r2: F16d → defendant	r5: F10d → defendant
r3: r2 < r1	r6: r5 < r4

Now consider a case with all four factors: [F6p, F12p, F10d, F16d]. It seems this should clearly be found for the plaintiff: however, we cannot apply r1 because of the distinction F10d and we cannot apply r4 because F16d distinguishes. Although neither distinction would be significant in CATO, being cancelled for both precedents by the other factors available, the reason model gives the case as unconstrained. We will address this problem in the next section.

4 THE IMPORTANCE OF ISSUES

The fourth problem discussed in the previous section arises because the reason model considers cases as unstructured bundles of factors, so that a difference which should not be considered significant prevents us from applying the rule which should constrain the case. We can use knowledge of the domain structure to solve this problem. That we do not exploit the full power of our precedents if we consider whole cases was noticed by Branting in [17]:

combining portions of multiple precedents can permit new cases to be resolved that would be indeterminate if new cases could only be compared to entire precedents. ([17], Abstract).

When Brüninghaus and Ashley adapted CATO to predict cases in IBP [21] they structured the cases around *issues*, as did Grabmair in his prediction system VJAP [24]. Grabmair reports an improvement over IBP through the use of values, but values raise several additional questions, such as the extent to which they are promoted by different factors and whether value preferences are global, or local to issues. Since precedential constraint with values has not yet been given a formal characterisation, we will restrict our consideration in this paper to factors. Issues are a well known concept in law: many law schools teach the Issue-Rule-Application-Conclusion (IRAC) method (or some variant) as a way of analysing legal cases. The

IRAC method was applied to the explanation of factor based reasoning in [11]. A key point about IRAC is that the rule (the *reason* in the sense of the model above) relates to an *issue*, not to the case as a *whole*. The issues in US Trade Secrets Law, taken from the Restatement of Torts, were used to group related factors together for IBP [21] and VJAP [24]. These issues were also the basis for the factor hierarchy in [3] and the Abstract Dialectical Framework in [2]. A similar structure is given by Rigoni's framework precedents, and we would argue that the role of framework precedents is to identify the issues in a domain. Other systems, such as CABARET [48] derive their framework of issues from statutes. Unlike factors, issues can be seen as in a *logical* relation to the outcome. To find for the plaintiff, it *must* be shown *both* that the information was a trade secret *and* that it was misappropriated. A trade secret *must both* be valuable *and* the information not generally known. To be misappropriated it *must* be *either* that improper means were used, *or* that the information was used in breach of a confidential relationship. We can express this as the following *non-defeasible* rules:

ROT1: TradeSecret ∧ and Misappropriated ↔ plaintiff
 ROT2: InfoValuable ∧ SecrecyMaintained ↔ TradeSecret
 ROT3: ImproperMeans ∨ (InfoUsed ∧ ConfidentialRelationship) ↔ Misappropriated

In [7] these issues are used to group CATO's factors as shown in Table 3⁶. Even though some factors appear under two issues, the issues contain only five to seven factors, greatly reducing the possible combinations of relevant factors. That using issues rather than whole cases to constrain decisions will enable us to decide more cases is evidenced by [21]. The issue based IBP was able to reach a prediction in 99.5% of cases, as opposed to the 73.1% achieved by a system considering cases as a whole.

This suggests that instead of describing cases simply as a set of factors, we should distribute these factors across the issues they relate to. Note also that structuring into issues is an implicit feature of rule based systems such as [47] and [2]. We can now apply the methods of precedential constraint developed in [27] and [37] not at the case level, but at the issue level. To see the difference this makes, we will consider a set of cases⁷, taken from [3] and used in [22], shown in Table 4. We have not re-analysed the decisions: the factors for each case are taken from Table II of [22].

Notice that, in all these cases, some issues are uncontested. It seems that we can regard the information as a trade secret, unless argued otherwise, and that there is a presumption that the information was used. On the other hand the plaintiff needs to establish that improper means were used or that a confidential relationship existed. To find the issue and rule in the case we look at the contested issues, and which factors led to the outcome. This is the method used to identify the rule and resolve the issue when applying the IRAC methodology in [11].

In the next sections we will illustrate the use of the standard reason model followed by the use of the proposed issue based

⁵This preference for F6p was used in *Mason v. Jack Daniel Distillery*, 518 So.2d 130 (Ala.Civ.App.1987): "courts have protected information as a trade secret despite evidence that such information could be easily duplicated by others competent in the given field. *KFC Corp. v. Marion-Kay Co.*, 620 F. Supp. 1160 (S.D.Ind. 1985); *Sperry Rand Corp. v. Rothlein*, 241 F. Supp. 549 (D.Conn. 1964)".

⁶In [24] Grabmair associated factors to issues a little differently. This does not, however affect any of the factors in our example below, and so we follow [7] here.

⁷*National Instrument Labs, Inc. v. Hycel, Inc.*, 478 F.Supp. 1179 (D.Del.1979), *M. Bryce & Associates, Inc. v. Gladstone*, 107 Wis.2d 241, 319 N.W.2d 907 (Wis.App.1982), *K & G Oil Tool & Service Co. v. G & G Fishing Tool Serv.*, 314 S.W.2d 782 (1958), *Televation Telecommunication Systems, Inc. v. Saindon*, 522 N.E.2d 1359 (Ill.App. 2 Dist. 1988), *Mason v. Jack Daniel Distillery*, 518 So.2d 130 (Ala.Civ.App.1987) and *The Boeing Company v. Sierracin Corporation*, 108 Wash.2d 38, 738 P.2d 665 (1987).

Table 3: CATO factors grouped by Issues [7]

Issue	Plaintiff Factors	Defendant Factors
InfoValuable	F8p Competitive Advantage F15p Unique Product	F16d Info Reverse Engineerable F20d Info Known to Competitors F24d Info Obtainable Elsewhere F27d Disclosure In Public Forum
SecrecyMaintained	F4p Agreed Not To Disclose F6p Security Measures F12p Outsider Disclosures Restricted	F10d Secrets Disclosed Outsiders F19d No Security Measures
ImproperMeans	F2p Bribe Employee F7p Brought Tools F14p Restricted Materials Used F22p Invasive Techniques F26p Deception	F17d Info Independently Generated F25d Info Reverse Engineered
InfoUsed	F7p Brought Tools F8p Competitive Advantage F14p Restricted Materials Used F18p Identical Products	F17d Info Independently Generated F25d Info Reverse Engineered
ConfidentialRelationship	F4p Agreed Not To Disclose F13p Noncompetition Agreement F21p Knew Info Confidential	F1d Disclosure In Negotiations F23d Waiver of Confidentiality

Table 4: Cases in the Example with Factors Grouped By Issue

Case		InfoValuable	SecrecyMaintained	ImproperMeans	InfoUsed	ConfidentialRelationship
National Instruments	P				F18p	F1d F21p
Bryce	P		F6p		F18p	F1d F4p F21p
K and G	P	F15p F16d	F6p	F14p 25d	F14p F18p F25d	F21p
Televation	P	F15p F16d	F6p F10d F12p		F18p	F21p
Mason	P	F15p F16d	F6p			F1d F21p
Boeing	P		F6p F10d F12p	F14p	F14p	F1d F4p F21p

reason model. We will see that when using issues, more cases are constrained because distinctions relating to issues unrelated to that governed by a rule no longer distinguish that rule and are relevant only if they constrain that other issue so as to lead to a different outcome.

4.1 Using the reason model

Suppose our first case⁸ is *National Instruments*. As can be seen from Table 4, the case turned on whether there was a confidential relationship, given that the plaintiff had made disclosures in negotiations (F1d). The defendant, however, did know that the information was confidential (F21p), and the court found for the plaintiff. The reason model then gives the three rules:

NatInstP: F21p → plaintiff NatInstD: F1d → defendant
NatInstO: NatInstD < NatInstP

If the next case is *Bryce*, we can see that it is constrained by these rules: the additional factors are not distinctions because both favour the plaintiff, and so do not give the defendant anything better than NatInstD, which is defeated by NatInstP, which also applies to *Bryce*. *Bryce* thus adds no new rules.

⁸The sequencing of the cases used here is for the purposes of illustrating our approach, and is not the actual sequence.

Now suppose we are presented with *K and G*. Here the plaintiff argues that improper means were used, because the defendant used restricted materials (F14p). The defendant counters this by a claim to have reverse engineered the information (F25d). Moreover the defendant argues that the information is not a trade secret because it was reverse engineerable (F16d)⁹. This is in turn countered by the claim that the uniqueness of the product (F15p) suggests that the information was not readily reverse engineerable. In the judgement both the issues were decided in favour of the plaintiff, since the reverse engineering had made use of restricted materials. Note that there was no need to decide the breach of confidence issue: improper means suffice to establish misappropriation. Although NatInstP applies, it cannot be used because the defendant has stronger rules than NatInstD. Thus the reason in *K and G* must cover two different issues, InfoValuable and ImproperMeans, and so we get rules spanning both these issues:

KGP: F15p and F14p → plaintiff
KGD: F16d and F25d → defendant

⁹Both F25d and F16d were introduced in CATO and relate to the same dimension, D14b. However, F25d, that the information was *actually* reverse engineered, relates to the issues of whether the information was used and whether improper means were used, whereas F16d, the *possibility* of reverse engineering, relates to whether the information was valuable and hence a trade secret.

KGO: KGD < KGP

Note, however, that this means that the reasons extracted from KGP conflate the two issues in dispute in the case. The next case is *Televation*. The plaintiff had made disclosures (F10d), distinguishing all the previous cases, although these were restricted (F12p). These restrictions were held sufficient to find that the plaintiff had made efforts to maintain secrecy. Again it was found that the uniqueness of the product argued against it being readily reverse engineerable. The misappropriation consisted of using the information, shown by F18p, and the confidential relationship, shown by F21p. Because, however, misappropriation was not contested, these do not form part of the reason. The reason model rules from *Televation* also cover two issues, InfoValuable and SecrecyMaintained:

TelevationP: F15p and F12p → plaintiff
 TelevationD: F16d and F10d → defendant
 TelevationO: TelevationD < TelevationP

We now reach *Mason*. With respect to the existence of a trade secret *Mason* is identical to *K and G*. However, *Mason* disclosed the information in negotiations (F1d), which distinguishes it from this case, and so KGP is not applicable. Similarly although it can instantiate NatInstP from *National Instruments*, that case is distinguished by F16d, and so the defendant has a reason stronger than NatInstD. So the reason for *Mason* must cover both trade secret and confidential relationship, and when *Mason* is found for the plaintiff, we get the rules:

MasonP: F15p and F21p → plaintiff
 MasonD: F16d and F1d → defendant
 MasonO: MasonD < MasonP

Finally consider *Boeing*. We have two contested issues: whether secrecy was maintained, with the same factors as *Televation*, and whether there was a confidential relationship with the same factors as *Bryce*. But we cannot use these to find for the plaintiff: we are not constrained by *Televation* without F15p, and we are not constrained by NatInstP as used in *Bryce* with F10d present.

In *Bryce*, *Mason* and *Boeing*, the decision seems clear given the preceding cases, but only *Bryce* is constrained under the reason model. Now we will consider the difference made by exploiting our understanding of the domain and structuring the cases into issues.

4.2 Using the Issue Based Reason Model

In this section we look at how the sequence of cases in 4.1 works out if we associate our reasons with issues, and rely on the framework provided by the Restatement of Torts (rules ROT1-3 above) to combine these partial findings. *National Instruments* concerned only one issue, Confidential Relationship, so our rules will be:

NatInstCRP: F21p → ConfidentialRelationship
 NatInstCRD: F1d → Not ConfidentialRelationship
 NatInstCR: NatInstCRD < NatInstCRP

In *Bryce*, we have the same issue, and we can use these rules: the additional factor also supports a confidential relationship. *K and G*, however, concerns two different issues, and so gives us distinct sets of rules for each of these two issues.

KGIVP: F15p → InformationValuable
 KGIVD: F16d → Not InformationValuable
 KGOIV: KGIVP < KGIVD

KGIMP: F15p → ImproperMeans
 KGIMD: F25d → Not ImproperMeans
 KGOIM: KGIMD < KGIMP

Now when we come to *Televation*, *K and G* constrains InformationValuable, but we get rules for the new issue, SecrecyMaintained.

TelevationSMP: F12p → SecrecyMaintained
 TelevationSMD: F10d → Not SecrecyMaintained
 TelevationSM: TelevationSMD < TelevationSMP

By using issues, when we come to *Mason*, the decision is constrained. We can use the rules from *K and G* to constrain *InformationValuable* and those from *National Instruments* to constrain *ConfidentialRelationship*. Under the result model above, F1d distinguished *K and G*, and F16d distinguished *National Instruments*. Similarly Boeing is constrained: by *Televation* with respect to *SecrecyMaintained* and by *National Instruments* (like *Bryce* the F4p factor is not needed) with respect to *ConfidentialRelationship*. F15p would have distinguished *Televation* and F10d *National Instruments* under the results model. Thus by focussing on issues, we are able to constrain cases which required new rules under the “whole case” reason model. We also argue that this better fits with legal practice: not only does it follow the IRAC methodology taught in law schools, but it also reflects how precedents are used in decisions. Consider this extract from *Mason*, finding that the information could be regarded as a trade secret¹⁰:

We note that absolute secrecy is not required ... “a substantial element of secrecy is all that is necessary to provide trade secret protection.” *Drill Parts*, 439 So.2d at 49. ... we note that courts have protected information as a trade secret despite evidence that such information could be easily duplicated by others competent in the given field. *KFC Corp. v. Marion-Kay Co.*, 620 F. Supp. 1160 (S.D.Ind. 1985); *Sperry Rand Corp. v. Rothlein*, 241 F. Supp. 549 (D.Conn. 1964).

Three precedents are used to justify the finding in *Mason*: for none of the three precedents was there any consideration of aspects of these cases not germane to the specific issue being resolved. Thus the focus provided by issues means that we are able to constrain more cases, since we can ignore differences which do not relate to the issue on which the case was decided. Issues would be even more useful in the results model, since they would allow us to ignore irrelevant pro-plaintiff as well as irrelevant pro-defendant factors. We now look at how we can handle dimensional features of cases.

5 RELATING TO DIMENSIONS

In *Bryce* the Restatement of Torts was explicitly cited as the framework for considering the case:

Some factors to be considered in determining whether given information is one’s trade secret are: (1) the **extent** to which the information is known outside of his business; (2) the **extent** to which it is known by employees and others involved in his business; (3) the

¹⁰Actually this suggests that the court used F6p rather than F15p to defeat F16d. This suggests that perhaps F6p should be added to the factors related to InfoValuable and used as the reason in KGIVP. Alternatively, TradeSecret could be considered as a single issue subsuming InfoValuable and MaintainSecrecy. This, however, is a matter of legal analysis, and for the purposes of this paper we adopt the analysis of [7].

extent of measures taken by him to guard the secrecy of the information; (4) the **value** of the information to him and to his competitors; (5) the **amount** of effort or money expended by him in developing the information; (6) the **ease or difficulty** with which the information could be properly acquired or duplicated by others. **Emphasis ours.**

These points are all reflected in CATO's factor hierarchy. But as the emphasised terms indicate, ascribing these factors is not simple, but requires a judgement as to whether the *extent* is *sufficient* for the factor to apply. This point was addressed by Horty in [27] and [28]. The issue was further discussed by Rigoni in [42]. Horty has modified his approach in [29], and a formal comparison of Horty and Rigoni's approaches is given in [37].

Horty's main example in [27] is taken from [39] and concerns change of fiscal domicile, decided on the basis of several considerations including length of absence and percentage of income earned abroad. In [39] absence was modelled as two factors, which we will call *shortStay* and *longStay*¹¹, favouring no change and change respectively. But this raises the question of how we determine whether a particular length of absence, say 24 months, is a *shortStay*, a *longStay*, or somewhere in between, and so neutral. Horty responds by introducing the notion of a *factor with magnitude*, (i.e. a factor deriving from a dimension with more than two values) based on the *dimensional fact* of length of stay. The ascription of factors on the basis of dimensional facts can also be found in [40]. Ascription of factors is constrained by precedents: in a previous case a judge may have found for change on the basis of an absence of 18 months, showing on the result model that any absence of at least 18 months must be considered a *longStay*. But the judge may have *spoken* of an absence of greater than one year, so that on the reason model that any absence over 12 months is to be considered *longStay*. Rigoni's suggestion was to see precedents as fixing "switching points", which determine which (if any) factor applies for various values of the dimensional fact. Rigoni also notes that a dimension may encompass multiple factors for a given side (as with disclosures (D3d) in CATO).

Note here that the precedents which impose bounds on the ranges occupied by factors are a different kind of precedent from those which resolve factor conflicts as discussed above: they express no *preferences*. Thus what is required to accommodate dimensional facts and factors with magnitude is not a different way of representing precedential constraint, but to recognise that we are looking at a two stage process, with each stage using different types of precedents. The need for two stages was observed in [40]:

Once the facts of a case have been established - and this is rarely straightforward since the move from evidence to facts is often itself the subject of debate - legal reasoning can be seen, following Ross [45] and Lindhal and Odelstad [33], as a two stage process, first from the established facts to intermediate predicates, and then from these intermediate predicates to legal

consequences. CATO has been explicitly identified with the second of these steps (e.g. [20]). ([40], p 22).

This can be seen clearly in [7] where factors – the intermediate predicates – were ascribed to cases by the machine learning program SMILE, before being passed to IBP to predict the legal consequences. More recently this two-stage approach has been used by Branting in [19] and [18]. Thus before we can consider whether a case is constrained, which can be done in terms of factors using the issue based reason model described above, we must first assign the factors. For some factors, those derived from many-valued dimensions, this will involve ascribing the factors on that dimension respecting ranges identified in precedent cases. This can be done using either the reason or the result model, or using Rigoni's switching points. For a discussion of mapping a dimensional fact (age) into ranges through precedents see [25].

Thus the conclusion is that attempting to model precedential constraint in terms of cases represented as sets of dimensions rather than sets of factors as in [37] conflates two distinct steps in the process of reasoning with legal cases. Cases are not represented as sets of dimensions: cases are represented as facts in HYPO and where they are represented as sets of points on dimensions, as in [40] and [14], these are dimensional *facts*, the legal significance of which is unknown until they are mapped into factors. If we represent cases as sets of dimensional facts (including dimensions with two values) as in [40], we can derive the factors applicable to the case. Or we can get our factors through machine learning as in [19]. We then organise these factors into issues and apply precedential constraint in terms of the factors associated with each issue as described in section 4.2. While some precedents will supply the plaintiff, defendant and priority rules as described in section 3.1, others will supply rules to move from dimensional facts to factors. To give an example from the fiscal domicile domain, such a rule would be something like: $longStay \leftarrow absence(A) \wedge A \geq 12$.

One issue in the ascription of factors is that in some cases they do not seem to be independent. Thus in the fiscal domicile case it is possible that there is a trade off between length of absence and amount of income earned, so that whether the percentage of income is considered to be "substantial" is relative to the length of absence. The question of balancing factors has been discussed in [32] and [23], and an equation representing the trade off was used in [12]. In that paper a single *factor* (e.g. *SufficientIncomeGivenAbsence*) is ascribed on the basis of the two dimensional *facts*. How factors are ascribed on the basis of facts relates to the first stage and the focus of this paper is on the second stage, namely determining how the precedents, when described in terms of factors, constrain the decision. Therefore we will not discuss the important and interesting questions relating to balancing and trade-offs further in this paper.

6 CONCLUDING REMARKS

A number of conclusions can be drawn from the above discussion:

- Reasoning with cases is a two stage process: first factors are ascribed on the basis of (often dimensional) facts, and then the cases are compared with precedents using factors.
- Precedential constraint should be considered in terms of factors, even if we wish to represent cases in terms of dimensional facts. Applicable dimensions show which aspects must

¹¹In [39] *long duration* and *not long duration* were used, but for reasons explained in section 2.1, negating factors is problematic and we follow CATO and [44] and use two distinct factors when the dimension can favour both sides. This also permits the possibility of a moderate duration being neutral.

be considered, while factors show which side is favoured in the particular case.

- Comparison (for both the results and the reason models) should be at the level of issues, to ignore irrelevant distinctions, and to reflect legal practice better.
- Precedents do not always have the same role:
 - *Framework* precedents (e.g. *Lemon v. Kurtzman*) identify the issues and set out the logical framework in which they are considered;
 - *Preference* precedents (the standard use in CATO) say how conflicting factors within an issue should be resolved;
 - *Ascription* precedents (e.g. *National Instruments* states its reasons for withholding F16d at some length), give reasons to determine if a factor should be ascribed to a case or not.

Here we have used the issues from IBP [7]. But we could have used coarser grained issues, perhaps merging the conjoined issues in IBP, or finer grained issues, using the abstract factors of [3] as issues, or even the nodes of the 2-regular hierarchy of [1]. The finer the granularity, the more decisions are constrained. Experiments to investigate the impact of different granularities on predictive accuracy would be interesting. It would also be interesting to explore the use of values rather than factors as the elements over which preferences are expressed as in [16] and [24]. The possibility of using multiple granularities could also be explored, with some arguments being in terms of issues, some in terms of abstract factors, others in terms of values, and others considering whole cases.

Perhaps the best way to deploy machine learning is for the first stage, factor ascription, as in [7] and [19]. Moreover, if we wish to address the second stage with machine learning, perhaps it would be better to predict issues rather than whole cases, and then combine the results using a logical framework to get the overall decision.

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