MODELING PURPOSIVE LEGAL ARGUMENTATION AND CASE OUTCOME PREDICTION USING ARGUMENT SCHEMES IN THE VALUE JUDGMENT FORMALISM

by

Matthias Grabmair

Dipl-Jur, University of Augsburg School of Law, 2007

LLM, University of Pittsburgh School of Law, 2005

MS in Intelligent Systems, University of Pittsburgh, 2011

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This dissertation was presented

by

Matthias Grabmair

It was defended on

April 1, 2016

and approved by

Kevin Ashley, School of Law, LRDC

Marek Druzdzel, School of Information Sciences

Alan Lesgold, School of Education

Eric Nyberg, Language Technologies Institute, Carnegie Mellon University

Dissertation Director: Kevin Ashley, School of Law, LRDC

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Matthias Grabmair, PhD

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Artificial Intelligence and Law studies how legal reasoning can be formalized in order to eventually be able to develop systems that assist lawyers in the task of researching, drafting and evaluating arguments in a professional setting. To further this goal, researchers have been developing systems, which, to a limited extent, autonomously engage in legal reasoning, and argumentation on closed domains. This dissertation presents the Value Judgment Formalism and its experimental implementation in the VJAP system, which is capable of arguing about, and predicting outcomes of, a set of trade secret misappropriation cases.

VJAP argues about cases by creating an argument graph for each case using a set of argument schemes. These schemes use a representation of values underlying trade secret law and effects of facts on these values. VJAP argumentatively balances effects in the given case and analogizes it to individual precedents and the value tradeoffs in those precedents. It predicts case outcomes using a confidence measure computed from the argument graph and generates textual legal arguments justifying its predictions. The confidence propagation uses quantitative weights assigned to effects of facts on values. VJAP automatically learns these weights from past cases using an iterative optimization method.

The experimental evaluation shows that VJAP generates case-based legal arguments that make plausible and intelligent-appearing use of precedents to reason about a case in terms of differences and similarities to a precedent and the value tradeoffs that both contain. VJAP's prediction performance is promising when compared to machine learning algorithms, which

do not generate legal arguments. Due to the small case base, however, the assessment of prediction performance was not statistically rigorous. VJAP exhibits argumentation and prediction behavior that, to some extent, resembles phenomena in real case-based legal reasoning, such as realistically appearing citation graphs.

The VJAP system and experiment demonstrate that it is possible to effectively combine symbolic knowledge and inference with quantitative confidence propagation. In AI&Law, such systems can embrace the structure of legal reasoning and learn quantitative information about the domain from prior cases, as well as apply this information in a structurally realistic way in the context of new cases.

PREFACE

Defending this work and submitting this dissertation concludes my time in the University of Pittsburgh's Intelligent Systems Program. Many people have been influential and supportive to me since I began my studies there and I would like to thank the most important ones in this foreword.

The Intelligent Systems Program has been an ideal research environment for me. Its student body is diverse, its faculty inspiring and personable, and its administration reliable and friendly. I want to thank Jan Wiebe and Diane Litman for directing the program very well and for helping its students to grow into successful researchers. I thank ISP administrators Ashley Nagy, Michele Thomas and, especially, Wendy Bergstein as well as LRDC administrator De Ivanhoe for their support and friendship.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ALGORITHMS

1.0 INTRODUCTION

1.1 FORMAL MODELS OF LEGAL REASONING

The field of Artificial Intelligence and Law (AI&Law), among other things, studies how the way lawyers reason about legal matters and argue about statutes and cases can be formalized. The goal for doing so is to eventually be able to develop systems that assist the lawyer in the task of researching, drafting and evaluating such arguments in a professional setting.

To further this goal, researchers have been developing systems which, to a limited extent, autonomously engage in some techniques of legal reasoning and argumentation on closed domains. In doing so, the field has evaluated a number of techniques and paradigms for representing legal information and conducting inference, from classical logic through non-monotonic logic and ontological representations to, recently, qualitative argumentation formalisms and, very recently, quantitative argumentation formalism.

This evaluation involves testing these techniques as to their suitability for modeling legal reasoning and argumentation phenomena. First, legal reasoning is usually evidence-based and hence inherently non-monotonic. Conclusions about a case are drawn and, upon the appearance of new evidence, have to be revised. Second, legal reasoning is less focused on logical truth than on the notion of establishing a statement in an argumentative discourse beyond a certain proof or persuasion standard. Lawyers search for the best possible argument, not the ultimate legal truth. Third, and most important, legal reasoning can be called ill-defined because of its convoluted appearance, occasional intentional vagueness, plethora of source documents, reliance on implicit assumptions and exceptions as well as the way its notion of interpretation seems to blend into reasoning about policy. In other words, an artificial intelligent legal agent needs to have a *deep* understanding of the law, the domain it governs and the policy objectives underlying this regulatory relationship.

1.2 PURPOSIVE LEGAL REASONING

Most prominently, Berman & Hafner [BH93, BH93] elaborated on the need for case-based legal reasoning systems to incorporate a representation of the purposes of the law in order to be able to reason about their domain on a deeper level. Various approaches have been made to explore this problem through descriptive formalisms (e.g. [BCS03]) of purposive legal reasoning, computational models of argument that take into account values (e.g. [BC03]), as well as experimental intelligent legal reasoning and argumentation systems (e.g. [CBC05a]).

This dissertation project contributes to this discussion by presenting the *Value Judgment Formalism* (VJF) and reporting on an experiment in implementing and evaluating an intelligent legal system that uses said formalism to generate arguments and predictions for trade secret misappropriation cases. We label the system VJAP for *Value Judgment-based Argumentative Prediction*. VJAP is unique and innovative in its combination of the following properties:

- It instantiates an argument graph structure for each case it analyzes using a set of argument schemes.
- It uses a representation of values underlying its domain of law and effects that certain facts have on these values.
- It argumentatively balances these effects in the context of the given case, and
- analogizes cases to individual precedents and the value tradeoffs that they contain.
- It predicts case outcomes based on a confidence measure computed from a case's argument graph and a set of quantitative weights assigned to the effects of facts on values.
- It automatically learns these weights from a dataset of past cases using an iterative optimization method.
- It generates textual legal arguments justifying its predictions.

1.3 HYPOTHESIS

The main hypothesis of this dissertation research and experiment can be formulated as follows:

Given sufficient domain knowledge and well-defined argument schemes, a computer system can autonomously generate intelligent legal arguments that take into account the values underlying the domain, as well as use these arguments to predict the outcome of cases using weight parameters learned from data.

The ability to generate intelligent legal arguments shall will be referred to as the *intelligent argument hypothesis*. The ability to predict case outcomes will be referred to as the *prediction hypothesis*. The hypotheses are formative hypotheses and are not subjected to rigorous statistical validation in this dissertation. Rather, the experiment shows that it is possible to construct a system capable of performing these two conjunctive tasks reasonably well, which will be shown through an non-statistical comparison against baseline algorithms and illustrations of the system's behavior.

There are three reasons for this. First, a system like VJAP with the aforementioned properties is conceptually new in AI&Law and hence an implementation and demonstration of feasibility amounts to a significant contribution in itself. Second, the IBP dataset of trade secret misappropriation decisions used for this experiment is small and had not been randomly selected when it was created. At the time of this experiment, however, the IBP dataset was the largest available dataset of its kind . Hence statistical validity criteria for validity of significance tests cannot reasonably be met in this experiment.

Third, the kinds of arguments produced by VJAP focus on intelligent analogies between a set of precedent cases and a case at bar to be decided. Arguments created by humans who are not familiar with all of the cases available to VJAP would likely make greater use of common sense knowledge unavailable to AI&Law systems at the time of this experiment. Those human arguments would likely not be sufficiently comparable to the ones generated by VJAP.

1.4 CONTRIBUTIONS

In assessing this hypothesis, the dissertation makes a number of contributions to AI&Law research as described in the following subsections.

1.4.1 Formalism Implementation

The value judgment formalism was conceived and published as a theoretical model comprising a set of representational concepts and corresponding argument schemes. Over the course of this dissertation work, the formalism has been computationally implemented and embedded in a case based reasoning system in the trade secret law domain. Next to the AGATHA system [CBC05a], this work presents the largest effort in taking an originally descriptive legal reasoning formalism through an implementation all the way to an empirical evaluation.

1.4.2 Argument Justified Prediction

VJAP is capable of (1) autonomously generating arguments in each individual case that are (2) weighted according to the purposive values underlying their reasoning in the context of both the given case and applicable precedent. Then, (3) case outcomes are predicted by evaluating these arguments. This interlocking argue-evaluate-predict architecture is unique among experimental systems in the current state of AI&Law. VJAP's experimental demonstration (see chapter 5) shows that it is possible to fruitfully combine symbolic knowledge and inference with quantitative confidence propagation. In AI&Law, such systems can embrace the structure of legal reasoning but also learn quantitative information about the domain from prior cases, as well as apply this information in a structure-compliant way in the context of a new case.

1.4.3 Quantitative Contextual Tradeoff Modeling

The VJF models tradeoffs between effects on values in the context of a given case. It takes recourse to tradeoffs in prior cases which can be analogized and distinguished, thereby affecting the confidence in the tradeoff argument. Such an approach has not been computationally evaluated previously in legal case-based reasoning.

1.5 ROADMAP

This dissertation is organized as follows. Chapter 2 gives a brief introduction to purposive legal reasoning and the legal theory assumptions made in creating the VJF. Chapter 3 presents the VJF and its concepts definition by definition. Chapter 4 explains how the VJF has been implemented in the VJAP system, including the specification of all argument schemes. Chapter 5 outlines the prediction experiment conducted to evaluate VJAP, discusses the results and then presents exploratory analyses of VJAP's features using data gathered during the experiment. Chapter 6 contains an explanation of the VJF and VJAP in relation to prior work as well as an in depth discussion of the system's limitations and perspectives for future work. Chapter 7 concludes this dissertation by assessing the experiment in terms of the hypotheses and contributions laid out in this introduction.

2.0 LEGAL REASONING WITH VALUES

Legal argumentation involves the intelligent creation, interpretation and application of inference rules to facts. Justifying a legal decision in a given case involves casting the case as an instance of a general rule, which should be followed to maintain the rule of law and facilitate certain policy objectives.

Perhaps the most well-known teaching example of legal reasoning with values is H.L.A. Hart's 1958 hypothetical where a sign at the entrance of a public park states that "Vehicles are prohibited in the park." [Har58]. A recent in depth discussion of the legal debate sparked by Schauer can be found in [Sch08]. This dissertation uses the example for purely illustrative purposes without prejudice to the legal theory debate and its positions (see 2.1).

Consider a variation of where a sign at the entrance to a public park states: "No animals in the park!" A bird in a cage should not fall under the rule, nor should a blind person's guide dog. Ordinary domestic dogs, however, should be prohibited from entering the park because of, say, public safety concerns since they may potentially bite pedestrians when feeling threatened.

If the dog is specially trained to assist a visually impaired person, however, this risk is virtually nonexistent. Here, the fact that the animal is trained changes the assessment of the case. A trained horse, on the other hand, should not be permitted to enter the park because it potentially produces animal waste that would negatively impact recreational use of the park. Here, the fact that the animal is a horse entails a different kind of purposive assessment of the facts and leads to a different outcome. The kind of animal entering the park and the question of whether it is trained or not interact outside of the scope of the explicit legal rule, "No animals in the park!"

The specific properties of the animal and the role of its training interact with the purposes of the legal rule and form a context in which argumentation about the impact of facts on the legal analysis is anchored. This dissertation refers to this kind of discourse as *purposive legal reasoning*, or *value-based legal reasoning*.

2.1 LEGAL THEORY ASSUMPTIONS

It is not the intent of this experiment, and certainly far beyond the scope of this dissertation, to support or rebut any substantive prior work in legal theory. Rather, the VJAP experiment starts from a number of established legal theory assumptions in order to develop a formalism of purposive case-based legal argumentation and implement it computationally. The resulting system then can be evaluated in terms of its capacity to generate intelligent legal arguments that take into account values and predict case outcomes from these arguments. As will be shown in chapter 5, this evaluation produces insights on how the formalism's legal theory assumptions influence the system's behavior. The core contribution of VJAP lies in this system-based empirical evaluation of a formal model and its assumptions towards a synthesis of research from formal legal methodology and empirical AI. It goes beyond the scope of prior systems in AI&Law because of the way it accounts for values, its ability to learn from prior cases, its use of argument schemes to generate case-based legal arguments arguments, as well as its assessment and use of these arguments to predict case outcomes (see related work in chapter 6).

2.1.1 Legal Argumentation is about Balancing Values

The main legal theory assumption underlying the value judgment formalism is that legal reasoning revolves around a balancing of competing principles / values / interests within the mechanisms and constraints of the given legal system. A legislation-focused civil law system mostly relies on techniques of statutory interpretation to operationalize the purpose of the law and intent of the legislator. A common law system has a much greater emphasis on applying rules extracted from precedent cases decided by authoritative courts. In other words, the imperatives of equitable dispute resolution are manifested in legislation and/or jurisprudence so that they are tangible enough to be applied in new situations.

Consequently, omnipotent yet hazy equitable principles and positive yet ambiguous sources of law now exist in a form of co-dependence. Adherence to the 'rule of law' becomes an equitable principle of its own and commands that the interlocking system of legislation and jurisprudence must be followed. On the other hand, this complex system may arguably lead to inequitable results in a specific case if applied too literally. To remedy this, interpretive legal methodologies provide dogmatic and argumentative tools with which an equitable outcome in specific cases can be justified while staying inside the boundaries provided by statutes, codes, regulations and precedent cases. Feteris [F+15] characterizes this "pragmatic argumentation" from consequences as a common tool judges employ to justify decisions in "hard cases".

2.1.2 Positive Law Guides Balancing

Interweaving equitable principles and the commandments of positive law to produce an argumentative justification of a desired outcome in a given factual case context is, at its core, a decision about a tradeoff between applicable values favoring each side. The second systemic assumption made by the model is that, in order to be coherent with the system of positive legal rules and precedent cases, this tradeoff needs to be segmented into smaller tradeoffs that plug into the legal hooks by said system to make it produce an equitable outcome in the context of the case at bar. In the model presented in this dissertation, such decisions about tradeoffs are referred to as *value judgments*.

In other words, the legal order maintains a set of legal norms (i.e. an interpretable framework of things that *should* and *should not* be) contained in written law, case law or customary law. These norms guide the resolution of conflicting interests of legal subjects in specific fact situations. In such a situation, *legal argumentation* means advocating that a certain solution/decision to a given problem (i.e. sustaining some interests at the expense of others) is more or less in accordance with the coordination of interests contained in the applicable legal norms. In applying written law, this takes the shape of statutory interpretation. In case law domains, it means relating the current problem to precedent in a way that relates to the policy decisions underlying the finding in the precedent. All nontrivial legal reasoning (i.e. everything beyond a straightforward backward chaining of rules) takes place in this area of interplay between legal norms and their underlying interest coordination.

2.1.3 Unified Terminology

The final assumption is a terminological one. A legal order regulates interactions between legal subjects, which can be thought of as agents. It acts as a coordinator of the various individual and collective interests which may cohere, compete and conflict. To do so, certain interests are considered legally "enforceable" or "protected".

Individual and collective interests underlying legal reasoning are typically termed "values", "principles", even just "interests", "purposes", "maxims", etc., among which one can debate about precise conceptual contours and terminological meanings. As we develop a formal model of such, we use the term "values" simply as a label for the corresponding elements which stand in for the interests of the concerned legal subjects without subdividing them into a more fine-grained topology. Recent work [Ash13] has related our conception of values and value judgments to Eisenberg's 'social propositions'.

2.1.4 Alexy's Weight Formula

The VJF assumes that, in realistic purposive legal reasoning, the balancing of interests takes place in the specific case rather than only in the abstract. For example, when arguing about abortion, many legal systems do not regard the right to life of the embryo to be absolutely superior to the right of a woman to free choice of action regarding her body. Rather, many legal orders will prohibit abortion only beyond a certain period of time into the pregnancy and/or only allow abortions in medically warranted cases. In the latter configuration, the question of what constitutes a 'medically warranted' abortion is not regulated further but needs to be established on a case by case basis.

This example illustrates how positive law can contain an *a priori* bias towards the right to life of the embryo but explicitly recognizes groups of cases forming exceptions because their specific facts mandate it. An attorney who wants to argue that her client's abortion should be legal needs to establish that the value balancing in her client's case is an instance of such an exception.

Prominent legal theorist Robert Alexy [Ale03b] has synthesized these two levels of balancing in his "Weight Formula," which is an arithmetic model of balancing competing legal values in a given case context as a function of the abstract weight of a principle and the degree of interference:

$$W_{i,j} = \frac{I_i \cdot W_i \cdot R_i}{I_j \cdot W_j \cdot R_j}$$

The calculated quantity $W_{i,j}$ is the "concrete" weight of two conflicting principles, i.e. a contextual measure of importance of applicable values. Balancing in a case "begins with the subsumption of the case under two competing principles (P_i, P_j), and continues with an assignment of values, first, to the intensity of interference (I_i, I_j) with (P_i, P_j), second, to the abstract weights (W_i, W_j) of both principles, and, third, to the degree of reliability of the empirical assumption (R_1, R_2) respecting what the measure in question means for the non-realization of P_i and the realization of P_j." [Ale10]

As can be seen, Alexy's formula takes into account both an abstract weight of the values as well as the degree of interference in the situation, thus making the balancing contextual, i.e. dependent on the degree of interference with a value in a given case.

Alexy further characterizes case analogy as a "third basic operation in law" next to balancing and subsumption (i.e. establishing that a specific set of facts falls within the scope of a legal concept), for each of which he provides a basic formal argument scheme. He further connects case comparison reasoning to balancing as follows: "[T]he analogy scheme cannot achieve coherence exclusively by its own means. The dialectic of reference to features of other cases ... cannot be rationally resolved without balancing." [Ale10]

As will be explained in chapter 4, VJAP computes the strength of its arguments in a given case by quantitatively comparing pro-plaintiff and pro-defendant effect weights. Its model is hence conceptually coherent with Alexy's weight formula.

2.2 MODELING CONTEXTUAL EFFECTS ON VALUES

2.2.1 Linear Combination

There are various aspects to formally modeling effects of facts in the context of a given case. Let a case consists of a number of component facts ('factors') in two sets of factors favoring the plaintiff (π) or defendant (δ), respectively: $C = F^{\pi} \cup F^{\delta}$ where $F^{\pi} = \{f_1^{\pi}, ..., f_n^{\pi}\}$ and $F^{\delta} = \{f_1^{\delta}, ..., f_m^{\delta}\}$. Further, let the normalized quantitative effect of a factor on a value v be denoted $w_v(f) \to [0, 1]$. Then, in the basic constellation, a straightforward way to compute total effects on the case favoring the plaintiff could just be the sum of all effects $w(C, \pi, v) = \sum_i^n w_v(f_i^{\pi})$.

2.2.2 Conflicting Effects

Factual effects on values do not always exist independently. In a trade secret misappropriation lawsuit the defendant may have obtained valuable product information from the plaintiff after having signed a nondisclosure agreement. If the defendant then uses that information to market a competing product, the fact that the agreement was signed will have weight in the resolution of the dispute since it relates to the plaintiff's confidentiality interest and the general principle of fairness in commercial transactions. However, if the plaintiff has disclosed the same product information in a public forum to other third parties, this confidentiality interest and fair competition principle carry less weight since the plaintiff has arguably waived the protection of his interest in the disclosure.

In terms of quantitatively modeling this scenario, one could assign greater weight to the waiver-by-disclosure argument than to the argument from the nondisclosure agreement. While this may work in this example, it may not scale up with a more complex knowledge representation.

2.2.3 Nonlinear Effects

In machine learning terms, such interdependent effects are nonlinear dependencies among input variables. In formal models of legal case-based reasoning, it means that two or more factual propositions (irrespective of polarity) appearing jointly in a given case have a different effect on the legal assessment of the case than the sum of their individual effects. Obviously such joint effects are intrinsic to legal reasoning. A wrongful act consists of *mens rea* (malicious intent) and *actus reus* (a wrongful act); liability requires damage, action and a causal relationship between the two, etc.

In AI&Law, such nonlinear dependencies among variables are very common. Whenever conjunctive antecedents are used in legal inferences, nonlinear contextual effects occur. If $mens\_rea \wedge actus\_reus \Rightarrow liability$ then $mens\_rea$ and $actus\_reus$ do not unfold their effect unless they appear in conjunction. This is a trivial matter to model as long as the inference warrants are explicit in legal source material or known to exist in the domain. Unfortunately, this assumption usually cannot be made outside well-structured statutory domains (such as the famous formalization of the British Nationality Act in Prolog [SSK+86]) or simple case examples. In order to intelligently reason about the hypothetical cases in the "No animals in the park" scenario at the beginning of this chapter, a deeper model of the domain is necessary.

2.2.4 Inverse Polarity Effects

Prakken & Sartor have correctly observed that a straightforward combination of two factors favoring a certain arguing party cannot be assumed to always results in a stronger argument for the same party [PS98]. They provide the example that both heat and rain are reasons to not go jogging, yet in conjunction they may form a reason to go jogging. In the trade secret misappropriation dataset we use for the experiment, no such polarity-inverting combinations of factors exist.

2.2.5 Conclusions about Effects on Values

For purposes of this dissertation, the following conclusions can be drawn about modeling factual effects in purposive legal reasoning:

1. Values can be realized or non-realized to different degrees depending on the facts of the case.
2. Effects of facts on values can have different weights so that a model can use these weights to assess value balancing arguments based on these facts.
3. In assessing these arguments, the totality of facts of a case needs to be taken into account.
4. If arguments analogize the case to precedent, then their assessment must take into account the facts of both cases.
5. Such analogy arguments are inseparable from the balancing nature of the purposive argument.
6. Nonlinear effects between individual facts can derive from explicit legal rules, or from deep reasoning about the domain. The latter is very hard at this time.

3.0 THE VALUE JUDGMENT FORMALISM

3.1 ARGUMENT REPRESENTATION

The VJF is intended to be implemented as a system capable of generating arguments in a model of defeasible reasoning with argument schemes and a knowledge base (e.g., a unification-based backward-chaining architecture like Carneades[1]). An argument is a statement that the fulfillment of a set of premise propositions warrant a conclusion conclusion proposition. An argument scheme is a "blueprint" of an argument containing free variables which can be instantiated in the generation process. A premise of a scheme can either be established from the knowledge base or taken from the conclusion of another argument, which in turn needs to be instantiated from a scheme, thereby gradually constructing an argument graph structure.

Definition 1 (argument)**.** *We denote an argument as $a_1 \wedge ... \wedge a_n \rightarrow c$, where $a_1, ..., a_n$ is a set of premise propositions and c is the argument's conclusion proposition. An argument for c is an argument against $\neg c$ and vice versa.*

In the VJF as implemented in this dissertation project, $\neg p$ represents the literal non-monotonic negation of the domain statements represented by p. For example, if p represents a positive statement that some fact is entailed by the given situation, then $\neg p$ simply states that the fact is not entailed without stating a new alternative fact to the contrary. Intuitively, double-negation turns a statement into itself.

In principle, a proposition p can be challenged by an argument for proposition q, where p and q are in some contrariness relation (compare the contrariness relation in ASPIC+ [Pra10]) such as classical logical negation. Different formalisms have different ways of interrelating

[1] http://carneades.github.io

conflicting literals. For purposes of this system, we restrict contrariness of propositions to the notion of negation outlined above.

An instantiation of a scheme is an argument of the form $p_1 \wedge ... \wedge p_n \rightarrow c$, where the respective literals (taken from the set of elements) are instances of the premises and the conclusion's free variables that have been unified with the variables contained in the premises. An argument can be *undermined* by an argument contra one of its premises. Similarly, arguments contra another argument's conclusion form *rebuttals*. We do not account for 'undercutting' arguments (i.e. arguments attacking the inference relation between premises and conclusion). We rely instead on the assumption that the semantic notion of the undercutting argument can be formed into a premise, thus being equivalent to an undermining attack. It is the purpose of this formalism to model legal inference as explicitly as possible in terms of premises and conclusions, thereby reducing the need for undercutters. Pollock first introduced formalizations of rebutting and undercutting [Pol87]. Prakken [Pra10] provides a detailed overview of the three kinds of defeat-relationships and their modeling in Dungean argumentation frameworks and credits both Vreeswijk [Vre93] and Elvang-Göransson et al. [EGKF93] with first formalizations of undermining arguments.

3.2 THE CORE FORMALISM

This section presents the main knowledge elements and basic argument schemes of the formalism. The core parts are almost identical to our prior publication in [GA11] and will be extended by quantitative effects.

3.2.1 Facts, Rules and Values

The first building block of our formalism is that of a *fact*. The formalism does not require any specific logical representation or use of variables, meaning that a proposition could be anything from a *factor* in the CATO-sense [Ale03a] to a complex compound expression in a graph-based knowledge representation technique as implemented in, for example, GREBE [Bra91].

Definition 2. *A **fact pattern** is an atomic or compound proposition in a formal language $\mathcal{L}$ representing a part of the domain of discourse. Let F be the set of possible fact patterns closed under union.*

In an adversarial setting of a plaintiff π and defendant δ arguing for case outcomes, facts that favor one side or another are denoted f^{π} or f^{δ} if needed.

Facts can be reasoned with using rules, which can either express common sense knowledge or legal norms. Since our formalism should be capable of reasoning not only with, but also *about* rules, we consider rules as a special kind of proposition. This way, they can be parts of premises and conclusions of argument schemes.

Definition 3. *A **rule** is a proposition of the form $f_1 \Rightarrow f_2$, where $f_1, f_2 \in F$, assigns a conclusion proposition to an antecedent fact pattern. Let C be the set of common-sense-knowledge (CSK) inference rules and L be the set of legal rules stemming from sources of law. Legal rules shall be referred to as **norms**.*

The second building block are values, which are labels for interests held by actors in the domain of discourse (see our terminological assumption in 2.1.3):

Definition 4. *A **value** is a legal concept abstracting a set of one or more interests of individual or groups of agents in the legal system such that one can speak of a change in a certain fact pattern as promoting or demoting the given value. Let V be the set of values in the domain of discourse.*

The notion of altering fact patterns and examining the effect of said modification on the realization of the interests involved is central to our model. Promotion or demotion effects are relative to a context/situation (see section 2.1.4).

The basis for such comparisons are *situations*, which are technically just sets of propositions describing a certain state of the world. However, we define them as tuples of facts, rules and norms for easier comprehension.

Definition 5. *A **situation** is a tuple $\langle F_s, C_s, L_s \rangle$ where $F_s \subseteq F$ are the given facts, $C_s \subseteq C$ are the available CSK inference rules and $L_s \subseteq L$ are the applicable legal norms. Let S be the set of possible situations.*

If $s \in S$ and proposition x is either a fact, common sense rule or norm (or set thereof), then we denote the new situation as $s' = s \cup x$ which was created by adding x to the respective tuple element of s.

We also use situations to define argumentative entailment.

Definition 6. *If an argument for fact f can be constructed using the available schemes and knowledge in a situation s or not, $s \vdash f$ and $s \nvdash f$ denote situation s as **argumentatively entailing** fact f (or not).*

The negation of entailment is non-entailment. Thus, an argument for $s \vdash f$ is simultaneously an argument against $s \nvdash f$ and vice versa.

It is noted that the technical meaning of our notion of entailment may vary according to the semantics of the argument model used in an implementation. In a model relying on Dungean semantics [Dun95], for example, the argument node representing the entailment relation will be part of a certain extension or a set thereof. In the VJAP implementation, confidence values are computed to represent the degree to which a statement is argumentatively established, thereby giving the system a kind of 'quantitative confidence semantics'.

3.2.2 Value Effects

3.2.3 Qualitative Effects

The next step is to introduce effects of factual changes on values. Similar to prior work [BCA09], we do this using a function δ for the differential effect of comparing two situations. We also define a special case of said difference if the situations to be compared differ by only one element. In such a case, we can attribute the differential effect exclusively to that element.

Definition 7 (Qualitative Value Effects)**.** *Assume $s_1, s_2 \in S$ and applicable values $V_s \subseteq V$. Then $\delta_{v_i}(s_1, s_2)$ shall be the **difference in manifestation** of value $v_i \in V_s$ in s_2 when compared to s_1 as follows:*

$$\delta_{v_i}(s_1, s_2) = \begin{cases} +++\ , \textit{ if } v_i \textit{ is overwhelmingly promoted} \\ ++\ \ , \textit{ if } v_i \textit{ is greatly promoted} \\ +\ , \textit{ if } v_i \textit{ is somewhat promoted} \\ \approx\ \ , \textit{ if } v_i \textit{ remains unchanged} \\ -\ , \textit{ if } v_i \textit{ is somewhat demoted} \\ --\ \ , \textit{ if } v_i \textit{ is greatly demoted} \\ ---\ , \textit{ if } v_i \textit{ is overwhelmingly demoted} \end{cases}$$

*If $m \in F \cup L$ (i.e. m is either a fact or a legal rule) and $s_2 = s_1 \cup m$, then we speak of $e_{v_i}(m, s_1) = \delta_{v_i}(s_1, s_2)$ as the **effects** of imposing m on s_1. Also, let $E^{+}_{V_s}(m, s_1)$, $E^{-}_{V_s}(m, s_1)$ and $E^{\approx}_{V_s}(m, s_1)$ be the set of (value, effect) tuples of values positively, negatively and neutrally affected, respectively, by the imposition of m on s_1.*

The measures of effects used here are qualitative, but are only proposed as a working model that needs to be adapted for the task and model at hand. Such coarsely segmented qualitative measures of influence make for a good working technique in descriptive work. For a detailed exploration of quantitative value tradeoffs among values, see, e.g., the recent work of Sartor [Sar10]. Newman & Marshall [NM91] use +/- labels to signal promotion and demotion in an options/goal matrix analysis of the applicable values/goals in the *Carney* case. The author has previously published extended descriptive example applications of the VJF using such qualitative measures in case-based legal reasoning [GA11], hypothetical reasoning [GA10] and event-progression-based practical reasoning [GA13b].

3.3 VJAP EXTENSIONS

From this point onwards, the formalism goes beyond what has been previously published since [GA11]. The extensions move the concepts explained further towards the VJAP implementation explained in the next chapter.

3.3.1 Quantitative Effects

When moving towards an implementation, qualitative effects are difficult to operationalize. Individual effects would need to be categorized into the seven scale discretization (or whichever granularity is chosen) and resolving conflicting arguments based on opposing value effects is not intuitive. Finally, it does not lend itself well to be inferred by means of machine learning from case data. To remedy this, we supplement the formalism with a quantitative notion of value effects.

Definition 8 (Adversarial Value Effects)**.** *Assume value $v \subseteq V$ and situation $s \in S$. The plaintiff and defendant are arguing for issue outcome facts o^π, o^δ, respectively. For plaintiff-favoring facts the output of the function*

$$\theta^+ : v, s, f^\pi, o^\pi \to [0, 1]$$

*represents the **positive fact effect** of f^π in s on v if outcome o^π were decided by the judge. Analogously, the output of the function*

$$\theta^- : v, s, f^\pi, o^\delta \to [-1, 0]$$

*represents the **negative fact effect** of f^π in s on v if outcome o^δ were decided by the judge. We presume these two functions to be mirror images of each other:*

$$\theta^+(v, s, f^\pi, o^\pi) = |\theta^-(v, s, f^\pi, o^\delta)|$$

We denote the set of all positive fact effects of deciding o^π for a given set of facts F^π across all values as $E^+_{o^\pi}(V, S, F^\pi)$ and the set of all mirror-image negative effect weights of deciding o^δ as $E^-_{o^\delta}(V, S, F^\pi)$. Corresponding defendant versions of these definitions are presumed to be apparent.

As an example, consider a case in which a plaintiff manufacturer has protected her sensitive product information from misappropriation by having the defendant sign a nondisclosure agreement. This affects both her interest in the protection of her property as well as her interest in confidentiality of the information. If the case were to be decided for the plaintiff (i.e. that a trade secret misappropriation had taken place), then this would have positive effects for these two values. The value of protection of private property is promoted because plaintiff is put in a better position to use the product information (her property) to gain revenue because the decision reprimands the defendant and possibly has further ramifications for her situation vis-a-vis her competitors. The value of protection of confidentiality is also promoted because plaintiff's measures to keep the information confidential are rewarded, which in turn is an enforcement example of the law upholding safety and predictability in business transactions.

On the other hand, if the case were the decided for the defendant, then this would have negative effects for these two values. The plaintiff's ability to use the product information she owns is no longer exclusive and hence impedes her standing vis-a-vis her competitors. Also, plaintiff's efforts to keep the information confidential by having the defendant sign a nondisclosure agreement were in vain, watering down the notion of security and predictability in business transactions.

In the model used in this experiment, the weight of these two effect sets is identical with inverse polarity. Preventing the negative consequences carries the same weight as incurring the positive ones and vice versa.

3.3.2 Value Judgments

A value judgment expresses that the positive effects of adding some fact or norm to a situation outweigh its negative effects, or vice versa. Different from the general definition in prior work (e.g. [GA11]), this definition is specific to models of case argumentation with a plaintiff and defendant party.

Definition 9. *Assume situation $s \in S$, $F^\pi, F^\delta \subset F$ and applicable values V. A* ***value judgment*** *in favor of the plaintiff is a proposition comparing value effect sets of the form*

$$E^+_{o^\pi}(V, s, F^\pi) > E^-_{o^\pi}(V, s, F^\delta)$$

.

If V is unambiguous this can be shortened to $E^+_{o^\pi}(s, F^\pi) > E^-_{o^\pi}(s, F^\delta)$. An inverted version exists for value judgments favoring the defendant.

In essence, a value judgment is a preference relation among decision options. A verbalization of definition 9 could be: "The outcome in s should be o^π because the positive effects on values V incurred by factors F^π outweigh the negative consequences incurred by factors F^δ when deciding o^π."

3.3.3 Scoped Value Judgments

In the context of legal reasoning, one typically assumes that the decision in question is a case outcome for either the plaintiff or defendant. In other words, the *scope* of the value judgment is global, i.e. spans the top-level outcome of the whole case. As established in section 2.1.2, however, value-based legal argumentation is focuses on letting value-based concerns flow into the case assessment while not deviating too far from the guidelines provided by positive law.

If the outcome of a case is governed by a rule

$$r : animal \land in\_park \Rightarrow violation$$

then the global value judgment is not at stake. This is because, in stating the rule, the legislator (or, with some qualifications, the authoritative court) has already made a global value judgment

$$E^+_{violation}(\{r\}, \{animal, in\_park\}) > E^-_{violation}(\{r\}, F^*)$$

where F^* is the set of hypothetical facts stating interests contra the rule that should still fall under the rule because a purposive assessment mandates it. In the animals in the park scenario, for example, pet dogs or horses should not be allowed in the park, even though the prohibition curtails the freedom of action of the dog and horse owners.

If, however, a trained assistance dog for a blind person wants to enter the park, the purposive assessment should go the other way because upholding the prohibition would obstruct the blind person's ability to go into the park herself. However, the rule cannot just be disposed of. Instead, a lawyer may argue that a trained assistance dog does not qualify as an animal *in the sense of the regulation*. While this example is trivial and purely illustrative, this restriction of the semantic meaning of terms to a certain document scope is an essential part of statutory reasoning and reasoning about rules derived from precedent cases.

The decisive issue of the case is similarly scoped. A new issue appears for which the blind person's advocate will submit the negative value judgment

$$E^{-}_{guidingdog=animal}(\{r\}, \{blindperson\}) > E^{+}_{guidingdog=animal}(\{r\}, \{blindperson\})$$

which says that the negative consequences of deeming the guiding dog an animal in the sense of the prohibition outweigh the negative consequences in a situation where a blind person wants to enter the park with her guiding dog while rule r is in force.

We can see that the existence of a rule governing the global case outcome creates a new value judgment whose scope is an antecedent of the rule. In this way, the global argument that the blind person should enter the park is refined into the argument that the guiding dog should not be deemed an animal in the sense of the prohibition.

Definition 10. *A* ***scoped*** *value judgment in favor of the plaintiff is a value judgment*

$$E^{+}_{c^{\pi}}(V, s, F^{\pi}) > E^{-}_{c^{\pi}}(V, s, F^{\delta})$$

where c is not the global decision outcome but the fulfillment of some intermediate legal concept which is an antecedent of some rule $r \in s$ which is necessary for a global outcome in favor of the plaintiff.

A corresponding scheme exists for scoped value judgments favoring the defendant.

Methodologically, this takes the shape of a 'teleological interpretation' of the prohibition. In this way, purposive reasoning can be conducted for specialized cases (or groups thereof) while upholding the validity of the positive legal rule and the larger scoped value judgment it contains. Naturally, this scoping effect of value judgments cascades down the tree of auxiliary rules and the intermediate legal concepts forming their antecedents. Skillful legal argumentation includes the ability to spot the 'weakest link' in this chain with the best chances of persuading the decision body to agree with a certain locally scoped value judgment whose effect propagates up to the global assessment of the case.

3.3.4 Terminological Assumption

Terminologically, a value judgment is a statement that a given tradeoff among effects should be resolved in a certain direction and in favor of a certain party. For the remainder of this dissertation, the term *tradeoff* is used instead of value judgment for brevity.

4.0 IMPLEMENTING THE FORMALISM

This chapter explains the experimental implementation of the VJF. Following prior work on HYPO [Ash91b], CATO [Ale03a] and IBP [AB06], the legal domain is trade secret misappropriation law. The experiment uses a manually created dataset of trade secret cases that have also been used in these prior systems. Sections 4.1 through 4.3.2 are substantively near-equivalent to prior explanations of the trade secret issue and factor domain model published in [AB06, BA03a, BA03b].

4.1 THE TRADE SECRET DOMAIN

In the trade secret cases of our dataset, plaintiff and defendant are competing producers of goods. Plaintiff has developed certain product information which the defendant obtains in some way and uses to develop and market a competing product. The plaintiff then sues the defendant for misappropriation of the trade secret by an alleged illegitimate use of the product information.

In order to succeed, the plaintiff needs to establish a set of requirements. Substantive American trade secret law is a combination of statutory law and case law. The latter has been consolidated in the Restatement (First) of Torts § 757, which many courts have adopted and which states the following:

> "One who discloses or uses another's trade secret, without a privilege to do so, is liable to the other if
> (a) he discovered the secret by improper means, or
> (b) his disclosure or use constitutes a breach of confidence reposed in him by the other in disclosing the secret to him, ..."

The passage states that one is liable for trade secret misappropriation if he or she [discloses or uses] another's [trade secret] that he or she has discovered by [improper means] or if said use or disclosure constitutes a [breach of confidence]. From this one obtains the following rule structure:

$$r_{tsm} : \textit{trade-secret-misappropriation-claim} \; \Leftarrow \textit{info-trade-secret} \; \wedge \textit{info-misappropriated}$$

The misappropriation itself is established from another rule:

$$r_{im} : \textit{info-misappropriated} \; \Leftarrow \textit{info-used} \; \wedge \textit{wrongdoing}$$

To simplify the structure, an intermediate concept *wrongdoing* is introduced. While this may appear like a representational trick, it actually corresponds to trade secret misappropriation law's basic requirement of a 'wrongful act', which is a core element of most tort liability causes of action. In the case of trade secret law, it takes the shape of either improper means or a breach of confidentiality.

$$r_{wd} : \textit{wrongdoing} \; \Leftarrow \textit{breach-of-confidentiality} \; \vee \textit{improper-means}$$

The concepts *info-used* , *breach-of-confidentiality* and *improper-means* are not clarified and need to be established from the facts. With regard to what constitutes a trade secret, the Restatement does not state a clear rule, but offers more information in a commentary (emphasis supplied):

> Comment b. Definition of trade secret
> "A trade secret may consist of any formula, pattern, device or compilation of **information which is used in one's business, and which gives him an opportunity to obtain an advantage over competitors** who do not know or use it. It may be a formula for a chemical compound, a process of manufacturing, treating or preserving materials, a pattern for a machine or other device, or a list of customers. It differs from other secret information in a business (see s 759) in that it is not simply information as to single or ephemeral events in the conduct of the business, as, for example, the amount or other terms of a secret bid for a contract or the salary of certain employees, or the security investments made or contemplated, or the date fixed for the announcement of a new policy or for bringing out a new model or the like. A trade secret is a process or device for continuous use in the operation of the business. Generally it relates to the production of goods, as, for example, a machine or formula for the production of an article. It may, however, relate to the sale of goods or to other operations in the business, such as a code for determining discounts,

rebates or other concessions in a price list or catalogue, or a list of specialized customers, or a method of bookkeeping or other office management.

The subject matter of a trade secret **must be secret**. Matters of public knowledge or of general knowledge in an industry cannot be appropriated by one as his secret. Matters which are completely disclosed by the goods which one markets cannot be his secret. Substantially, a trade secret is known only in the particular business in which it is used. It is not requisite that only the proprietor of the business know it. He may, without losing his protection, communicate it to employees involved in its use. He may likewise communicate it to others pledged to secrecy. Others may also know of it independently, as, for example, when they have discovered the process or formula by independent invention and are keeping it secret. Nevertheless, a substantial element of secrecy must exist, so that, except by the use of improper means, there would be difficulty in acquiring the information. An exact definition of a trade secret is not possible. 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 extent of 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."

Two requirements follow from the emphasized text passages in the commentary. First, the information needs to be valuable in the sense that it conveys a competitive advantage. Second, the inventor must make efforts to keep the information a secret.

$$r_{its} : \textit{info-trade-secret} \Leftarrow \textit{info-valuable} \wedge \textit{maintain-secrecy}$$

Here as well, the two antecedent concepts *info-valuable* and *maintain-secrecy* are somewhat vague and courts enjoy some flexibility in applying it to cases and reaching equitable results.

These five issues for which no set rule exists (*info-valuable* , *maintain-secrecy* , *info-valuable* and *maintain-secrecy*) will be referred to as the model's *leaf issues* as they are the leaves of the model's rule tree (see Fig. 1).

Since trade secret misappropriation law is substantially case law, attorneys will draw upon precedent cases via analogies and distinctions to strengthen their arguments that, in a given case at bar, all necessary leaf issues of the trade secret law rules are fulfilled or not given the facts in the case and that the desired outcome is warranted.

As will be shown, the VJAP system autonomously creates such purposive arguments and predicts a case outcome by propagating confidence values across the argument graph from learned weight parameters that represent the persuasive force of the effect a certain fact has on the applicable values.

A number of prior formal value-based descriptive accounts of this trade secret domain have been made (e.g. [BCS03, GCM03]). Chorley & Bench-Capon's AGATHA system implemented the theory construction formalism in a system capable of generating case outcome predictions in an adversarial game-like argumentation setting. A 'best theory' of the domain was produced through an A^* search over the space of possible theories. A 'theory' in their sense is a composite structure of prediction rules and preferences among these rules derived from prior cases.

VJAP pursues a similar objective as AGATHA, but uses a different conceptualization of purposive legal reasoning. Most importantly, VJAP does not predict a case using rules and preference relations among them as extracted from precedents. Instead, the facts and tradeoffs contained in the precedents are grounds for arguments which themselves become the predictors for the case using a quantitative semantics. For a detailed treatment of related work on other value-based formalisms, see section 6.2.

4.2 CASES AND FACTORS

In the dataset we use, cases are represented as sets of *factors* from a total of 26 possible factors (i.e. factual propositions in the formalism sense) that correspond to relevant patterns of facts in the trade secret domain that tend to favor one side or the other. They are numbered $\mathrm{F}1_\delta$ through $\mathrm{F}27_\delta$ with $\mathrm{F}9_\pi$ having gone out of use over the course of prior work. There are 13 factors each favoring plaintiff and favoring defendant.

A complete list of factors is given in appendix A. Factors are atomic in our representation, i.e. they are not reasoned about using formalized knowledge of finer granularity. Wyner & Peters have explored ways of inferring factors from text using smaller constituents they call "factoroids" [WP10]. Recent work by Al-Abdulkarim et al. strives for a deeper model of the trade secret domain [AAABC].

As a running example for this section, consider the DYNAMICS case[1]. It was decided in 1980 and has the following factors:

- $F15_{\pi}$[unique-product] : Plaintiff's information was unique in that plaintiff was the only manufacturer making the product.
- $F6_{\pi}$[security-measures] : Plaintiff took active measures to limit access to and distribution of its information.
- $F4_{\pi}$[agreed-not-to-disclose] : Defendant entered into a nondisclosure agreement with plaintiff.
- $F5_{\delta}$[agreement-not-specific] : The nondisclosure agreement did not specify which information was to be treated as confidential.
- $F27_{\delta}$[disclosure-in-public-forum] : Plaintiff disclosed its information in a public forum.

As a brief thought experiment, the case facts can be thought of as a narrative when embedded into boilerplate text containing the domain assumptions:

> **DYNAMICS (1980)**
> Plaintiff had developed product information and was marketing a product based on the information. Plaintiff's information was unique in that plaintiff was the only manufacturer making the product. Plaintiff took active measures to limit access to and distribution of its information. Plaintiff disclosed its information in a public forum.
>
> At some point, defendant obtained the product information. Defendant entered into a nondisclosure agreement with plaintiff. The nondisclosure agreement did not specify which information was to be treated as confidential.
>
> Eventually, defendant developed a competing product and commenced to sell it. Thereafter, plaintiff brought suit against defendant for trade secret misappropriation.

From reading this description of DYNAMICS, one understands that the plaintiff will have problems arguing that he has made effective efforts to maintain the secrecy of the information since he has disclosed the information in a public forum. On the other hand, the information was unique and defendant did sign a nondisclosure agreement, albeit a nonspecific one.

[1] Dynamics Research Corp. v. Analytic Sciences Corp., 9 Mass. App. 254, 400 N.E.2d 1274, 209 U.S.P.Q. 321 (1980).

4.3 ISSUES

To generate arguments in DYNAMICS, we need to relate these facts to the elements of the Restatement model explained above. In line with prior work in IBP, these rule elements will be labeled *issues*.

Definition 11. *An* ***issue*** *is an intermediate legal concept (treated formally as a factual proposition) in the domain of discourse that is argumentatively established through pro and con arguments by two opposing parties aiming to prove/disprove the issue. A party succeeding at proving/disproving a given issue is referred to as the party* ***winning*** *the issue.*

As explained, issues that are not established from Restatement rules are special because they are reasoned about by taking recourse to precedent cases. As explained in 3.3.3, they are anchors for scoped value judgments.

Definition 12. *A* ***leaf issue*** *is an issue that is argumentatively established by pro and con factors, or by factors for two opposing parties aiming to prove/disprove the issue.*

By contrast, other issues are either the top level issue (in this experiment: *trade-secret-misappropriation-claim*) or intermediate issues (*info-trade-secret* , *improper-means* and *info-misappropriated*).

Definition 13. *An* ***intermediate issue*** *is an issue that is established conjunctively or disjunctively from other issues.*

Definition 14. *The* ***main issue*** *is the global issue of interest in a given argument.*

In order to subsume the facts of DYNAMICS under the leaf issues, one can draw the following semantic connections:

- F15$_\pi$[unique-product] : The fact that plaintiff's information was unique is relevant for *info-valuable* .
- F6$_\pi$[security-measures] : The fact that plaintiff took active measures to limit access to and distribution of its information is relevant for *maintain-secrecy* .
- F4$_\pi$[agreed-not-to-disclose] : The fact that defendant entered into a nondisclosure agreement with plaintiff is relevant for *breach-of-confidentiality* and *maintain-secrecy* .

- F5$_\delta$[agreement-not-specific] : The facts that the nondisclosure agreement was not specific is relevant for *breach-of-confidentiality* .
- F27$_\delta$[disclosure-in-public-forum] : The fact that plaintiff disclosed its information in a public forum is relevant for *maintain-secrecy* .

In this matter, we can connect all 26 factors to the leaf issues of the Restatement model and produce the complete VJAP model displayed in Fig. 1. A tabular specification of the all issues and factor connections is given in appendix B.

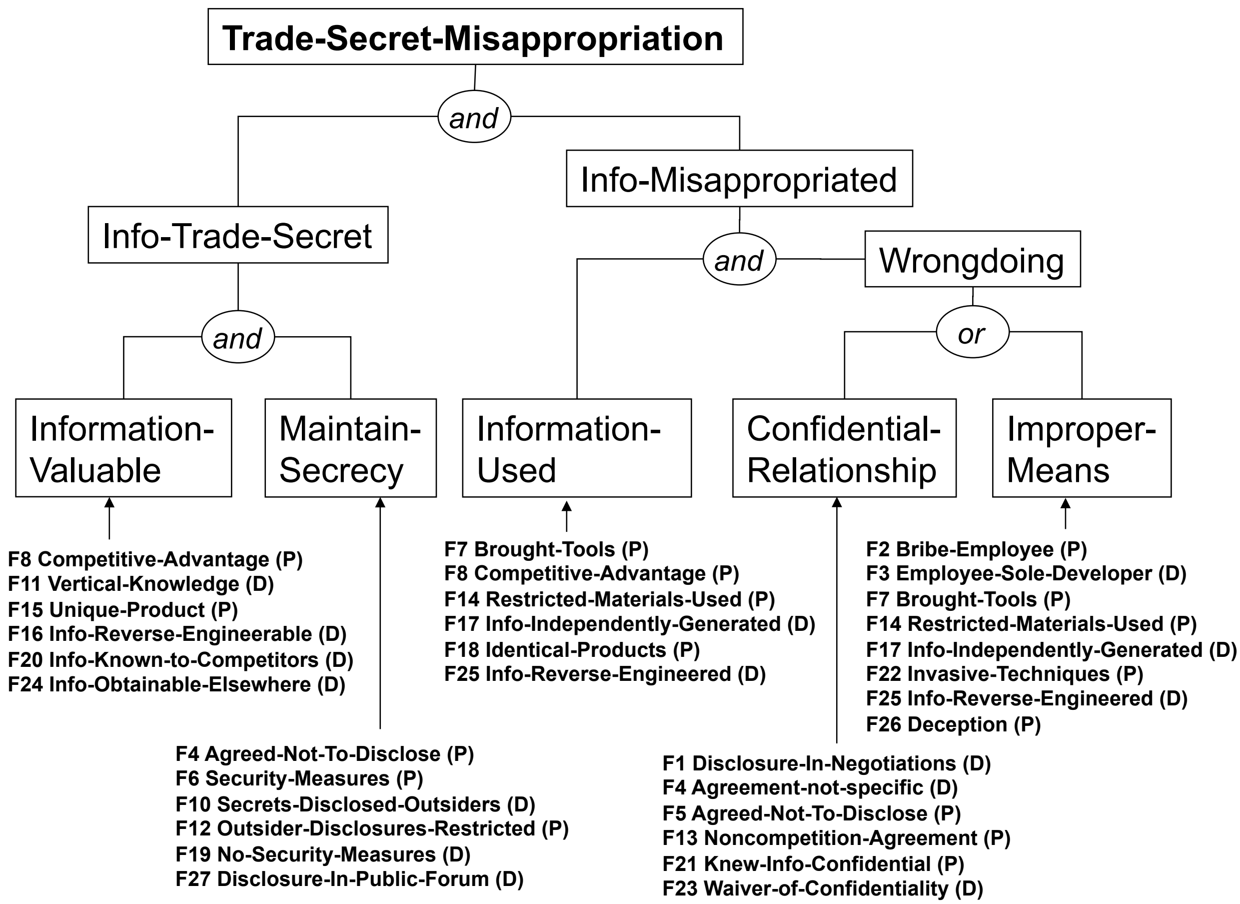

Figure 1: Diagrammatic view of VJAP domain model of issues and associated factors.

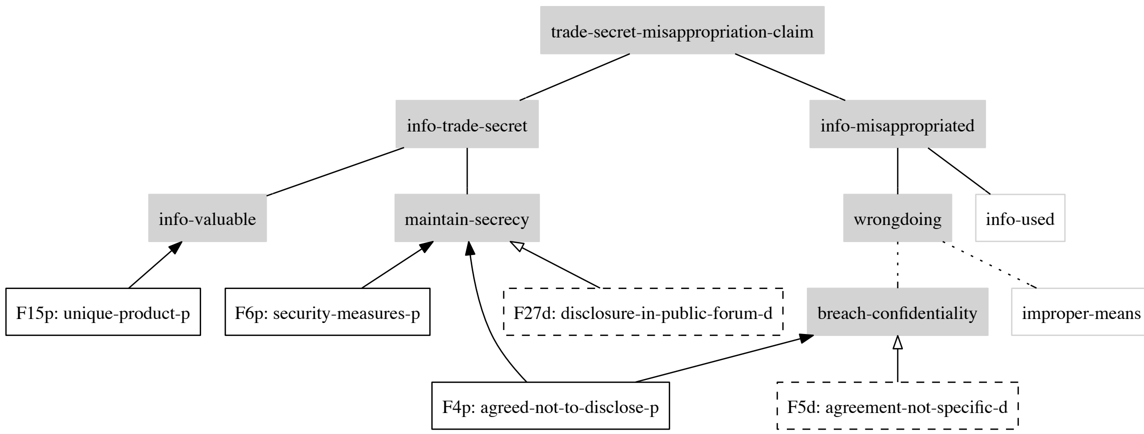

Figure 2: DYNAMICS's factors and issues in the VJAP model. Issues in grey boxes, π factors in solid line boxes, δ factors in dashed line boxes

4.3.1 Leaf Issue Statuses and Presumptions

The formal representation of the state of affairs in DYNAMICS can then be diagrammatically displayed as in Fig. 2. One can recognize the plaintiff's dilemma in trying to establish *maintain-secrecy* and *breach-of-confidentiality* as both issues are *contested* by factors favoring the defendant. *info-valuable* , on the other hand, is π-*exclusive*.

Definition 15. *In a given case, a leaf issue is considered:*

- ***raised*** *if at least one related factor is present, no matter for whom,*
- π***-exclusive*** *and* δ***-exclusive*** *if the issue is raised and all related factors favor the plaintiff or defendant, respectively*
- ***contested*** *if at least one related factor for each plaintiff and defendant is present,*

In DYNAMICS, no factors for *info-used* and *improper-means* are present. In the VJAP model (as in IBP [BA03b]), if a case contains no factors for a certain leaf issue, it is considered *not raised* and one of two alternatives applies. For *info-valuable* , *maintain-secrecy* and *info-used* the issue is presumed to have been conceded by the defendant and is hence won by the plaintiff. This is because the cases in the trade secret corpus have been manually annotated from written decision texts, which do necessarily give a complete statement of the facts, but only of those facts relevant to the litigation. Hence, if something is not mentioned, it is likely to be presumed as not obstructing the litigation because it would otherwise be addressed explicitly. In DYNAMICS, *info-used* is presumed conceded by the defendant and won by the plaintiff.

In the alternative, *breach-of-confidentiality* or *improper-means* will not be considered conceded by the defendant, but as simply not raised and hence functionally equivalent to being won by the defendant, since the plaintiff has the burden of proof and allegations of improper conduct and evidence connected thereto is hardly omitted from opinions. However, if both *breach-of-confidentiality* and *improper-means* are not raised in a case, it means that the misappropriation of the information has not been addressed in the opinion. Accordingly, it likely must have been undisputed and the defendant's counsel strategized to challenge the suit on the ground that the information is not a trade secret. In such a case, *wrongdoing* is considered conceded and won by the plaintiff.

Also, *improper-means* and *breach-of-confidentiality* 's disjunctive relationship requires the system to be able to recognize whether the case is being brought on both of the alternatives or just a single one, in which case the lack of factors pertaining to the irrelevant alternative must not short-circuit the prediction.

It should be noted that this assumption is made in light of the experience of examining and working with the IBP dataset of trade secret cases. It was by no means an operational assumption at the time of the case annotation.

4.3.2 Relationship to IBP

VJAP's domain model of the Restatement rule and the associations between factors and leaf-issues are a variation of the domain model developed by Brüninghaus & Ashley for the issue-based prediction system (IBP) [BA03b]. It is displayed in Fig. 3 and can be compared with VJAP's model in Fig. 1 above. The differences between the two are the following:

- In IBP, $\mathrm{F11}_\delta$[vertical-knowledge] was not associated with any factor.

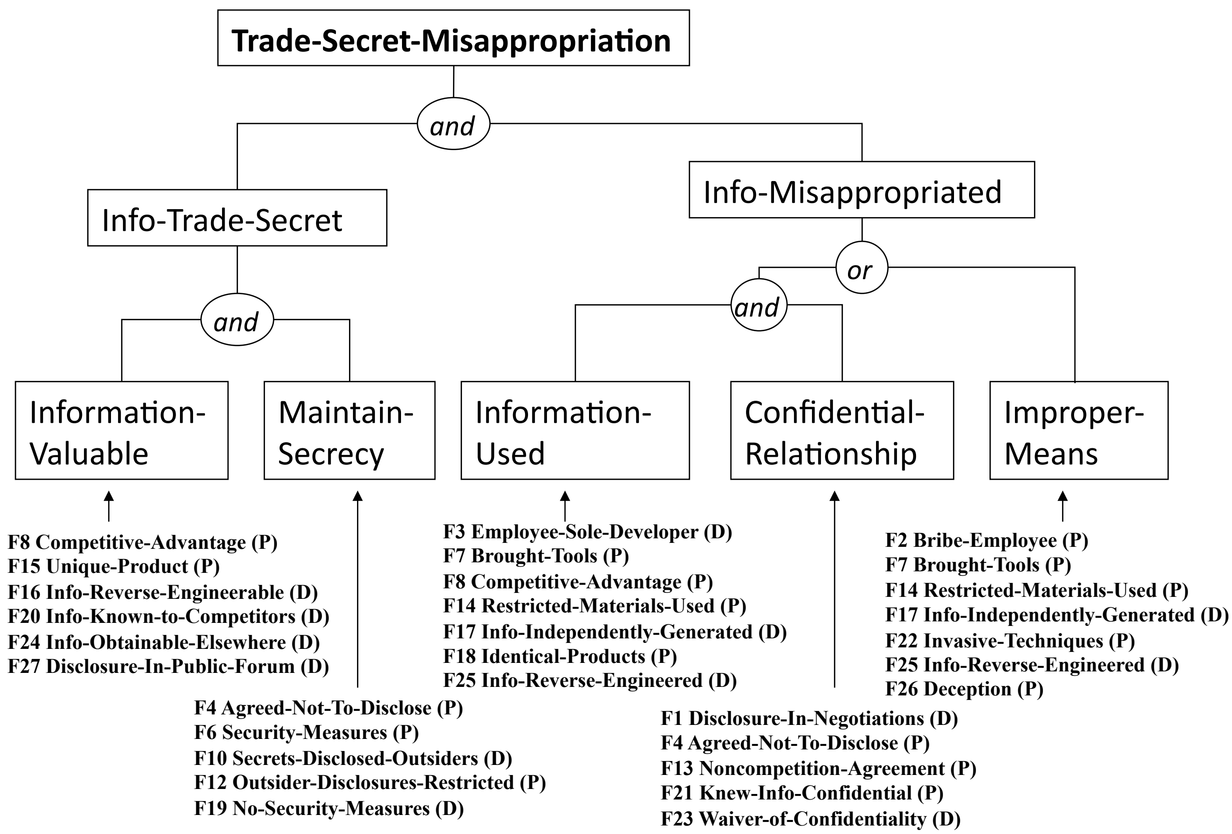

Figure 3: IBP's domain model and factor associations.

$F11_\delta$[vertical-knowledge] stands in for a situation where the plaintiff's information was about customers and suppliers (i.e. it may have been available independently from customers or even in public directories). VJAP associates it with *info-valuable* because customer and supplier information arguably is not valuable information in the sense of the Restatement.

- In IBP, *improper-means* was established from either *improper-means* or, alternatively, a conjunction of *breach-of-confidentiality* and *info-used* . In other words, improper means alone establishes a misappropriation, even without the information being used. In VJAP, the Restatement rule is interpreted as reflected in the rules in section 4.1, i.e. the information needs to have been used and the defendant needs to have committed some form of wrongdoing, which in turn can be done by either a breach of confidentiality or improper means.

IBP employed a specially developed algorithm in conjunction with its domain model to produce outcome predictions of cases. The algorithm as published in [AB06] is reproduced in Fig. 31.

Algorithm 4.1 IBP's prediction algorithm

```
Input: Current fact situation cfs
Identify issues raised by factors in cfs
For each issue raised, determine the side favored for that issue:
if all issue-related factors favor the same side then
  return that side
else
  retrieve issue-related cases in which all issue-related factors apply
  if there are issue-related cases then
    Theory-Testing: form hypothesis that same side s will win which won majority of cases
    if all issue-related cases favor side s then
      return side s
    else
      else try to explain away exceptions with outcomes contrary to hypothesis
      if all exceptions can be explained away through knockout factors then
        return side s favored by hypothesis
      else
        return "abstain"
      end if
    end if
  end if
  if no issue-related cases are found then
    Broaden-Query:
    if query can be broadened then
      call Theory-Testing for each set of retrieved cases
    else
      return "abstain"
    end if
  end if
end if
Combine prediction for each issue according to domain model
Output: Predicted outcome for cfs and explanation.
```

A trace of IBP's algorithmic prediction of DYNAMICS is given in Fig. 31. It is taken from the original IBP implementation, not the reimplementation evaluated in chapter 5. A longer such trace in the KG case which makes use of all of the algorithm's features like explaining away counterexamples and broadening the query can be found in appendix E.

```
Prediction for DYNAMICS, which was won by DEFENDANT
  Factors favoring plaintiff: (F15 F6 F4)
  Factors favoring defendant: (F27 F5)

Issue raised in this case is CONFIDENTIAL-RELATIONSHIP
  Relevant factors in case: F4(P)
The issue-related factors all favor the outcome PLAINTIFF.

Issue raised in this case is SECURITY-MEASURES
  Relevant factors in case: F27(D) F6(P) F4(P)
Theory testing has clear outcome for DEFENDANT.
  MOTOROLA (F2 F4 F5 F27 F20 F6)
  JOSTENS (F4 F5 F6 F17 F20 F27)
  HALLMARK (F4 F6 F13 F27)
  CMI (F4 F6 F10 F16 F17 F20 F27)

Issue raised in this case is INFO-VALUABLE
  Relevant factors in case: F27(D) F15(P)
Therory testing has clear outcome for DEFENDANT.
  NATIONAL-REJECTORS (F7 F10 F15 F16 F18 F19 F27)

Outcome of the issue-based analysis:
  For issue INFO-VALUABLE, DEFENDANT is favored.
  For issue SECURITY-MEASURES, DEFENDANT is favored.
  For issue CONFIDENTIAL-RELATIONSHIP, PLAINTIFF is favored.

=> Predicted outcome for DYNAMICS is DEFENDANT, which is correct.
```

Figure 4: IBP's prediction algorithm predicting DYNAMICS.

Despite using a variation of its domain model, VJAP is different from IBP in that it does not use one prediction algorithm but wraps the Restatement model into a full argument generation system capable of value-based legal reasoning.

Moreover, VJAP does not make use of manually flagged 'knockout factors'. In IBP, knockout factors are used in the explain-away functionality of the algorithm to discard cases that are counterexamples to the hypothesis that, when deciding a contested leaf issue, a set of plaintiff factors trumps a set of defendant factors. These factors (specifically, $F20_{\delta}$,

$F23_{\delta}$, $F19_{\delta}$ and $F27_{\delta}$) are deemed to be so strongly in favor of the defendant that they prevent cases from always being considered useful counterexamples regarding any specific issue with which they are not associated. VJAP does not use such manually chosen knockout factors and, as will be explained, compensates through the use of generic inter-issue tradeoff argument schemes.

4.4 VALUE-BASED REASONING IN THE TRADE SECRET DOMAIN

VJAP embraces the concepts of the VJF and enriches its variation of the IBP domain rules with a model of four legally relevant values in the trade secret domain. Similar to the approach taken in the domain model and other AI&Law work on the trade secret dataset (e.g. [BCS03, ABC05]), VJAP associates factors with values. In doing so, every factor-value relationship is labeled as one of six possible effect types. The effects are then made quantifiable using the concept of adversarial value effects in definition 8 of the VJF.

4.5 VALUE INTERACTIONS

VJAP knows six different ways in which a factor can affect the applicable interests. They can be arranged into three complementary pairs: more vs. less legitimate interests, waived vs. protected interests, as well as interference vs non-interference with interests.

4.5.1 More vs. Less Legitimate Interests

Certain facts increase the legitimacy of a subject's claim that her interest is warranted to be protected. For example, $F15_{\pi}$[unique-product] increases the legitimacy of the plaintiff's property interest because a unique product can lead to a competitive advantage that can be monetarily quantified.

Certain facts decrease the legitimacy of a subject's claim that her interest is warranted to be protected. For example, $F20_{\delta}$[info-known-to-competitors] decreases the legitimacy of the plaintiff's property interest because product development information that is known to competitors, if at all, grants a much weaker competitive advantage and it may be coherent with the law to not interfere by awarding a misappropriation claim.

4.5.2 Waivers vs. Protections of Interests

Certain actions amount to waiving protectable interests. For example, in a case where $F1_{\delta}$[disclosure-in-negotiations] applies, the plaintiff has arguably waived his property interest in the product information by disclosing it in negotiations.

Other actions qualify as active protections of ones interest in something, possibly leading to a higher degree of protection of that interest by the law. For example, in a case where $F13_{\pi}$[noncompetition-agreement] applies, the plaintiff has actively protected his confidentiality interest by entering into a noncompetition agreement with the defendant.

4.5.3 Interference vs. Non-interference of Interests

Finally, interests can be interfered with or not. If the defendant obtained plaintiff's product information through deception ($F26_{\pi}$[deception]), then the general public's interest in everyone adhering to fair competition practices has been violated.

If, however, the defendant discovered plaintiff's information through reverse engineering ($F25_{\delta}$[info-reverse-engineered]), then this is evidence that the plaintiff's property interest has not been violated.

4.5.4 Semantic Overlap between Value Effects and Restatement Issues

It should be noted that some value effects have recognizable semantic overlap with issues in the Restatement rules. For example, the question of whether factors have protective effects on plaintiff's confidentiality interest (e.g. $F13_{\pi}$[noncompetition-agreement] or $F6_{\pi}$[security-measures]) is very similar to an argument about *maintain-secrecy* as mentioned in the Restatement, possibly causing the impression of redundant modeling of certain concepts.

However, quite to the contrary.

Overlap between legal concepts is very common and systemically essential to legal reasoning because of the nature of positive law as a system which coordinates tradeoffs between competing interests. The misappropriation requirement in the Restatement rule is a special case of the broader torts law concept of a wrongful act. The product information being valuable is a special case of an entity in which one can have property rights and which can be damaged by a wrongful act. The process of assessing the same facts through the lenses of concepts laid out in positive law, concepts relating to policy objectives, and concepts related to an equitable assessment of competing interests, as well as the use of semantic overlap or differentiation between them is essential to to deep legal reasoning.

4.6 TRADE SECRET DOMAIN VALUES

VJAP models four values underlying the trade secret domain. These are the protection of plaintiff's property and confidentiality interest as well as the general public's interest in fair competition and the usability of publicly available information. This value systematization of the domain is unique to VJAP and is, in the author's opinion, an adequate model. Other value models of the trade secret domain can be found in, for example, [BCS03, ABC05, CBC05b].

It is not the purpose of the VJAP model or experiment to prove this particular value model as being correct or superior to other models. Rather, it has been developed as a plausible set of values and effects to implement the VJF into a case-based reasoning system and demonstrate its capabilities in generating purposive legal arguments and using them to predict case outcomes.

4.6.1 Protection of Property Interest

The most complex value is the protection of the plaintiff's property interest. Through innovative research, companies generate information which has intrinsic value because it can be monetized by means of developing a product based on the information. It thus value: *protection-property-interest*

- more-legitimate: $F8_\pi$ $F15_\pi$
- less-legitimate: $F16_\delta$ $F20_\delta$ $F24_\delta$ $F11_\delta$ $F17_\delta$
- protection: $F4_\pi$ $F6_\pi$ $F12_\pi$ $F13_\pi$
- waiver: $F27_\delta$ $F1_\delta$ $F19_\delta$ $F23_\delta$ $F10_\delta$
- interference: $F2_\pi$ $F7_\pi$ $F14_\pi$ $F21_\pi$ $F22_\pi$ $F26_\pi$ $F18_\pi$
- non-interference: $F25_\delta$

Figure 5: formalization of the protection of property value

confers an advantage over competitors who do not have this information. The undesirable consequence of this property interest not being protected is that the plaintiff cannot capitalize the information even though he has invested substantially in its development.

Trade secret law protects this interest by stating that a wrongful interference with it may incur liability (see the Restatement rule in section 4.1). For that to happen, however, purposive requirements are that the interest is sufficiently legitimate, has not been waived put possibly protected by the owner, and has been wrongfully interfered with.

VJAP models the protection of plaintiff's property interest as given in Fig. 5. An exhaustive list of factors is given in appendix A.

4.6.2 Protection of Confidentiality Interest

The plaintiff also has an interest in the confidentiality of certain transactions to be protected by the law. While the subject of, say, a confidentiality agreement is the potentially valuable product information, the legal good in focus here is not the value of the information (as in the property interest above) but the safety in commercial transactions provided by the plaintiff's ability to rely on confidential information to not be made public or used wrongfully.

Hence, the undesirable consequence if plaintiff's interest in confidentiality not being value: *protection-confidentiality-interest*

- less-legitimate: $F20_\delta$ $F24_\delta$ $F5_\delta$
- protection: $F4_\pi$ $F6_\pi$ $F12_\pi$ $F13_\pi$ $F21_\pi$
- waiver: $F1_\delta$ $F10_\delta$ $F19_\delta$ $F23_\delta$ $F27_\delta$
- interference: $F14_\pi$ $F2_\pi$

Figure 6: formalization of the protection of confidentiality value

adequately protected is not a loss of monetary value but the loss of safety and predictability in commercial transactions. Fig. 6 shows VJAP's model of the protection of plaintiff's confidentiality interest.

4.6.3 Protection of Fair Competition

The general public has an interest in fair competition practices which the law protects by providing that any wrongfully caused damage is subject to liability and, if needed, punitive damages. VJAP models this value purely by means of interference effects as given in Fig. 7.

4.6.4 Protection of Usability of Public Information

Finally, the general public has an interest in public information being effectively usable to enable innovation and healthy competition. Intellectual property law regulates the tradeoffs between this objective and protecting the property interest of an innovator to be able to sufficiently benefit from her investment in innovation before the information is released into the public domain. In striking this tradeoff the defendant is interested in establishing the information as being in the public domain by referring to the facts of the case and the nature of the information in question. VJAP models this in the form of legitimacy effects on the value as given in Fig. 8.

value: *protection-fair-competition*

- interference: F14$_\pi$ F2$_\pi$ F26$_\pi$ F18$_\pi$ F21$_\pi$ F7$_\pi$

Figure 7: formalization of the protection of fair competition value

value: *protection-public-information*

- more-legitimate: F17$_\delta$ F20$_\delta$ F24$_\delta$ F11$_\delta$ F16$_\delta$ F25$_\delta$ F27$_\delta$
- less-legitimate: F14$_\pi$ F21$_\pi$ F15$_\pi$

Figure 8: formalization of the protection of usability of public information value

4.6.5 A Value Assessment of DYNAMICS

Using these assignments of factors to values one can describe the value effects in DYNAMICS as follows:

Favoring the plaintiff:

- Plaintiff's property interest is legitimate because (F15$_\pi$) plaintiff's information was unique in that plaintiff was the only manufacturer making the product.
- Plaintiff has protected his property interest because (F6$_\pi$) plaintiff took active measures to limit access to and distribution of its information, and (F4$_\pi$) defendant entered into a nondisclosure agreement with plaintiff.
- Plaintiff has protected his confidentiality interest because (F6$_\pi$) plaintiff took active measures to limit access to and distribution of its information and (F4$_\pi$) defendant entered into a nondisclosure agreement with plaintiff.
- The general public's interest in the usability of publicly available information does not apply in this case because (F15$_\pi$) plaintiff's information was unique in that plaintiff was

the only manufacturer making the product.

Favoring the Defendant:

- Plaintiff has waived his property interest because F27$_\delta$ plaintiff disclosed its information in a public forum.
- Plaintiff has waived his confidentiality interest because F27$_\delta$ plaintiff disclosed its information in a public forum.
- Plaintiff's interest in confidentiality is not legitimate because (F5$_\delta$) the nondisclosure agreement did not specify which information was to be treated as confidential.
- The general public's interest in the usability of publicly available information applies in this case because (F27$_\delta$) plaintiff disclosed its information in a public forum.

4.7 EFFECT TRADEOFFS

Arguing about the outcome of a trade secret case in a given party's favor involves using the tradeoffs between the positive and negative effects of each decision option on the applicable values to the greatest persuasive effect and convincing the decision maker to agree with a given value judgment, i.e. the resolution of a tradeoff in favor of one party.

4.7.1 Global Effect Tradeoff

At the macroscopic level, deciding this tradeoff does not necessarily require a legal regime unless adherence to rules or precedent influences the decision.

For the whole case, we can then define the total effect weight in favor of a party in a case as the sum over all favorable effects on applicable values incurred by the factors in the case.

Definition 16 (global effect weight)**.**

$$ew(\alpha, c) = \sum_{j}^{|V|} \sum_{k}^{|\mathit{effects}(v_j,c,\alpha)|} \sum_{l}^{|\mathit{factors}(e,c)|} \theta(v_j, e_k, f_l)$$

The global effect tradeoff in the case is then a comparison of the global effect weight for each plaintiff and defendant. Given numerical weights for values and factor effects, this tradeoff prediction can be made without recourse to either legal rules contained in the Restatement of Torts or precedent cases. In the experiment, this model serves as a baseline for predicting case outcomes (see the GTW condition in chapter 5).

While a case-by-case assessment with consistent values can be implemented as a quantitative prediction model, it does not correspond to legal reality. Real-world legal reasoning relies on statutory rules and/or authoritative precedent cases to ensure predictability and security in legal transactions as well as implement constitutional guarantees. Nevertheless, the guidelines and safeguards provided by codified or precedential law are not intended to replace an equitable assessment of each case. Ideally, the law provides a comprehensive yet flexible blueprint of substantive rules and procedural guarantees that render the value judgments made by the lawmaker (and the tradeoffs therein) tangible for implementation and adjudication.

In legal reality, positive law goes beyond implementing equitable concerns by constituting a new purpose, namely adherence to the positive law itself as an ordering principle, the "rule of law" as opposed to the "rule of man". The law must rule, yet the law must, for the most part, produce equitable outcomes of the cases it governs. This interplay between abstract notions of equity, purpose and policy on the one hand and manifest normative language on the other hand, is legal reasoning and argumentation.

One focal aspect of legal reasoning is the desire to anchor equity concerns inside legal sources and the discourse structure they provide by interpreting written law or providing and elaborating analogies to or distinctions from a previously decided authoritative case. Even in a case where the positive law would produce an inequitable outcome, it cannot be dispensed with. Rather, an argumentative hook is established through which purposive concerns can influence the way in which the rules are applied to the case.

This is reflected in the way, for example, Alexy interrelates reasoning with cases to balancing [Ale10] and Feteris states that "[b]y referring to the goals and values in relation to the circumstances of the concrete case, the judge can explain how the original weighing of interests from the perspective of the goal of the rule formulated by the legislator must be 'translated' to the new situation so that it would result in a new formulation of the rule in which an exception is made for the concrete case." [F+15]

In the context of our model, this means that we design a hybrid system that is able to reason with rules yet, in applying them, takes account of the underlying value tradeoffs. The argumentative technique we employ is what we call the "standard of proof" that the plaintiff has to meet in a case in order to satisfy a requirement of a legal rule and establish his claim. Copious literature exists on this topic. Gordon & Walton [GW09] provide a detailed survey of prior formal accounts of proof burdens and standards in AI&Law and explore how they can be modelled formally in an argument model similar to VJAP.

Specifically, we give the system the capacity to argue that, due to purposive concerns, the plaintiff's burden of persuasion to establish a certain issue has been met (in a plaintiff argument) or not (in a defendant argument) given the circumstances of the case.

One way to accomplish this is by referring to value effect tradeoffs (i.e. purposive concerns) inside an issue to state an equitable concern, and then drawing upon precedent cases to support the argument by anchoring it in a legal source.

The second approach is to engage in value effect balancing across two issues, where a party's strong position on one issue makes up for its weakness in another. In other words, the over-satisfaction of the burden of persuasion in one issue renders it equitable to grant the party a lower standard of persuasion in the weaker issue. Again, the system will then cite a precedent case to anchor this argument in a legal source. In a follow-up arguments, the opposing party can then attack the analogy to the precedent, thereby undermining the value argument's legal source legitimacy, and the other party in turn can defend its analogy.

4.7.2 Global Effect Tradeoff in DYNAMICS

Fig. 9 illustrates the global tradeoff between values and factor effects for plaintiff and defendant in the DYNAMICS case as previously enumerated in 4.6.5. The left side of the diagram shows plaintiff factors whose effects on the values in the center are displayed through labeled edges. The right side of the diagram shows defendant factors and their effects on the values. The global tradeoff can be thought of as the balancing act between the left and right side of the diagram.

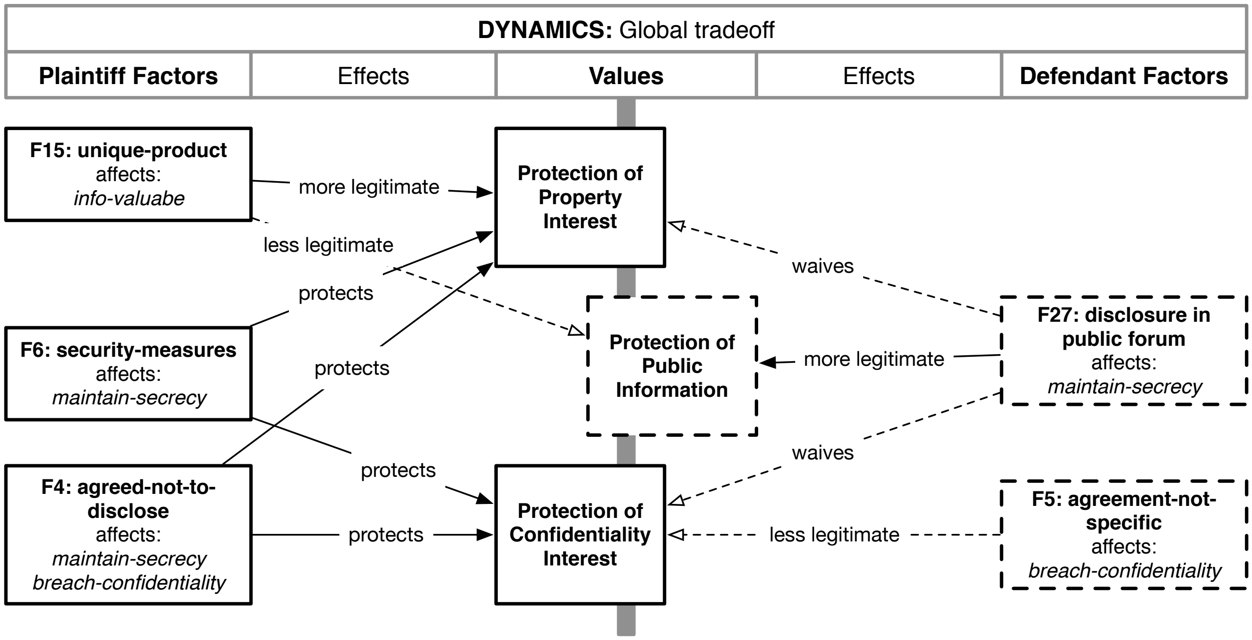

Figure 9: Diagrammatic view of global tradeoff in DYNAMICS.

4.7.3 Scoping Effect Tradeoffs

4.7.3.1 Local Tradeoff Confidence From the viewpoint of the VJAP model, in order to engage in tradeoff reasoning about an issue, the global tradeoff in the case needs to be dissected into sub-tradeoffs (analogues to scoped value judgments in 3.3.3), involving effect weight sums of smaller scope. By restricting an effect weight sum to an issue, we can quantify the purposive strength of a party α on a given issue i given the factors in the case that relate to the issue.

Definition 17 (local effect weight)**.**

$$ew(\alpha, c, i) = \sum_{j}^{|V|} \sum_{k}^{|effects(v_j, c, \alpha)|} \sum_{l}^{|factors(e,c) \cap factors(i)|} \theta(v_j, e_k, f_l)$$

Definition 18 (local tradeoff confidence)**.**

$$\phi_{lto}(\alpha, c, i) = \frac{ew(\alpha, c, i)}{ew(\alpha, c, i) + ew(\overline{\alpha}, c, i)}$$

Local tradeoffs can be inverted to obtain the local tradeoff for the opposing side. Because both tradeoffs cover the same factors, it holds that:

$$\phi_{lto}(\alpha, c, i) = 1 - \phi_{lto}(\overline{\alpha}, c, i)$$

4.7.3.2 Local Tradeoffs in DYNAMICS Fig. 10 shows the local tradeoff for *maintain-secrecy* between pro-plaintiff and pro-defendant effects. It is a partition (i.e. a subset) of the global tradeoff in Fig. 9. It shows that plaintiff can argue that the effects of F6$_\pi$ and F4$_\pi$ outweigh those of F27$_\delta$.

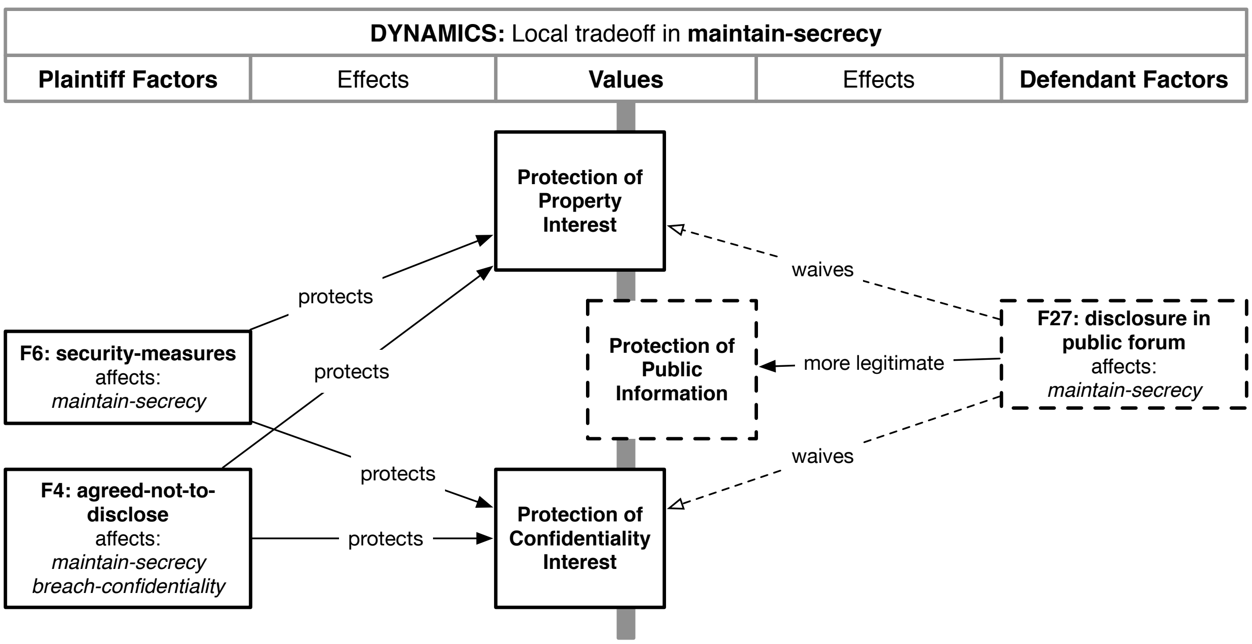

Figure 10: Partition of DYNAMICS for local tradeoff for *maintain-secrecy* .

4.7.3.3 Inter-Issue Tradeoff Confidence Consequently, an inter-issue tradeoff derives strength from effect weights across two issues: the weak issue i_w and the strong issue i_s.

Definition 19 (inter-issue tradeoff confidence)**.**

$$\phi_{iito}(\alpha, c, i_s, i_w) = \frac{ew(\alpha, c, i_s)}{ew(\alpha, c, i_s) + ew(\overline{\alpha}, c, i_w)}$$

Like local tradeoffs, inverting an inter-issue tradeoff to the opposing side maintains its coverage of factors. Hence, it also holds that

$$\phi_{iito}(\alpha, c, i) = 1 - \phi_{iito}(\overline{\alpha}, c, i)$$

It should be noted, however, that inverting an inter-issue tradeoff is not possible when a side argues that its strong position on issue one outweighs its weak position on an issue where the side has no factors at all.

4.7.3.4 Inter-Issue Tradeoffs in DYNAMICS Fig. 11 shows the inter-issue tradeoff for *breach-of-confidentiality* between pro-plaintiff and pro-defendant effects. As the local tradeoff, it is a partition (i.e. a subset) of the global tradeoff in Fig. 9. It shows that plaintiff can compensate an arguably weak position (F4$_\pi$ vs. F5$_\delta$) by arguing that his strong position on *info-valuable* (unchallenged F15$_\pi$) affords him a lower burden of persuasion on *breach-of-confidentiality* .

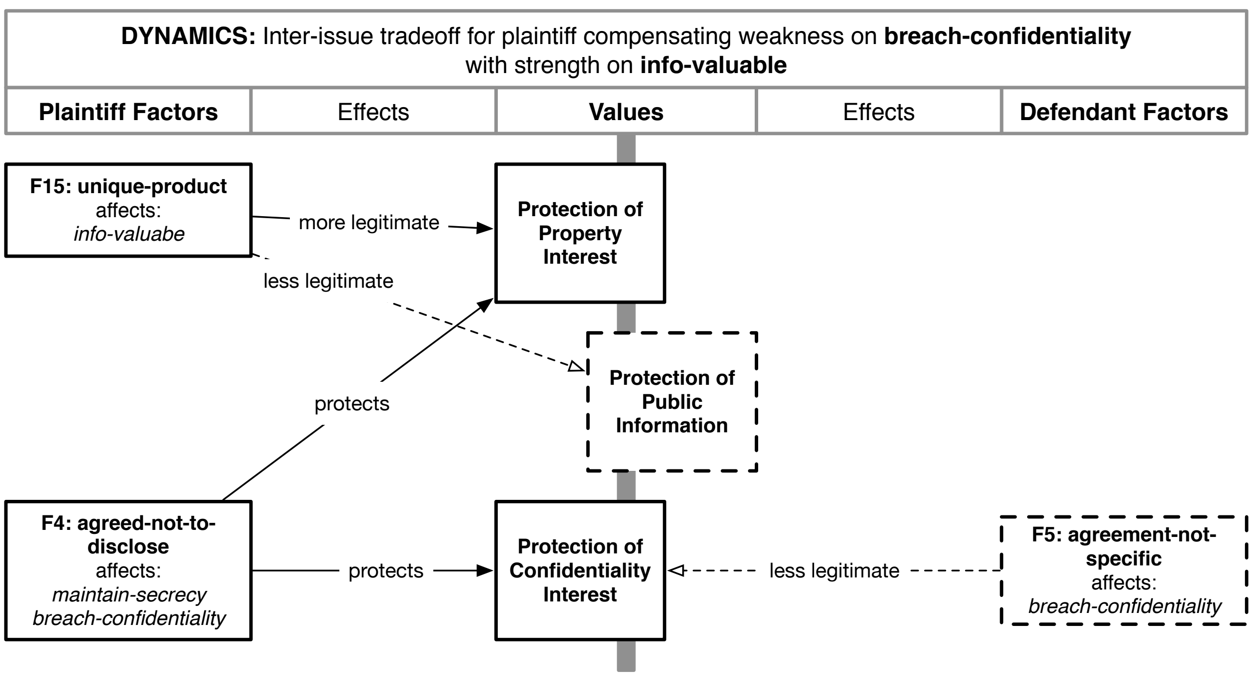

Figure 11: Inter-issue tradeoff for *breach-of-confidentiality* in DYNAMICS.

4.8 ARGUMENT GRAPH CONSTRUCTION

VJAP generates an argument graph structure for every case it predicts using an exhaustive search through a backward chaining of argument schemes. Algorithm 34 shows a pseudo-code form of the scheme-based search strategy.

For an issue in focus, all available argument schemes are checked whether they apply. If they do, they are instantiated and their premise propositions are recursively argued about using the same procedure. The search continues until no new arguments can be found and the graph is complete. The result is a bipartite graph of argument and statement nodes whose edges are consequence and premise relations.

4.8.1 Confidence Propagation

Once all graphs have been generated, VJAP takes a set of value effect weight parameters θ (compare definitions 16 and 17) and propagates a confidence measure across the graph towards the *trade-secret-misappropriation-claim* root statement, whose confidence is used in predicting the case outcome.

In the VJAP model, there are two ways of aggregating confidence in a statement given arguments pro and con:

- **proportional confidence**: The sum of all pro-argument confidences over the sum of all arguments (pro and con). This is used in instances where all arguments about a statement are important. For example, in arguing about whether a precedent is analogous to the current case, all similarities and distinctions should be taken into account. If no arguments are found, the confidence is 0. If no con-arguments with non-zero confidence but at least one such pro-argument are found, the confidence is equal to that of the strongest pro-argument.
- **propmax confidence**: The confidence of the strongest pro-argument over the sum of the confidences of the strongest pro- and con-argument. This is done in instances where the confidence of a statement depends on only the strongest argument for each side and additional weaker arguments are not of interest. For example, the confidence of a

Algorithm 4.2 VJAP argument graph construction

Initial algorithm call with parameter $p = c \vdash$ *trade-secret-misappropriation-claim*
assume: case c, rules r_{tsm}, r_{im}, r_{wd}
input: proposition p
$args_p \leftarrow \emptyset$
for all $\alpha \in \{\pi, \delta\}$ **do**
  if $p = c \vdash i$ where i is an intermediate issue **then**
    $args_p \leftarrow args_p \cup \{$arg. a for/against $c \vdash i$ from domain rule, recurse on a's premises$\}$
  else
    if $p = c \vdash i$ where i is a leaf issue **then**
      if i is conceded in c **then**
        $args_p \leftarrow args_p \cup \{$arg. a from conceded issue i in $c\}$
      end if
      if i is unambiguous in c for side α **then**
        $args_p \leftarrow args_p \cup \{$arg. a from unambiguous issue i in $c\}$
      end if
      if i is contested in c for side α **then**
        $args_p \leftarrow args_p \cup \{$arg. a for local tradeoff in i, recurse on a's premises$\}$
      end if
      if i is contested in c for side α or unambiguous for side $\overline{\alpha}$ **then**
        $args_p \leftarrow args_p \cup \{$args. $a_1 ... a_n$ for inter-issue tradeoffs in i, recurse on a_i's premises$\}$
      end if
    end if
    if p is about existence of precedent for local tradeoff in c **then**
      $args_p \leftarrow args_p \cup \{$args. $a_1 ... a_n$ for local tradeoff precedent, recurse on a_i's premises$\}$
    end if
    if p is about existence of precedent for inter-issue tradeoff in c **then**
      $args_p \leftarrow args_p \cup \{$args. $a_1 ... a_n$ for inter-issue tradeoff prec't, recurse on a_i's premises$\}$
    end if
    if p is about analogy between c and precedent p for tradeoff to **then**
      $args_p \leftarrow args_p \cup \{$args. $a_1 ... a_n$ for/against analogy between c and p regarding $to\}$
    end if
  end if
end for
return $args_p$

tradeoff having been used authoritatively in prior cases stands and falls with the best such precedent argument that a side can make. Lawyers will usually restrict themselves to present their strongest precedent only. Also, from a modeling point of view, one does not want the one very good analogy argument to be outweighed by a larger number of weak opposing precedent arguments.

It should be noted that VJAP only works with quantitative effect weights and does not assign context-independent abstract weights to values as Alexy does in his weight formula (see section 2.1.4). This design choice was made because the data set available for the experiment was limited. In an earlier version of VJAP, abstract value weights were used as multiplicative coefficients for the effect parameters, but did not have a noticeable impact on prediction. The were hence removed to simplify the parameters to be learned and to ensure that weight maps learned across different experiments were comparable (see section 5.6.2.2). This choice was purely pragmatic in the context of this experiment and does in now way contest the relevance of abstract weights in legal reasoning.

4.8.2 Schematic Example

Fig. 12 shows a pattern schema for the argument graphs that VJAP generates. Going from arguments in the domain model at the top (collapsed to save space) to deep arguments about leaf issues, tradeoffs, precedents, and analogy/distinction arguments between precedent and the case at bar.

As illustrated in algorithm 34, the graph is generated via scheme backward-chaining top down. Then, confidence measures are propagated back up. At every level, statements aggregate confidence using either proportional or propmax confidence formulae.

4.9 ARGUMENT SCHEMES

This section presents all argument schemes used by the experimental system to implement the value judgment formalism. For each scheme, there is a brief intuitive explanation and formal

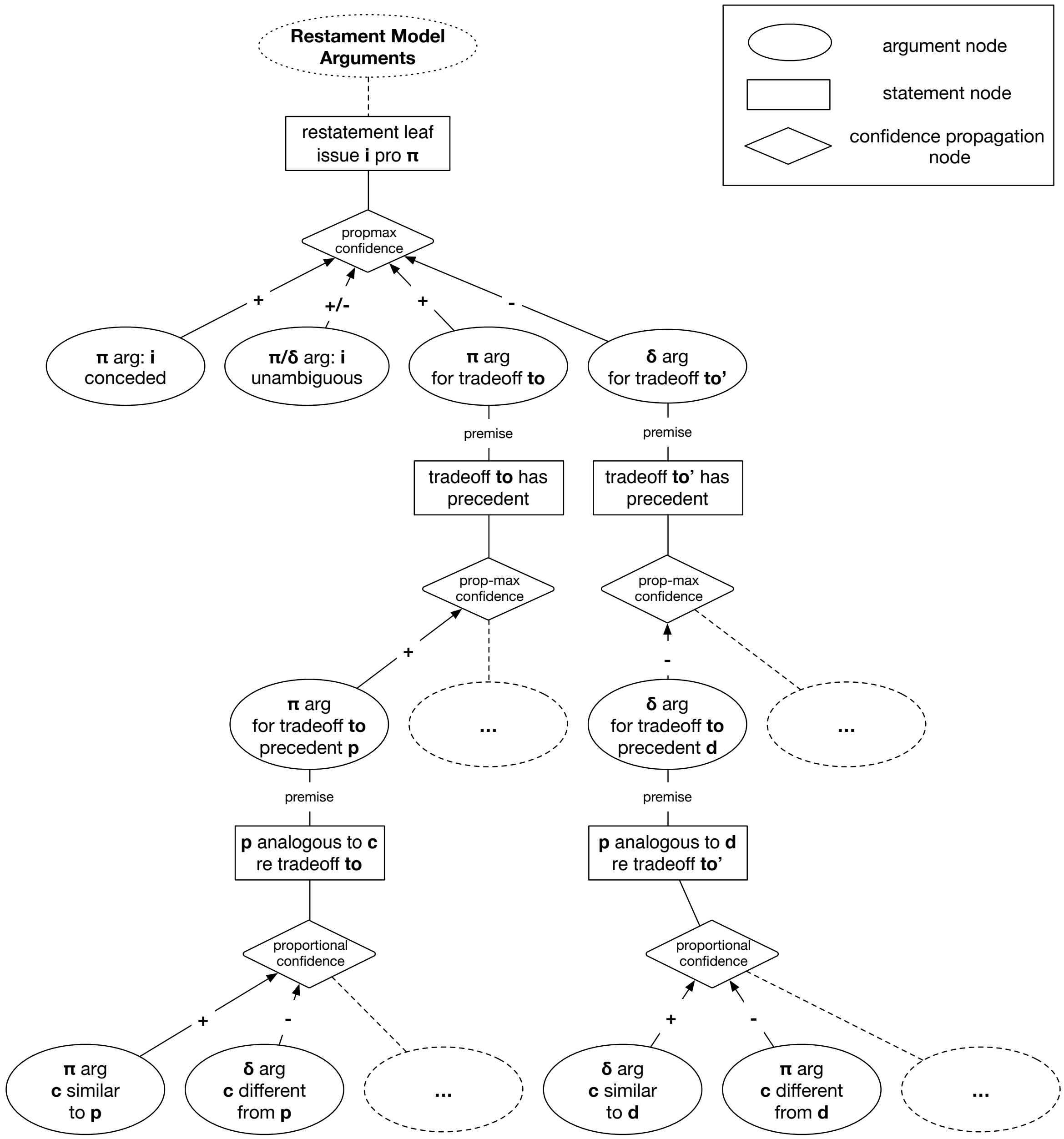

Figure 12: Statement and argument structure for reasoning about a Restatement issue with tradeoffs in VJAP.

specification followed by an example verbalization from a generated argument where available. For a small number of schemes (mostly pro-defendant) where a verbalization function was not implemented, an example verbalization was manually edited from the program's string templates in a way comparable to already implemented schemes. Factor diagrams of all cases supplementing the example verbalizations can be found in appendix D.

4.9.1 General

The following general schemes do not make use of any value-based reasoning and are common to all models in the system. They are used to instantiate arguments in the VJAP model of the Restatement rules establishing liability for a trade secret misappropriation. Their definitions are intuitive and so they will be given without much additional explanation.

4.9.1.1 For Fact From Antecedents A fact is established as the consequence of a rule from the rule's conjunctive antecedents. The confidence of the argument is hence the minimum of the individual confidences in the antecedent facts.

Definition 20 (Argument for fact from antecedents)**.** *Assume situation $s \in S$, arguing side α, fact $f^\alpha \in F$ and f^α's conjunctive antecedents $A = a_1, ..., a_n$ according to rule $r \in R$.*

IF:

$$\forall a_x \in A : S \vdash a_x$$

THEN ARGUE:

$$s \vdash f^\alpha$$

WITH CONFIDENCE:

$$\phi(s \vdash i) = MIN_{x=1}^{n} \phi(a_x)$$

> **Example from DYNAMICS:** *"Plaintiff has a claim for trade secret misappropriation because plaintiff's information is a trade secret and plaintiff's information has been misappropriated."*

4.9.1.2 For Fact from Disjoint Antecedents A legal issue is established as the consequence of a rule from the rule's disjunctive antecedents. Consequently, the confidence of the argument will be the maximum of the confidences in each of the antecedent facts.

Definition 21 (Argument for fact from disjoint antecedents)**.** *Assume situation $s \in S$, arguing side α, fact $f^\alpha \in F$ and f^α's disjunctive antecedents $A = a_1, ..., a_n$ according to rule $r \in R$.*

IF:

$$\forall a_x \in A : S \vdash a_x$$

THEN ARGUE:

$$s \vdash f^\alpha$$

WITH CONFIDENCE:

$$\phi(s \vdash i) = MAX_{x=1}^{n} \phi(a_x)$$

> **Example from DYNAMICS:** *"Defendant has committed some wrongdoing with regard to the information because defendant breached a confidential relationship."*
>
> **Alternative example from FRANKE:** *Defendant has committed some wrongdoing with regard to the information because defendant has used improper means to obtain plaintiff's information.*

4.9.1.3 Against Fact Issue from Missing Antecedent

A side argues that the opponent fails to establish a given issue by pointing out that the opponent fails to establish a necessary antecedent. This is equivalent to *undermining* arguments.

It must be noted that this scheme was not used for the prediction experiment. The reason is that the prediction was done by generating the plaintiff argument for *trade-secret-misappropriation-claim* and comparing it to a static prediction threshold of .5. In this process, all defendant arguments get generated implicitly as part of the argument graph. If this scheme were included, a prediction threshold of 0 would have to be used. However, the generated argument graph would contain a mirror image of itself as all pro-plaintiff arguments are con arguments for the defendant and vice versa. To eliminate this redundancy, this scheme was omitted for the prediction experiment and prediction threshold of .5 was used instead.

Definition 22 (Argument against fact from missing antecedent)**.** *Assume situation $s \in S$, arguing side α, fact $f^\alpha \in F$ and f^α's (conjunctive or disjunctive) antecedents $A = a_1, ..., a_n$*

according to rule $r \in R$.

IF:

$$\exists a_x \in A : S \nvdash a_x$$

THEN ARGUE:

$$s \nvdash f^\alpha$$

WITH CONFIDENCE:

$$\phi(s \nvdash f^\alpha) = \begin{cases} MAX_{x=1}^{n} \phi(s \nvdash a_x), \textit{ for conjunctive antecedents} \\ MIN_{x=1}^{n} \phi(s \nvdash a_x), \textit{ for disjunctive antecedents} \end{cases}$$

Example from DYNAMICS: *"Plaintiff cannot substantiate a claim for trade secret misappropriation because plaintiff's information has not been misappropriated."*

4.9.1.4 For Issue from Conceded Issue

A legal issue is established for π because the case does not contain any factors pertaining to it and the issue is concedable.

Definition 23. *Assume situation $s \in S$, arguing side α, concedable legal issue $i \in F$ favoring side π.*

IF:

$$s \textit{ does not contain any factor pertaining to } i$$

THEN ARGUE:

$$s \vdash i \textit{ in favor of pi}$$

WITH CONFIDENCE:

$$\phi(s \vdash i) = 1.0$$

Example from DYNAMICS: *"Defendant has conceded that defendant has used plaintiff's product information."*

4.9.1.5 For Issue from Undisputed Factor

All factors related to a given issue in a given case favor the same side.

Definition 24. *Assume situation $s \in S$, arguing side α, legal issue $i \in F$ favoring side a.*

IF:

$$\textit{all factors relating to } i \textit{ in } s \textit{ favor side } a$$

THEN ARGUE:

$$s \vdash i \textit{ in favor of } a$$

WITH CONFIDENCE:

$$\phi(s \vdash i) = 1.0$$

> **Example from DYNAMICS:** *"The value of the information is undisputed as the only relevant evidence is that the product information was unique."*

4.9.1.6 Against Issue from Undisputed Factor

All factors related to a given issue in a given case favor the same opposite side.

Definition 25. *Assume situation $s \in S$, arguing side α, legal issue $i \in F$ favoring side a*

IF:

$$\textit{all factors relating to } i \textit{ in } s \textit{ favor opposite side } \overline{a}$$

THEN ARGUE:

$$s \nvdash i \textit{ in favor of } \overline{a}$$

WITH CONFIDENCE:

$$\phi(s \nvdash i) = 1.0$$

Example from FRANKE *"It is undisputed that there is no breach of a confidential relationship as the only relevant evidence is that plaintiff disclosed its product information in negotiations with defendant."*

4.9.2 Establishing Issues from Tradeoffs

The following argument schemes argue in favor of leaf issues from tradeoffs. They make use of value judgments in their instantiation and their confidence propagation.

4.9.2.1 For Issue from Local Tradeoff A side argues that a given contested issue should be decided in its favor because a balancing of all affected values related to the issue has to be decided in its favor.

Definition 26. *Assume situation $s \in S$, arguing side α, legal issue $i \in F$ favoring side α, supporting factors $s \vdash F_i^{\alpha}$ and positive value effects $E^{+}(s, F_i^{\alpha})$, opposing factors $s \vdash F_i^{\overline{\alpha}}$ and negative value effects $E^{-}(s, F_i^{\overline{\alpha}})$.*

IF:

$$F_i^{\alpha} \neq \emptyset$$

$$F_i^{\overline{\alpha}} \neq \emptyset$$

$$\textit{precedent with same effect tradeoff: } \exists p : E_i^{+}(p, F_i^{\alpha}) > E_i^{-}(p, F_i^{\overline{\alpha}})$$

THEN ARGUE:

$$s \vdash i \textit{ in favor of } \alpha \textit{ because } E_i^{+}(s, F_i^{\alpha}) > E_i^{-}(s, F_i^{\overline{\alpha}})$$

WITH CONFIDENCE:

$$\phi_{lto}(\alpha, s, i) + \phi(\exists p : E_i^{+}(p, F_i^{\alpha}) > E_i^{-}(p, F_i^{\overline{\alpha}}))$$

4.9.2.2 For Local Tradeoff from Precedent

A side argues in favor of applying a local tradeoff to the case at bar and deciding a given issue in its favor because there is a precedent case with the same tradeoff which was decided in its favor. It is important to note that the precedent having the same tradeoff means that it contains the same sets of effects, but not necessarily the same set of factors.

Definition 27. *Assume situation $s \in S$, arguing side α, local tradeoff argument that $E_i^+(s, F_i^\alpha) > E_i^-(s, F_i^{\overline{\alpha}})$ and precedent case p decided for α containing local tradeoff $E_i^+(p, F_i^\alpha) > E_i^-(p, F_i^{\overline{\alpha}})$.*

IF:

$$E_i^+(s, F_i^\alpha) = E_i^+(p, F_i^\alpha)$$

$$E_i^-(s, F_i^{\overline{\alpha}}) = E_i^-(p, F_i^{\overline{\alpha}})$$

$$s \textit{ analogous to } p \textit{ regarding } E_i^+(\{s/p\}, F_i^\alpha) > E_i^-(\{s/p\}, F_i^{\overline{\alpha}})$$

THEN ARGUE:

$$E_i^+(s, F_i^\alpha) > E_i^-(s, F_i^{\overline{\alpha}})$$

WITH CONFIDENCE:

$$\phi(s \textit{ analogous to } p \textit{ regarding } E_i^+(\{s/p\}, F_i^\alpha) > E_i^-(\{s/p\}, F_i^{\overline{\alpha}}))$$

Example verbalization in SANIRAB, plaintiff on *breach-of-confidentiality* :

"Defendant breached a confidential relationship because defendant entered into a nondisclosure agreement. This outweighs the fact that plaintiff disclosed the information in negotiations.

In purposive terms, in SANIRAB, the fact that plaintiff has protected his property interest because of the nondisclosure agreement and plaintiff has protected his confidentiality interest because of the nondisclosure agreement outweighs the fact that plaintiff has waived his property interest because of the disclosure during negotiations and plaintiff has waived his confidentiality interest because of the disclosure during negotiations.

The same tradeoff with regard to a breach of a confidential relationship was made in AFFILIATED-HOSPITAL, which was also decided for plaintiff.

There, defendant had breached a confidential relationship because defendant had entered into a nondisclosure agreement and plaintiff and defendant had entered into a noncompetition agreement. This outweighed the fact that plaintiff had disclosed the information in negotiations.

In purposive terms, in AFFILIATED-HOSPITAL, the fact that plaintiff had protected his property interest because of the nondisclosure agreement and the noncompetition agreement and plaintiff had protected his confidentiality interest because of the nondisclosure agreement and the noncompetition agreement outweighed the fact that plaintiff had waived his property interest because of the disclosure during negotiations and plaintiff had waived his confidentiality interest because of the disclosure during negotiations."

4.9.2.3 For Issue from Inter-Issue Tradeoff A side argues that a given issue on which it is weak should be decided in its favor because of another issue on which it is strong and the positive effects of this decision on the strong issue outweigh its negative effects on the weak issue.

Definition 28. *: Assume situation $s \in S$, arguing side α, weak and strong issues $i_w, i_s \in F$ favoring side α, supporting factors $s \vdash F^{\alpha}_{i_s}, F^{\alpha}_{i_w}$ and positive value effects $E^{+}(s, F^{\alpha}_{i_s})$, opposing factors $s \vdash F^{\overline{\alpha}}_{i_w}$ and negative value effects $E^{-}(s, F^{\overline{\alpha}}_{i_w})$.*

IF:

$$F^{\alpha}_{i_s} \neq \emptyset$$

$$F^{\overline{\alpha}}_{i_w} \neq \emptyset$$

$$\textit{precedent with same tradeoff: } \exists p : E^{+}_{i_s}(p, F^{\alpha}_{i_s} \cup F^{\alpha}_{i_w}) > E^{-}_{i}(p, F^{\overline{\alpha}}_{i_w})$$

THEN ARGUE:

$$s \vdash i \textit{ in favor of } \alpha \textit{ because } E^{+}_{i_s}(s, F^{\alpha}_{i_s} \cup F^{\alpha}_{i_w}) > E^{-}_{i}(s, F^{\overline{\alpha}}_{i_w})$$

WITH CONFIDENCE:

$$\phi_{iito}(\alpha, s, i_s, i_w) + \phi(\exists p : E^{+}_{i_s}(p, F^{\alpha}_{i_s} \cup F^{\alpha}_{i_w}) > E^{-}_{i}(p, F^{\overline{\alpha}}_{i_w}))$$

4.9.2.4 For Inter-Issue Tradeoff from Precedent

A side argues in favor of applying an inter-issue tradeoff to the case at bar and decide a given issue in its favor because there is a precedent case with the same tradeoff which was decided in its favor. Again, it is important to note that the precedent having the same tradeoff means that it contains the same sets of effects, but not necessarily the same set of factors.

Definition 29. *Assume situation $s \in S$, arguing side α, inter-issue tradeoff argument that $E^+_{i_s}(s, F^{\alpha}_{i_s} \cup F^{\alpha}_{i_w}) > E^-_i(s, F^{\overline{\alpha}}_{i_w})$ and precedent case p decided for α containing inter-issue tradeoff $E^+_{i_s}(p, F^{\alpha}_{i_s} \cup F^{\alpha}_{i_w}) > E^-_{i_w}(p, F^{\overline{\alpha}}_{i_w})$.*

IF:

$$E^+_{i_s}(s, F^{\alpha}_{i_s} \cup F^{\alpha}_{i_w}) = E^+_{i_s}(p, F^{\alpha}_{i_s} \cup F^{\alpha}_{i_w})$$

$$E^-_i(s, F^{\overline{\alpha}}_{i_w}) = E^-_i(p, F^{\overline{\alpha}}_{i_w})$$

$$s \textit{ analogous to } p \textit{ regarding } E^+_{i_s}(\{s/p\}, F^{\alpha}_{i_s} \cup F^{\alpha}_{i_w}) > E^-_i(\{s/p\}, F^{\overline{\alpha}}_{i_w})$$

THEN ARGUE:

$$E^+_{i_s}(s, F^{\alpha}_{i_s} \cup F^{\alpha}_{i_w}) > E^-_i(s, F^{\overline{\alpha}}_{i_w})$$

WITH CONFIDENCE:

$$\phi(s \textit{ analogous to } p \textit{ regarding } E^+_{i_s}(\{s/p\}, F^{\alpha}_{i_s} \cup F^{\alpha}_{i_w}) > E^-_i(\{s/p\}, F^{\overline{\alpha}}_{i_w}))$$

Example verbalization in DYNAMICS, defendant on *info-valuable* :

"Plaintiff's product information is not sufficiently valuable because the plaintiff has taken such little efforts to maintain the secrecy of the information that, despite the lack of strong evidence for the defendant, it must be assumed that plaintiff's product information is not sufficiently valuable because deciding otherwise would be inconsistent with the purposes underlying trade secret law.

Specifically, regarding the maintenance of secrecy by the plaintiff, the public disclosure amounts to such a clear waiver of property interest, a scenario where usability of public information is critical and such a clear waiver of confidentiality interest regarding the lack of maintenance of secrecy by the plaintiff that the lack of value of the information must be deemed sufficiently established despite the lack of strong evidence for the defendant and the fact that the product information was unique.

A similar inter-issue tradeoff was made in NATIONAL-REJECTORS, which was decided for defendant. There, regarding the maintenance of secrecy by the plaintiff, the disclosure to outsiders amounted to such a clear waiver of property interest and such a clear waiver of confidentiality interest, the public disclosure amounted to such a clear waiver of property interest, a scenario where usability of public information is critical and such a clear waiver of confidentiality interest and the absence of security measures amounted to such a clear waiver of property interest and such a clear waiver of confidentiality interest that the reverse-engineerability qualified as the lack of value of the information despite the fact that the product information had been unique."

4.9.3 Arguments about Local Tradeoff Precedent

4.9.3.1 For Local Tradeoff Precedent Analogy A side argues that a case and a precedent which share the same local tradeoff of interest are sufficiently analogous that the precedent lends persuasive force to the application of the tradeoff in the case at bar in favor of the arguing side. By virtue of both cases sharing the same tradeoff, the analogy argument is presumed to be valid and the confidence in it is the confidence of the tradeoff in the case at bar or the precedent, whichever is weaker.

It should be noted that this means VJAP retrieves potential precedents by virtue of their sharing a tradeoff with the case at bar. This involves two sets of value effects (i.e. a waiver of confidentiality interest versus an violation of fair competition principles), irrespective of which factors constitute these effects. This is substantially different from (and arguably 'deeper' than) the precedent candidate retrieval on the factor level as employed in HYPO, CATO and IBP.

In other words, VJAP retrieves precedents that may be superficially different in terms of the factors they share yet similar on a deeper level in terms of their shared value effects. For example, in the case at bar the defendant may have bribed one off plaintiff's employee's ($F2_\pi$[bribe-employee]) whereas in the precedent the defendant my have used invasive techniques ($F22_\pi$[invasive-techniques]) to obtain the product information. Both cases share the deeper similarity, however, that the defendant has violated the principle of fair competition. This can be thought of as pushing CATO's substitution argument move using higher-level concepts in the factor hierarchy [Ale03a] up into the candidate generation step.

In drawing this analogy, it may turn out that the despite this deep similarity, the superficial differences may have a greater impact than suggested in the analogy. For example, courts may consider $\mathrm{F2}_{\pi}$ to be a much graver violation of the fair competition principle than $\mathrm{F22}_{\pi}$. In VJAP, this is not explicitly reflected in this analogy scheme (although it potentially affects the confidence function through the *min*-operation). Rather, two more schemes are defined below which use factor-level differences in effect-level analogies to distinguish the precedent and thus rebut the analogy.

Definition 30. *Assume situation $s \in S$, arguing side α, precedent case p decided for α containing local tradeoff $E_i^+(p, F_i^{\alpha}) > E_i^-(p, F_i^{\overline{\alpha}})$ and upper argument antecedent that s analogous to p to establish that $E_i^+(s, F_i^{\alpha}) > E_i^-(s, F_i^{\overline{\alpha}})$.*

IF:

$$s \textit{ has tradeoff } E_i^+(s, F_i^{\alpha}) > E_i^-(s, F_i^{\overline{\alpha}})$$

$$p \textit{ has tradeoff } E_i^+(p, F_i^{\alpha}) > E_i^-(p, F_i^{\overline{\alpha}})$$

THEN ARGUE:

$$s \textit{ analogous to } p \textit{ regarding } E_i^+(\{s/p\}, F_i^{\alpha}) > E_i^-(\{s/p\}, F_i^{\overline{\alpha}})$$

WITH CONFIDENCE:

$$min(\phi_{lto}(\alpha, s, i), \phi_{lto}(\alpha, p, i))$$

This argument's verbalization is already covered by the verbalization of the upper argument for local tradeoff from precedent.

4.9.3.2 For Local Tradeoff Precedent Analogy from Supporting Surplus Factor in Current Case In analogizing to a precedent, a party may point out a favorable factor that is present in the current case and not in the precedent but still part of the local tradeoff argued about in the analogy. The resulting argument is an *a fortiori* argument that this favorable excess factor in the current case makes the argument even stronger.

This argument scheme provides the analogy confidence with a bonus that is the sum of all effect weights associated with the surplus factor.

Definition 31. *Assume situation $s \in S$, arguing side α, precedent case p decided for α containing local tradeoff $E_i^+(p, F_i^\alpha) > E_i^-(p, F_i^{\overline{\alpha}})$ and upper argument antecedent that s analogous to p to establish that $E_i^+(s, F_i^\alpha) > E_i^-(s, F_i^{\overline{\alpha}})$.*

IF:

$$s \text{ has tradeoff } E_i^+(s, F_i^\alpha) > E_i^-(s, F_i^{\overline{\alpha}})$$

$$p \text{ has tradeoff } E_i^+(p, F_i^\alpha) > E_i^-(p, F_i^{\overline{\alpha}})$$

$$\exists f^\alpha : s \vdash f^\alpha, p \nvdash f^\alpha$$

$$f^\alpha \in F_i^\alpha$$

THEN ARGUE:

$$s \text{ analogous to } p$$

$$E_{i_s}^+(s, F_{i_s}^\alpha) > E_i^-(s, F_{i_w}^{\overline{\alpha}}) \text{ is even stronger than } E_{i_s}^+(p, F_{i_s}^\alpha) > E_i^-(p, F_{i_w}^{\overline{\alpha}})$$

$$\text{due to pro } \alpha \text{ effects of } f^\alpha$$

WITH CONFIDENCE:

$$\sum_{j}^{|V|} \sum_{k}^{|effects(v_j, s, \alpha)|} \theta(v_j, e_k, f^\alpha)$$

4.9.3.3 Against Local Tradeoff Precedent Analogy from Surplus Factor in Current Case

As pointed out above in section 4.9.3.1, analogies to precedents may be challenged by pointing out that there exists a factor in the current case disfavoring the side arguing for the analogy that is not part of the precedent but should still be part of the tradeoff, thereby weakening the analogy.

This argument scheme penalizes the analogy confidence in the amount of the sum of all effect weights associated with the surplus factor.

Definition 32. *Assume situation $s \in S$, arguing side α, precedent case p decided for opponent $\overline{\alpha}$ containing local tradeoff $E_i^+(p, F_i^{\overline{\alpha}}) > E_i^-(p, F_i^\alpha)$ and upper opponent argument antecedent that s analogous to p to establish that $E_i^+(s, F_i^{\overline{\alpha}}) > E_i^-(s, F_i^\alpha)$.*

IF:

$$s \textit{ has tradeoff } E_i^+(s, F_i^{\overline{\alpha}}) > E_i^-(s, F_i^{\alpha})$$

$$p \textit{ has tradeoff } E_i^+(p, F_i^{\overline{\alpha}}) > E_i^-(p, F_i^{\alpha})$$

$$\exists f^{\overline{\alpha}} : s \vdash f^{\overline{\alpha}}, p \nvdash f^{\overline{\alpha}}$$

$$f^{\overline{\alpha}} \in F_i^{\overline{\alpha}}$$

THEN ARGUE:

$$s \; \boldsymbol{not} \textit{ analogous to } p \textit{ because}$$

$$E_{i_s}^+(p, F_{i_s}^{\overline{\alpha}}) > E_i^-(p, F_{i_w}^{\alpha}) \textit{ was weaker than } E_{i_s}^+(s, F_{i_s}^{\overline{\alpha}}) > E_i^-(s, F_{i_w}^{\alpha})$$

$$\textit{due to pro } \overline{\alpha} \textit{ effects of } f^{\overline{\alpha}} \textit{ in } s$$

WITH CONFIDENCE:

$$\sum_{j}^{|V|} \sum_{k}^{|effects(v_j, s, \overline{\alpha})|} \theta(v_j, e_k, f^{\overline{\alpha}})$$

4.9.3.4 Against Local Tradeoff Precedent Analogy from Surplus Factor in Prec't

Similarly to the previous scheme, the analogy can be challenged based on a surplus factor in the precedent that favors the challenging party and should be part of the tradeoff, thereby weakening the analogy.

This argument scheme penalizes the analogy confidence in the amount of the sum of all effect weights associated with the surplus factor.

Definition 33. *Assume situation $s \in S$, arguing side α, precedent case p decided for opponent $\overline{\alpha}$ containing local tradeoff $E_i^+(p, F_i^{\overline{\alpha}}) > E_i^-(p, F_i^{\alpha})$ and upper opponent argument antecedent that s analogous to p to establish that $E_i^+(s, F_i^{\overline{\alpha}}) > E_i^-(s, F_i^{\alpha})$.*

IF:

$$s \textit{ has tradeoff } E_i^+(s, F_i^{\overline{\alpha}}) > E_i^-(s, F_i^{\alpha})$$

$$p \textit{ has tradeoff } E_i^+(p, F_i^{\overline{\alpha}}) > E_i^-(p, F_i^{\alpha})$$

$$\exists f^{\overline{\alpha}} : p \vdash f^{\overline{\alpha}}, s \nvdash f^{\overline{\alpha}}$$

$$f^{\overline{\alpha}} \in F_i^{\overline{\alpha}}$$

THEN ARGUE:

$$s \textbf{\textit{ not}} \textit{ analogous to } p$$

$$E_{i_s}^{+}(p, F_{i_s}^{\overline{\alpha}}) > E_i^{-}(p, F_{i_w}^{\alpha}) \textit{ was stronger than } E_{i_s}^{+}(s, F_{i_s}^{\overline{\alpha}}) > E_i^{-}(s, F_{i_w}^{\alpha})$$

$$\textit{due to pro } \overline{\alpha} \textit{ effects of } f^{\overline{\alpha}} \textit{ in } p$$

WITH CONFIDENCE:

$$\sum_{j}^{|V|} \sum_{k}^{|effects(v_j,s,\overline{\alpha})|} \theta(v_j, e_k, f^{\overline{\alpha}})$$

4.9.3.5 Example Textual Local Tradeoff Analogy Arguments

VJAP creates the following example argument for the defendant on *info-valuable* in AM-SKIER:

"Plaintiff's product information is not sufficiently valuable because plaintiff's information was about customers and suppliers. This outweighs the fact that the product information was unique.

In purposive terms, in AM-SKIER, the fact that plaintiff's property interest is less legitimate because of the information being about customers and suppliers and the general public's interest in the usability of public information is more relevant because of the information being about customers and suppliers outweighs the fact that the general public's interest in the usability of public information is less relevant because of the product's uniqueness and plaintiff's property interest is more legitimate because of the product's uniqueness.

The same tradeoff with regard to the value of the information was made in NATIONAL-REJECTORS, which was also decided for defendant.

There, plaintiff's product information was not sufficiently valuable because the information could have been learned by reverse-engineering. This outweighed the fact that the product information had been unique.

In purposive terms, in NATIONAL-REJECTORS, the fact that plaintiff's property interest was less legitimate because of the reverse-engineerability and the general public's interest in the usability of public information was more relevant because of the reverse-engineerability outweighed the fact that the general public's interest in the usability of public information was less relevant because of the product's uniqueness and plaintiff's property interest was more legitimate because of the product's uniqueness.

Defendant's position in AM-SKIER is even stronger than in NATIONAL-REJECTORS because here plaintiff's information was about customers and suppliers. This reinforces an argument that plaintiff's property interest is less legitimate and the general public's interest in the usability of public information is more relevant.

Plaintiff may argue that AM-SKIER is distinguishable from NATIONAL-REJECTORS because there the information could have been learned by reverse-engineering, which is not the case in AM-SKIER. Arguably, this made defendant stronger in the value tradeoff regarding the value of the information in NATIONAL-REJECTORS since plaintiff's property interest was less legitimate and the general public's interest in the usability of public information was more relevant because of the reverse-engineerability."

4.9.4 Arguments about Inter-Issue Tradeoff Precedent

4.9.4.1 For Inter-Issue Tradeoff Precedent Analogy This is the inter-issue equivalent of 4.9.3.1 and all explanations here apply similarly to this scheme. A side argues that a case and a precedent which share the same inter-issue tradeoff of interest are sufficiently analogous that the precedent lends persuasive force to the application of the tradeoff in the case at bar in favor of the arguing side. By virtue of both cases sharing the same tradeoff, the analogy argument is presumed to be valid and the confidence in it is the confidence of the tradeoff in the case at bar or the precedent, whichever is weaker.

Definition 34. *Assume situation $s \in S$, arguing side α, precedent case p decided for α containing inter-issue tradeoff $E^+_{i_s}(p, F^\alpha_{i_s} \cup F^\alpha_{i_w}) > E^-_i(p, F^{\overline{\alpha}}_{i_w})$ and upper argument antecedent that s analogous to p to establish that $E^+_{i_s}(s, F^\alpha_{i_s} \cup F^\alpha_{i_w}) > E^-_i(s, F^{\overline{\alpha}}_{i_w})$.*

IF:

$$s \textit{ has tradeoff } E^+_{i_s}(s, F^\alpha_{i_s} \cup F^\alpha_{i_w}) > E^-_i(s, F^{\overline{\alpha}}_{i_w})$$

$$p \textit{ has tradeoff } E^+_{i_s}(p, F^\alpha_{i_s} \cup F^\alpha_{i_w}) > E^-_i(p, F^{\overline{\alpha}}_{i_w})$$

THEN ARGUE:

$$s \textit{ analogous to } p \textit{ regarding } E^+_{i_s}(\{s/p\}, F^\alpha_{i_s} \cup F^\alpha_{i_w}) > E^-_i(\{s/p\}, F^{\overline{\alpha}}_{i_w})$$

WITH CONFIDENCE:

$$min(\phi_{lto}(\alpha, s, i), \phi_{lto}(\alpha, p, i))$$

This argument's verbalization is already covered by the verbalization of the upper argument for inter-issue tradeoff from precedent.

4.9.4.2 For Inter-Issue Tradeoff Precedent Analogy from Supporting Surplus Factor in Current Case

This is the analogous scheme for 4.9.3.2 for inter-issue tradeoff analogies.

Definition 35. *Assume situation $s \in S$, arguing side α, precedent case p decided for α containing inter-issue tradeoff $E^+_{i_s}(p, F^\alpha_{i_s} \cup F^\alpha_{i_w}) > E^-_i(p, F^{\overline{\alpha}}_{i_w})$ and upper argument antecedent that s analogous to p to establish that $E^+_{i_s}(s, F^\alpha_{i_s} \cup F^\alpha_{i_w}) > E^-_i(s, F^{\overline{\alpha}}_{i_w})$.*

IF:

$$s \textit{ has tradeoff } E^+_{i_s}(s, F^\alpha_{i_s} \cup F^\alpha_{i_w}) > E^-_i(s, F^{\overline{\alpha}}_{i_w})$$

$$p \textit{ has tradeoff } E^+_{i_s}(p, F^\alpha_{i_s} \cup F^\alpha_{i_w}) > E^-_i(p, F^{\overline{\alpha}}_{i_w})$$

$$\exists f^\alpha : s \vdash f^\alpha, p \not\vdash f^\alpha$$

$$f^\alpha \in F^\alpha_{i_s} \cup F^\alpha_{i_w}$$

THEN ARGUE:

$$s \textit{ analogous to } p$$

$$E^+_{i_s}(s, F^\alpha_{i_s} \cup F^\alpha_{i_w}) > E^-_i(s, F^{\overline{\alpha}}_{i_w}) \textit{ is even stronger than } E^+_{i_s}(p, F^\alpha_{i_s} \cup F^\alpha_{i_w}) > E^-_i(p, F^{\overline{\alpha}}_{i_w})$$

$$\textit{due to pro } \alpha \textit{ effects of } f^\alpha \textit{ in } s$$

WITH CONFIDENCE:

$$\sum_j^{|V|} \sum_k^{|\mathit{effects}(v_j,s,\alpha)|} \theta(v_j, e_k, f^\alpha)$$

4.9.4.3 Against Inter-Issue Tradeoff Precedent Analogy from Supporting Surplus Factor in Current Case

This is the analogous scheme for 4.9.3.3 for inter-issue tradeoff analogies.

Definition 36. *Assume situation $s \in S$, arguing side α, precedent case p decided for opponent $\overline{\alpha}$ containing inter-issue tradeoff $E^+_{i_s}(p, F^{\overline{\alpha}}_{i_s} \cup F^{\overline{\alpha}}_{i_w}) > E^-_i(p, F^\alpha_{i_w})$ and upper opponent argument antecedent that s analogous to p to establish that $E^+_{i_s}(s, F^{\overline{\alpha}}_{i_s} \cup F^{\overline{\alpha}}_{i_w}) > E^-_i(s, F^\alpha_{i_w})$.*

IF:

$$s \textit{ has tradeoff } E^+_{i_s}(s, F^{\overline{\alpha}}_{i_s} \cup F^{\overline{\alpha}}_{i_w}) > E^-_i(s, F^\alpha_{i_w})$$

$$p \textit{ has tradeoff } E^{+}_{i_s}(p, F^{\overline{\alpha}}_{i_s} \cup F^{\overline{\alpha}}_{i_w}) > E^{-}_{i}(p, F^{\alpha}_{i_w})$$

$$\exists f^{\overline{\alpha}} : s \vdash f^{\overline{\alpha}}, p \nvdash f^{\overline{\alpha}}$$

$$f^{\overline{\alpha}} \in F^{\overline{\alpha}}_{i_s} \cup F^{\overline{\alpha}}_{i_w}$$

THEN ARGUE:

$$s \textit{ \textbf{not} analogous to } p \textit{ because}$$

$$E^{+}_{i_s}(p, F^{\overline{\alpha}}_{i_s} \cup F^{\overline{\alpha}}_{i_w}) > E^{-}_{i}(p, F^{\alpha}_{i_w}) \textit{ was weaker than } E^{+}_{i_s}(s, F^{\overline{\alpha}}_{i_s} \cup F^{\overline{\alpha}}_{i_w}) > E^{-}_{i}(s, F^{\alpha}_{i_w})$$

$$\textit{due to pro } \overline{\alpha} \textit{ effects of } f^{\overline{\alpha}} \textit{ in } s$$

WITH CONFIDENCE:

$$\sum_{j}^{|V|} \sum_{k}^{|e(v_j, s, \overline{\alpha})|} \theta(v_j, e_k, f^{\overline{\alpha}})$$

4.9.4.4 Against Inter-Issue Tradeoff Precedent Analogy from Opposing Surplus Factor in Precedent This is the analogous scheme for 4.9.3.4 for inter-issue tradeoff analogies.

Definition 37. *Assume situation $s \in S$, arguing side α, precedent case p decided for opponent $\overline{\alpha}$ containing inter-issue tradeoff $E^{+}_{i_s}(p, F^{\overline{\alpha}}_{i_s} \cup F^{\overline{\alpha}}_{i_w}) > E^{-}_{i}(p, F^{\alpha}_{i_w})$ and upper opponent argument antecedent that s analogous to p to establish that $E^{+}_{i_s}(s, F^{\overline{\alpha}}_{i_s} \cup F^{\overline{\alpha}}_{i_w}) > E^{-}_{i}(s, F^{\alpha}_{i_w})$.*

IF:

$$s \textit{ has tradeoff } E^{+}_{i_s}(s, F^{\overline{\alpha}}_{i_s} \cup F^{\overline{\alpha}}_{i_w}) > E^{-}_{i}(s, F^{\alpha}_{i_w})$$

$$p \textit{ has tradeoff } E^{+}_{i_s}(p, F^{\overline{\alpha}}_{i_s} \cup F^{\overline{\alpha}}_{i_w}) > E^{-}_{i}(p, F^{\alpha}_{i_w})$$

$$\exists f^{\overline{\alpha}} : p \vdash f^{\overline{\alpha}}, s \nvdash f^{\overline{\alpha}}$$

$$f^{\overline{\alpha}} \in F^{\overline{\alpha}}_{i_s} \cup F^{\overline{\alpha}}_{i_w}$$

THEN ARGUE:

$$s \textit{ \textbf{not} analogous to } p \textit{ because}$$

$$E^{+}_{i_s}(s, F^{\overline{\alpha}}_{i_s} \cup F^{\overline{\alpha}}_{i_w}) > E^{-}_{i}(s, F^{\alpha}_{i_w}) \textit{ is weaker than } E^{+}_{i_s}(p, F^{\overline{\alpha}}_{i_s} \cup F^{\overline{\alpha}}_{i_w}) > E^{-}_{i}(p, F^{\alpha}_{i_w})$$

$$\textit{due to pro } \overline{\alpha} \textit{ effects of } f^{\overline{\alpha}} \textit{ in } p$$

WITH CONFIDENCE:

$$\sum_{j}^{|V|} \sum_{k}^{|e(v_j,s,\overline{\alpha})|} \theta(v_j, e_k, f^{\overline{\alpha}})$$

4.9.4.5 Example Textual Inter-Issue Tradeoff Analogy Arguments VJAP creates the following example argument for the plaintiff on *maintain-secrecy* in ILG-INDUSTRIES:

> "The plaintiff has taken efforts to maintain the secrecy of the information because disclosures to outsiders were subject to confidentiality restrictions. In fact, plaintiff's product information is so valuable that plaintiff must enjoy a lower standard to prove that the plaintiff has taken efforts to maintain the secrecy of the information because deciding otherwise would be inconsistent with the purposes underlying trade secret law.
>
> Specifically, regarding the value of the information, the product's uniqueness amounts to no scenario where usability of public information would be important and such a legitimate property interest regarding the value of the information that the confidentiality of outside disclosures alone must qualify as the maintenance of secrecy by the plaintiff despite the fact that plaintiff disclosed its product information to outsiders.
>
> A similar inter-issue tradeoff was made in ALLEN, which was decided for plaintiff. There, regarding the value of the information, the competitive advantage amounted to such a legitimate property interest and the product's uniqueness amounted to no scenario where usability of public information would be important and such a legitimate property interest that the maintenance of secrecy by the plaintiff was deemed sufficiently established despite the lack of strong evidence for plaintiff and fact that plaintiff had not adopted any security measures.
>
> Defendant may argue that ILG-INDUSTRIES is distinguishable from ALLEN because there access to the product information had saved time or expense, which is not the case in ILG-INDUSTRIES. Arguably, this made plaintiff stronger in the value tradeoff regarding the value of the information in ALLEN since plaintiff's property interest was more legitimate because of the competitive advantage.
>
> Defendant may argue that ILG-INDUSTRIES is distinguishable from ALLEN because there plaintiff had disclosed its product information to outsiders, which was not the case in ALLEN. Arguably, this makes plaintiff stronger in the value tradeoff regarding the value of the information in ILG-INDUSTRIES since plaintiff had waived his property interest and plaintiff had waived his confidentiality interest because of the disclosure to outsiders."

5.0 THE EXPERIMENT

5.1 DATA

The original IBP case collection comprises 186 cases as reported in [AB06]. Each case consists of a subset of 26 factors representing common fact patterns in trade secret cases as well as the year in which it was decided. The annotation of the cases with these factors were done by domain experts over the course of prior work on HYPO, CATO and IBP (see section 6.2.1).

Some of these 185 cases contain exclusively pro-plaintiff or pro-defendant factors. For purposes of our tradeoff-based system, these are of little use as predicting them correctly is straightforward and does not involve any tradeoff-based argumentation.

Hence, in this experiment, we use a subset of the IBP dataset comprising of 121 (74 plaintiff, 47 defendant) cases that have at least one factor for both plaintiff and defendant, thereby allowing balancing arguments. The removal of these cases also explains the difference in performance of the IBP system and the machine learning baselines published in [AB06].

In these 121 cases, seven cases turned out to have identical features (i.e. sets of factors), As very similar cases are not implausible in a legal setting, these seven cases were not removed from the data set. Also, a number of cases are sub-/supersets of other cases, leading to occasional *a fortiori* arguments.

Conceptual development, implementation and error analysis focused on a small set of representative development cases.[1]

[1]DYNAMICS, DICKS, JOSTENS, EASTERN-MARBLE, KG, FRANKE, ALLEN, AM-SKIER, ILG-INDUSTRIES

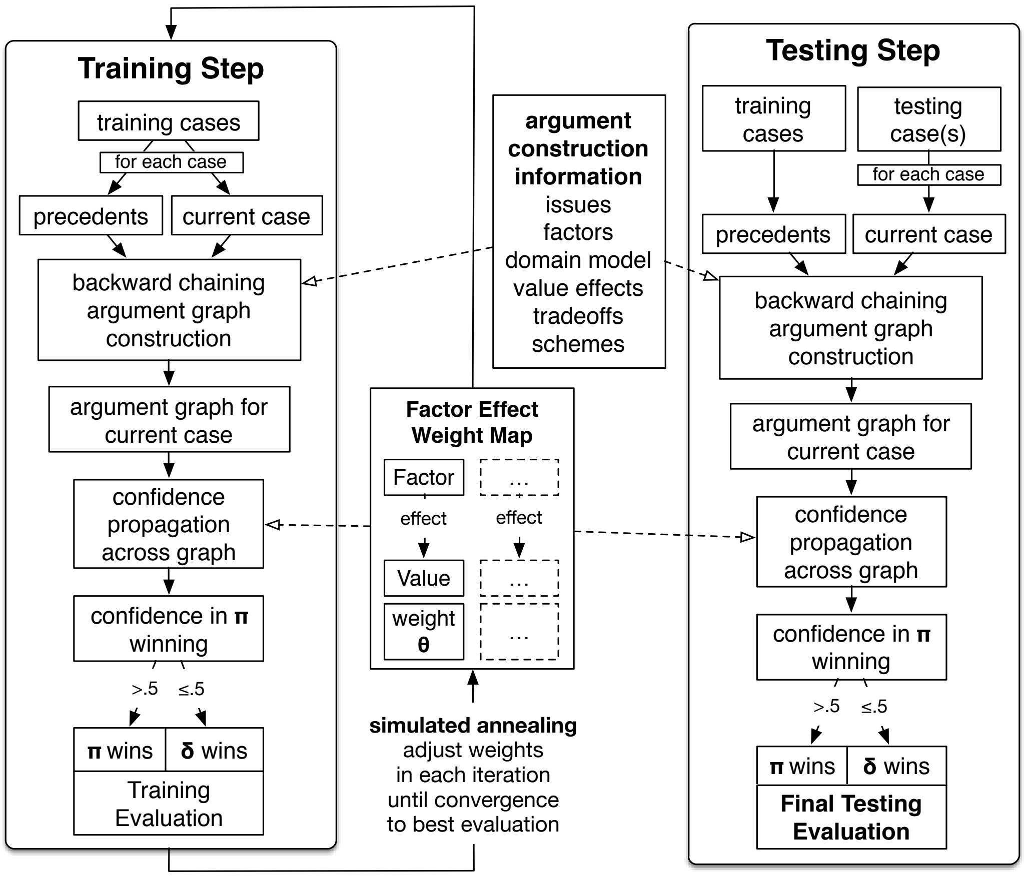

Figure 13: Diagram of VJAP's system architecture for training and testing

Fig. 13 shows a diagram of the The VJAP experimental system and its flow of training and testing step. The system was implemented in Clojure with the help of open source libraries for HTML export, profiling and various smaller components.

In training, the system generates an argument graph for every case in the training set by instantiating argument schemes in a backward chaining method top down starting from the top issue of whether the plaintiff has a claim for a trade secret misappropriation down to arguments about analogies and distinctions between the case and precedents (see algorithm 34). Once the graph is constructed, the system computes the confidence of said statement regarding the plaintiff's claim by using the factor effect weight map parameters to calculate the confidence of the leaf-nodes of the argument graph (see the bottom row in Fig. 12). These initial confidence values are then propagated bottom up (or 'feed forward' in neural network terminology) using the confidence functions of the argument schemes (see the confidence functions in the scheme definitions in 4.9) and the proportional confidence and propmax confidence functions for statements (see section 4.8.1 and Fig. 12).

The root node of the graph represents the issue of whether the plaintiff has a claim for a trade secret misappropriation. Once this node's confidence has been determined, it is compared against a prediction threshold of .5, where the case is predicted as being won by the plaintiff if the confidence exceeds this threshold. If it does not, then the plaintiff is predicted as the winner.

In the training step, this top down graph construction, bottom up confidence propagation and winner prediction is done for every case in the training set, after which the overall prediction accuracy is then determined. In the test step, the same is done for the cases in the test set with the qualification that, in testing, argument graphs for test cases can only be constructed using the training cases as precedents. In the training step, the system tries to learn optimal fact effect weight parameters to maximize prediction accuracy. To accomplish this, the construction-propagation-prediction pattern happens in a loop during which the system iteratively searches for the optimal weight map using a technique called *simulated annealing* [SK83].

In simulated annealing as implemented in VJAP, the training loop is run for a predefined number of iterations and the parameters (i.e. the weights of the fact effects on values) are adjusted at each iteration by replacing one random effect weight with a new random effect weight, thus generating a 'neighboring' weight map to the current one. This new weight map is then evaluated through confidence propagation and overall prediction accuracy. If the neighboring weight map is better or equally good, it replaces the current weight map and the algorithm goes on into the next cycle.

If the new weight map performs worse, then the system will nevertheless make it the current weight map with a small probability that is computed (using a 'cooling schedule' function) from the system's 'temperature', which is a function of the remaining and total number of cycles in the annealing process. The intuition is that, by occasionally taking a 'bad move', the search is less likely to get stuck in local optima in the multidimensional space of possible weight map parameters. Details of VJAP's implementation of simulated annealing are given in algorithm. 25.

At the end of the annealing process, the best found weight map is kept and the system moves on to the testing step. There, the test cases are predicted in the same construction-propagation-prediction fashion by simply using the trained effect weight parameters without any more optimization. The final accuracy is the number of correctly predicted test cases over the number of all test case predictions.

5.3 BASELINE EXPERIMENTAL CONDITIONS

As baselines for evaluating the VJAP prediction performance, we use the following prediction system configurations.

- **major-label**: The most simple baseline always predicting the label of the majority of the cases in the dataset, which is that the plaintiff wins the case.
- **Naive Bayes**: A simple Naive Bayes classifier which performed second-best in an earlier evaluation of IBP [BA03b].
- **Decision Tree**: A C4.5 decision tree learner [Qui14] which was the second-best performing baseline in [BA03b]. We chose decision trees over support vector machines because of the small dataset.
- **IBP**: A reimplementation of IBP's prediction algorithm given its historical assumptions regarding the domain model and factor associations as explained in section 4.3.2. It was reimplemented to the best of the author's ability from available documentation.
- **IBP-noEE**: The same reimplementation of IBP, but without the functionality of explaining away counterexamples using knockout factors and abstaining instead. As explained in section 4.3.2, this is to evaluate IBP's prediction algorithm without the benefit of knowing the impact of certain factors beforehand.

All standard machine learning models were trained using Weka 3.6.13 [HFH+09].

5.4 VJAP EXPERIMENTAL CONDITIONS

The following experimental configurations of the VJAP system were tested for their predictive performance:

- **Global Tradeoff Weight (GTW)**: Cases are predicted by whichever side has the highest total effect weight (see section 2.2.1) with the case going to the plaintiff in case of a tie.
- **VJAP-full**: Cases are predicted using the full argument graph including local and inter-issue tradeoff-based arguments. If the confidence in the plaintiff's argument for a trade secret misappropriation surpasses the decision threshold of .5, plaintiff is predicted as winner, otherwise defendant.
- **VJAP-local**: As VJAP-full, but only local tradeoff argument schemes are used. This condition is conceptually similar to IBP-noEE as factor conflict resolution only happens inside an issue and quantifies the impact of inter-issue-tradeoffs.
- **VJAP-no-precedent**: As VJAP-full, but without precedent-based argument schemes, i.e. tradeoffs are solely resolved on the basis of effect weights. Results will be compared with the performance of GTW to examine the impact of scoping the global tradeoff into smaller issue-based tradeoffs.
- **VJAP-timeline**: As VJAP-full, but with the restriction that cases may only be argued on the basis of cases that had been decided at least one year before the year of the case to be predicted. The goal is to assess the system's ability to reason with no or little precedent in some cases and many possible precedent cases in others and to examine which precedents are relied on the most by later cases.

5.5 EXPERIMENT CONFIGURATION

Both experimental conditions and baseline models were evaluated as to their accuracy in a leave-one-out experiment over the full case base and a 5-fold cross validation. The system first learns factor effect parameters using training cases and then predicts the test cases in single execution of the two steps shown in Fig. 13. The accuracy measure then reflects the system's performance on the test cases.

In leave one out, the two steps are executed 121 times, each time another case becomes the 'single case test set' and the remaining 120 cases function as the training set. The accuracy measure is the computed over all the individual predictions of all 121 runs. In 5-fold cross validation, the 121 cases were randomly assigned to 5 sets of about equal size. During each of five runs, a different set functions as the test and the remaining four sets as training data. It should be noted that the nine development cases mentioned above were used in both the leave-one-out and cross-validation condition. For all VJAP and IBP models, the same 5 cross-folds were used. Weka's cross validation function was used for the naive bayes and decision tree baselines resulting in different random foldings for these two conditions.

Unless otherwise specified, all VJAP experiments were run using a simulated annealing algorithm (see Fig. 25) with a linear cooling schedule [SK83] on 300 iteration, for the first 25% of which a full new random weight map was generated. For the remaining iterations the last best random weight map was modified by replacing a random weight with a new random value between 0.00 and 0.99 in 0.01 increments. The intention behind this discretization lies in the original intent to implement the VJF with an even coarser scheme of 0.0 to 0.9 in .1 increments for the weights. This would be more reminiscent of the qualitative degrees of influence (see definition 7) which were used in the first publications of the formalism in [GA10, GA11, GA13b].

5.6 RESULTS

5.6.1 Prediction Performance Evaluation

The prediction performance of VJAP and baseline models is compared only in an exploratory demonstration without subjecting the results to statistical significance tests. This is due to the small size and characteristics of the dataset. First, the IBP set of trade secret cases has not been created by annotating a random sample of trade secret cases with factors.

Algorithm 5.1 annealing algorithm for VJAP conditions

input: training case-base C, number of iterations n
generate random θ
do simulated annealing over n iterations:
for all $i = 1..n$ **do**
  $\theta' \leftarrow$ random neighbor of θ
  for all $c_j \in C$ **do**
    generate c_j's argument graph (or load if cached)
    predict c_j by propagating confidence across c_j's argument graph:
    if $\phi(p_\pi | c_j, \theta') >$ decision threshold **then**
      predict π, else δ
    end if
  end for
  $acc^i \leftarrow$ prediction accuracy over all $c_j \in C$
  if $acc^i > acc*$ **then**
    $acc* \leftarrow acc^i$
    $\theta* \leftarrow \theta'$
    $\theta \leftarrow \theta'$
  else
    if $acc^i = acc^{i-1}$ **then**
      $\theta \leftarrow \theta'$
    else
      with probability $e^{-\frac{acc^{i-1} - acc^i}{\frac{i}{n}}}$: $\theta \leftarrow \theta'$
    end if
  end if
end for

Rather, the cases were manually chosen to be included to produce a case base with sufficient coverage of issues and factors. Hence, one cannot speak of the cases as having been randomly sampled from a population. It should be noted that, to the best knowledge of the author, the IBP dataset is the only case factor and outcome dataset of its kind. Second, since the case outcome is a binary prediction, appropriate data points for a T-Test or other method would have to be the accuracy of the models on k cross folds. Given that the dataset only comprises of 121 cases, k has to be small. As stated, this experiment uses $k = 5$.

In a hypothetical statistical test for whether VJAP performs similar to the baselines, one would then compare whether there is a statistically significant difference between the set of k data points for VJAP's best performing model on each fold versus those of the best baseline. Here k data points in each sample will inevitably be too small to do a reasonable test for which type of distribution the points follow. Finally even if one were to assume that the accuracies were normally distributed and would do a T-test on the two samples with, say, 5 data points each, the resulting significance p-value would only speak as to the confidence in not making a type 1 error, i.e. rejecting the true hypothesis that the means of both populations are equal if it were in fact true. The statistical power of that T-test (i.e. the confidence in not failing to reject said hypothesis if it were in fact false, a type 2 error) would be very low due to the small sample size.

Hence, the prediction performance of VJAP and baseline models is compared only in an exploratory demonstration and a confirmation of the results in an empirical evaluation of sufficient size is left for future work. Fig. 5.6.1 presents the prediction performance results. All measures are accuracy, i.e. number of correct predictions over the total number of predictions made. Average training accuracy and standard deviation across folds is reported for the prediction methods where it was available from. Specifically, they are not given for naive bayes and decision trees because the standalone version of Weka does not provide these quantities by default without a manual implementation. Also, training error for IBP models is not available because IBP does not have a training stage but rather uses its repository of cases directly in the prediction process (see algorithm 31).

model	LOO	train	5-fold	train	fold-SD
GTW	.802	.84	.805	.845	.059
VJAP-full	.793	.828	.779	.837	.046
VJAP-local	.694	.717	.691	.725	.095
VJAP-no-precedent	.711	.727	.715	.73	.097
VJAP-timeline	.843	.854	.821	.862	.079
major-label	.612	*n/a*	.612	*n/a*	*n/a*
naive-bayes	.843	*n/a*	.851	*n/a*	*n/a*
decision tree	.777	*n/a*	.835	*n/a*	*n/a*
IBP	.81	*n/a*	.725	*n/a*	.112
IBP-noEE	.587	*n/a*	.562	*n/a*	.14

Table 1: Results table of predictive accuracy of baseline and experimental models.

5.6.1.1 VJAP vs. Machine Learning Baseline The results of the cross-validation runs are close to those of the leave one out experiment for all experimental conditions. VJAP-full and VJAP-timeline perform slightly worse, the apparent reason for which is likely less training data in the cross fold than in the leave on out condition. Among the baselines, naive bayes performs better during cross-validation (.851) condition than in leave-one-out (.843). C4.5 decision trees performs slightly worse on leave one out (.777) yet performs second best (.835) in the cross-validation condition.

A plausible explanation for this is that, as is not uncommon among decision tree models, it suffers from overfit in the leave one out and shows some effect of the sampling artifact in the train-test condition. Five folds in cross-validation then reduce overfit and allow the model to perform better. Due to VJAP-full and VJAP-timeline performing slightly worse than in leave-one-out, naive bayes and decision tree baselines perform best during cross validation, albeit by only a small margin above VJAP-timeline.

5.6.1.2 VJAP vs. IBP IBP's prediction algorithm as published in [AB06] was reimplemented. As discussed in section 4.3.2, IBP used a slightly different domain model and different factor associations, the most visible being the non-use of $F11_\delta$[vertical-knowledge] . This historical model was used as the author does not claim that the domain model and factor association assumptions made in the development of VJAP are the single correct model.

IBP performs at .81 in the leave one out condition. In cross-validation, the model degrades to .725, which can be explained by the fact that IBP's prediction algorithm uses the cases directly as points of reference without any separate trained parameters like the VJAP models have in the form of the $\theta(...)$ weight map tuples. IBP is hence more severely affected by the cross-validation because a smaller case base means strictly less information for IBP versus VJAP which works with its full set of parameters, even if less training data is available to train them.

The VJAP model that is conceptually closest to IBP is VJAP-local, which uses local tradeoff argument in a way similar to IBP's issue analysis and theory testing. However, IBP usually performs better than VJAP-local, which may be due to IBP's limited ability to reason across issues using the hand-flagged knockout factors, which VJAP-local does not have. When IBP is deprived of this knockout factor functionality in the IBP-noEE condition, its performance drops below that of the major label baseline. The best performing experimental condition, VJAP-timeline, consistently outperforms IBP.

IBP's earlier experiments in [BA03b] were done on the full 185 case dataset and reported a .91 accuracy in the leave one out condition. To test reproducibility of the historical results, two small leave-one-out side experiments were conducted with the reimplementation and assessed as to predictive accuracy:

- full 185 full case base with IBP's original domain model: .854
- full 185 full case base with VJAP's domain model and $F11_\delta$: .79

The reimplemented version of IBP with the original domain model and factor assignments achieved .854 accuracy. However, despite efforts to produce the best reimplementation from the available documentation, the author was not able to reproduce the reported .91 accuracy on the 185 case dataset. With the available IBP documentation, the author could not say with certainty which assignment of factors to leaf issues was used in the model whose performance reached .91. Also, for lack of precise documentation, the author understood IBP's behavior as presuming unraised issues in favor of the plaintiff.

5.6.1.3 Comparison Among VJAP Models In leave one out, the GTW baseline using a linear combination of effect weights performs surprisingly well at .802 which is about the same as VJAP-full. Also, GTW's performance does not degrade in the cross-validation condition, suggesting that the argument-based VJAP models are more dependent on having access to a larger pool of training cases and citable precedents for argument construction.

VJAP-full performs at .793 in leave one out and decreases to .779 in cross validation. VJAP-local (.694) and VJAP-noprecedent (.711) perform significantly worse and do not degrade during cross-validation. For VJAP-noprecedent, this can be explained by the fact that it does not use cases in prediction but only tradeoff arguments. Similar to GTW, it hence predicts on the basis of weight effect parameters alone which makes it less dependent on sufficient amounts of training data.

The poor performance of VJAP-local confirms what IBP-noEE's degradation has hinted at, namely that reasoning in the logically connected domain model alone without recourse to some plus/minus interactions across leaf issues predicts badly. IBP-noEE fails under this condition because it cannot refer to its knockout factors. VJAP-local performs badly because it does not have access to inter-issue tradeoffs.

This is strong evidence for VJAP's systemic assumption that requirements of legal rules are not semantically separated from each other. Rather, they re interdependent regarding the question of whether one specific requirements is deemed fulfilled given the specific facts of the case, the fulfillment of its 'semantically connected requirements', and the raised purposive concerns. In other words, legal rules discretize and structure the legal decision process, but they do not segment the case assessment into smaller issues which can be decided in isolation.

VJAP-full uses all available argument schemes and performs significantly better than VJAP-noprecedent, which suggests that arguing exclusively with tradeoff arguments fails to account for the normative force of the principle that cases, when litigated, are decided with recourse to prior case law. Hence, adherence to precedent established itself as a fifth quasi-value next to the four values VJAP models explicitly and, when taken into account through precedent argument schemes, contributes to the higher predictive power of VJAP-full and VJAP-timeline.

VJAP-timeline uses the same set of argument schemes as VJAP-full but restricts case-based arguments to temporally plausible ones given the chronology of the case dataset. It produces the best prediction performance of all VJAP models in the leave one out (.843, on par with naive bayes) and cross validation conditions (.821, slightly lower than the highest machine learning baseline). The plus in accuracy comes at the cost of a higher standard deviation across the folds (.079) when compared to VJAP-full (.046). This suggests that the restriction to temporally plausible precedent arguments makes the system more sensitive to folding because it reduces the scope of possible precedents for cases even further. VJAP's unrestricted ability use all available training cases as precedents seems to produce a more stable prediction performance.

As will be explained in section 5.6.2.2, a comparison of weight maps further reveals that VJAP-timeline learns different weights than GTW. This means that linear GTW and non-linear VJAP models are not equivalent in terms of the weight the parameters assign to legal values in the domain of discourse.

5.6.2 Exploratory Analysis

5.6.2.1 Decision Threshold Variation All experimental conditions have been run with a plaintiff confidence decision threshold of 0.5, i.e. if the confidence of the case situation entailing the top level issue is greater than 0.5, the case is predicted for the plaintiff and for the defendant otherwise.

This threshold was deliberately set at the beginning of the experiment work with the assumption that the simulated annealing optimization is able to adapt the weights accordingly and the weight maps created across runs are comparable (see section 5.6.2.2). In a more traditional machine learning setting, the decision threshold could be a another parameters and learned from data as well.

To assess the impact of assuming a static threshold, the best performing experimental condition VJAP-timeline has been run on the full dataset over 18 iterations with decision thresholds from .05 to .95 in .05 increments. A threshold of 0 is presumed to result in an all-plaintiff prediction and a threshold of 1 in an all-defendant prediction. Fig. 14 shows the resulting receiver operating characteristic (ROC) and accuracy tradeoff curves.

The ROC plot has a curve for plaintiff and defendant predictions each. It can be seen that the best tradeoff for both plaintiff and defendant prediction performance is around the .85 true positive / .15 false positive 'ledge'. The same point beyond which overall performance declines can be seen in the accuracy tradeoff plot on the right at around .85/.85.

Fig. 15 shows how setting the prediction threshold impacts prediction accuracy for plaintiff cases, defendant cases and the whole case base. Prediction performance peaks around the middle of the threshold around .45, which corresponds to the point right before the 'ledge' we have seen in Fig. 14. This is close enough to the set threshold of .5 so that no serious objections arise regarding whether the trained models make suboptimal use of their predictive capacity and potentially making the system's behavior less informative.

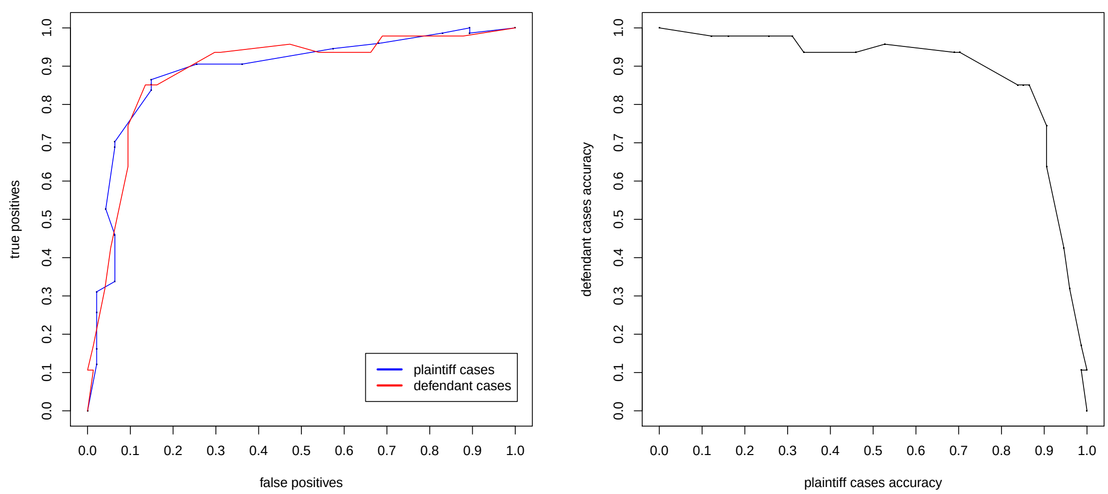

Figure 14: ROC curves (left) and accuracy tradeoff curve (right)

5.6.2.2 Weight Map Analysis At each of the 121 runs of VJAP-timeline's and GTW's leave-one-out condition, the best trained weight map was saved. The result is a dataset of

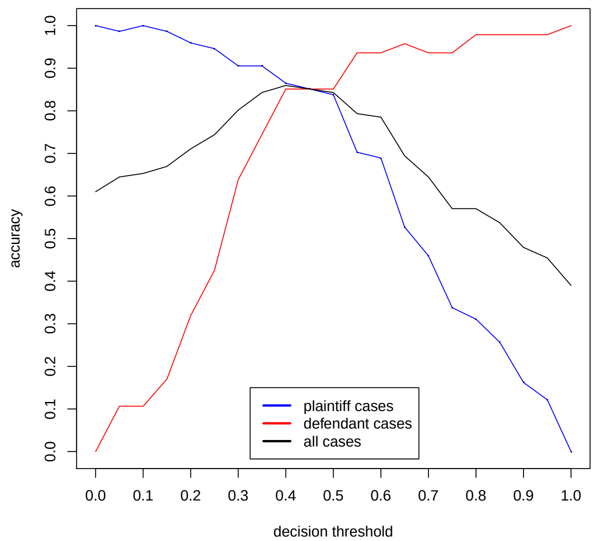

Figure 15: prediction accuracies for different thresholds

121 'trained weights' for every one of the 55 weight parameters in the VJAP model. Fig. 16 shows paired histograms for three exemplary effect weights in a VJAP-timeline (left) versus GTW comparison (right). The Y axes designate the spectrum of possible values of the weight parameter in the [0, 1] interval. The X axes show the number of runs (of the 121 in the leave-one-out condition) in which the final trained weight for the effect parameter fell into a certain segment of the Y axis intervals.

The top-most pair of histograms show the weight attached to the protective effect of $F13_{\pi}$ on the plaintiff's confidentiality interest. In VJAP-timeline, the weight is trained with uniform-appearing distribution of values over all runs. In GTW, by contrast, it shows a strong tendency to be trained with low weight value.

The middle pair of histograms shows the distribution of weight values for $F11_{\delta}$'s legitimizing effect on the general public's interest in the usability of public information. There, VJAP-timeline strongly tends to learn this parameter as one of low weight. GTW also seems to favor low values over high ones, but with a flatter overall distribution.

The histograms at the bottom show the distribution of the learned weights for the waiver effect of $F19_{\delta}$ on plaintiff's property interest. Both VJAP-timeline and GTW tend to assign higher weight to this parameter, but again with VJAP-timeline making the tendency much more pronounced.

A complete analytic comparison of the full set of trained weight distributions and their interpretation in the context of the trade secret domain is beyond the scope of this experiment and left for future work. The observation that, when optimized for prediction performance, the two models generate different weight maps is evidence that VJAP's argument model (which is, in machine learning terms, nonlinear in a very structured way) is able to make better use of the learned weights than a non-argument-based linear model is.

Two box-plot diagrams with the full distributions of all weights for VJAP-timeline and GTW can be found in appendix F.

5.6.2.3 Citation Graph Analysis VJAP-timeline uses argument schemes to predict case outcomes through argumentation involving prior cases. As has been established in the discussion of the predictive performance results, this argumentative interrelation of cases matters in that it becomes predictive information that is not represented in a parameter but inherent in VJAP's argumentative inference technique. This resembles real legal reasoning, where cases, over the course of time, form a system (or 'theory' [McC95, BCS03]) of the domain. Constructing citation graphs of large collections of legal decisions has become a more and more popular sense-making technique among legal experts (e.g. [BIKZ09]).

To produce such a citation graph for the VJAP-timeline condition, a reference weight map was trained on the full 121 cases dataset for the VJAP-timeline condition for 500 iterations (achieving a training error of .859) and saved. Using this reference weight map, the system generated the strongest plaintiff and defendant argument for all five leaf issues of the domain model. If the strongest argument for a given side is a tradeoff-based argument that involved a precedent analogy, we call it a *tradeoff analogy citation*. Fig. 17 gives a bird's eye view of the generated chronological display of all cases and their tradeoff analogy citations for each plaintiff and defendant. It must be emphasized that the citation links as produced by VJAP timeline do not necessarily reflect the real citations in the opinions of these cases. Rather, they reflect on which precedents VJAP relies to predict a given case using tradeoff arguments.

One can recognize that the network forms a complicated web in which a small number of decisions are cited by VJAP-timeline very often while others are not. Also, as can be seen when zoomed in, some of the most cited cases have no incoming arcs at the top, meaning that the arguments VJAP makes for these cases are tradeoff arguments without reference to a prior case. In legal jargon these are called 'cases of first impression' which, as the timeline progresses, become frequently cited 'landmark cases'.

Also, influential cases tend to have complex fact situations, which in turn require a more elaborate decision and complex balancing. In the VJAP model, this corresponds to cases having many factors. Because of the many factors, they contain many possible tradeoffs and, accordingly, can be cited by a number of subsequent cases with fewer factors. These cases, in turn, tend to be less cited because they are less complex. Fig. 18 shows an excerpt of the citation graph where two frequently cited complex cases (STRUCTURAL-DYNAMICS and MOTOROLA) are cited by four simpler cases which in turn are not cited by subsequent cases. The latter can be seen because they do not have incoming edges at the bottom side.

Another phenomenon that seems to manifest intelligence is that in sparser areas of the graph, smaller specialized 'lines of cases' are formed. Cases along such a lines will typically be less complex than landmark cases, but very similar to each other.

Fig. 19 shows such a line of cases for the defendant, which traverses CORROON, FREEDONIA and OPTIC-GRAPHICS with the latter three being instances of cases with identical factors but decided at different points in time. As can be seen from the top outgoing edges, FREEDONIA cites CORROON for one argument along with a second case which is outside the picture to the left. DWORKIN is identical to FREEDONIA, but relies on both FREEDONIA and the more influential CORROON but not the off-screen case to the left. OPTIC-GRAPHICS then relies entirely on DWORKIN.

In VJAP-timeline, identical cases at different points in time show different citation patterns. A possible objection is that the citation graph only shows references to prior cases in the strongest argument in each issue of a case. There may be multiple 'strongest' arguments in a case with identical confidence that each refer to a different prior case. In such situations, the choice of which argument's reference to a precedent to display in the graph could be characterized as partly arbitrary. However, even given the possibility of such choices occurring, the citation graph produced by VJAP-timeline does not resemble the result of an artificial clustering algorithm but exhibits patterns typical of real citation graphs of legal decisions.

5.6.2.4 Incorrectly Predicted Cases Fig. 20, 21, 22 and 23 show cases that VJAP regularly predicts incorrectly.

ALLEN in Fig. 20 is typically incorrectly predicted for the defendant. One can see that the defendant is unambiguously favored on *maintain-secrecy* and *wrongdoing* but still loses the case. In order to predict it correctly, VJAP needs to have the two plaintiff factors outweigh these two defendant-favoring issues by means of inter-issue tradeoffs. Interestingly, in VJAP-timeline, ALLEN cannot cite any precedent case for supporting these tradeoffs since it was decided in 1958 and no prior decision is sufficiently similar. This way, the tradeoff arguments miss out on the added persuasiveness of a precedent backing.

AL-LABORATORIES 21 is also typically wrongly predicted for the defendant. It only has one factor for each plaintiff and defendant, each causing unambiguous issues for their side. Similar to ALLEN, defendant's unambiguous position on *maintain-secrecy* would have to be outweighed by means of an inter-issue tradeoff. However, because the case has only two factors, it is to specific that VJAP cannot find any precedent except for, interestingly, ALLEN.

ALLEN and AL-LABORATORIES suggest a pattern that cases with issues that unambiguously favor the defendant can only be predicted correctly by means of inter-issue tradeoffs. These in turn appear to require precedent cases to acquire enough argument confidence to trump defendant's arguments from the unambiguous issue.

The final example of a typically incorrectly predicted case is THOMAS in Fig. 22, which was also incorrectly predicted for the defendant even though she has no unambiguous issue, and the plaintiff has twice as many factors. With the weight map trained for VJAP-timeline at the time of extracting this example, the plaintiff argument's confidence was .486, which is just shy of the .5 threshold. Also, only two precedent cases could be found for THOMAS even though it was decided in 1975.

This suggests that VJAP, when trained over more annealing iterations, could learn to correctly predict THOMAS consistently. On the other hand, one or more 'quasi-complementary' cases may exist which outweigh it in training, i.e. THOMAS and a hypothetical other case could not not be predicted correctly. A typical example of a case that cannot be predicted correctly based on an inter-issue tradeoff without presumably forcing other cases to be predicted incorrectly is FRANKE 23. There, the plaintiff wins solely because of $F26_{\pi}$[deception] despite three factors and two unambiguous issues for the defendant. Note that it was decided as early as 1953 and hence cannot back up its inter-issue tradeoffs with precedents. $F26_{\pi}$ would have to be weighted very highly to predict it correctly, possibly so high as to cause incorrect predictions in other cases. A study of such complementarity relationships among cases in value-based argumentation is left for future work.

5.6.3 Generation of Textual Arguments

Examples of generated textual arguments have been given throughout section 4.9. The arguments display plausible (i.e. do not contain fallacies) and systematic reasoning with cases, their factors and the underlying values without adding any semantic 'dummy' content which is not anchored in either VJAP's knowledge factors, model representation or argumentative concept encoded into the argument schemes. The texts do contain redundant formulations and, when read over longer passages, can be recognized as having been generated by by a computer program. However, they appear less algorithm-like than IBP's explanations of its predictions (compare appendix E) and one can imagine ways of making the generation more natural by, for example, using variations of stock formulations in a probabilistic grammar and interspersing filler words.

This experiment does not evaluate whether the arguments generated by VJAP correspond to the arguments made by the parties and the court in the actual opinions that were the basis for the dataset of annotated case. Presumably they will not map very well to the opinions, especially since VJAP does not use a deeper knowledge representation like GREBE [Bra91] but uses the rather flat representation of cases as sets of predefined factors.

This phenomenon, however, is problem for all AI systems conducting symbolic reasoning in a discourse-focused domain that is not purely descriptive of an unambiguous physical state of affairs (e.g. symbolic spatial reasoning about objects). If AI&Law progresses towards the development of artificial agents that are able to reason intelligently about legal information, this potential discrepancy will likely become a much more visible challenge than it is at this point.

While the author does not dispute this ‘weakness’ of the arguments generated by VJAP, pending further developments in AI&Law research and evaluation methodology, the generation of plausible case-based arguments that take into account values based on a knowledge base is a significant contribution.

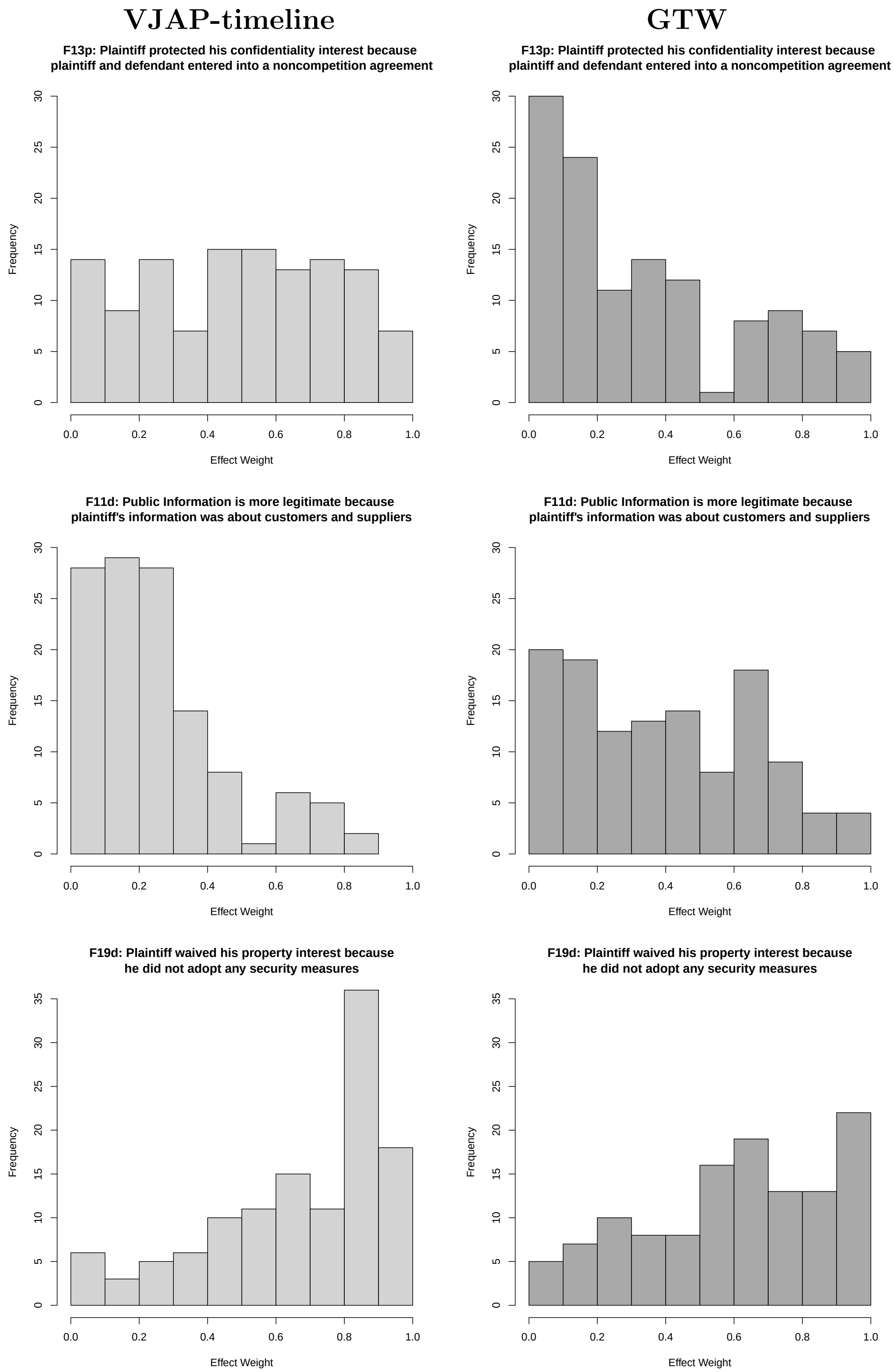

Figure 16: Histograms distribution of three example weights across 121 optimized weight maps in VJAP-timeline (left) and GTW (right).

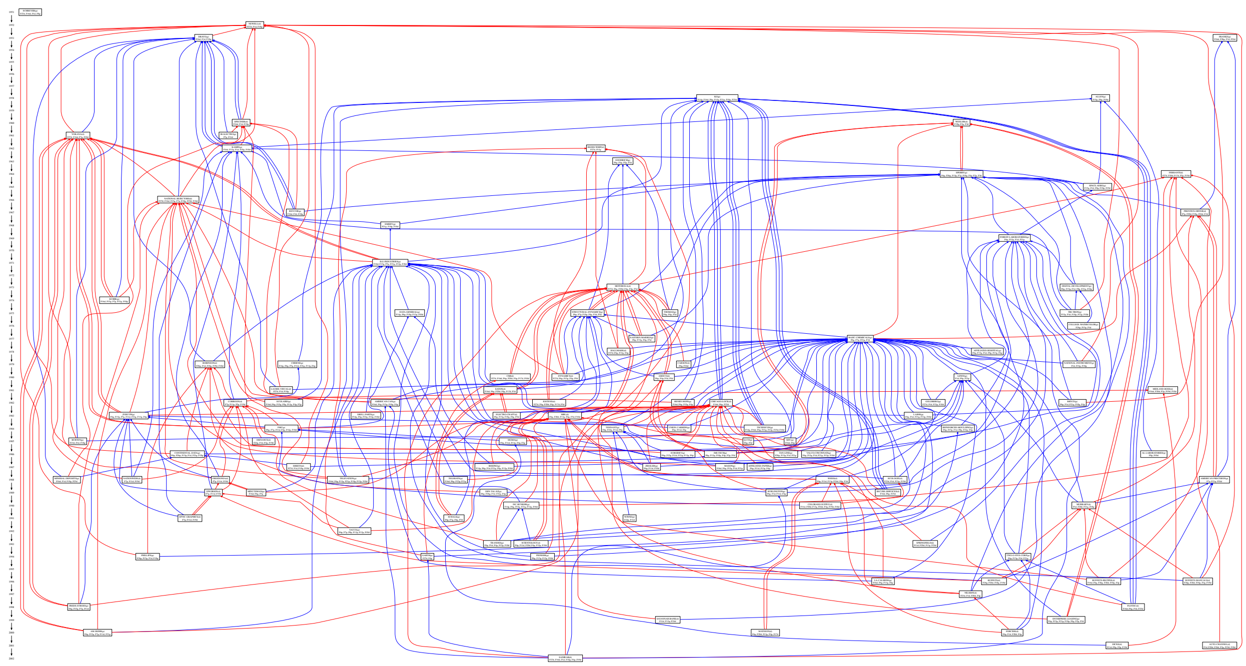

Figure 17: Bird's eye view of the generated top-to-bottom chronological display of all cases and their tradeoff analogy citations for each plaintiff (blue) and defendant (red). Note: In the pdf version of this dissertation, the graph can be comfortably explored by zooming in.

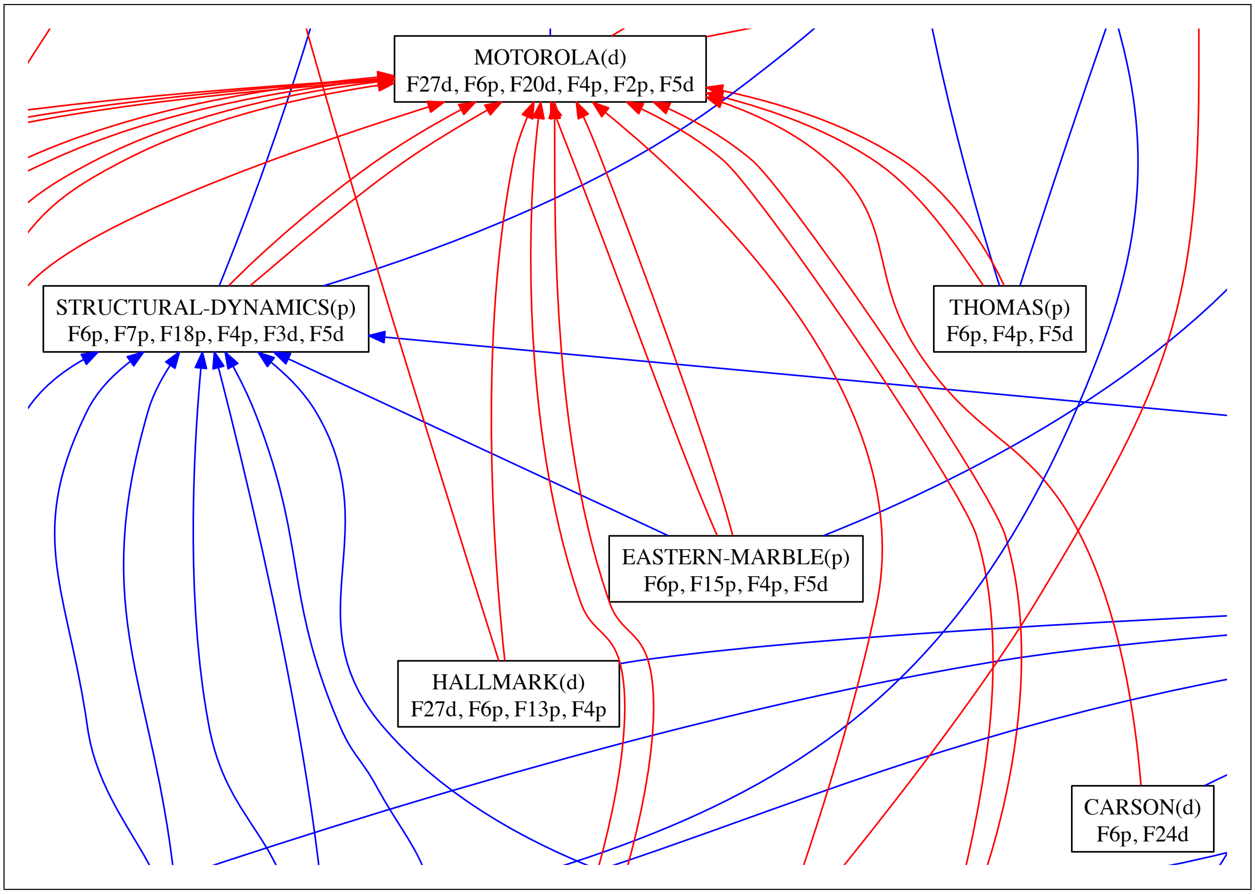

Figure 18: Excerpt from the citation graph showing two frequently cited complex cases (STRUCTURAL-DYNAMICS and MOTOROLA) and four simpler cases which are not cited by subsequent cases

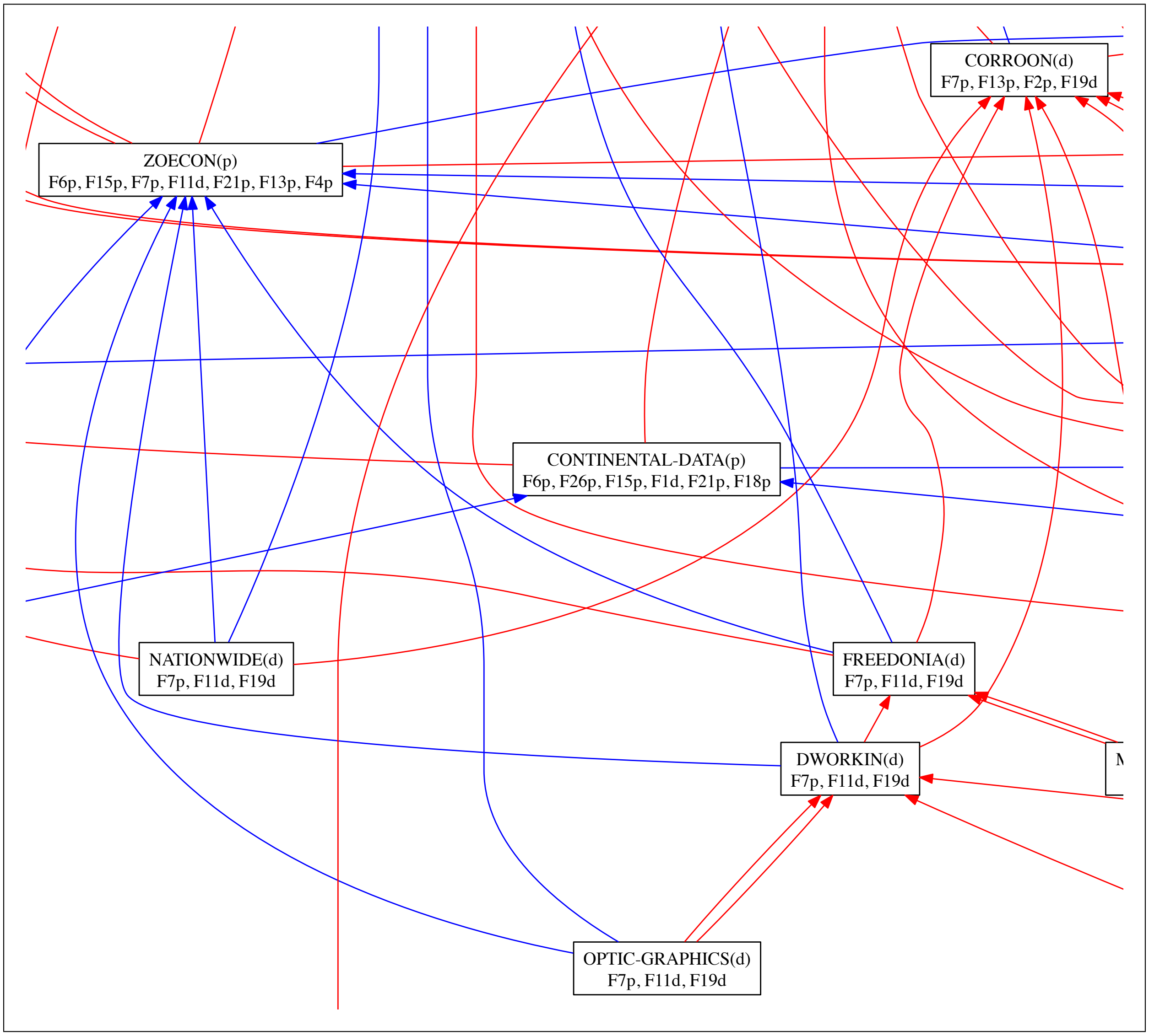

Figure 19: Excerpt from the citation graph showing a line of defendant cases on the bottom right

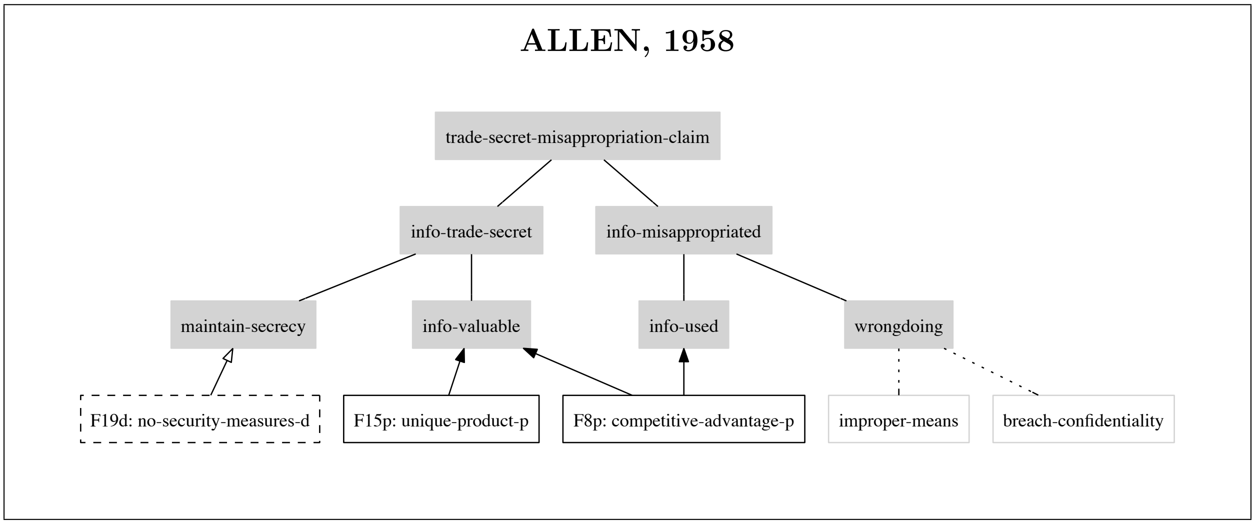

Figure 20: Factor and domain model constellation in ALLEN

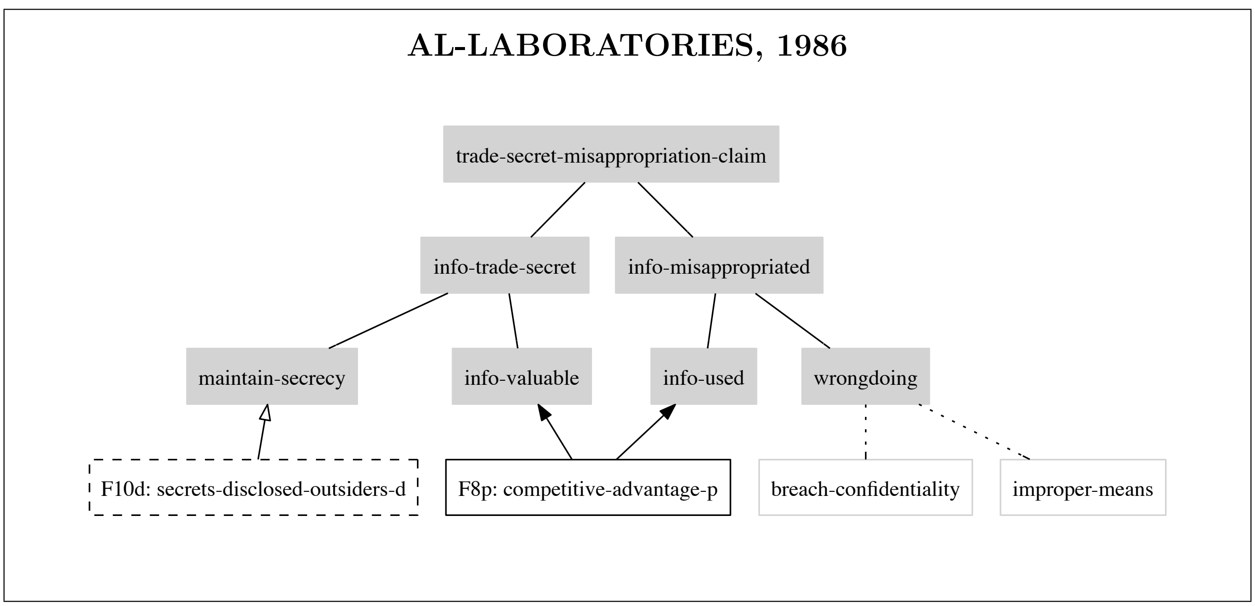

Figure 21: Factor and domain model constellation in AL-LABORATORIES

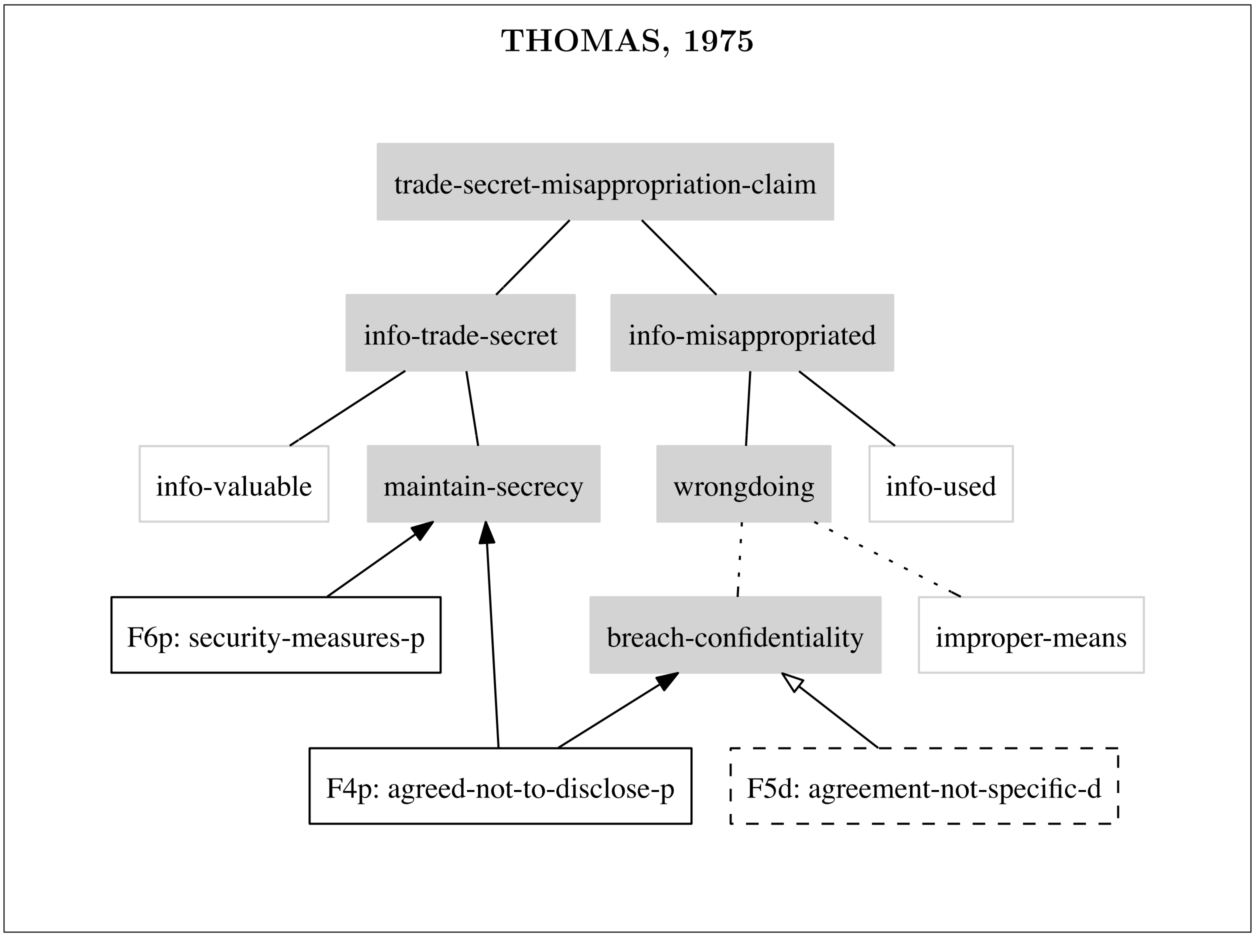

Figure 22: Factor and domain model constellation in THOMAS

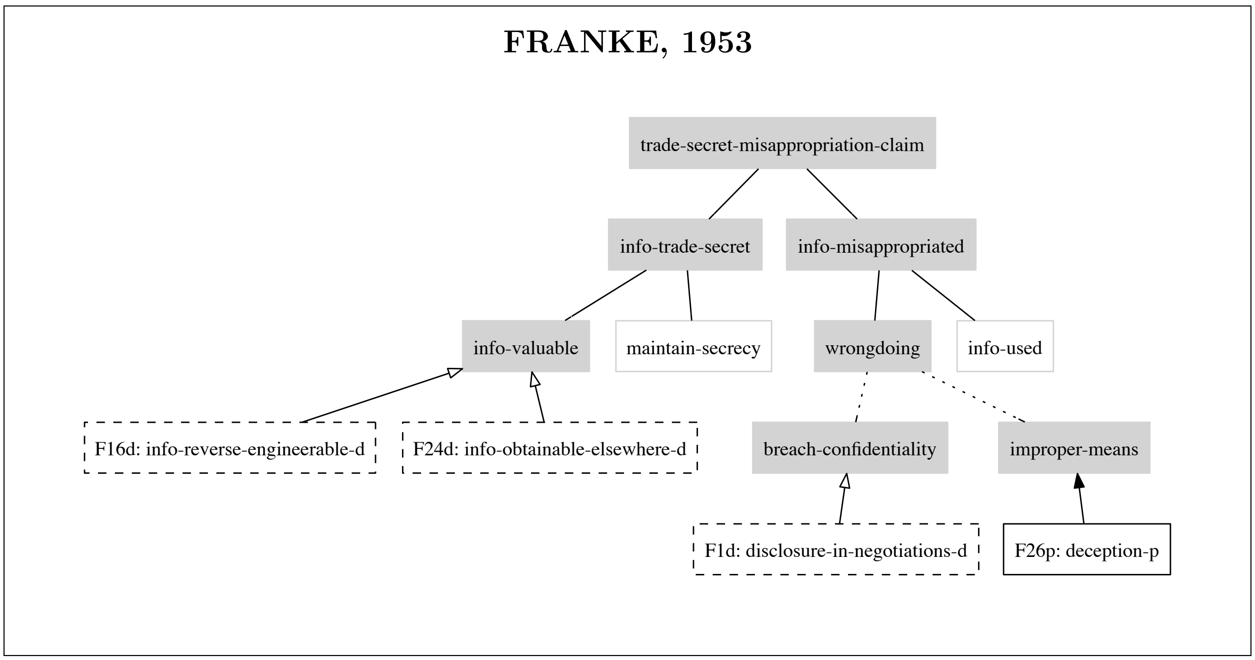

Figure 23: Factor and domain model constellation in FRANKE

6.0 DISCUSSION

6.1 RELATION TO PROBABILISTIC ARGUMENT MODELING

VJAP uses its own generic implementation of argument generation via schemes and inference via quantitative confidence propagation. This is conceptually similar to the author's previous work [GGW10] which cast the Carneades argumentation formalism [GPW07] into deterministically parametrized Bayesian Networks. Through forward reasoning, this allows one to infer probabilities about model states (e.g., acceptability of a statement/argument) when modeling parameters (e.g. assumptions by the audience) as probability distributions over possible values. A detailed survey of how different kinds of uncertainties and possible approaches to integrate them into probabilistic graphical argumentation models can be found in [GA13a].

Prior applications of bayesian networks to legal reasoning have predominantly modeled evidential reasoning in criminal cases (e.g. Thagard's ECHO system in [Tha04], more recently Vlek et al., [VPRV15]).

VJAP's confidence propagation model in argument graphs can be thought of as dynamically generating a bayesian network [Pea85] with an argument model informing the conditional probability functions (as opposed to conditional probability tables), which compute the argument scheme confidence as well as proportional and propmax confidence of statement variables. The effect weights form the causal layer of the network which models priors over the 'persuasive force' an audience assigns to a given value effect while the top level variable of the network represents the probability of the plaintiff winning the case. In this conceptualization, learning the effect weight parameters while minimizing the number of incorrectly predicted cases resembles the classical bayesian network task of learning the probability of a given ‘illness’ (the court’s appreciation of factual effects on values) from ‘symptoms’ (a database of decided cases).

6.2 RELATION TO PRIOR WORK IN AI&LAW

In the academic field of AI&Law, the most influential and comprehensive explanation of the insufficiency of symbolic logic in modeling legal reasoning was Berman & Hafner’s 1986 landmark paper [BH86]. It made a compelling argument that legal reasoning is inherently non-monotonic in the way it draws inferences from information and opinion, not at all well-formed in its textual manifestation, relying on large amounts of common sense and domain knowledge, as well as fundamentally dependent on the principles/values underlying the law. Since then, the field has made progress on a number of these issues. In the context of this experiment, two developments are focal. First, formal models of argumentation have largely supplanted classical logic as the accepted representation of legal reasoning. A number of systems have been developed that generate arguments for and/or predict outcomes of cases. Second, as in the greater AI disciplines of knowledge representation and reasoning, the acquisition of usable domain and common sense knowledge continue to be an obstacle to the development of non-trivial systems that can reason ’in depth’ about case facts, factual terminology in legal rules and the interactions between the two. As a consequence, AI&Law research has made efforts to narrow the gap to autonomous purposive reasoning from the top down by creating formalisms of value-based legal argumentation. The VJAP experiment reaches across these two developments. At its core is the value judgment formalism, originally conceived as a domain-neutral formalism of purposive legal reasoning, which was developed into a computer program and has been evaluated.

6.2.1 Case-based Reasoning Systems

Ashley’s HYPO [Ash91a, Ash91b] generated case-based legal arguments for plaintiff and defendant in trade secret law cases. It used 13 dimensions corresponding to fact patterns in the trade secret law domain and a manually coded dataset of cases, each represented by a set of the dimensions corresponding to the facts of the case. HYPO generated 3-ply arguments by drawing analogies between the case at bar and precedent cases based on sets of joined factors. This analogy could then be attacked by distinctions based on disjoint factors and followed up by an analogy to a counter-example case. The argument generation module revolved around a concept of on-point-ness of a precedent relative to the current case which functioned as a qualitative distance measure between cases based on set comparisons in a structure called the 'claim lattice'. Even though HYPO's dimensions correlate to a notion of 'degree of support' for a party's argument, it did not have an explicit representation of values underlying the trade secret domain. Also, it did not predict case outcomes and lacked the ability to explain why analogies and distinctions matter beyond the direction of the parties favored by the factors/dimensions.

This approach has since been enhanced by structures refining knowledge about the domain. CATO [Ale03a] builds upon HYPO by simplifying the 13 dimensions into 26 binary factors, representing cases as binary vectors of the applicable factors and interrelating the factors in a hierarchy, allowing for more sophisticated arguments in legal factor-case-based reasoning (e.g. downplaying or substitution of a factor with another one in a case analogy if both factors had the same parent in the hierarchy) and for predicting outcomes. CATO sparked a long lasting series of follow-up work (see section 6.2.3 below). A recent example is the work of Wyner et al. [WBCA11], who have formalized a number of argument schemes for CATO-style reasoning in ASPIC+.

As explained in detail in chapter 4 a further refinement was IBP [BA03b], where factors have been grouped by issues, which in turn were interrelated through a static domain model. This enhanced domain understanding and allows for the generation of more sophisticated argument as well as case outcome prediction (IBP).

Rissland's and Skalak's CABARET [RS91] interleaves rules and cases. HYPO-style case-based reasoning (including the claim lattice) is used in various ways to augment rule-based reasoning, e.g. by explaining away an unfulfilled predicate or broadening an open-textured term. It thereby engages in a limited conception of statutory interpretation. This is done using a heuristic guided by an argument for a particular side and produces rule-based

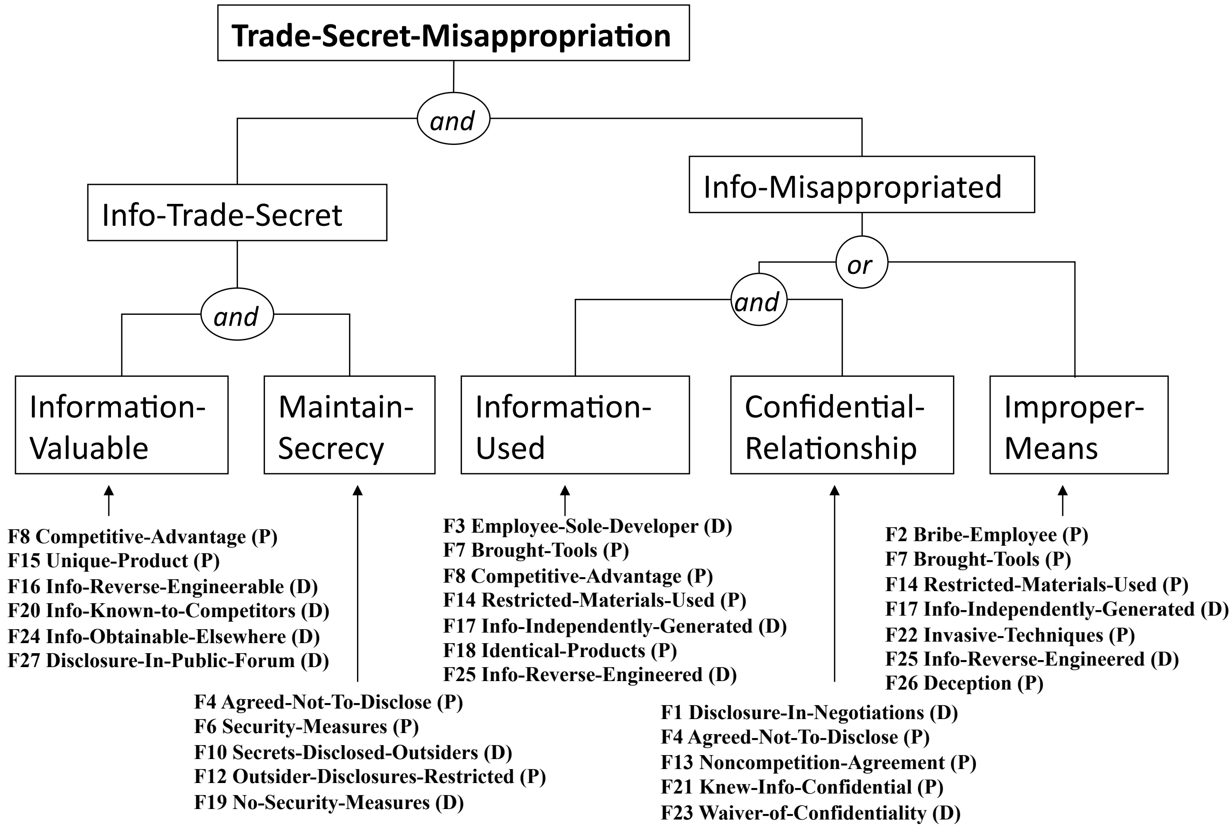

Figure 24: Diagrammatic view of the IBP domain model of issues and associated factors

and case-based arguments as well as anticipated counterarguments. This way, the system constructs a narrow theory of the applicable rules and cases by reshaping rules through case-based argument. CABARET's argumentation creation is domain-neutral, i.e. it does not contain any representation of teleological preference among arguments/theories or case outcome prediction.

Branting's GREBE [Bra91] is a sophisticated hybrid rule- and case-based reasoning system which relied on large amounts of manually created common sense knowledge. It employs an algorithm that tries to establish a goal from both common sense knowledge, rules and cases. Differently from CABARET and the HYPO-CATO-IBP line of work, it uses structure mapping in a semantic network representation to retrieve and compare cases. Match strength is determined using a quantitative heuristic.

Its output is a textual legal analysis of a given case along a narrow theory of applicable rules and similar cases. In terms of theory construction, it improves upon CABARET in that its representation of cases allows the modeling of reasoning in precedent cases to some extent and would lend itself well to modeling purpose-oriented inference in the argumentation process. While GREBE's sophisticated common sense knowledge model already goes a long way in representing the intricacies of its domain in a deep model, it did not, to the author's best knowledge, invoke purposes or values as justifications in the arguments it produced.

Another noteworthy property of GREBE is that it was evaluated through a human assessment of its textual arguments, which is a methodological landmark. A comparable evaluation for VJAP may prove to be more difficult because of its inferior, flat representation of facts. A closer investigation of the possibility of such an evaluation is left for future work.

6.2.2 Purposive Reasoning Formalisms

6.2.3 Theory Construction

McCarty [McC95] states: "the important process in legal reasoning is not theory application, but theory construction." The term "theory construction" can be understood both narrowly as constructing any (non-static) inference license on which a given case can be decided, as well as broadly, where the theory claims to have a bigger-picture conception of what the law is. At the core of McCarty's conception of a theory is, very similar to our systemic assumptions, a legal rule (or "prototype") (or set thereof) whose precise shape needs to be argued in every case ("deformation") in a way that makes it preferable (on grounds possibly going beyond the case at hand) to others.

In [McC95] McCarty presents a computational reconstruction of arguments in the Eisner v. Macomber case. In line with his own statements about theories, he formalizes legal concepts used in the decision as patterns and discusses arguments about how facts can be subsumed under those concepts or not. His program is limited in functionality, but provides a proof of concept of a formalization process centering on the description and matching of facts and legal concepts guided by a notion of coherence and substantive adequacy.

In what became a very influential line of work, Bench-Capon & Sartor have cast case-based reasoning as a form of *theory construction* [BCS03]. In their model, a *theory* or case law consists of six elements:

- a set of factors representing the domain
- a set of cases represented as sets of these factors along with a case outcome
- a set of rules to predict the outcomes of cases
- a set of legally relevant values underlying the domain
- a set of bilateral preference relations among rules to resolve conflicting rules when predicting cases
- a set of bilateral preference relations among sets of values representing their importance, which are used to infer preference relations among rules

In follow-up work, [CBC05b] at 6.3, Chorley & Bench-Capon explain a value-driven method of theory construction, which "first reflect[s] on the values and then produce[s] a ranking [of said values]. [One] will then choose factors to represent these values, and cases to establish the desired value order. It is, of course, arguable that this is not the approach that lawyers would take, since they would want to order values in the context of the facts of the particular case, and would not wish to consider the importance of values abstractly. Lawyers might well, therefore, prefer the safe method method which does rely more heavily on the facts of particular cases."

They derive this 'safe' method from Prakken & Sartor who "represen[t] a precedent with conflicting factors as a set of conflicting logical arguments" [PS98]. It was introduced as a constructor move in the initial publication of the theory construction formalism [BCS03]. "[T]he conjunction of all the pro-plaintiff factors present gives one rule, the conjunction of all the pro-defendant factors give another rule, and the priority between them is determined by the decision." [CBC05b]. In creating such rule pairs, a similar preference relation is created in between the two sets of values associated with a case's plaintiff and defendant factors.

The rules and preference relations created from a case by means of this 'safe' method can be seen as a form of tradeoff between sets of values that is derived from a case outcome by means of a generalization from a case's factors to its values. The created value set preference then can be used to establish preferences among other rules in the theory which in turn can be used to predict the outcomes of cases who are not yet part of the theory, thereby closing the circle.

Here lies the main difference between the theory construction model and the VJ formalism presented here. In theory construction, sets of values are subject to a preference relation, which then affects a case to be decided by ordering predictive rules. In this inference step, no analogy- or distinction-based recourse is made to the case from which the rules and value preferences stem. In the VJ formalism, it is not sets of values that get weighed but rather sets of effects that factors have on the values. Also, these weightings do not produce preferences between rules but rather produce case-based analogy and/or distinction arguments for whether the requirement of a universal quasi-statutory rule (stemming from the Restatement of Torts) is fulfilled or not.

Chorley & Bench-Capon investigated the representations of the relationship between factors and values in [CBc03, CBC05b]. They replaced a pure qualitative ordering of values with a quantitative weight for values and factors and reported results on a subset of IBP cases that has been publicly available [CBc03]. In furtherance, they "provid[e] structure to our values, by identifying the different extents to which the factors promote their values. In what follows, therefore, we will therefore use the term "structured value" rather than dimension." [CBC05b]. In a 'simple' model, factors are grouped into disjoint values (i.e. values share no factors) and partially ordered from strongest pro-plaintiff to strongest pro-defendant. A 'complex' model then allows for factors to be shared across values while the overall partial ordering per value is preserved. They further investigate quantitative factor weights to represent these orderings.

A series of computer systems by Chorley & Bench-Capon implemented the theory construction model. CATE was a tool for manual creation and testing of theories [CBC04] which generated theories as executable Prolog programs. The following AGATHA system is able to "construct theories as a side effect of producing an argument in the style of HYPO and CATO like systems" [CBC05a], operationalizing the argument-like theory constructors in [BCS03] in an adversarial-like argument game setting. The argument was conducted automatically by AGATHA using A* search with the goal to produce the best theory according to a number of criteria. The search algorithm branches open a tree whose nodes are theories that are branched out by applying the possible theory construction moves to it. The heuristic for the search algorithm was computed by the ETHEL program by assessing each theory node according to a number of properties, including explanatory power in the case base, simplicity of the theory, depth in the search tree. AGATHA was evaluated with different configurations to explore the possibilities in dialogue-based theory construction [CBC05a].

6.2.4 Case-Based Reasoning as Practical Reasoning with Values

Prior work by Greenwood et al. [GCM03] similarly models CATO-like case-based legal reasoning as an instance of a general formalism of argumentative persuasion focusing on the effects of an action on applicable values in a situation towards a certain goal. They define a general set of argument schemes for attacking practical reasoning arguments based on that formalism and cast CATO's argument moves as subclasses of these schemes. In particular, they work with a subset of the dataset used in this experiment, which they also relate to values. They characterize "legal argumentation with cases as the proposal and defence of an interpretation of some past case or cases using [a certain argument scheme] to establish the desirability of a goal, followed by the contention that deciding the new case should be decided for our side to achieve that goal using [another scheme]".

Using Pearson v. Post, Atkinson et al. [ABCM05] have cast legal case-based reasoning into argumentative practical reasoning using VAFs for representation and inference. In [BCAC05], they relate this approach to the theory construction model.

They later affirmed this connection between legal case-based reasoning and practical reasoning [ABC05]. Recent work by Bench-Capon & Atkinson [BCA09] also uses contextual effects on values in argumentative practical reasoning about actions in multi-agent systems using a transition system representation.

Like [GCM03], the VJF and its schemes in [GA10, GA11, GA13b] model case-based legal reasoning as a system of argument moves involving different ways that facts interact with values. This interaction promotes actions or decisions as desirable or not given the assumption that the argumentative persuasion is associated with latent preferences among the value effects brought about by the decision options.

Conceptually, the VJF is different in that it does not use an abstract, qualitative preference relation between values as presented in Bench-Capon's value based argumentation frameworks [BC03] or work by Greenwood et al. [GCM03]. Instead, the VJF relies purely on degrees of promotion or demotion of values by factual differences between situations. On the other hand, these are functionally equivalent to preferences between actions in situation spaces as presented in [BCA09]. Also, preferences among values are themselves propositions that may be argued about in, for example, a hierarchical argumentation framework as in [Mod06].

The choice among these formalisms for value-based legal argumentation thus effectively becomes a choice of functionally near-equivalent systematizations given ones assessment of the degree to which they authentically model the legal reasoning phenomenon of interest for the purpose at hand.

The development of the VJF was motivated by the author's experience of how legal reasoning with values is taught and reasoned about in theory. One such influence is the weight formula by Alexy (see section 2.1.4) which provides a metaphorical quantitative model of how effects on values are to be balanced. As shown through in-depth examples, the VJF provides an intuitive systematization of the formation of intermediate legal concepts [GA11] in case-based reasoning as well as argument moves in reasoning with hypotheticals [GA10].

Through the VJAP experiment, the VJF has been implemented and shown to be a suitable core for a system engaging in argument generation, weight parameter learning from data and case outcome prediction synthesizing weights and arguments. To that end, it was extended with a quantitative weight model, computable value judgments in the form of local and inter-issue tradeoff arguments as well as the ability to analogize and distinguish precedent cases in terms of these tradeoffs. Finally, it autonomously generates textual arguments.

6.3 LIMITATIONS OF VJAP AND FUTURE WORK

A number of limitations of the VJAP model provide perspectives for interesting future work.

6.3.1 Rigorous Statistical Evaluation of Prediction Performance

As has been discussed in section 5.5, VJAP's prediction performance has to be subjected to a rigorous empirical evaluation on a larger dataset satisfying statistical requirements.

6.3.2 Greater Instrumentarium of Case-Based Argument Schemes

Even though VJAP does model values and factual effects at a deep level, it's repository of analogizing and distinguishing is limited. Emphasizing and downplaying of similarities and differences in the VJF have already been explored in prior descriptive work [GA11]. This provides a starting point for future work in incorporating these into the implementation. Similarly, prior work has modeled reasoning with hypotheticals [GA10, Ash09].

6.3.3 Interface to State of the Art Knowledge Representation

Despite its ability to reason about values and effects, VJAP's fact model and representation are inferior to more sophisticated knowledge representations like that of GREBE [Bra91] or explored methodologically in recent work [AAABC]. Future work could explore the use of general purpose knowledge ontologies and representation techniques to give VJAP s a more fine-grained understanding of facts. This in turn would invite further work on refining the value effect topology beyond the six types in this experiment. Given some progress, it may be worth revisiting a human evaluation of the natural language arguments generated by a future version of VJAP.

6.3.4 Towards Case-Based Reasoning from Natural Language Text

Finally, as natural language processing technology advances and the knowledge acquisition bottleneck widens, VJAP's capabilities may at some point include autonomously consulting texts of relevant decisions, statutes, scholarly articles and written arguments. VJAP's argumentation capabilities could be extended and made compatible to the developments in legal argument retrieval as recently explored in [AW13].

7.0 CONCLUSIONS

7.1 EVALUATION OF HYPOTHESIS

This final chapter discusses whether the hypotheses and contributions in section 1.3 and 1.4 are supported by results and exploratory analyses of the VJAP experiment.

7.1.1 Prediction Capacity Hypothesis

The results in section 5.6 reveal the following evidence relevant to the assessment of the prediction hypothesis. First, an explorative comparison of VJAP's performance to that of the baselines shows that:

1. In leave-one-out configuration, VJAP-timeline predicts case outcomes as accurately as the best tested machine learning method (naive bayes).
2. In a five-fold cross validation experiment the best-performing experimental VJAP-timeline and VJAP-full degrade slightly. This suggests that VJAP performs better the more training data it has without a recognizable tendency to overfit. Machine learning baselines suffer from overfit during a leave-one-out condition but improve in the cross validation where they perform better than VJAP.
3. The performance of a reimplemented IBP is about equivalent to VJAP-full in the leave one out condition, but lower than VJAP-timeline in all conditions. If IBP is deprived of its manually flagged knockout factors, its performance degrades even more.

Second, VJAP performs best when precedent arguments are restricted to cases that temporally precede the case to be predicted. VJAP's performance degrades as the model is simplified by either removing the temporal restriction, removing inter-issue tradeoffs, removing precedent arguments entirely or performing prediction solely on a linear sum of the value effect weights. This supports the following conclusions:

1. VJAP-full performs significantly better than VJAP-noprecedent, which suggests that arguing with tradeoffs alone has less explanatory power than case-based argumentation with tradeoffs.
2. VJAP-full also performs much better than VJAP-local, suggesting that value-based plus-minus argumentation across separate elements of a legal rule contributes to explanatory power. This is evidence that antecedents of legal rules do not exist in perfect separation but interrelate through balancing of values.
3. VJAP-full performs similarly to the GTW linear sum of a case's value effect weights. The Restatement rule model and case-based reasoning schemes do not add anything to the predictive power beyond the effect of the learned weight parameters.
4. VJAP-timeline exploits the Restatement rule and temporally restricted case-based arguments to produce the best prediction performance. A comparison of weight maps further reveals that VJAP-timeline learns different weights than GTW. This means that linear GTW and non-linear VJAP models are not equivalent in terms of the weight the parameters assign to legal values in the domain of discourse.

Overall, the results of the prediction experiment show that

- the combination of a rule-based domain model and value-based case-based legal reasoning schemes,
- when value effect weights are learned from sufficient amounts of training data, and
- precedent arguments are restricted to temporally plausible analogies
- show promising exemplary prediction performance when compared to general purpose machine learning models
- which is evidence for the hypothesis that a system with such capabilities can be constructed, subject to the qualification that
- a future rigorous empirical validation is mandated once a suitable dataset of cases becomes available

7.1.2 Intelligent Legal Argumentation Hypothesis

The VJAP experiment results and exploration have produced the following evidence pertaining to the intelligent argument hypothesis.

1. VJAP produces natural language verbalizations for all arguments it creates, thereby justifying its inference in terms of facts, intermediate legal concepts, rules, values, precedent cases, tradeoffs, analogies and distinctions, all of which rest on valid legal theory assumptions. Also, the composed textual answers do not immediately strike the reader as artificial, unsound or implausible beyond artifacts of automatic text generation like redundant formulations and phrasal repetitions.
2. A proper empirical evaluation of the generated arguments could be done two ways. One way would be to manually compare the generated arguments to the actual decisions of the cases, which will likely produce a poor outcome given the simplifications made in the representation and annotation of the cases in the dataset. Another way would be to compare the arguments to arguments created created by humans. However, their comparability may be doubtful since human participants will likely resort to common sense arguments rather than the most authoritative precedent analogy which realistic legal reasoning involves.
3. As explained for the prediction hypothesis, VJAP-timeline performs best of all VJAP conditions and is also the most 'realistic' one. It utilizes the full set of restatement rules, argument schemes for tradeoffs and precedents as well as accounts for case law chronology. All these features have been modeled and implemented to be authentic aspects of legal reasoning. The fact that they, in combination, perform best among all VJAP models (and IBP) is evidence of the system's intelligence in reasoning about cases.
4. Specifically, the fact that VJAP performs better with tradeoffs *and* precedents than it does with tradeoffs alone supports our legal theory assumption in section 2.1.1 that adherence to precedent unfolds its own persuasive effect next to the legal values we model explicitly.
5. An examination of the distribution of the generated argument weights shows that across a large number of iterations, certain weights score higher or lower and with lower variance

than others. This suggests that the system converges to latent structures in the tradeoffs made between different values of the trade secret domain.

6. Also, these weights differ from the ones learned in the non-argument GTW model, showing that there is an interaction between this VJF implementation of case-based legal argument learned weights.
7. An examination of the precedent citation graph generated by VJAP-timeline reveals patterns such as developing 'lines of cases', complex 'landmark' decisions vs. simpler cases of lesser influence. While there is no evaluation as to whether these references occur in the actual opinions of the cases, the system nevertheless produces an organized, coherent systematization of its case-base which does not strike the viewer as the product of a statistical inference method such as a decision tree.

Overall, the experiment shows that

- a legal case based reasoning system
- when equipped with sufficient argument schemes, domain knowledge and value effect weight parameters learned from data
- can produce natural language arguments which make use of formalized legal theory and methodology techniques and which are intelligent in so far as they
- are understandable by humans and contain plausible legal reasoning,
- predict case outcomes better than legal case based reasoning system that make less or no use of such concepts, and
- organize cases into a system of interdependence by means of precedent arguments exhibiting certain patterns also occurring in realistic case law domains,
- thereby supporting the hypothesis that it is possible to construct a system with such capability, subject to the qualification that
- a future rigorous empirical validation of the generated textual arguments is mandated

7.2 EVALUATION OF CONTRIBUTIONS

The VJAP implementation of the VJF and its empirical evaluation as presented here makes a number of significant contributions to AI&Law.

- The VJF experiment compiled significant amount of evidence regarding its hypotheses about the feasibility of developing a system capable of producing intelligent value-based legal arguments and using these arguments to make accurate predictions of case outcomes. It thereby contributes to formal models of legal reasoning through the techniques it has successfully or unsuccessfully applied, and its insights on how the formalism's legal theory assumptions influence the system's behavior.
- Next to the AGATHA system [CBC05a] it presents the largest effort in developing a descriptive formalism into a computer system, subjecting it to an empirical evaluation, analyzing the observable behaviour of the system and reflecting on its ramifications. Its results are encouraging and the experiment provides a stepping stone for future systems in AI&Law towards agents capable of intelligently engaging in legal argument and a synthesis of research from formal legal methodology and empirical AI.
- VJAP goes beyond the scope of prior systems in AI&Law because of the way it accounts for values, its ability to learn from prior cases, its use of argument schemes to generate case-based legal arguments arguments, as well as its assessment and use of these arguments to predict case outcomes. Its interlocking argue-evaluate-learn-predict architecture is unique among experimental systems in the current state of AI&Law. Its behaviour has been presented in a high degree of detail, thereby making a methodological contribution to future experimental work in AI&Law by providing a point of reference.

APPENDIX A

FACTORS

F1$_\delta$[disclosure-in-negotiations] : plaintiff disclosed its product information in negotiations with defendant.

F2$_\pi$[bribe-employee] : defendant paid plaintiff's former employee to switch employment, apparently in an attempt to induce the employee to bring plaintiff's information.

F3$_\delta$[employee-sole-developer] : defendant's employee was the sole developer of plaintiff's product.

F4$_\pi$[agreed-not-to-disclose] : defendant entered into a nondisclosure agreement with plaintiff.

F5$_\delta$[agreement-not-specific] : the nondisclosure agreement did not specify which information was to be treated as confidential.

F6$_\pi$[security-measures] : plaintiff took active measures to limit access to and distribution of its information.

F7$_\pi$[brought-tools] : plaintiff's former employee brought product development information to defendant.

$F8_\pi$[competitive-advantage] : defendant's access to plaintiff's product information saved it time or expense.

$F10_\delta$[secrets-disclosed-outsiders] : plaintiff disclosed its product information to outsiders.

$F11_\delta$[vertical-knowledge] : plaintiff's information was about customers and suppliers (i.e. it may have been available independently from customers or even in directories).

$F12_\pi$[outsider-disclosures-restricted] : plaintiff's disclosures to outsiders were subject to confidentiality restrictions.

$F13_\pi$[noncompetition-agreement] : plaintiff and defendant entered into a noncompetition agreement.

$F14_\pi$[restricted-materials-used] : defendant used materials that were subject to confidentiality restrictions.

$F15_\pi$[unique-product] : plaintiff's information was unique in that plaintiff was the only manufacturer making the product.

$F16_\delta$[info-reverse-engineerable] : plaintiff's product information could be learned by reverse-engineering.

$F17_\delta$[info-independently-generated] : defendant developed its product by independent research.

$F18_\pi$[identical-products] : defendant's product was identical to plaintiff's.

$F19_\delta$[no-security-measures] : plaintiff did not adopt any security measures.

$F20_{\delta}$[info-known-to-competitors] : plaintiff's information was known to competitors.

$F21_{\pi}$[knew-info-confidential] : defendant obtained plaintiff's information altough he knew that plaintiff's information was confidential.

$F22_{\pi}$[invasive-techniques] : defendant used invasive techniques to gain access to plaintiff's information.

$F23_{\delta}$[waiver-of-confidentiality] : plaintiff entered into an agreement waiving confidentiality.

$F24_{\delta}$[info-obtainable-elsewhere] : the information could be obtained from publicly available sources.

$F25_{\delta}$[info-reverse-engineered] : defendant discovered plaintiff's information through reverse engineering.

$F26_{\pi}$[deception] : defendant obtained plaintiff's information through deception.

$F27_{\delta}$[disclosure-in-public-forum] : plaintiff disclosed its information in a public forum.

APPENDIX B

ISSUES

main issue: ***trade-secret-misappropriation-claim***
antecedents (conjunctive): [*info-trade-secret* , *info-misappropriated*]
proposition: *Plaintiff has a claim for trade secret misappropriation*

Figure 25: issue information for *trade-secret-misappropriation-claim*

intermediate issue: ***info-trade-secret***
antecedents (conjunctive): [*info-valuable* , *maintain-secrecy*]
proposition: *Plaintiff's information is a trade secret*

Figure 26: issue information for *info-trade-secret*

intermediate issue: ***info-misappropriated***

antecedents (conjunctive): [*info-used* , *wrongdoing*]

proposition: *plaintiff's information has been misappropriated*

Figure 27: issue information for *trade-secret-misappropriation-claim*

intermediate issue: ***wrongdoing***

antecedents (disjunctive): [*improper-means* , *breach-of-confidentiality*]

proposition: *defendant acted wrongfully regarding the information*

concedable?: if no antecedent raised

Figure 28: issue information for *wrongdoing*

leaf issue: ***info-valuable***

proposition: *Plaintiff's product information is valuable*

π factors:

- $F15_{\pi}$[unique-product]
- $F8_{\pi}$[competitive-advantage]

δ factors:

- $F11_{\delta}$[vertical-knowledge]
- $F16_{\delta}$[info-reverse-engineerable]
- $F24_{\delta}$[info-obtainable-elsewhere]
- $F20_{\delta}$[info-known-to-competitors]

concedable?: *true*

Figure 29: issue information for *info-valuable*

leaf issue: ***maintain-secrecy***

proposition: *the plaintiff has taken efforts to maintain the secrecy of the information*

π factors:

- $F6_\pi$[security-measures]
- $F4_\pi$[agreed-not-to-disclose]
- $F12_\pi$[outsider-disclosures-restricted]

δ factors:

- $F27_\delta$[disclosure-in-public-forum]
- $F10_\delta$[secrets-disclosed-outsiders]
- $F19_\delta$[no-security-measures]

concedable?: *true*

Figure 30: issue information for *maintain-secrecy*

leaf issue: ***info-used***

proposition: *defendant has used plaintiff's product information*

π factors:

- $F7_\pi$[brought-tools]
- $F8_\pi$[competitive-advantage]
- $F14_\pi$[restricted-materials-used]
- $F18_\pi$[identical-products]

δ factors:

- $F25_\delta$[info-reverse-engineered]
- $F17_\delta$[info-independently-generated]

concedable?: *true*

Figure 31: issue information for *info-used*

leaf issue: ***breach-of-confidentiality***

proposition: *defendant breached a confidential relationship*

π factors:

- $F4_\pi$[agreed-not-to-disclose]
- $F13_\pi$[noncompetition-agreement]
- $F21_\pi$[knew-info-confidential]

δ factors:

- $F1_\delta$[disclosure-in-negotiations]
- $F5_\delta$[agreement-not-specific]
- $F23_\delta$[waiver-of-confidentiality]

concedable?: *false*

Figure 32: issue information for *breach-of-confidentiality*

leaf issue: ***improper-means***

proposition: *defendant used improper means*

π factors:

- $F2_\pi$[bribe-employee]
- $F7_\pi$[brought-tools]
- $F14_\pi$[restricted-materials-used]
- $F22_\pi$[invasive-techniques]
- $F26_\pi$[deception]

δ factors:

- $F3_\delta$[employee-sole-developer]
- $F17_\delta$[info-independently-generated]
- $F25_\delta$[info-reverse-engineered]

concedable?: *false*

Figure 33: issue information for *improper-means*

APPENDIX C

CASES

A. H. Emery Co. v. Marcan Products Corporation, 380 F.2d 11

A.L. Laboratories, Inc. v. Philips Roxane, Inc., 803 F.2d 378 (8th Cir. 1986)

Affiliated Hospital Products v. Baldwin, 373 N.E.2d 1000

Affiliated Paper Companies, Inc. v. Hughes, 667 F.Supp. 1436

Allen Manufacturing Company v. Loika, 145 Conn. 509, 144 A.2d 306 (1958)

American Can Co. v. Mansukhani, 728 F.2d 818 (7th Cir.1982)

American Precision Vibrator Co. v. National Air Vibrator Co., 764 S.W.2d 274 (Tex.App.-Houston [1st Dist.] 1988)

American Wheel & Eng. v. Dana Molded Products, 132 Ill.App.3d 205, 476 N.E.2d 1291, 87 Ill.Dec. 299 (1985)

Amoco Production Co. v. Lindley, 609 P.2d 733 (Okla.1980)

Anaconda Co. v. Metric Tool & Die Co., 485 F.Supp. 410

Analogic Corp. v. Data Translation, Inc., 371 Mass. 643, 358 N.E.2d 804 (1976)

Arco Industries Corp. v. Chemcast Corp., 633 F.2d 435, 208 USPQ 190 (6th Cir.1980)

Aries Info. Systems v. Pacific Management Systems, 366 N.W.2d 366 (Minn.App.1985)

Automated-Systems v. Service-Bureau, 401 F.2d 619 (10 Cir.1968)

B.C. Ziegler and Co. v. Ehren, 141 Wis.2d 19, 414 N.W.2d 48 (Ct.App.1987)

B.F. Goodrich Co. v. Wohlgemuth, 117 Ohio App. 493, 192 N.E.2d 99 (1963)

Basic Chemicals, Inc. v. Benson, 251 N.W.2d 220 (Iowa 1977)

Black, Sivalls & Bryson, Inc. v. Keystone Steel Fab., 584 F.2d 946 (10th Cir.1978)

Boost Co. v. Faunce, 17 N.J.Super. 458, 86 A.2d 283 (App.Div.1952)

Brown v. Fowler, 316 S.W.2d 111 (Tex.Civ.App.1958)

Burlington Northern v. Omaha Public Power Dist., 888 F.2d 1228

Burten v. Milton Bradley Co., 763 F.2d 461

Business Intelligence Services, Inc., v. Hudson, 580 F. Supp. 1068

Business Trends Analysts v. Freedonia Group, Inc., 700 F. Supp. 1213

CMI Corp. v. Jakob, 209 USPQ 233 (W.D.Okla. 1980)

Carbonic Fire Extinguishers, Inc. v. Heath, 190 Ill.App.3d 948, 547 N.E.2d 675, 138 Ill.Dec. 508

Carson Products Co. v. Califano, 594 F.2d 453

Carver v. Harr, 132 N.J.Eq. 207, 27 A.2d 895 (Ch.1942)

Cherne Industrial, Inc. v. Grounds & Associates, Inc., 278 N.W. 2d 81 (Minn.1979)

Chicago Lock Co. v. Fanberg, 676 F.2d 400

College Watercolor Group, Inc. v. William H. Newbauer, Inc., 468 Pa. 103, 360 A.2d 200 (1976)

Commonwealth v. Robinson, 7 Mass.App.Ct. 470, 388 N.E.2d 705 (1979)

Computer Print Systems v. Lewis, 422 A.2d 148

Consolidated Brands, Inc. v. Mondi, 638 F.Supp. 152

Crown Industries Inc. v. Kawneer Co., 335 F.Supp. 749 (N.D.Ill.1971)

Data General Corp. v. Digital Computer Controls Inc., 357 A.2d 105 (Del.Ch.1975)

Defiance Button Machine Co. v. C & C Metal Products Corp., 759 F.2d 1053 (2d Cir.1985)

Demit of Venezuela, C.A. v. Electronic Water Systems, 547 F. Supp. 850

Den-Tal-Ez, Inc. v. Siemens Capital Corp., 389 Pa.Super. 219, 566 A.2d 1214 (1989)

Digital Development Corporation v. International Memory Systems, 185 USPQ 136 (S.D.Cal.1973)

Drill Parts & Service Co., v. Joy Manufacturing Co., 439 So.2d 43 (Ala.1983)

Dworkin v. Blumenthal, 551 A.2d 947

Dynamics Research Corp. v. Analytic Sciences Corp., 400 N.E.2d 1274

E. I. duPont de Nemours v. American Potash & Chemical Corp., 200 A.2d 428

E. V. Prentice Dryer Co. v. Northwest Dryer & Machinery Co., 246 Or. 78, 424 P.2d 227 (1967)

E. I. duPont deNemours & Company v. Christopher, 431 F.2d 1012

Eastern Marble Products Corp. v. Roman Marble, Inc., 372 Mass. 835, 364 N.E.2d 799 (1977)

Eaton Corp. v. Appliance Valves Corp., 526 F. Supp. 1172

Ecologix, Inc. v. Fansteel, Inc., 676 F.Supp. 1374

Elcor Chemical Corporation v. Agri-Sul, Inc., 494 S.W.2d 204 (Tex.Civ.App.1973)

Electro-Craft Corporation v. Controlled Motion, 332 N.W.2d 890 (Minnesota)

FMC Corp. v. Taiwan Tainan Giant Ind. Co, Ltd, 730 F.2d 61 (2nd Cir.1984)

Ferranti Electric, Inc. v. Harwood, 43 Misc.2d 533, 251 N.Y.S.2d 612 (1964)

Forest Laboratories, Inc. v. Formulations, Inc., 299 F.Supp. 202 (E.D.Wis.1969)

Forro Precision, Inc. v. International Business Machines Corp., 673 F.2d 1045 (9th Cir.1982)

Frank W. Winne and Son, Inc. v. Palmer, 1991 WL 155819 (E.D.Pa.)

Franke v. Wiltschek, 209 F.2d 493 (2nd Cir. 1953)

Goldberg v. Medtronic, 686 F.2d 1219 (7th Cir. 1982)

Hallmark Personnel of Texas, Inc., v. Franks, 562 S.W.2d 933 (Tex.Civ.App. (1st Dist.) 1978)

Healy, Inc. v. Murphy, Inc., 357 Mass. 728, 260 N.E.2d 723 (1970)

Henry Hope X-Ray Products v. Marron Carrel, Inc., 674 F.2d 1336

Hickory Specialties, Inc. v. B & L Laboratories, Inc., 592 S.W.2d 583 (Tenn.App.1979)

Hisel v. Chrysler Corp., 94 F.Supp. 996 (W.D.Mo.1951)

Houser v. Snap-On Tools Corp., 202 F.Supp. 181 (D.Md.1962)

Hurst v. Hughes Tool Co., 634 F.2d 895

Hyde Corporation v. Huffines, 158 Tex. 566, 314 S.W.2d 763

ILG Industries, Inc. v. Scott, 49 Ill.2d 88, 273 N.E.2d 393 (1971)

ISC-Bunker Ramo Corp. v. Altech, Inc., 765 F.Supp. 1310 (N.D.Ill.1990)

Imi-Tech Corp. v. Gagliani, 691 F. Supp. 214 (S.D.Ca. 1986)

In re Innovative Construction Systems, 793 F.2d 875 (7th Cir.1986)

Integrated Cash Management Services, Inc. v. Digital Transactions Inc., 732 F.Supp 370 (S.D.N.Y.1989)

J. Irizarry Y Puente v. President & F. of Harvard Col., 248 F.2d 799, 115 U.S.P.Q. 202 (1st Cir.1957)

Jostens, Inc. v. National Computer Systems, Inc., 318 N.W.2d 691 (Minn.1982)

Junkunc v. S.J. Advanced Technology and Mfg. Corp., 149 Ill.App.3d 114, 498 N.E.2d 1179, 101 Ill.Dec. 671

K & G Oil Tool & Service Co. v. G & G Fishing Tool Serv., 314 S.W.2d 782 K-2 Ski Co. v. Head

Ski Co. Inc., 506 F.2d 471 (9th Cir.1974)

KFC Corp. v. Marion-Kay Co., Inc., 620 F.Supp 1160 (D.C.Ind 1985) Kamin v. Kuhnau, 232 Or. 139, 374 P.2d 912 (1962)

Kearns v. Ford Motor Company, 203 U.S.P.Q. 884 (E.D.Mich.1978)

Kewanee Oil Co. v. Bicron Corp., 416 U.S. 470, 94 S.Ct. 1879, 40 L.Ed.2d 315 (1974)

Kubik, Inc. v. Hull, 56 Mich.App. 335, 224 N.W.2d 80 (1974)

Laser Industries, Ltd. v. Eder Instrument Co., 573 F.Supp. 987

Lowndes Products Inc. v. Brower, 259 S.C. 322, 191 S.E.2d 761 (1972)

Luccous v. J.C. Kinley Company, 376 S.W.2d 336

M. Bryce & Associates, Inc. v. Gladstone, 107 Wis.2d 241, 319 N.W.2d 907 (Wis.App.1982)

MBL (USA) Corp. v. Diekman, 112 Ill.App.3d 229, 445 N.E.2d 418, 67 Ill.Dec. 938 (1983)

Mason v. Jack Daniel Distillery, 518 So.2d 130 (Ala.Civ.App.1987)

Midland-Ross Corp. v. Sunbeam Equipment Corp., 316 F.Supp. 171 (W.D.Pa.1970)

Midland-Ross Corp. v. Yokana, 293 F.2d 411 (3rd Cir.1961)

Mineral Deposits Ltd. v. Zigan, 773 P.2d 606 (Colo.App.1988)

Minnesota Mining & Mfg. Co. v. Technical Tape Corp., 23 Misc.2d 671, 192 N.Y.S.2d 102 (Sup.Ct.1959)

Minuteman, Inc. v. Alexander, 147 Wis.2d 842, 434 N.W.2d 773 (1989)

Mitchell Novelty Co. v. United Mfg. Co., 199 F.2d 462 (7 Cir.1952)

Modern Controls Inc. v. Andreadakis, 578 F.2d 1264 (8 Cir.1978)

Motorola, Inc. v. Fairchild Camera and Instrument Corp., 366 F.Supp. 1173 (D.Ariz.1973)

Mycalex Corporation of America v. Pemco Corporation, 159 F.2d 907 (4th Cir.1947)

National Instrument Labs, Inc. v. Hycel, Inc., 478 F.Supp. 1179 (D.Del.1979)

National Rejectors, Inc., v. Trieman, 409 S.W.2d 1 (Mo.1966)

Nationwide Mutual Insurance v. Stenger, 695 F. Supp. 688 (D.Conn.1988)

Newell v. O. A. Newton & Son Co., 104 F.Supp. 162 (D.C.Del.1952)

Optic Graphics, Inc. v. Agee, 87 Md.App. 770, 591 A.2d 578 (1991)

Peggy Lawton Kitchens, Inc. v. Hogan, 18 Mass.App.Ct. 937, 466 N.E.2d 138 (1984)

Phillips v. Frey, 20 F.3d 623 (5th Cir.1994)

Pioneer Hi-Bred Intern. v. Holden Foundation Seeds, Inc., 35 F.3d 1226 (8th Cir.1994)

Plant Industries, Inc. v. Coleman, 287 F.Supp. 636 (C.D.Cal.1968)

Pressure Science, Inc. v. Kramer, 413 F.Supp. 618 (D.Conn.1976)

Q-Co. Industries, Inc., v. Hoffman, 625 F. Supp. 608 (S.D.N.Y.1985)

Revcor, Inc. v. Fame, Inc., 85 Ill.App.2d 350, 228 N.E.2d 742 (1967)

Robert S. Weiss & Associates v. Wiederlight, 208 Conn. 525, 546 A.2d 216

Sandlin v. Johnson, 152 F.2d 8 (8th Cir.1945)

Schalk v. State, 823 S.W.2d 633 (Tex.Crim.1991)

Schreyer v. Casco Products Corp., 190 F.2d 921 (2nd Cir.1951)

Schulenburg v. Signatrol, 212 N.E.2d 865, 33 Ill.2d 379 (1965)

Sealectro Corporation v. Tefco Electronics, Inc., 32 Misc.2d 11, 223 N.Y.S.2d 235 (Westchester Co.Sup.Ct.1961)

Secure Services Technology v. Time and Space Processing, 722 F. Supp. 1354 (E.D.Va.1989)

Selection Research v. Murman, 230 Neb. 786, 433 N.W.2d 526 (1989)

Sheets v. Yamaha Motors Corp., USA, 657 F.Supp. 319

Sigma Chemical Co. v. Harris, 605 F. Supp. 1253 (E.D. Mo. 1985)

Smith v. BIC Corp., 869 F.2d 194

Smith v. Dravo Corp., 203 F.2d 369 (7th Circuit)

Smith v. Snap-On Tools Corp., 833 F.2d 578

Solo Cup Co. v. Paper Machinery Corp., 240 F.Supp. 126 (E.D.Wisc.1965)

Space Aero Products Co. v. R.E. Darling Co., 238 Md. 93, 208 A.2d 74 (1965)

Speciner v. Reynolds Metals Company, 279 F.2d 337 (2nd Cir.1960)

Speedry Chemical Products, Inc. v. Carter's Ink Company, 306 F.2d 328 (2d Cir.1962)

Sperry Rand Corp. v. Rothlein, 241 F.Supp. 549 (D.Conn.1964)

Springfield Rare Coin Galleries, Inc. v. Mileham, 250 Ill.App.3d 922, 620 N.E.2d 479, 189 Ill.Dec. 511 (1993)

Structural Dynamics Research Corp. v. Engineering Mechanics Research Corp., 401 F.Supp. 1102 (E.D.Mich.1975)

Surgidev Corp. v. Eye Technology, Inc., 648 F.Supp. 661 (D.Minn. 1986)

Syntex Ophthalmics, Inc. v. Tsuetaki, 701 F.2d 677

Technicon Data Systems Corp. v. Curtis 1000, Inc., 224 U.S.P.Q. 286

Telerate Systems, Inc. v. Caro, 689 F.Supp. 221 (S.D.N.Y.1988)

Televation Telecommunication Systems, Inc. v. Saindon, 522 N.E.2d 1359 (Ill.App. 2 Dist. 1988)

Telex Corp. v. IBM Corp., 510 F.2d 894 (10th Cir.1975)

Tennant Co. v. Advance Mach. Co., Inc., 355 N.W.2d 720 (Minn.Ct.App.1984)

The Boeing Company v. Sierracin Corporation, 108 Wash.2d 38, 738 P.2d 665 (1987)

Thomas v. Best Mfg. Corp., 234 Ga. 787, 218 S.E.2d 68 (1975)

Trandes Corp. v. Guy F. Atkinson Co., 996 F.2d 655 (4th Cir.1993)

Tri-Tron Intern. v. Velto, 525 F.2d 432 (9th Cir.1975)

Tyson Metal Products, Inc. v. McCann, 376 Pa. Super. 461, 546 A.2d 119

USM Corp. v. Marson Fastener Corp., 379 Mass. 90, 393 N.E.2d 895 (1979)

Union Carbide Corp. v. UGI Corp., 731 F.2d 1186

Valco Cincinnati, Inc. v. N & D Machining Service, Inc., 24 Ohio St.3d 41, 492 N.E.2d 814 (1986)

Van Rensselaer v. General Motors Corp., 223 F.Supp. 323, 139 U.S.P.Q. 359 (E.D.Mich.1962)

Wanberg v. Ocean Spray Cranberries, Inc., 194 U.S.P.Q. 350 (N.D.Ill. 1977)

Wexler v. Greenberg, 399 Pa. 569, 160 A.2d 430 (1960)

Zoecon Industries v. American Stockman Tag Co., 713 F.2d 1174

APPENDIX D

CASE DIAGRAMS

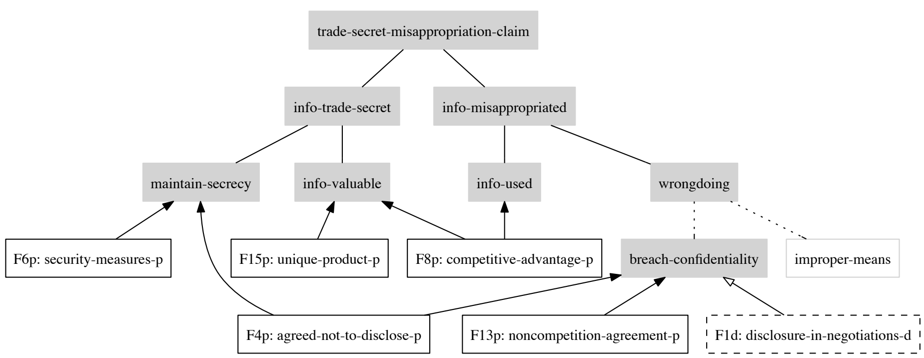

Figure 34: case diagram for AFFILIATED-HOSPITAL

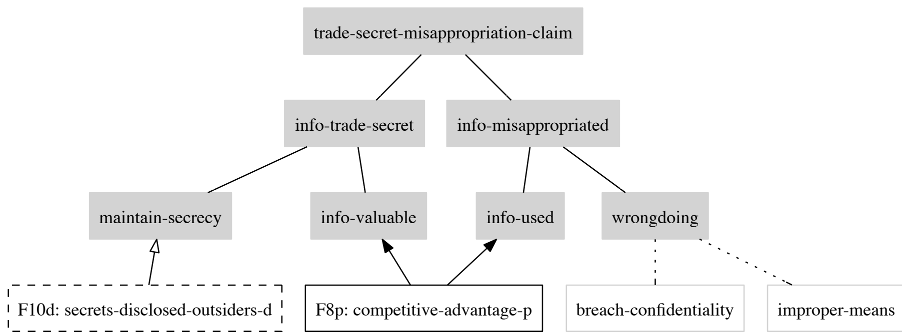

Figure 35: case diagram for AL-LABORATORIES

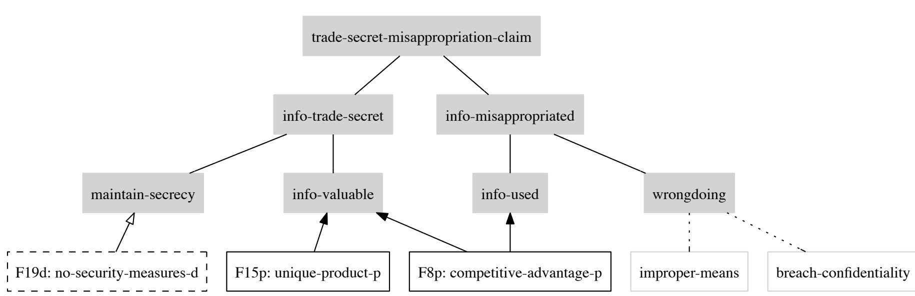

Figure 36: case diagram for ALLEN

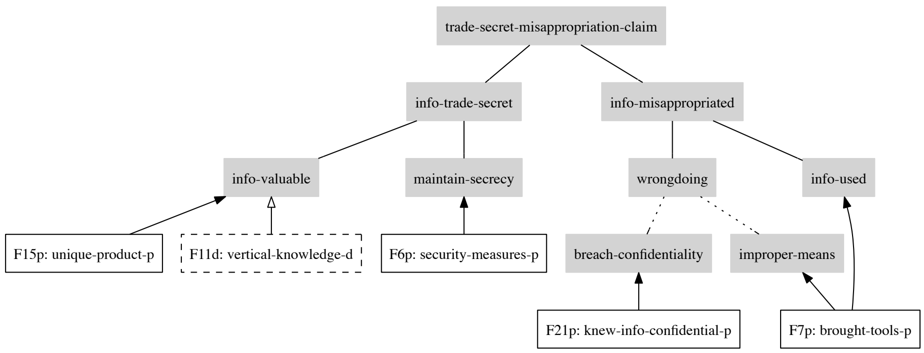

Figure 37: case diagram for AM-SKIER

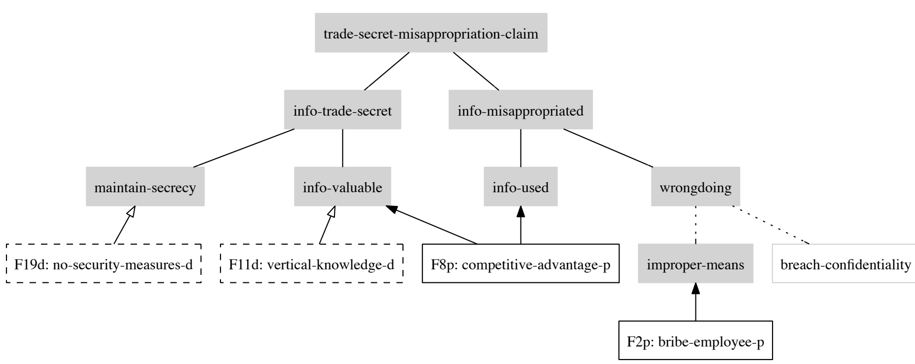

Figure 38: case diagram for DICKS

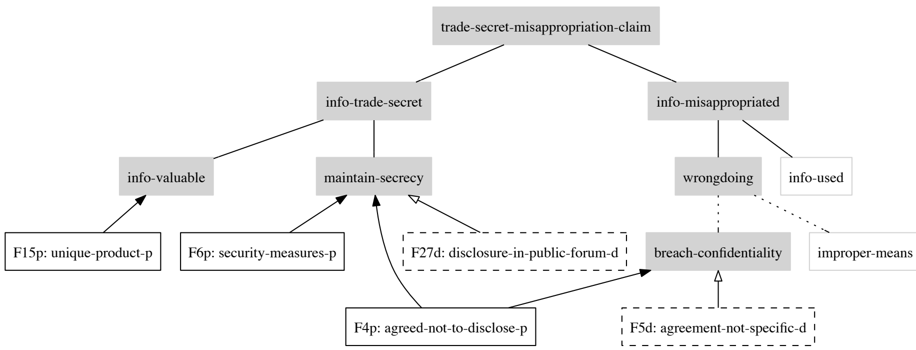

Figure 39: case diagram for DYNAMICS

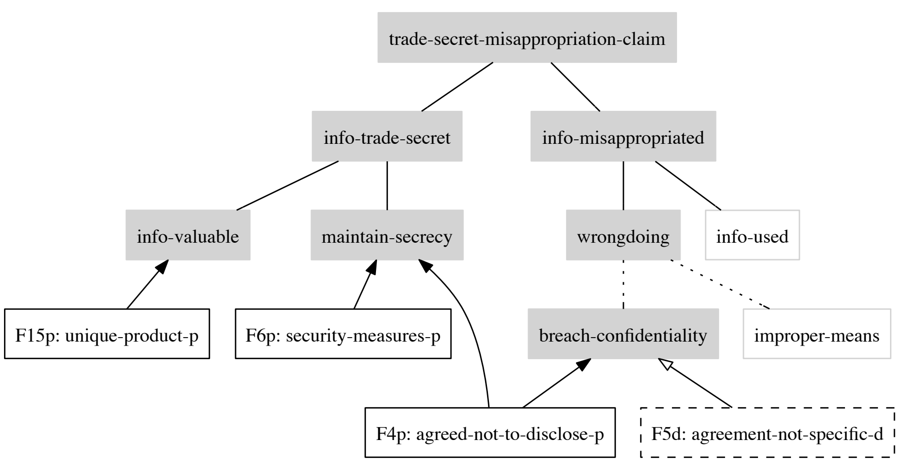

Figure 40: case diagram for EASTERN-MARBLE

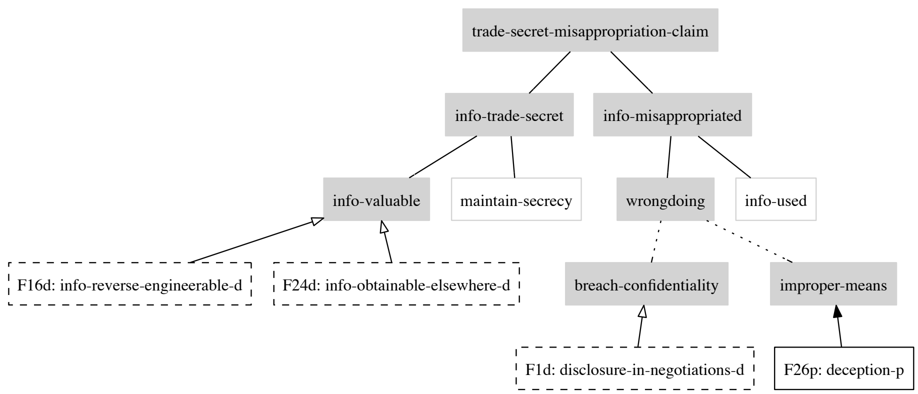

Figure 41: case diagram for FRANKE

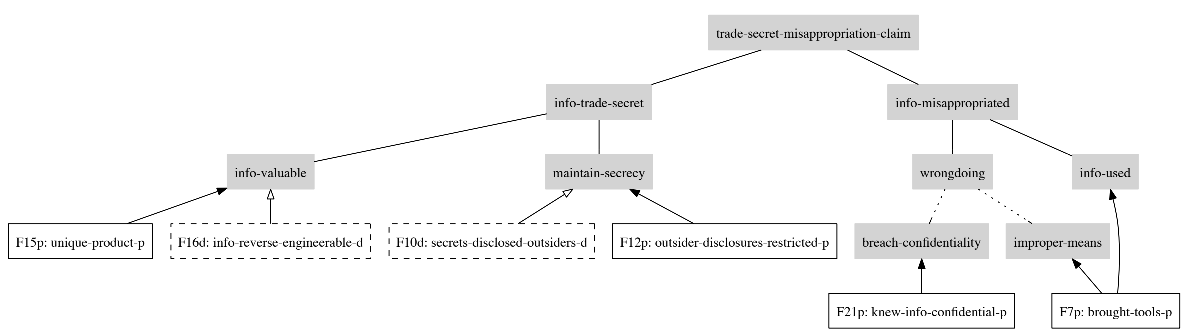

Figure 42: case diagram for ILG-INDUSTRIES

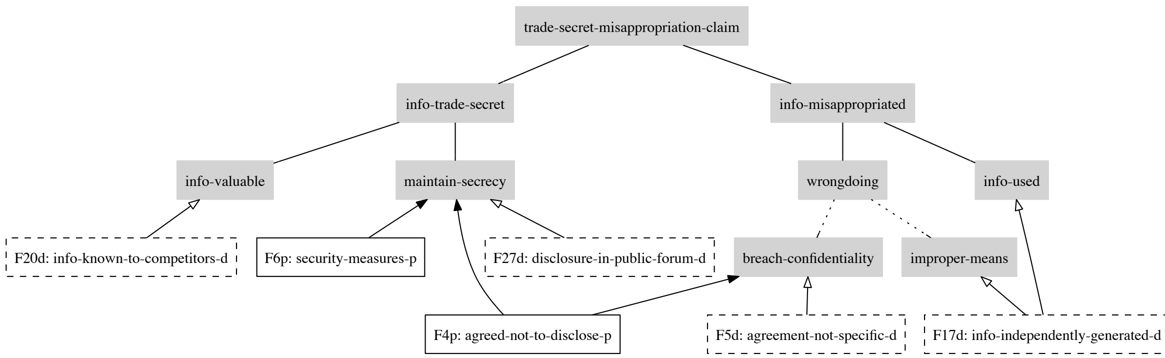

Figure 43: case diagram for JOSTENS

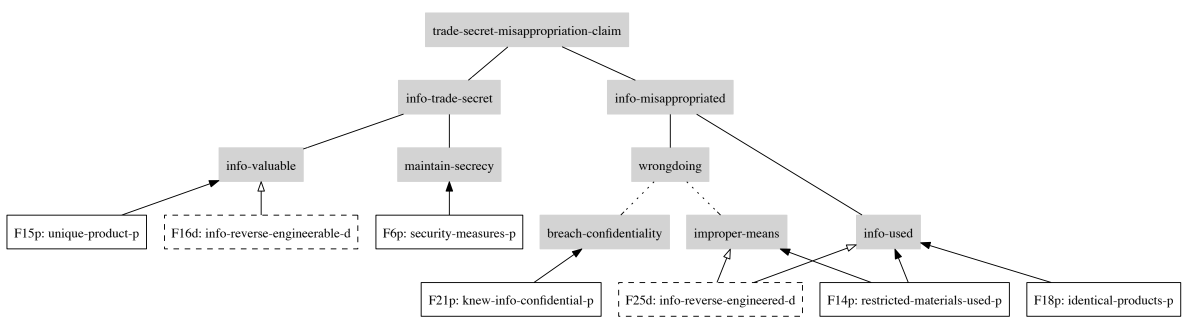

Figure 44: case diagram for KG

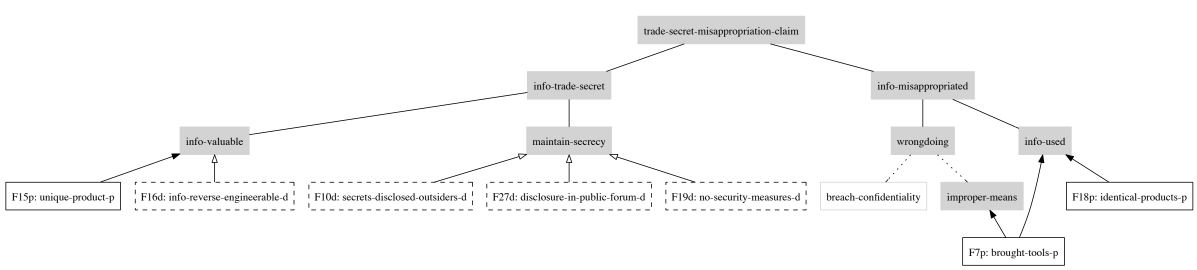

Figure 45: case diagram for NATIONAL-REJECTORS

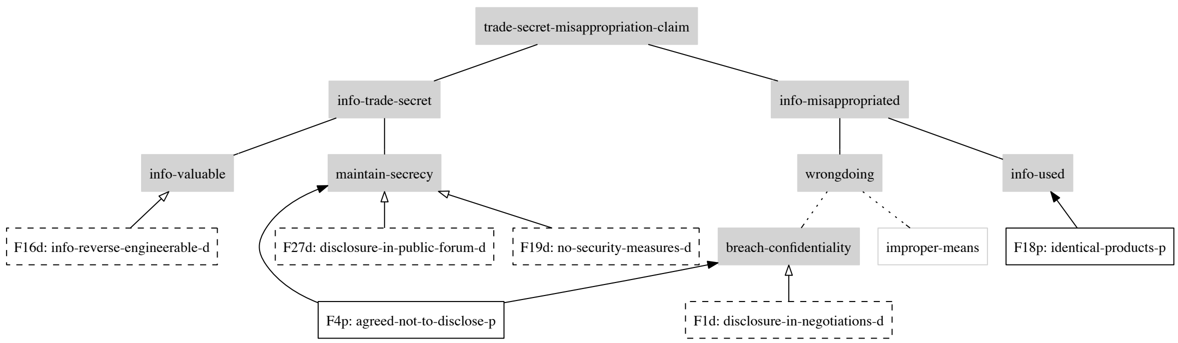

Figure 46: case diagram for SANIRAB

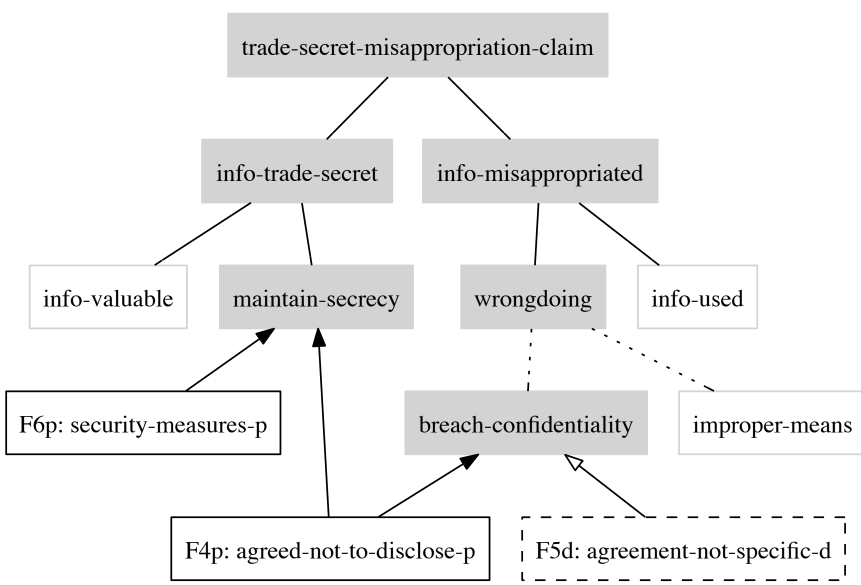

Figure 47: case diagram for THOMAS

APPENDIX E

IBP KG PREDICTION

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Prediction for KG, which was won by PLAINTIFF
  Factors favoring plaintiff: (F21 F18 F15 F14 F6)
  Factors favoring defendant: (F25 F16)
Issue raised in this case is SECURITY-MEASURES
  Relevant factors in case: F6(P)
The issue-related factors all favor the outcome PLAINTIFF.
Issue raised in this case is INFO-USED
  Relevant factors in case: F25(D) F18(P) F14(P)
Theory testing did not retrieve any cases, broadening the query.
For INFO-USED, the query can be broadened for PLAINTIFF.
Each of the pro-P Factors (F14 F18) is dropped for new theory testing.
  Theory testing with Factors (F14 F25) gets the following cases:
  (TECHNICON PLAINTIFF F6 F10 F12 F14 F16 F21 F25)
  In this broadened query, PLAINTIFF is favoredd.
  Theory testing with Factors (F18 F25) gets the following cases:
  (MINERAL-DEPOSITS PLAINTIFF F1 F16 F18 F25)
  In this broadened query, PLAINTIFF is favored.
By an a-forteriori argument, the PLAINTIFF is favored for INFO-USED.
Issue raised in this case is INFO-VALUABLE
  Relevant factors in case: F16(D) F15(P)
Theory testing has no clear outcome, try to explain away exceptions.
Cases won by plaintiff:
  AMERICAN-CAN (F4 F6 F15 F16 F18)
  HENRY-HOPE (F4 F6 F15 F16)
  ILG-INDUSTRIES (F7 F10 F12 F15 F16 F21)
  KAMIN (F1 F10 F16 F18 F15)
  KUBIK (F7 F15 F16 F18 F21)
  MASON (F15 F16 F6 F21 F1)
  TELEVATION (F6 F10 F12 F15 F16 F18 F21)
Cases won by defendant:
  NATIONAL-REJECTORS (F7 F10 F15 F16 F18 F19 F27)
Trying to explain away the exceptions favoring DEFENDANT
```

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  NATIONAL-REJECTORS can be explained away because of the unshared
  ko-factor(s) (F27 F19).
Therefore, PLAINTIFF is favored.
Issue raised in this case is CONFIDENTIAL-RELATIONSHIP
  Relevant factors in case: F21(P)
The issue-related factors all favor the outcome PLAINTIFF.
Outcome of the issue-based analysis:
   For issue CONFIDENTIAL-RELATIONSHIP, PLAINTIFF is favored.
   For issue INFO-VALUABLE, PLAINTIFF is favored.
   For issue INFO-USED, PLAINTIFF is favored.
   For issue SECURITY-MEASURES, PLAINTIFF is favored.
Predicted outcome for KG is PLAINTIFF, which is correct.
```

APPENDIX F

LEARNED WEIGHTMAP EXAMPLES

Fig. 48 and 49 each show a box plot of the value effect weight distribution of the 121 best weight maps created in the VJAP-timeline condition on the dataset with 300 annealing iterations. Every entry on the left side is a triple *(value, effect type, causal factor)*. Acronyms for values are: PP: Protection of Property, PC: Protection of Confidentiality, PI: Public Information, FC: Fair Competition.

Every horizontal slice of the box plot represents the distribution of the labeled effect weight over 121 complete simulated annealing optimization processes, i.e. the distribution of an effect weight's value across 121 different which maps with about equally good prediction performance.

The black dot represents the median weight and the two rectangles to the left and right of it each represent the partition of the 0-1 interval where the two 'middle' 25% of the data above and below the median fall, respectively. This means that a wider rectangle corresponds to greater, and a narrower rectangle to lower, variance in the weight distribution. The highest and lowest 25% are shown as the dashed lines on the left and right side.

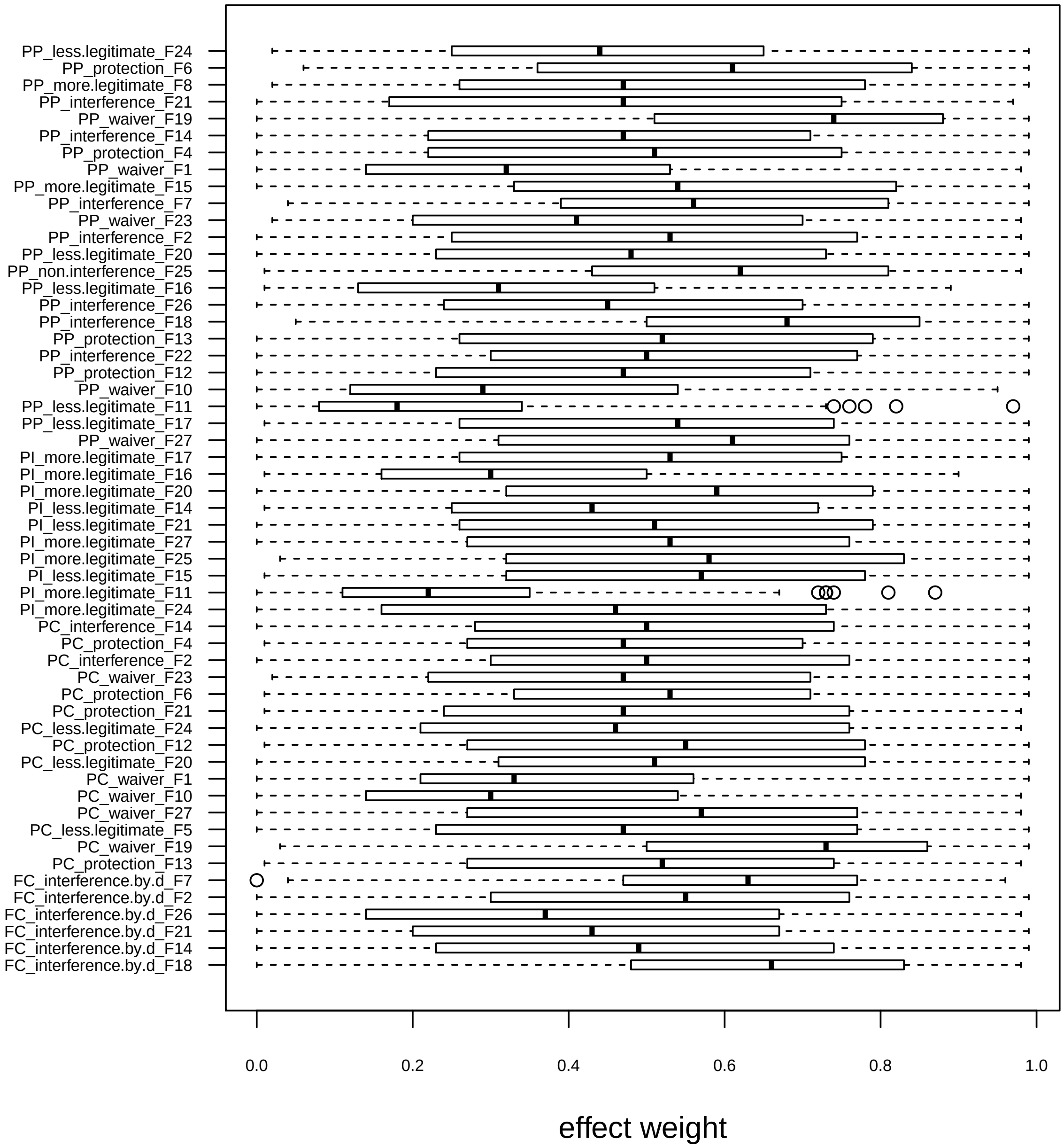

Figure 48: weightmap for VJAP-Timeline condition

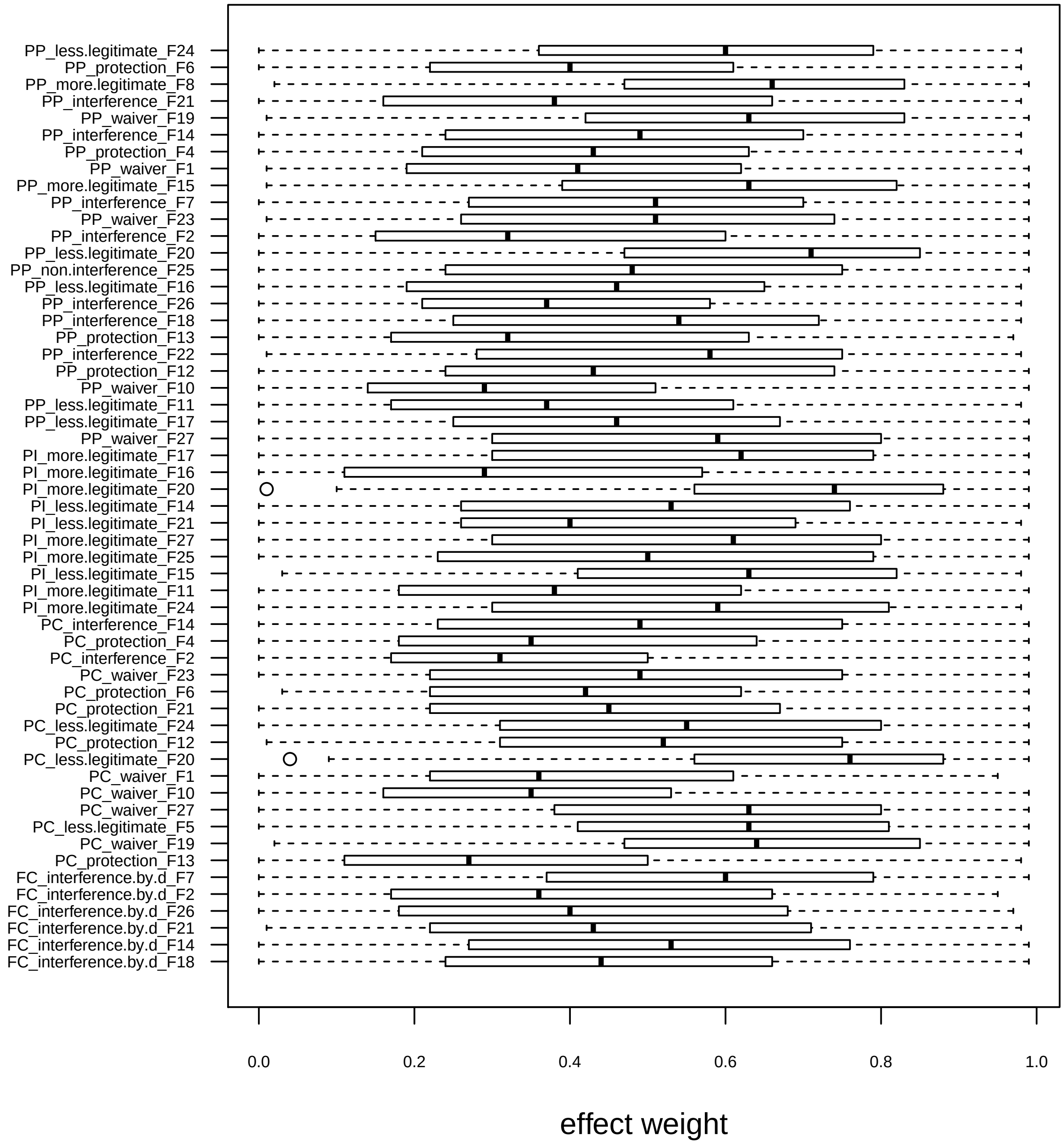

Figure 49: weightmap for Global Tradeoff Weight condition (GTW)

BIBLIOGRAPHY

[AAABC] Latifa Al-Abdulkarim, Katie Atkinson, and Trevor Bench-Capon. A methodology for designing systems to reason with legal cases using abstract dialectical frameworks. *Artificial Intelligence and Law*, pages 1–49.

[AB06] Kevin D Ashley and Stefanie Brüninghaus. Computer models for legal prediction. *Jurimetrics*, pages 309–352, 2006.

[ABC05] Katie Atkinson and Trevor Bench-Capon. Legal case-based reasoning as practical reasoning. *Artificial Intelligence and Law*, 13(1):93–131, 2005.

[ABCM05] Katie Atkinson, Trevor Bench-Capon, and Peter McBurney. Arguing about cases as practical reasoning. In *Proceedings of the 10th international conference on Artificial intelligence and law*, pages 35–44. ACM, 2005.

[Ale03a] Vincent Aleven. Using background knowledge in case-based legal reasoning: a computational model and an intelligent learning environment. *Artificial Intelligence*, 150(1):183–237, 2003.

[Ale03b] R. Alexy. On balancing and subsumption. a structural comparison. *Ratio Juris*, 16(4):433–49, December 2003.

[Ale10] R. Alexy. Two or three? In Martin Borowski, editor, *On the Nature of Legal Principles, Archiv für Rechts- und Sozialphilosophie, Beiheft 119*, volume Beiheft 119, pages 9–18. 2010.

[Ash91a] Kevin D Ashley. *Modeling legal arguments: Reasoning with cases and hypotheticals*. MIT press, 1991.

[Ash91b] Kevin D. Ashley. Reasoning with cases and hypotheticals in hypo. *In: Int. J. ManMachine Studies*, 34:753–796, 1991.

[Ash09] Kevin D Ashley. Teaching a process model of legal argument with hypotheticals. *Artificial Intelligence and Law*, 17(4):321–370, 2009.

[Ash13] K. Ashley. Evaluating the uses of values in a model of legal reasoning with cases incorporating theories and values. In Henry Prakken Katie Atkinson and Adam Wyner, editors, *From Knowledge Representation to Argumentation in AI,* *Law and Policy Making, Festschrift in Honour of Trevor Bench-Capon*. College Publications, 2013.

[AW13] Kevin D Ashley and Vern R Walker. From informanon retrieval (ir) to argument retrieval (ar) for legal cases: Report on a baseline study. 2013.

[BA03a] Stefanie Brüninghaus and Kevin D Ashley. Combining case-based and model-based reasoning for predicting the outcome of legal cases. In *Case-based reasoning research and development*, pages 65–79. Springer, 2003.

[BA03b] Stefanie Brüninghaus and Kevin D Ashley. Predicting outcomes of case based legal arguments. In *Proceedings of the 9th international conference on Artificial intelligence and law*, pages 233–242. ACM, 2003.

[BC03] Trevor J. M. Bench-Capon. Persuasion in practical argument using value-based argumentation frameworks. *Journal of Logic and Computation*, 13:2003, 2003.

[BCA09] Trevor Bench-Capon and Katie Atkinson. Action-state semantics for practical reasoning. In *Proceeding of the Fall Symposium on the Uses of Computational Argument*, 2009.

[BCAC05] Trevor Bench-Capon, Katie Atkinson, and Alison Chorley. Persuasion and value in legal argument. *Journal of Logic and Computation*, 15(6):1075–1097, 2005.

[BCS03] Trevor Bench-Capon and Giovanni Sartor. A model of legal reasoning with cases incorporating theories and values. *Artificial Intelligence*, 150(1):97–143, 2003.

[BH86] Donald Berman and Carole Hafner. Obstacles to the development of logic-based models of legal reasoning. *Computer Power and Legal Language*, pages 183–214, 1986.

[BH93] Donald H Berman and Carole D Hafner. Representing teleological structure in case-based legal reasoning: the missing link. In *Proceedings of the 4th international conference on Artificial intelligence and law*, pages 50–59. ACM, 1993.

[BIKZ09] Michael J Bommarito II, Daniel Katz, and Jon Zelner. Law as a seamless web?: comparison of various network representations of the united states supreme court corpus (1791-2005). In *Proceedings of the 12th international conference on artificial intelligence and law*, pages 234–235. ACM, 2009.

[Bra91] L Karl Branting. Building explanations from rules and structured cases. *International journal of man-machine studies*, 34(6):797–837, 1991.

[CBc03] Alison Chorley and Trevor Bench-capon. Reasoning with legal cases as theory construction: Some experimental results. In *In Bourcier, D.(ed), Proceedings of Jurix 2003. IOS PressAmsterdam*. Citeseer, 2003.

[CBC04] Alison Chorley and Trevor Bench-Capon. Support for constructing theories in case law domains. In *Database and Expert Systems Applications*, pages 508–517. Springer, 2004.

[CBC05a] Alison Chorley and Trevor Bench-Capon. Agatha: Using heuristic search to automate the construction of case law theories. *Artificial Intelligence and Law*, 13(1):9–51, 2005.

[CBC05b] Alison Chorley and Trevor Bench-Capon. An empirical investigation of reasoning with legal cases through theory construction and application. *Artificial Intelligence and Law*, 13(3-4):323–371, 2005.

[Dun95] Phan Minh Dung. On the acceptability of arguments and its fundamental role in nonmonotonic reasoning, logic programming and n-person games. *Artificial Intelligence*, 77:321–357, 1995.

[EGKF93] Morten Elvang-Gøransson, Paul J Krause, and John Fox. Acceptability of arguments as 'logical uncertainty'. In *Symbolic and Quantitative Approaches to Reasoning and Uncertainty*, pages 85–90. Springer, 1993.

[F$^+$15] Eveline T Feteris et al. The role of pragmatic argumentation referring to consequences, goals, and values in the justification of judicial decisions. 2015.

[GA10] Matthias Grabmair and Kevin D Ashley. Argumentation with value judgments - an example of hypothetical reasoning. In *Proceedings of the 2010 conference on Legal Knowledge and Information Systems: JURIX 2010: The Twenty-Third Annual Conference*, pages 67–76. IOS Press, 2010.

[GA11] Matthias Grabmair and Kevin D Ashley. Facilitating case comparison using value judgments and intermediate legal concepts. In *Proceedings of the 13th international conference on Artificial intelligence and law*, pages 161–170. ACM, 2011.

[GA13a] Matthias Grabmair and Kevin D Ashley. A survey of uncertainties and their consequences in probabilistic legal argumentation. In *Bayesian Argumentation*, pages 61–85. Springer, 2013.

[GA13b] Matthias Grabmair and Kevin D. Ashley. Using event progression to enhance purposive argumentation in the value judgment formalism. In *Proceedings of the Fourteenth International Conference on Artificial Intelligence and Law*, ICAIL '13, pages 73–82, New York, NY, USA, 2013. ACM.

[GCM03] Katie Greenwood, Trevor Bench Capon, and Peter McBurney. Towards a computational account of persuasion in law. In *Proceedings of the 9th international conference on Artificial intelligence and law*, pages 22–31. ACM, 2003.

[GGW10] Matthias Grabmair, Thomas F Gordon, and Douglas Walton. Probabilistic semantics for the carneades argument model using bayesian networks. In *COMMA*, pages 255–266, 2010.

[GPW07] Thomas F Gordon, Henry Prakken, and Douglas Walton. The carneades model of argument and burden of proof. *Artificial Intelligence*, 171(10):875–896, 2007.

[GW09] Thomas F Gordon and Douglas Walton. Proof burdens and standards. In *Argumentation in Artificial Intelligence*, pages 239–258. Springer, 2009.

[Har58] Herbert Lionel Adolphus Hart. Positivism and the separation of law and morals. *Harvard law review*, pages 593–629, 1958.

[HFH+09] Mark Hall, Eibe Frank, Geoffrey Holmes, Bernhard Pfahringer, Peter Reutemann, and Ian H Witten. The weka data mining software: an update. *ACM SIGKDD explorations newsletter*, 11(1):10–18, 2009.

[McC95] L Thorne McCarty. An implementation of eisner v. macomber. In *Proceedings of the 5th international conference on Artificial intelligence and law*, pages 276–286. ACM, 1995.

[Mod06] S. Modgil. Value based argumentation in hierarchical argumentation frameworks. In *Proceeding of the 2006 conference on Computational Models of Argument: Proceedings of COMMA 2006*, pages 297–308, Amsterdam, The Netherlands, The Netherlands, 2006. IOS Press.

[NM91] Susan Newman and Catherine Marshall. Pushing toulmin too far: Learning from an argument representation scheme. *Xerox PARC, Palo Alto, CA, USA, Technical Report SSL-92*, 45, 1991.

[Pea85] Judea Pearl. *Bayesian networks: A model of self-activated memory for evidential reasoning.* University of California (Los Angeles). Computer Science Department, 1985.

[Pol87] John L Pollock. Defeasible reasoning. *Cognitive science*, 11(4):481–518, 1987.

[Pra10] Henry Prakken. An abstract framework for argumentation with structured arguments. *Argument and Computation*, 1(2):93–124, 2010.

[PS98] Henry Prakken and Giovanni Sartor. Modelling reasoning with precedents in a formal dialogue game. In *Judicial Applications of Artificial Intelligence*, pages 127–183. Springer, 1998.

[Qui14] J Ross Quinlan. *C4. 5: programs for machine learning.* Elsevier, 2014.

[RS91] Edwina L. Rissland and David B. Skalak. Cabaret: Rule interpretation in a hybrid architecture. *International Journal of Man-Machine Studies*, 1991.

[Sar10] Giovanni Sartor. Doing justice to rights and values: teleological reasoning and proportionality. *Artificial Intelligence and Law*, 18(2):175–215, 2010.

[Sch08] Frederick Schauer. A critical guide to vehicles in the park. *University of Virginia Legal Working Paper Series*, page 93, 2008.

[SK83] M. P. Vecchi S. Kirkpatrick, C. D. Gelatt. Optimization by simulated annealing. *Science*, 220(4598):671–680, 1983.

[SSK+86] M. J. Sergot, F. Sadri, R. A. Kowalski, F. Kriwaczek, P. Hammond, and H. T. Cory. The british nationality act as a logic program. *Communications of the ACM*, 29, 1986.

[Tha04] Paul Thagard. Causal inference in legal decision making: Explanatory coherence vs. bayesian networks. *Applied Artificial Intelligence*, 18(3-4):231–249, 2004.

[VPRV15] Charlotte Vlek, Henry Prakken, Silja Renooij, and Bart Verheij. Constructing and understanding bayesian networks for legal evidence with scenario schemes. In *Proceedings of the 15th International Conference on Artificial Intelligence and Law*, pages 128–137. ACM, 2015.

[Vre93] Gerard Vreeswijk. *Studies in defeasible argumentation.* 1993.

[WBCA11] Adam Z Wyner, Trevor JM Bench-Capon, and Katie M Atkinson. Towards formalising argumentation about legal cases. In *Proceedings of the 13th international conference on artificial intelligence and law*, pages 1–10. ACM, 2011.

[WP10] Adam Wyner and Wim Peters. Lexical semantics and expert legal knowledge towards the identification of legal case factors. In *JURIX*, volume 10, pages 127–136, 2010.