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A distinct novel feature of modular argumentation in compare with other modular logic-based systems like Prolog is that it allows references to different semantics in the same module at the same time, a feature critically important for application of argumentation in legal domains like contract dispute resolution where the outcomes of court cases often depend on whether credulous or skeptical modes of

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# Modular Argumentation For Modelling Legal Doctrines in Common Law of Contract

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Abstract. To create a programming environment for contract dispute resolution, we propose an extension of assumption-based argumentation (ABA) into modular assumption-based argumentation (MABA) in which different modules of argumentation representing different knowledge bases for reasoning about beliefs and facts and for representation and reasoning with the legal doctrines could be built and assembled together. A distinct novel feature of modular argumentation in compare with other modular logic-based systems like Prolog is that it allows references to different semantics in the same module at the same time, a feature critically important for application of argumentation in legal domains like contract dispute resolution where the outcomes of court cases often depend on whether credulous or skeptical modes of reasoning were applied by the contract parties. We apply the new framework to model the doctrines of contract breach and mutual mistake.

# 1. Introduction

**Example 1.1** Imagine that your organization had contracted a software company to integrate the computer systems of its head office and a newly acquired business following a design from your IT department. The integration failed. Your organization sued the software company. The company argues that both sides have made a mistake in believing that the design is workable. It hence asks for relief of performance. How should the court rule ? Would it be possible to arbitrate such disputes online ?

Common law has a case-by-case basis. The main task in reasoning with cases is to construct a theory from past cases that produces the desired legal result and to persuade the judge of its validity [6,26]. As the vast and increasing number of cases lead to many conflicting decisions and an increased uncertainty in the law, Restatements (First and Second) of Contracts have been proposed to "restate" clearly and precisely the principles and rules of common law [38]. The restatements are especially helpful when there are not many precedent cases similar to the case at hand, a situation that is characterstic of e-commerce. The clear and precise presentation of the legal doctrines in Restatement Second (Rest 2d) makes it especially appropriate for formal modeling. Such model would

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make the intepretation of cases much easier and less arbitrary. Legal doctrines in Restatement Second could be viewed as a widely accepted interpretation of the principles, guidline and rules for constructing theories in reasoning with cases.

In AI, much work has been done to study computational models for different aspects of law. One of the earlest legal reasoning system is the rule-based system of Sergot et al. [37] determing whether an applicant is eligible for British citizenship based on logic rules encoding the British Nationality Act. Though representing a major application of logic programming as a tool for constructing legal expert systems, the proposal was critized as jurisprudentially not convincing[25]. Further, it also does not deal with precedents. Systems capable of reasoning with precedents include among others TAXMAN [26], HYPO [1,35], CABERET [33]. The main task they perform is to construct a theory from precedent cases producing the desired legal outcome for the current case.

Legislation and precedents are the most important legal sources[40]. A disputant, having constructed a theory from these in his favour, has to persuade the judge on its validity[6,26] by presenting arguments to defend it against attacking arguments presented by his opponent. Formal argumentation in AI develops a number of frameworks, of which the most abstract is the argumentation framework proposed in [13] defined by a set of "atomic" arguments together with a binary relation representing the attack relation between arguments. The semantics of abstract argumentation is based on the notion of acceptability of arguments: an argument A is acceptable wrt a set S of arguments iff S attacks every argument attacking A. Due to the close resemblance between a proof of argument acceptance and an informal dispute, formal argumentation is considered as providing a natural platform for dispute resolution in many aspects [3,5,6,22,23,31,30].

To integrate reasoning with cases into formal argumentation, arguments for or against legal theories and attacks between them must be identified. In [7] Berman and Hafner argued that disputants build such arguments from factors of the case but justify them by appealing to the value their acceptance would advance. In [29] Prakken illustrated a method for expressing such values in the system of Prakken and Sartorr [32]. Sartor [36] modeled reasoning with cases as dialectical theory construction via a set of operators directed by teleology. Value-based argumentation was shown to provide a natural platform for case-based reasoning in [3,5,6]. There, a judge, seen as a theory constructor, decides on competitive theories taking into account the preference over the social values they advance. Attention has been made to analyse how a judge makes this decision [5], or how a judge considers a case factor as relevant [34] via argumentation. A legal doctrine can be viewed as guidelines to make these tasks of a judge less dependent on his own preference and personality. To articulate the values desired by the society, judges are expected to argue "deductively" with legal doctrines and "inductively" with precedents. Since legal doctrines often have been thoroughly examined, the social values they bring about are convincing and accountable. For instance, as repeatedly described in many legal sources (e.g. [24]), the doctrines of impossibility and frustration [18] help to restore *fairness* in unexpected situations by allocating the loss fairly.

Reasoning about factors also calls for argumentation. The contexts of contract consisting of different knowledge bases about beliefs and expertise of contract parties as well as about common social, legal domains at the time of contract making or performance need to be built. This is done during legal proceedings by exchanges of arguments between the parties and the judge. The acceptance of the exchanged arguments are based on permissible evidences, permissible common domain knowledge and social norms. While there is a significant body of research on protocols for such exchanges [12,5,22,23,31,30], evidential reasoning in AI is less well studied [4]. Poole in [27] has illustrated how a scenario-based approach can be modelled as abductive reasoning in his Theorist system. Bex et al. in [8] argues for the relevance of argumentation schemes, and the combination of argumentation schemes with scenario-based approach in [9]. Argumentation schemes can be seen as semi-formal defeasible rules [39]. An argumentation scheme is associated with a number of critical questions identifying attacks against arguments based on it. For example, an argumentation scheme for evidential reasoning "If a witness says that P then P" has a critical question "is the witness sincere?". Argumentation schemes are rooted in informal argumentation[11]. Argumentation schemes can be represented in a nomonotonic logic like in [39], or assumption-based argumentation like in [15], or abstract argumentation framework like in [2].

To our best knowledge, there has not been sufficient work focusing on contract interpretation. Exceptions are the formalism of [41,42] using meta-level rules in first order logic to deduce contractual obligations and the rule-based system of [21] supporting decision makers, both for disputes in the offer-and-acceptance area of contract. It is not clear how to apply these formalisms for modelling other legal doctrines since they are silent on important aspects, for example, how contexts are structured or how to represent risk attitudes of contract parties.

To resolve contract disputes the court often has to construct hypothetical contracts, also called intended contracts, to represent what the parties would have agreed on had they forseen the unexpected situations. Legal doctrines in contract laws provide rules and guidelines for determining risk allocation in intended contracts. The court's decision will then follow the terms of the risk allocation in the intended contracts.

To motivate the introduction of modular argumentation for contract dispute resolution, we first introduce the doctrine of mutual mistake. The mutual mistake doctrine allows one party to rescind a contract because both parties have acted on a mistaken belief about an existing fact. The party seeking relief must show that 1) the mistake concerns a basic assumption on which the contract was based, and 2) the mistake has a major impact on the fairness of the contract , and 3) the risk of this type of mistake is not allocated to the party seeking relief. For illustration of the doctrine, we recall several famous court cases below [20].

**Example 1.2** (Sherwood Case, Michigan, 1887) Walker, a cattle breeder, agreed to sell Sherwood, a banker, a cow (Rose 2d of Aberlone) which both parties believe to be barren. The price was 80 USD. Prior to the delivery, Walker discovered that Rose 2d is pregnant and refused to deliver her. The market price of a pregnant cow was around 800 USD. Sherwood sued, prevailed in trial court but lost in appeal. The appeal court based its decision on mutual mistake.

**Example 1.3** (Wood Case, Wisconsin, 1885) Clarissa Wood found a colourful stone. She was told it could possibly be a topasz. She asked Boyton, a jewellry dealer. Boyton was not sure either and offered to buy it for one dollar. Wood declined. But later she needed money and returned to sell it to Boyton for one dollar. Later it turned out to be a rough diamont worth around 700 dollars. Wood brought a court action for the return of the stone citing mutual mistake. The court agreed that there was a mutual mistake but still ruled in favor of Boyton though not quite clear reasons had been given.

Analyzing this case under the doctrine of mutual mistake, modern courts and scholars agree with the ruling for the reason of conscious ignorance meaning that Wood had known that there was a risk that the stone could be more valuable but still decided to sell it. Hence she should be allocated the risk of her decision.

Many modern courts and law schools advocate the allocation of risk based on efficiency as illustrated in the following case.

**Example 1.4** (Stees v Leonard, Minnesota, 1874) Leonard, the defendant, had a contract with Stees to build a house following a given specification commissioned by Stees. But due to unforeseen soil conditions, the construction collapsed twice when it reached certain height. Leonard then refused to continue. Stees sued for breaching of contract. Leonard defended himself by reason of mutual mistake in not foreseeing the soil conditions and faulty specification. The court ruled in favor of Stees for reasons that although there was a mutual mistake, as an expert in this building business, Leonard is expected to foresee such conditions and to take appropriate measures. The failure to do so should be at the risk of Leonard.

The decision could be completely different if Stees has the resource and means to detect more cheaply than Leonard the soil conditions and the mistakes in the specification (see Bentley v State, Wisconsin, 1889 [20])

How should the dispute in example 1.1 be resolved ? The decision depends on many factors. If your organization does not have much expertise in IT then the software company would be the more efficient cost bearer and the decision could be in the favor of your organization (witness Stees v Leonard). But if your organization has a reputed software engineering department or has been warned about possible problems in the design before signing the contract then the ruling could very well be in favor of the defendant (witness Bentley v State).

To represent and reason with the doctrine of mutual mistake, a number of distinct knowledge bases about the beliefs of the contract parties and their expertises as well as about common market, social and legal knowledge at the time of contract making need to be established. A module representing the mutual mistake doctrine should then combine these knowledge bases to determine the outcome of the case.

The paper is organized as follows. In chapter 2, we recall the most basics of abstract argumentation and assumption-based argumentation and then introduce modular argumentation. In chapter 3, we give a definition of contract appropriate for our purpose and introduce a notion of context for the doctrine of mutual mistake. We represent the doctrine of mutual mistake by introducing the idea of intended contracts in chapter 4. In chapter 5 we model the doctrine of mutual mistake in modular argumentation.<sup>2</sup>

## 2. Modular Argumentation

An abstract argumentation framework [13] is a pair (AR, attacks) where AR is a set of arguments and attacks is a binary relation over AR representing the relation that an argument A attacks an argument B for  $(A, B) \in attacks$ . The semantics of abstract

<sup>&</sup>lt;sup>2</sup>This paper is an extended version of [17]

argumentation is determined by the acceptability of arguments and various associated notions of extensions. For the purpose of this paper, we introduce only one of them. A set of arguments is said to be *conflict-free* if it does not contain two arguments attacking each other. A confict-free set S of arguments is said to be *admissible* if S counterattacks each attack against it, i.e. for each argument A that attacks some argument B in S there is an argument C in S that attacks A. A maximal admissble set of arguments is called a *preferred extension*.

Abstract argumentation provides a natural platform for understanding many legal procedures [3,5,6,22,23,31,30]. But it does not provide a programming environment in which the arguments for such procedures could be constructed automatically. To address this issue, an instance of abstract argumentation called assumption-based argumentation where the arguments are deductive proofs based on assumptions [14] could be used.

An assumption-based argumentation (ABA) framework is a triple  $(\mathcal{R}, \mathcal{A}, \overline{\phantom{a}})$  where  $\mathcal{R}$  is set of inference rules of the form  $l_0 \leftarrow l_1, \ldots l_n$  (for  $n \ge 0$ ) over a language  $\mathcal{L}$ , and  $\mathcal{A} \subseteq \mathcal{L}$  is a set of assumptions, and  $\overline{\phantom{a}}$  is a (total) mapping from  $\mathcal{A}$  into  $\mathcal{L}$ , where  $\overline{x}$  is referred to as the *contrary* of x. Assumptions in  $\mathcal{A}$  do not appear in the heads of rules in  $\mathcal{R}$ .

A (backward) deduction of a conclusion  $\alpha$  based on (or supported by) a set of premises P is a sequence of sets  $S_1, \ldots, S_m$ , where  $S_i \subseteq \mathcal{L}$ ,  $S_1 = \{\alpha\}$ ,  $S_m = P$ , and for every i, where  $\sigma$  is the selected sentence in  $S_i: \sigma \notin P$  and  $S_{i+1} = S_i - \{\sigma\} \cup S$  for some inference rule of the form  $\sigma \leftarrow S \in \mathcal{R}$ .

A sentence l is supported by a set of propositions X denoted by  $X \models l$  if there exists a backward deduction for l from some  $X' \subseteq X$ . An *argument* for  $x \in \mathcal{L}$  supported by a set of assumptions X is a (backward) deduction from x to X and denoted by (x, X). An argument (x, X) attacks an argument (y, Y) if x is the contrary of some assumption in Y. The obtained abstract argumentation framework is denoted by  $AA_{\mathcal{F}}$ . The semantics of an ABA  $\mathcal{F}$  is defined by  $AA_{\mathcal{F}}$ .

Given an ABA framework  $\mathcal{F}$ , a proposition  $\pi \in \mathcal{L}$  is said to be a *credulous conse*quence of  $\mathcal{F}$ , denoted by  $\mathcal{F} \vdash_{cr} \pi$  if it is supported by an argument in some preferred extension E of  $AA_{\mathcal{F}}$ .  $\pi$  is said to be a *skeptical consequence* of  $\mathcal{F}$ , denoted by  $\mathcal{F} \vdash_{sk} \pi$ if in each preferred extension of  $AA_{\mathcal{F}}$  there is an argument supporting  $\pi$ .

Often it is helpful to work with a direct semantics of ABA that is defined directly without reference to  $AA_{\mathcal{F}}$  as follows. A set of assumptions S attacks an assumption  $\alpha$  if there is an argument (y, Y) with  $Y \subseteq S$  and  $y = \overline{\alpha}$ . S attacks a set of assumptions R if S attacks an assumption in R.

A set of assumptions S is *admissible* if S attacks each set of assumptions R that attacks S, and S does not attack itself. A maximal admissible set of assumptions is called a *preferred set of assumptions*. The relationship between the direct semantics of an ABA  $\mathcal{F}$  and its corresponding AA  $AA_{\mathcal{F}}$  is captured by the following properties [16]:

- 1. Let S be an admissible set of arguments in  $AA_{\mathcal{F}}$ . Then the union of all assumptions of the arguments in S is an admisisble set of assumptions in  $\mathcal{F}$ .
- 2. Given an admissible set of assumptions S in  $\mathcal{F}$ , then the set of all arguments whose assumptions belonging to S is admissible in  $AA_{\mathcal{F}}$ .
- 3. A sentence  $\sigma$  is supported by an argument in a preferred extension E of  $AA_{\mathcal{F}}$  iff  $\sigma$  is supported by the set of all assumptions in the arguments of E.

A modular assumption-based argumentation (MABA) framework is structured into distinct modules where exactly one of them is considered as the main module while

the others are called submodules. A module is basically an ABA framework with the exceptions that the premises in its rules are either sentences in  $\mathcal{L}$  or a *module call* of the form call(l, M, t) where l is a non-assumption sentence in  $\mathcal{L}$ , M is a module in which l occurs,  $t \in \{cr, sk\}$  is the type of semantics of M according to which l is defined (i.e.  $M \vdash_t l$ ). Note that in this paper, we restrict ourself to two types of semantics, notably the credulous and skeptical preferred semantics defined shortly before.

**Example 2.1** Let  $\mathcal{F}$  be a MABA framework consisting of two modules  $M_1, M_0$  where  $M_1$  consists of a single rule

$$h \leftarrow call(p, M_0, cr), call(q, M_0, cr)$$

and  $M_0$  consists of two rules

$$p \leftarrow \neg q$$
 and  $q \leftarrow \neg p$ 

with  $\mathcal{A} = \{\neg p, \neg q\}$  and  $\overline{\neg p} = p$  and  $\overline{\neg q} = q$ .

 $M_0$  has two preferred sets of assumptions  $\{\neg p\}$  and  $\{\neg q\}$ .

Hence,  $M_0 \vdash_{cr} p$  and  $M_0 \vdash_{cr} q$ . Hence both module calls  $call(p, M_0, cr), call(q, M_0, cr)$  are accepted. As result,  $M_1$  has an unique extension in which h is concluded.

Note that  $\mathcal{F}$  is distinct to the ABA framework consisting of three rules:

 $h \leftarrow p, q \text{ and } p \leftarrow \neg q \text{ and } q \leftarrow \neg p$ 

in which h is not concluded wrt any semantics.

In this paper, we restrict our consideration to stratified MABA frameworks where the modules names are ranked (by ordinals) such that all module calls in rules belonging to a module of rank k refer to modules of ranks lower than k. The rank of the main module is the highest rank. The MABA framework in example 2.1 is an example of stratified modular argumentation.

The semantics of stratified MABA framework is defined inductively by defining the semantics of the higher ranks modules based on the semantics of lower ranks modules. Suppose that the semantics (i.e. extensions) of all modules of ranks lower than the rank of a module M have been defined. A (*backward*) *deduction* of a conclusion  $\alpha$  wrt module M based on (or supported by) a set of premises P is defined similarly as the backward deduction wrt ABA framework with the exception that when the selected element  $\sigma$  is a module call of the form call(l, N, t) then  $N \vdash_t l$  and  $S_{i+1} = S_i - \{\sigma\}$ .

The notions of arguments, extensions and consequences wrt a module M in MABA are defined similarly as in usual ABA frameworks. For a MABA framework  $\mathcal{F}$ , we write  $\mathcal{F} \vdash_t p$  if  $M \vdash_t p$  where M is the main module of  $\mathcal{F}$  and  $t \in \{cr, sk\}$ .

## 3. Modeling Contracts and Contract Contexts

We assume a language  $\mathcal{L}$  containing a finite set of integers and a partial order  $p \succ q$  between the integers representing that p is greater than q by orders of magnitude. We further assume that  $\mathcal{L}$  also contains fluents and actions. Fluents are propositional symbols for representing properties or attributes like "Pregnant, Barren" in the concerned contexts.

**Definition 3.1** A contract between contractor CO (as seller or service provider) and contractee CE (as buyer or service requester) is modeled as a six-tuple  $\Gamma = \langle CO, CE, T, \kappa, \pi, RA \rangle$  where

- 1. T identifies the transaction or service that contractor promises to perform.
- 2.  $\kappa$  specifies properties of T or of the environment of T
- 3.  $\pi$  describes the price of performing T
- 4. RA allocates risks among the contract parties and consists of rules of the form  $\sigma \rightarrow CX$  stating that if condition  $\sigma$  holds at the time of making the contract then the risk is allocated to  $CX \in \{CO, CE\}$ .

In cases where the identities of contractor and contractee are clear from the context, we often denote a contract as a quadruple  $\langle T, \kappa, \pi, RA \rangle$  or  $\langle T, \kappa, \pi \rangle$  if RA is empty.

The semantics of a contract  $\Gamma = \langle T, \kappa, \pi, RA \rangle$  states that under condition  $\kappa$ , the contractor CO is obliged to perform the transaction T for a price  $\pi$  paid by contractee CE. But under the doctrine of mutual mistake, the court could make exceptions by allowing either of the parties to rescind the contract if a mutual mistake has been made. But if a condition  $\sigma$  holds at the time of making the contract and the party asking to rescind the contract (denoted by CX) is the risk bearer under such condition (i.e. the rule  $\sigma \rightarrow CX$  belongs to RA) then no such exception is granted.

**Example 3.1** The contract between Sherwood and Walker in the Sherwood case is represented by  $\langle Walker, Sherwood, SaleOfCow, True, 80, \emptyset \rangle$  stating that a cow is sold to Sherwood for the price of 80 USD. No conditions and risk allocation are given.

Similarly, the contract between Wood and Boynton in the Wood case is represented by  $\langle Wood, Boynton, SaleOfStone, True, 1, \emptyset \rangle$ 

The semantics of contracts depend on their contexts characterized by the beliefs, expertises of the contract parties. Contexts under different doctrines are different.

**Definition 3.2** A context under the doctrine of mutual mistake (or just context for short) of a contract  $\Gamma = \langle T, \kappa, \pi, RA \rangle$  between contractor CO and contractee CE is defined as a 7-tuple  $\langle \delta, CK, KO, BO, KE, BE, Cost \rangle$  where CK, KO, BO, KE, BE are ABAs and

- 1.  $\delta$  is a fluent representing the unexpected condition causing the reconsideration of contract  $\Gamma$ .
- 2. *CK* describes a body of common market, social and legal knowledge about the contract domain at the time of making the contract established by the court, i.e. the contract parties may not be aware of much of it at the time of making their contract.
- 3. KO, KE describe respectively the general domain knowledge contractor CO and contractee CE are expected to know at the time of making the contract.
- 4. BO, BE contain the evidences and facts about the relevant beliefs of contractor CO and contractee CE respectively at the time of making the contract.

5. A cost function Cost specifies the cost of possible actions the contract parties could carry out to detect the unexpected condition  $\delta$ .

**Example 3.2** (Sherwood Case, continued) The context of the contract in the Sherwood case is represented by  $\langle Pregnant, CK, KO, BO, KE, BE \rangle$ :

- CK = (R<sub>0</sub>, A, ¬) with A = {Barren}, Barren = ¬Barren and R<sub>0</sub> consists of the following rules: r<sub>1</sub> : Price(800) ← Pregnant r<sub>2</sub> : 800 ≻ 80 ←
  - $r_3: \neg Barren \leftarrow Pregnant.$

The intuition of  $\mathcal{A} = \{Barren\}$  is that it is an accepted commonsense that cows are assumed to be barren unless there is explicit evidence to the contrary.

- KO = KE = CK
- $BO = BE = (\mathcal{R}_1, \mathcal{A}, \overline{\phantom{a}})$  with  $\mathcal{R}_1 = \mathcal{R}_0 \cup \{Price(80) \leftarrow Barren\}$  representing a situation where both Sherwood and Walker fully believed (by commonsense) that the cow is barren with a price tag of 80.
- There are no actions that the parties could do to check the pregnancy of the cow (note that the case happened in 1887). Hence no Cost function.

**Example 3.3** (Wood Case, continued) The context of the contract in the Wood case is represented by  $\langle Diamond, CK, KO, BO, KE, BE \rangle$ :

•  $CK = (\mathcal{R}_0, \mathcal{A}, \overline{\phantom{a}})$  with  $\mathcal{A} = \emptyset$  and  $\mathcal{R}_0$  consists of the following rules:  $r_1 : Price(700) \leftarrow Diamond$   $r_2 : 700 \succ 1 \leftarrow$  $r_3 : False \leftarrow Topasz, Diamond.$ 

The intuition of  $A = \emptyset$  is that commonsense does not make any assumption about this type of stones.

- $KO = KE = (\mathcal{R}_0, \mathcal{A}_1, \overline{\phantom{a}})$  with  $\mathcal{A}_1 = \{Topasz, \neg Topasz\} : \overline{Topasz} = \neg Topasz$  and  $\overline{\neg Topasz} = Topasz$  representing that both Wood and Boynton are not expected to know whether the stone is a topasz or not <sup>3</sup>.
- $BO = BE = (\mathcal{R}_1, \mathcal{A}_1, \overline{\phantom{a}})$  and  $\mathcal{R}_1 = \{Price(1) \leftarrow Topasz\}$ , representing that both Wood and Boynton were not sure whether the stone is topasz or not, but accepted to trade it for the price of one dollar.
- There are no actions that the parties could do to check the type of the stone. Hence no Cost function.

## 4. Intended Contracts

Contract parties often do not specify their contract completely. In a dispute, the court has to complete it with the terms that the parties would have agreed to had they negoti-

<sup>&</sup>lt;sup>3</sup>One can ask why not  $A_1 = \{\}$  or  $A_1 = \{Topasz, \neg Topasz, Diamond, \neg Diamond\}$ . Wood was aware that the stone could possibly be a topasz but may be not. Therefore, it is not possible that  $A_1 = \{\}$ . The idea that the stone could be a diamond does not come up at all at the time of making the deal. Hence no contract party could assume that it could be a Diamond. Therefore it is not possible that  $A_1 = \{Topasz, \neg Topasz, Diamond, \neg Diamond\}$ .

ated over the unforeseen situation. In the following, we first define the notion of mutual mistake before giving the definition of the notion of complete intended contracts.

**Definition 4.1** Let  $\Gamma_0 = \langle T, \kappa, \pi, RA \rangle$  be a contract between a contractor CO and a contractee CE and  $CNT = \langle \delta, CK, KO, BO, KE, BE, Cost \rangle$  be a context of  $\Gamma_0$ .

- We say that both contract parties have made a mutual mistake in the context CNT by believing in a condition λ, called the intended condition iff following conditions are satisfied:
  - (a)  $BO \vdash_{cr} \lambda$  and  $BE \vdash_{cr} \lambda$ , i.e. both parties believed that  $\lambda$  (possibly) holds at the time of making the contract.
  - (b)  $\lambda \models \kappa$ , *i.e.*  $\lambda$  *is a specific condition of*  $\kappa$ .
  - (c)  $\{\delta\} \cup CK \vdash_{sk} \neg \lambda$ , *i.e. the parties made a mistake in believing that*  $\lambda$  *holds at the time of contract making.*
  - (d)  $BO \cup \{\lambda\} \vdash_{sk} Price(\pi)$  and  $BE \cup \{\lambda\} \vdash_{sk} Price(\pi)$ , *i.e.* both parties accept price  $\pi$  under condition  $\lambda$ .
- 2. We say that the contact parties have made a **mutual mistake violating a basic assumption** wrt CNT if a mutual mistake has been made by the contract parties and one of the following conditions holds:
  - (a)  $\{\delta\} \cup CK \vdash_{sk} \neg T$ , *i.e* T is not executable under  $\delta$ .<sup>4</sup>
  - (b) If  $CK \cup \{\delta\} \vdash_{sk} Price(p)$  then either  $CK \vdash_{sk} p \succ \pi$  or  $CK \vdash_{sk} \pi \succ p$ .

Condition 2 determines that  $\lambda$  is a "basic assumption" in the sense that its nonsatisfaction would either invalidate the transaction or service T or the market value of T is qualitatively different to  $\pi$  (by orders of magnitude) and hence one of the parties would not accept  $\pi$  as the contract price as it will suffer a significant loss.

**Example 4.1** Let  $\Gamma = \langle SaleOfCow, True, 80 \rangle$  be the original contract in the Sherwood case and CNT be the context defined in example 3.2. Both parties have made a mutual mistake in believing that the cow is barren since 1) both ABA frameworks BO, BE have a preferred extension containing the assumption Barren, and 2) it is a tautology that Barren  $\models$  True and 3) {Pregnant}  $\cup$  CK  $\vdash_{sk} \neg$ Barren and 4)  $BX \cup \{Barren\} \vdash_{sk} Price(80) \text{ for } BX \in \{BO, BE\}.$ 

Since  $CK \cup \{Pregnant\} \vdash_{sk} Price(800)$  and  $CK \vdash_{sk} 800 \succ 80$ , it follows that the mistake violates a basic assumption.

There are two principles for determining risk allocation for unexpected situations. The conscious ignorance principle states that if a party was aware that its knowledge is limited but still went ahead with the contract, this party should bear the risk of the contract [38]. The other principle is based on efficiency stating that risks should be allocated to the party that could bear it at the least cost [28].

<sup>&</sup>lt;sup>4</sup>For example, CO sells to CE an annuity (T) on some person P's life. Then P must be alive ( $\lambda = alive$ ) (CK could contain a rule like *annuity*  $\rightarrow alive$ ).

But if if it turns out that P was already dead at the time of making the contract ( $\delta = dead$ ) then CE can rescind the contract.

**Definition 4.2** Let  $\Gamma = \langle T, \kappa, \pi, RA \rangle$  be a contract between CO and CE. The complete intended contract of  $\Gamma$  in the context  $CNT = \langle \delta, CK, KO, BO, KE, BE, Cost \rangle$ , denoted by  $Compl(\Gamma, CNT)$  is defined as follows:

- 1. If a mutual mistake violating a basic assumption (with  $\lambda$  being the intended condition) has been made wrt CNT then  $Compl(\Gamma, CNT) = \langle T, \lambda, \pi, RB \rangle$  where RB is obtained by adding risk allocation clauses to RA as follows:
  - (a) **Conscious Ignorance**: Adding  $\delta \to CO$  to RA if BO  $\forall_{sk} \lambda$  (i.e. the contractor does not fully believe in  $\lambda$ ), and Adding  $\delta \to CE$  to RA if  $BE \forall_{sk} \lambda$ .
  - (b) Efficiency If a party could reasonably anticipate the unexpected situation δ more efficient than other party, this party should bear the risk. Formally, this doctrine is represented by adding

 $\delta \to CO$  to RA if there is some reasonable action  $\alpha$  the contractor CO could do to detect  $\delta$ , i.e.  $\{\alpha\} \cup KO \vdash_{cr} \delta^5$ , and for each reasonable action  $\beta$  that could be carried out by CE to detect  $\delta$ ,  $Cost(\beta) \succ Cost(\alpha)$  holds.

An action  $\alpha$  is said to be reasonable if its cost is acceptable wrt price of the contract, i.e.  $\pi \succ Cost(\alpha)$ .

Similar conditions for assigning risk to CE

2. If no mutual mistake violating a basic assumption has been made wrt CNT then  $Compl(\Gamma, CNT) = \Gamma$ .

**Example 4.2** (Sherwood, continuation of example 4.1) From  $BO \vdash_{sk} Barren$  and  $BE \vdash_{sk} Barren$ , it follows that the principle of conscious ignorance does not allocate any risk to the contract parties. As there are no actions the parties could have carried out to check the pregnancy of the cow at the time of making the contract, no risk is allocated to the parties by the principle of efficiency. Therefore, no party should carry the risk of the cow being pregnant. The complete intended contract coincides with the original one.

The complete contract would have been different if this case happens in our time when cheap pregnancy tests are available. The knowledge base KO of Walker would contain a clause pregnant  $\leftarrow$  test stating that a test will reveal that the cow is pregnant and the cost function satisfies  $80 \succ Cost(test)$ . According to the efficiency principle, Walker would have to bear the risk of the cow being pregnant, i.e.  $Compl(\Gamma, CNT) =$  $\langle SaleOfCow, Barren, 80, \{pregnant \rightarrow Walker\} \rangle$ .

**Example 4.3** (Wood, continued) From  $BO \vdash_{cr} \neg Topasz$  and  $BE \vdash_{cr} \neg Topasz$ , it follows that the principle of conscious ignorance allocates risk to both parties. Therefore, the complete intended contract is

 $Compl(\Gamma, CNT) = \langle SaleOfStone, Topasz, 1, \{ diamont \rightarrow Wood, diamont \rightarrow Boynton \} \rangle.$ 

Hence none of the parties could rescind the contract.

The semantics of a contract under the doctrine of mutual mistake could be restated as follows: *The obligation of the contractor is to perform the contract transaction in* 

<sup>&</sup>lt;sup>5</sup>In [17], we have required that  $\{\alpha\} \cup KO \vdash_{sk} \delta$  that is a rather strong condition as practically one may take precaution to prevent fire and fire could still happen as there are no fire prevention system that works perfectly in all scenarios

exchange for a payment from the contractee. But if a mutual mistake violating a basic assumption has been made and CX does not have to bear the risk in the complete intended contract then CX could rescind the contract. Otherwise CX is not allowed to rescind the contract.

#### 5. Modular Argumentation for Contract Dispute Resolution

Given a contract  $\Gamma = (T, \kappa, \pi, RA)$  between CO and CE and a context  $CNT = \langle \delta, CK, KO, BO, KE, BE, Cost \rangle$ , we present a modular ABA framework consisting of submodules representing the contexts of a contract dispute together with a main module denoted by  $Th_{\Gamma}$  for representing the doctrines for contract breach and mutual mistake.

Formally,  $Th_{\Gamma}$  is a modular ABA framework consisting of rules and facts defined in the following where the assumptions in  $Th_{\Gamma}$  are represented by negative literals whose contraries are the corresponding positive literals:

- 1. Self-explaining facts:
- $Contract(CO, CE, \Gamma), Transaction(T, \Gamma), Price(\pi, \Gamma), Conditions(\kappa, \Gamma)$
- 2. A fact  $Hold(\delta, \Gamma)$  stating that condition  $\delta$  actually held at the time of making the contract.
- 3. A rule of the form

 $RiskAllocatedTo(CX, \Gamma) \leftarrow Hold(\sigma, \Gamma)$ 

for each risk allocating rule  $\sigma \rightarrow CX$  in RA

4. Two rules representing the doctrine that a failure to perform a considered promise constitutes a breach of contract. Formally these rules state that if CX is a party in a contract Γ then CX must perform his part of the bargain in the contract unless there are exceptions for him to rescind it:

 $\begin{array}{l} Pay(CE,\pi) \leftarrow Contract(CO,CE,\Gamma), \ Transaction(T,\Gamma), \ Perform(CO,T)^{6} \\ Price(\pi,\Gamma), \ \neg Rescind(CE,\Gamma) \end{array}$ 

 $Perform(CO, T) \leftarrow Contract(CO, CE, \Gamma), Transaction(T, \Gamma), \neg Rescind(CO, \Gamma)$ 

5. The doctrine of mutual mistake provides a class of exceptions to the doctrine of contract breach when both parties make mistake and is represented by

 $Rescind(CX, \Gamma) \leftarrow MutualMistake(\lambda, \Gamma), ViolateBA(\Gamma), \neg RiskAllocatedTo(CX, \Gamma)$ 

6. The following rule represents that the contract is based on a mutual mistake. Its intuition is exlained in definition 4.1:

<sup>&</sup>lt;sup>6</sup>Note that we make a simplifying assumption here that the contractee pays only after the contractor has delivered the promised service. Many contracts require the contractee to pay in advance or make a deposit. These contracts would require slightly different rules here.

 $\begin{aligned} MutualMistake(\lambda,\Gamma) \leftarrow Hold(\delta,\Gamma), \ call(\neg\lambda, CK \cup \{\delta\}, sk), \ Condition(\kappa,\Gamma), \\ call(\kappa,\lambda,sk), \ call(\lambda,BO,cr), \ call(\lambda,BE,cr), \\ call(Price(\pi),BO \cup \{\lambda\},sk), \\ call(Price(\pi),BE \cup \{\lambda\},sk) \end{aligned}$ 

7. Three rules for establishing that a basic assumption has been violated in the contract  $\Gamma$ . Their intuition is explained in definition 4.1, step 2.

 $ViolateBA(\Gamma) \leftarrow Hold(\delta, \Gamma), \ call(\neg T, CK \cup \{\delta\}, sk)$ 

 $\begin{aligned} ViolateBA(\Gamma) \leftarrow Price(\pi, \Gamma), \ Hold(\delta, \Gamma), \\ call(Price(p), CK \cup \{\delta\}, sk), \ p \succ \pi \end{aligned}$ 

 $\begin{aligned} ViolateBA(\Gamma) \leftarrow Price(\pi, \Gamma), \ Hold(\delta, \Gamma), \\ call(Price(p), CK \cup \{\delta\}, sk), \ \pi \succ p \end{aligned}$ 

8. Two rules for representing the principle of conscious ignorance.

 $RiskAllocatedTo(CO, \Gamma) \leftarrow MutualMistake(\lambda, \Gamma), \ call(\neg\lambda, BO, cr)$  $RiskAllocatedTo(CE, \Gamma) \leftarrow MutualMistake(\lambda, \Gamma), \ call(\neg\lambda, BE, cr)$ 

9. Rules capturing a special case albeit probably a most frequent case, of the efficiency principle in allocating risk.

 $RiskAllocatedTo(CX, \Gamma) \leftarrow Detectable(CX, \delta), \neg Detectable(\overline{CX}, \delta)^{7}$ 

 $Detectable(CX, \delta) \leftarrow call(\delta, KX \cup \{\alpha\}, cr), ReasonableAction(CX, \alpha)$ 

 $ReasonableAction(CX, \alpha) \leftarrow Action(CX, \alpha), Price(\pi, \Gamma), \\ call(\pi \succ Cost(\alpha), KX, sk)$ 

where  $Action(CX, \alpha)$  states that CX is capable to carry out action  $\alpha$  at a cost  $Cost(\alpha)$ .

The MABA framework consisting of  $Th_{\Gamma}$  as the main module and the ABA frameworks CK,KO,BO,KE,BE as submodules is called the legal theory of  $\Gamma$  wrt the mutual mistake doctrine and denoted by  $\mathcal{F}_{\Gamma}$ . Further positive literals of the form  $call(\alpha, M, t)$ in  $Th_{\Gamma}$  are called input literals of  $Th_{\Gamma}$ . A set of input literals is consistent if it contains no two literals of the form  $call(\alpha, M, sk)$  and  $call(\neg \alpha, M, t)$ . It is not difficult to see

**Theorem 5.1** Let  $\Gamma = (T, \kappa, \pi, RA)$  be a contract between CO and CE and  $CNT = \langle \delta, CK, KO, BO, KE, BE, Cost \rangle$  be a context of  $\Gamma$ . Assuming that the price for T is uniquely determined from the knowledge base CK, following assertions hold:

 $<sup>^{7}\</sup>overline{CX}$  is the opposite party of CX

- 1.  $Th_{\Gamma} \cup S$  has an unique preferred extension<sup>8</sup> where S is a consistent set of input literals of  $Th_{\Gamma}$
- 2. If  $\mathcal{F}_{\Gamma} \vdash_{sk} Rescind(CX, \Gamma)$  then both contract parties have made a mutual mistake violating a basic assumption and the risk is not allocated to CX under the doctrine of mutual mistake and hence CX could rescind the contract.

**Proof**  $Th_{\Gamma} \cup S$  is stratified in the sense that the predicates in it could be ranked with decreasing order as follows:

 $\{Pay, Perform\}, \{Rescind\}, \{RiskAllocatedTo\}, \{MutualMistake, Violate\}, \{Detectable\}, \{ReasonableAction, Action, Price, Contract, Transaction, call\}. In [10,14], it has been shown that stratified ABA frameworks have exactly one preferred extension that is also grounded and stable. It could be shown in almost exact the same ways that <math>Th_{\Gamma} \cup S$  has an unique preferred extension that is also grounded, and stable.

The second statement follows immediately from the structures of the rules.

In general, the presented proof system is not complete due to the fact that to prove conscious ignorance, one should prove that  $BO \not\vdash_{sk} \lambda$ . Though  $BO \vdash_{cr} \neg \lambda$  implies  $BO \not\vdash_{sk} \lambda$ , the reverse is not true. The trade-off here is that the computational complexity of  $BO \vdash_{cr} \neg \lambda$  is NP-complete while that of proving  $BO \not\vdash_{sk} \lambda$  is  $\prod_{2}^{p}$  [19].

# 6. Conclusion and Future Works

In legal proceedings, the knowledge and belief bases forming the contexts of legal doctrines are constructed incrementally by the parties during their exchanges of arguments. Such exchanges also consitute a proof of the facts and evidences that the dispute parties need to prove [5,22,23,31,30]. We believe that for practical system of dispute resolution, procedures for contract dispute resolution along these lines play an essential role.

We proposed modular argumentation to allow reference to different semantics of a argumentaton module at the same time. The new approach is applied to model the mutual mistake doctrine. In related paper, we have applied our framework to model other doctrines for relief of performance like the doctrine of impossibilities, impracticality and frustration of purpose [18].

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### References

[1] K. D. Ashley. Reasoning with cases and hypotheticals in HYPO. *International Journal of Man-Machine Studies*, 34(6):753–796, 1991.

<sup>&</sup>lt;sup>8</sup>It is not difficult to see that the extension is also grounded and stable.

- [2] K. Atkinson and T. Bench-Capon. Abstract argumentation scheme frameworks. In AIMSA '08: Proceedings of the 13th international conference on Artificial Intelligence, pages 220–234, Berlin, Heidelberg, 2008. Springer-Verlag.
- [3] K. Atkinson and T. J. M. Bench-Capon. Legal case-based reasoning as practical reasoning. Artificial Intelligence and Law, 13(1):93–131, 2005.
- [4] T. Bench-Capon and H. Prakken. Introducing the logic and law corner. *Journal of Logic and Computation*, 18(1):1–12, 2008.
- [5] T. J. M. Bench-Capon, K. Atkinson, and A. Chorley. Persuasion and value in legal argument. *Journal of Logic and Computation*, 15(6):1075–1097, 2005.
- [6] T. J. M. Bench-Capon and G. Sartor. A model of legal reasoning with cases incorporating theories and values. Artificial Intelligence, 150(1-2):97–143, 2003.
- [7] D. H. Berman and C. D. Hafner. Representing teleological structure in case-based legal reasoning: the missing link. In *ICAIL '93: Proceedings of the 4th international conference on Artificial intelligence* and law, pages 50–59, New York, NY, USA, 1993. ACM.
- [8] F. Bex, H. Prakken, C. Reed, and D. Walton. Towards a formal account of reasoning about evidence: argumentation schemes and generalisations. *Artificial Intelligence and Law*, 11(2):125–165, 2003.
- [9] F. Bex, S. Van den Braak, H. Van Oostendorp, H. Prakken, B. Verheij, and G. Vreeswijk. Sense-making software for crime investigation: how to combine stories and arguments? *Law, Probability and Risk*, 6(1-4):145–168, 2007.
- [10] A. Bondarenko, P. M. Dung, R. A. Kowalski, and F. Toni. An abstract argumentation theoretic approach to default reasoning. *Artificial Intelligence*, 93(1-2):63–101, 1997.
- [11] Douglas Walton. Argumentation Schemes for Presumptive Reasoning. ISBN: 080582071X DDC: 168 LCC: BC183. LEA, Mahwah, NJ, USA, alk. paper edition, 1996.
- [12] P. M. Dung. Logic programming as dialog-game. Technical report, AIT, 1993.
- [13] P. M. Dung. On the acceptability of arguments and its fundamental role in nonmonotonic reasoning, logic programming, and n-person games. *Artificial Intelligence*, 77(2):321–257, 1995.
- [14] P. M. Dung, R. Kowalski, and F. Toni. Dialectic proof procedures for assumption-based, admissible argumentation. Artificial Intelligence, 170(2):114–159, 2006.
- [15] P. M. Dung, Kowalski Robert A., and F. Toni. Argumentation in AI, chapter Assumption-based Argumentation. Springer-Verlag, 2009.
- [16] P. M. Dung, P. Mancarella, and F. Toni. Computing ideal skeptical argumentation. Artificial Intelligence, 171(10-15):642–674, July 2007.
- [17] P. M. Dung and P. M. Thang. Modular argumentation for modelling legal doctrines in common law of contract. In *Proceedings of the 21st Annual Conference, JURIX 2008*, volume 189 of *Frontiers in Artificial Intelligence and Applications*, pages 108–117, Florence, Italy, Dec. 2008. IOS Press.
- [18] P. M. Dung, P. M. Thang, and N. D. Hung. Modular argumentation for modelling legal doctrines. In *ICAIL 2009*, Barcelona, Spain, 2009. ACM Press.
- [19] Dunne and T. J. M. Bench-Capon. Coherence in finite argument systems. *Artificial Intelligence*, 141(1):187–203, 2002.
- [20] E. A. Farnsworth, W. F. Young, and C. Sanger. *Contracts: Cases and Materials*. ISBN: 1587780577. Foundation Press, 6 edition, June 2001.
- [21] A. v. d. L. Gardner. An Artificial Intelligence Approach to Legal Reasoning. Mit Press Series Of Artificial Intelligence And Legal Reasoning. MIT Press, Cambridge, MA, USA, 1987.
- [22] T. F. Gordon. The pleadings game: an exercise in computational dialectics. *Artificial Intelligence and Law*, 2(4):239–292, 1994.
- [23] T. F. Gordon, H. Prakken, and D. Walton. The Carneades model of argument and burden of proof. *Artificial Intelligence*, 171(10–15):875–896, 2007.
- [24] Guenter Freitel. Frustration and Force Majeure. Sweet and Maxell Press, UK, 2nd edition, 2004.
- [25] A. Lodder and J. Zelznikow. Developing an online dispute resolution environment: Dialogue tools and negotiation support systems in a three-step model. *Harvard Negotiation Law Review*, 10:287–337, 2005.
- [26] L. T. McCarty. An implementation of eisner v. macomber. In ICAIL '95: Proceedings of the 5th international conference on Artificial intelligence and law, pages 276–286, New York, NY, USA, 1995. ACM.
- [27] D. Poole. Logical Argumentation, Abduction and Bayesian Decision Theory: A Bayesian Approach to Logical Arguments and it's Application to Legal Evidential Reasoning. *Cardozo law review*, 22(5-6):1733–1746, 2001.

- [28] R. A. Posner. *Economic Analysis of Law*. Wolters Kluwer Law and Business Press, Feb. 2007.
- [29] H. Prakken. An exercise in formalising teleological case-based reasoning. Artificial Intelligence and Law, 10(1-3):113–133, 2002.
- [30] H. Prakken. Formal systems for persuasion dialogue. *The Knowledge Engineering Review*, 1:163–188, 2006.
- [31] H. Prakken and G. Sartor. A dialectical model of assessing conflicting arguments in legal reasoning. *Artificial Intelligence and Law*, 4(3-4):331–368, 1996.
- [32] H. Prakken and G. Sartor. Modelling reasoning with precedents in a formal dialogue game. Artificial Intelligence and Law, 6(2-4):231–287, 1998.
- [33] E. Rissland and D. Skalak. Cabaret: rule interpretation in a hybrid architecture. *International Journal of Man-Machine Studies archive*, 34(6):839–887, 1991.
- [34] B. Roth and B. Verheij. Cases and dialectical arguments an approach to case-based reasoning. In OTM Workshops, volume 3292 of Lecture Notes in Computer Science, pages 634–651. Springer, 2004.
- [35] K. D. A. S. Bruninghaus. Predicting outcomes of case-based legal arguments. In *ICAIL 2003*, NewYork, USA, 2003. ACM Press.
- [36] G. Sartor. Teleological arguments and theory-based dialectics. Artificial Intelligence and Law, 10(1):95– 112, 2002.
- [37] 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(5):370–386, 1986.
- [38] J. B. Steven and A. E. Melvin. *Contract Law: Selected Source Materials*. Foundation Press, 2007 edition, 2007.
- [39] B. Verheij. Dialectical argumentation with argumentation schemes: an approach to legal logic. Artificial Intelligence and Law, 11(2-3):167–195, 2003.
- [40] B. Verheij. About the logical relations between cases and rules. In JURIX08, volume 189 of Frontiers in Artificial Intelligence and Applications, pages 21–32, Florence, Italy, 2008. IOS Press.
- [41] H. Yoshino. The systematization of legal meta-inference. In ICAIL, pages 266–275, 1995.
- [42] H. Yoshino. Logical structure of contract law system for constructing a knowledge base of the united nations convention on contracts for the international sale of goods -. JACIII, 2(1):2–11, 1998.

# Modular Argumentation For Modelling Legal Doctrines in Common Law of Contract

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