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Formalising Arguments about the
Burden of Persuasion

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ABSTRACT:

This paper presents an argument-based logic for reasoning about allocations of the burden of persuasion. The logic extends the system of Prakken (2001), which in turn modified the system of Prakken & Sartor (1996) with the possibility to distribute the burden of proof over both sides in an argument game. First the (2001) system is put in the context of a distinction of three types of proof burdens and it is argued that the proof burdens of that system are in fact burdens of persuasion. Then the (2001) system is modified to allow for defeasible reasoning about allocations of such burdens within the logic. The usefulness of the resulting system is illustrated with applications to real legal cases.

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Formalising Arguments about the Burden of Persuasion*

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1 INTRODUCTION

The allocation of burden of proof is a fundamental aspect of legal reasoning: not only is it an important aspect of the regulation of legal procedures, but it often is decisive in determining the outcome of legal disputes (on the legal aspects of the burden of proof see [15]). AI & law research has devoted a lot of attention to the issue of the burden of proof, providing the first formal analyses of it.

One approach addresses the burden of proof within theories of nonmonotonic reasoning. The basic idea ([14]) is that the law, by using various techniques—like the separation of general rules and their exceptions and the use of explicit presumptions— distinguishes two classes of propositions, according to what conditions must be satisfied for them to be able to justify a legal conclusion: propositions requiring a logical demonstration from established premises, and propositions that can be assumed unless the contrary is logically demonstrated. The first propositions are those for which the burden of proof is on the party interested in establishing them, and the latter are those for which the burden of proof is on the other party. This distinction is then modelled according to nonmonotonic logics (for instance, propositions which can be assumed unless the contrary is shown can be represented as negations by failure in extended logic programs, as justifications of defaults in default logic, and so on). This approach succeeds in linking the logical structure of the substantive arguments being exchanged between the parties and the corresponding allocation of burdens (the logical machinery for nonmonotonic reasoning automatically induces an allocation of the burden of proof).

However, as one of us noted in [8], this approach using a 'standard' nonmonotonic logic cannot represent distributions of the burden of proof over the parties. In such an approach counterarguments by opponent always succeed if they cast doubt but with distributed burdens a logic is needed in which a doubt- raising argument only succeeds if the one who moves it does not have the burden of proof. Accordingly, in [8] the logic of [10] was modified to meet these demands. A

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purely procedural version was proposed, with explicit allocations of the burden of proof instead of implicitly in the logical representation of legal rules.

The present paper aims to extend the resulting system in two respects. Firstly, [8] does not distinguish between types of burdens, while the law distinguishes three types, namely, burden of production, burden of persuasion and tactical burden of proof. In [11] we gave a logical account of these three types and now we want to put the system of [8] in the context of that account: we will argue that that system was about the burden of persuasion. Secondly, in [8] the allocations of the burden of persuasion are fixed and undisputable while in actual legal reasoning they are often themselves subject to dispute. In this paper we want to allow for reasoning *about* the burden of persuasion within the logic.

It should be noted that the argument games defined in this paper are not intended as a model of actual legal dialogue but as a proof theory for a nonmonotonic logic. We do not claim that the debates generated by these games adequately model legal disputes. All we claim is that our games draw the correct defeasible inferences from a given body of information and an associated allocation of the burden of persuasion. It remains to be seen how the present logical model can be integrated with dialogical and procedural models of legal argument.

In the remainder of this paper first the logical formalism on which we will build will be introduced (Section 2) and our analysis in [11] of the legal notions will be summarised (Section 3). Then the new logic for reasoning about the burden of persuasion will be presented in Section 4 and it will be applied to some examples in Section 5. Related research will be discussed in the concluding section.

2   LOGICAL PRELIMINARIES: THE INFERENCE SYSTEM (IS)

In the present section we summarise[1] our previous work on which we will build, namely the system introduced in [10] (let us call it IS, for Inference System). IS is a logic for defeasible argumentation expressive enough to deal with contradictory rules, rules with assumptions, inapplicability statements and priority rules. Information is expressed as a set of rules in the language of extended logic programming, which has both negation as failure or *weak negation* ($\sim$) and classical, or *strong negation* ($\neg$). A *literal* is of the form P, $\neg P$, $\sim P$ or $\sim \neg P$ (where P is an atomic proposition). A literal without $\sim$ is called a *strong literal*. Each rule is preceded by a term, its name. Rules are *strict*, represented with $\rightarrow$, or else *defeasible*, represented with $\Rightarrow$. Facts are written as strict rules with empty antecedents. Conflicts between arguments are resolved with the help of a partial preorder on the rules. Accordingly, the input information of the system is an *IS theory* $T_{IS} = (R, \leq)$, where R is a set of strict and defeasible rules and $\leq$ a partial preorder of R.[2]

Arguments can be formed by chaining rules, ignoring weakly negated literals in their antecedent. The set of well-formed arguments of an IS theory T is denoted as $Args_T$. It is assumed to be finite throughout this paper. Conflicts between arguments are decided according to a binary relation of *defeat* among arguments, which is partly induced by rule priorities. When two arguments defeat each other, they *weakly defeat* each other, while if one defeats the other but not vice versa, the one *strictly defeats* the other.

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[1]This summary is essentially taken from [11].

[2]Subscripts will below be omitted if there is no danger of confusion. Also, in this paper we slightly rephrase the terminology and notation of [11], which spoke of "ordered theories" and denoted the set of rules by T.

There are three ways in which an argument Arg_2 can defeat an argument Arg_1. The first is *assumption* defeat (in [10] called "undercutting" defeat), which occurs if a rule in Arg_1 contains $\sim L$ in its body, while Arg_2 has a conclusion L (note that $\sim L$ reads as 'L cannot be derived'). The other two forms of defeat are only possible if Arg_1 does not assumption-defeat Arg_2. One way is by *excluding* an argument, which happens when Arg_2 concludes for some rule r in Arg_1 that r is not applicable (formalised as $\neg\texttt{appl}(r)$). The other is by *rebutting* an argument, which happens when Arg_1 and Arg_2 contain rules that are in a head-to-head conflict and Arg_1's rule has no priority over the conflicting rule in Arg_2 (according to $\leq$). Note that all these attacks can be targeted at the final rule or conclusion of an argument but also at each intermediate rule or conclusion.

Arguments are assigned a dialectical status in terms of three classes: the 'winning' or *justified* arguments, the 'losing' or *overruled* arguments, and the 'ties', i.e., the *defensible* arguments. The same statuses can also be defined for propositions: a proposition is *justified* if there exists a justified argument for it, and it is *defensible* if it is not justified but there exists a defensible argument for it.

Whether an argument is justified can be tested in a so-called argument game between a proponent and an opponent for the argument. Proponent starts with an argument that he wants to prove justified and then each player must defeat the other player's previous argument. Moreover, proponent's defeating arguments must be such that they *strictly* defeat opponent's arguments, i.e., they may not in turn be defeated by their targets. Finally, proponent is not allowed to repeat his arguments. A player wins if the other player has run out of moves. The initial argument is *justified* if the proponent has a winning strategy in this game. Non-justified arguments are *overruled* if they are defeated by a justified argument, otherwise they are *defensible*. This argument game is sound and complete with respect to Dung's ([2]) grounded semantics.

In [10] a version of IS was also defined in which the rule priorities are not simply given but are expressed as IS rules and must be defeasibly derived within the system just as any other conclusion. In Section 4.3.2 we will say more about this version of IS.

Note that the argument game does not allow backtracking. In a model of real dialogue this would be a problem since in real dialogues often alternative attacks are tried. However, since our argument game is meant as a proof theory, all that matters is whether proponent has a winning strategy for his initial argument. This can be verified by searching the game tree (the tree of all possible games for the initial argument) and in such a search all relevant attacks will be examined.

To be able to describe the three burdens of proof we must also explain how the IS logic can be used in the context of a legal proceeding. The IS logic assumes a static IS theory but in reality it is, of course, created dynamically in during a proceeding, regulated by some legal procedure. In this paper we abstract from the details of such procedures and simply assume that a legal proceeding consists of a sequence of stages characterised by different IS theories and where the parties can move from one stage to another by adding arguments. A stage then consists of the premises of all arguments stated at that point. The outcome of a proceeding is determined by applying the argument game of IS to the final stage. We also apply the argument game to intermediate stages, to verify what would be the outcome of the proceeding if an intermediate stage were the final stage.

3   LEGAL ANALYSIS

In this section we summarise our analysis in [11] of three types of the burden of proof. A common distinction is that between the burdens of persuasion and production. The *burden of*

persuasion specifies which party loses on an issue if the evidence is balanced. Whether this burden is met is determined in the final stage of a proceeding, after all evidence is provided. The *burden of production* specifies which party has to offer evidence on an issue at different points in a proceeding. If the burden of production is not met, the issue will be decided as a matter of law against the burdened party, while if it is met, the issue will be decided regardless of the burden. In the law, the two burdens are usually determined by the 'operative facts' for a legal claim, i.e., the facts that legally are ordinarily sufficient reasons for the claim. The law often designates the operative facts with rule-exception structures. For instance, for manslaughter the operative facts are that there was a killing and that it was done with intent, while an exception is that it was done in self-defence. Therefore, at the start of a criminal proceeding, the prosecution has the burden to produce evidence on 'killing' and 'intent'; if fulfilled, a burden for the defence is created to produce evidence for 'self-defence'. For operative facts the burdens of production and persuasion usually go together so in our example the prosecution also has the burden of persuasion for 'killing' and 'intent'. However, for exceptions things are more complicated. In criminal proceedings usually the defence only has a burden of production for an exception while if fulfilled, the prosecution then has a burden of persuasion against the exception. For instance, once the defence has produced evidence for 'self-defence', the prosecution has the burden of persuasion that there was no self-defence. By contrast, in civil cases often the burden of persuasion holds for an exception also: for instance, in Dutch and Italian law insanity at the time of accepting an offer is an exception to the rule that offer and acceptance create a contract, but if the evidence on insanity is balanced, the party claiming insanity will lose on that issue.

How can these two notions be analysed in our IS logic? Because of its inherent procedural nature, the burden of production cannot be defined in purely logical terms but the burden of persuasion can be defined as the task to provide a justified argument for the issue on which the burden rests. (Though we will refine this below.) *Proof standards* can be formalised by a careful definition of the rebuttal relation between arguments: a stronger argument should strictly rebut a weaker argument only if the degree to which it is stronger satisfies the applicable proof standard; otherwise both arguments should rebut each other.

Besides the burdens of production and persuasion there also is the *tactical burden of proof*. It is not allocated by law but induced by the defeasible nature of the reasoning and the estimated quality of the evidence and arguments produced so far. In the words of [15] this burden is a matter of tactical evaluation in that a party must assess the risk of losing on an issue if no further evidence concerning that issue is produced. Suppose in our example that the prosecution provided evidence for 'killing' and 'intent', after which the defence produced evidence for 'self-defence'. The prosecution must now assess the risk of losing if the current stage were the final stage. If this risk is real then the prosecution had better provide counterevidence on 'self-defence'. In other words, the prosecution now not only has the burden of persuasion but also a tactical burden with respect to self-defence. Clearly, a tactical burden can shift between the parties any number of times during a proceeding, depending on who would likely win if no more evidence were provided. However, the exact content of this burden is not the same for both parties: if one has the burden of persuasion, then the tactical burden is stronger than if one does not have it since if the evidence is balanced the one who must persuade the trier of fact loses.

In our IS logic the tactical burden is automatically captured by the dialectical asymmetry of the argument game: the party who has the burden of persuasion is proponent and therefore has to strictly defeat the other parties' arguments, while the other party, being the opponent, only has to weakly defeat the proponent's argument. This accounts both for the possibility that the tactical burden shifts between the parties and for the fact that for one party it is stronger than for the other.

In sum, at first sight it would seem that the interplay between the tactical burden and the burden of persuasion can be directly modelled in the IS system. However, there is a problem (which in fact is a problem for almost all current nonmonotonic logics).

In the IS argument game the roles of the parties are fixed during a game: proponent always has the burden of persuasion, i.e., the burden to justify his arguments, while opponent merely has the burden to interfere with proponent's arguments by advancing defensible counterarguments. However, as noted above, in the law the burden of persuasion can be distributed over the parties. Consider again the issue of accepting an offer while insane: as we said above, in Dutch and Italian law defendant has not only the burden of production but also the burden of persuasion with regard to this exception. Suppose now that a defendant fulfills her burden of production by providing a written medical statement, after which the plaintiff provides counterevidence that casts doubt about whether the statement is authentic. If the trier of fact is in doubt, i.e., if he is neither convinced that the statement is authentic nor that it is not authentic, he will have to find for plaintiff. As argued in [8], this cannot be modelled in a standard argument-based logic since there counterarguments by opponent always succeed if they cast doubt: here, however, a logic is need in which a doubt-raising argument only succeeds if the one who moves it does not have the burden of persuasion. In [8] the IS logic was modified to meet these demands. The main aim of the present paper is to modify this system further to allow for reasoning *about* the burden of persuasion.

4 A LOGIC FOR REASONING ABOUT THE BURDEN OF PERSUASION

In this section we will first briefly summarise the way in which IS was modified in [8] to allow for distributions of the burden of persuasion over the parties. Since in the new system such distributions are fixed and undisputable, we then further modify the system to model reasoning about the burden of persuasion within the logic.

4.1 The Litigation Inference System (LIS)

In [8] the IS argument game was extended with the possibility of switching dialectical roles. Let us call the resulting logical system LIS (Litigation Inference System). The LIS argument game is between two players, called plaintiff (π) and defendant (δ) which at any time can have either proponent role (P) or opponent role (O), depending on the context. The input of LIS is a *LIS theory $T_{LIS} = (R, \leq, b_\pi, b_\delta)$* where:

- $(R, \leq)$ is an IS theory.

- b_π and b_δ are mutually consistent and disjoint subsets of strong literals occurring in the rules in R.

The sets b_π and b_δ contain the burdens of persuasion for plaintiff and defendant respectively, that is, the propositions for which they have to act in proponent role.

In the LIS argument game plaintiff starts as proponent and defendant starts as opponent, but then these roles are reversed each time the player currently having opponent role moves an argument for a conclusion for which the sets b_π and b_δ allocate the burden of persuasion to him. The player then becomes the proponent with regard to that conclusion and thus he has to strictly defeat the other player's arguments. Thus while in IS plaintiff is always proponent and defendant

is always opponent, in LIS the parties of the litigation can change their dialectical role. LIS thus enables us to represent distributions of the burden of persuasion over the parties.

4.2 Reasoning About the Burdens of Proof

Though legal systems have general rules and principles on allocating the burden of proof, they can be vague, open-textured and conflicting just like in any other area of law, so sometimes the burden of proof itself becomes the subject of dispute (see also [7]). In fact, such disputes only concern the burdens of production and persuasion, since as just explained the tactical burden is automatically induced by the defeasible nature of the reasoning involved in fulfilling a burden of persuasion. Since the burden of production is allocated through rule-exception structures, reasoning about the burden of production is in fact reasoning about the backing or correct interpretation of rules. In previous work one of us showed how such debates can be formalised as reasoning about the grounds supporting a rule (see [13]). This leaves the modelling of reasoning about the burden of persuasion. Since LIS allows explicit allocations of the burden of persuasion as an additional parameter of the logic, what we now need is that these explicit allocations can be derived within the logic itself.

4.3 The Augmented Litigation Inference System (ALIS)

We now want to modify LIS by letting the contents of the sets b_π and b_δ be the outcome of an argument-based reasoning process. The resulting system will be called ALIS, for Augmented Litigation Inference System. To define ALIS we assume that the language includes a two-place predicate `burden` and a naming convention for strong literals of the language. Formulas of the form $\text{burden}(p, l)$ say that player p has the burden of persuasion for the literal denoted by the term l. To avoid selfreference, we do not allow that l is the name of the `burden` literal in which it occurs. As for notation, if p is a variable for a player, then the function expression $\bar{p}$ denotes the other player and if φ is a variable for a literal, then $\overline{\varphi}$ denotes the complement of the literal (the complement of an atom L is $\neg L$ and the complement of a negated atom $\neg L$ is L).

4.3.1 ALIS with Fixed Priorities

We now first define ALIS for the case with fixed priorities. In Section 4.3.2 a version with defeasible priorities will be defined.

Definition 4.1 *An* ALIS *theory is a pair* $T_{ALIS} = (R, \leq)$*, where* R *is a set of rules partially ordered by* $\leq$*, in a language containing the two-place predicate* `burden` *and a naming convention for strong literals of the language.* R *is also assumed to contain the following strict rules:*

$$\text{burden}(p, l) \rightarrow \neg\,\text{burden}(p, \bar{l})$$
$$\text{burden}(p, l) \rightarrow \neg\,\text{burden}(\bar{p}, l)$$
$$\text{burden}(p, l) \rightarrow \neg\,\text{burden}(\bar{p}, \bar{l})$$

The three strict rules ensure that the burdens of each player are consistent and that if one player has the burden of persuasion for a proposition, the other player does not have it for the same or complementary proposition.

We now explain the main idea of ALIS. The new argument game allows any player to explicitly claim any dialectical role, but if a player claims proponent role then he has the technical obligation to strictly defeat the previous argument, while if he claims opponent role he runs the risk of meta-attack on the burden of proof. More precisely, if a player p claims opponent role,

and moreover moves a weakly defeating argument, then $\bar{p}$ can attack that argument by arguing that p has the burden of proof. If $\bar{p}$ can win such a line of argument then that indicates that p cannot succeed by taking the opponent role, namely, by weakly defeating: a party having the burden of proof only succeeds by satisfying the requirements of the proponent role, namely, by putting forward justified arguments.

Definition 4.2 (Dialogue moves) *For any ALIS theory T, the set M_T of well-formed* moves *is defined as $\{\pi, \delta\} \times \{P, O\} \times Args_T$, where the three elements of a move m are denoted by, respectively:*

- $pl(m)$, *the* player *of the move,*

- $r(m)$, *the* dialectical role *of the move's player,*

- $a(m)$, *the* argument *moved.*

A dialogue *on the basis of T is any sequence of well- formed moves $m_1, \ldots, m_i, \ldots$ such that $pl(m_i) = \pi$ iff i is odd and $pl(m_i) = \delta$ iff i is even.*

To define the new argument game, it must be made explicit at which point an argument defeats another. We say that A defeats B on φ if φ is a conclusion of A and A defeats B since B has assumption or conclusion $\overline{\varphi}$ or since φ says that a rule in B is excluded.

We can now define the protocol of the new argument game. (In the definitions below 'φ *since S*' denotes an argument with conclusion φ and premises S.)

Definition 4.3 (Protocol with fixed priorities)
A well-formed move m_i is legal *in a finite dialogue $d = m_1, \ldots, m_{i-1}$ iff it satisfies the following constraints:*

1. $r(m_1) = P$;

2. *if $i > 1$ and $r(m_i) = P$ then $a(m_i)$ was not earlier moved in d by $pl(m_i)$ and;*

    (a) *$a(m_i)$ strictly defeats $a(m_{i-1})$ or*
    (b) *$a(m_i) = $ "$\mathtt{burden}(\bar{p}, \varphi)$ since S" where $a(m_{i-1})$ weakly defeats $a(m_{i-2})$ on φ;*

3. *if $i > 1$ and $r(m_i) = O$ then*

    (a) *if $pl(m_i) = \pi$ and $r(m_{i-1}) = O$ then $a(m_i)$ was not earlier moved in d by $pl(m_i)$; and*
    (b) *$a(m_i)$ defeats $a(m_{i-1})$.*

As in IS and LIS a player wins a game in ALIS if the other player has run out of moves and an argument is justified if proponent has a winning strategy in a game starting with the argument.

All protocol conditions are taken from the LIS protocol, except conditions (2b) and (3a). The first of these formalises the main addition of ALIS to LIS while the rationale of (3a) is to exclude infinite dialogues where both players keep repeating weakly rebutting arguments in opponent role: in such a case it is plaintiff's task to argue that defendant has the burden of proof. The ALIS protocol is also in one respect more liberal than LIS: while in ALIS the players can freely adopt any role, in LIS a move has proponent role if its conclusion is in the burdens of the moving player and otherwise it has the opposite role as its target.

We now prove that ALIS properly extends LIS. By this we mean that the same justified conclusions that can be obtained in ALIS can be obtained in LIS by adding an explicit allocation of the burden of proof to LIS corresponding to the justified conclusions on the burden of persuasion in ALIS. To this end we make the allocations of the burden of persuasion relative to a set of arguments.

Definition 4.4 *Let S be a set of arguments. The literal sets b_π^S and b_δ^S are defined as follows. For any strong literal L named by term l:*

- $L \in b_\pi^S$ *iff* `burden`(π, l) *is a conclusion of an argument in S.*

- $L \in b_\delta^S$ *iff* `burden`(δ, l) *is a conclusion of an argument in S.*

At first sight this definition allows the burdens of both parties to be overlapping and mutually inconsistent, which is excluded in LIS. However, the idea is that S is not just any set of arguments but that it is the set of justified arguments. In that case the desired properties of the burden sets are guaranteed by the strict rules on proof burdens that are in T according to Definition 4.1. We now prove that this is indeed the case.

Theorem 4.5 *For any ALIS theory $(R, \leq)$ it holds that if S is the set of ALIS-justified arguments of $(R, \leq)$ then S is the set of LIS-justified arguments of the LIS theory $(R, \leq, b_\pi^S, b_\delta^S)$.*

PROOF. We first prove that we can without loss of generality consider winning strategies without replies in P role to moves in P role. If a player replies in P role to a move in P role then his argument strictly defeats its target. Then any reply to the same argument moved in O role is a reply to the argument moved in P role, so in both cases the player can move the same reply. So if the player has a winning strategy in one case he also has a winning strategy in the other case.

Consider next any winning ALIS strategy W for π. We prove that W can be transformed into a winning LIS strategy. The nontrivial cases are when W contains π-moves that are not legal in LIS. These are implicit role switches adopting O role (case 1) and `burden` moves made legal by clause (2b) of Definition 4.3 (case 2).

(1) Consider first any implicit role switch m_i moved by π. Since m_i weakly defeats m_{i-1}, δ can repeat (part of) m_{i-2} in O role in reply to m_i so to win π must now move an argument with conclusion `burden`(δ, l). Since W is a winning strategy for π, we have that $l \in b_\delta^S$ so m_i is legal in LIS and m_{i+1} is not legal in LIS. So in both ALIS and LIS π can win by replying to m_{i-1} with m_i.

(2) Consider next any move $m_i = (\pi, P, a)$ in W made legal by clause (2b) of Definition 4.3 where the conclusion of a is `burden`(δ, l). Then $l \in b_\delta^S$ so m_{i-1} is not legal in LIS. So in both ALIS and LIS π can win by replying to m_{i-3} with m_{i-2}. □

4.3.2   ALIS with Defeasible Priorities

The IS system as defined in [11] has two versions: one in which the rule priorities are fixed and simply given in addition to the rules and one in which the rule priorities are defeasible and must be derived within the system. In the latter version, rule priorities can be reasoned about as any other legal issue. In [8] the LIS system was only defined for fixed priorities but we want to define ALIS for both cases. Therefore we now redefine LIS for the case with defeasible priorities and then extend it to a new version of ALIS.

We first recall the essentials of IS with defeasible priorities. An IS theory now is just a set R of rules, including priority rules. To express priority rules a distinguished predicate $\prec$ is used:

$r \prec r'$ means that r' has priority over r. The dialogue game is adjusted as follows. Firstly, the defeat relations between arguments are now made relative to priorities. Proponent's defeating arguments must now strictly defeat their target according to the priorities stated in proponent's argument. This will be denoted as a-defeat, where a is the argument moved by proponent. Opponent's arguments, by contrast, must now defeat their target taking no priorities into account. This will be denoted by $\emptyset$-defeat. Secondly, proponent now has an additional option, namely, to move a priority argument according to which opponent's last argument does not defeat its target any more. In other words, according to proponent's priority argument opponent's last argument is now strictly defeated by its target.

To obtain a version of LIS with defeasible priorities, we simply omit the $\leq$ component of LIS theories and add the mechanism of dialectical role switch to the dialogue game with defeasible priorities. The ALIS dialogue protocol is then redefined as follows.

Definition 4.6 (Protocol with defeasible priorities) *A well-formed move m_i is legal in a finite dialogue $d = m_1, \ldots, m_{i-1}$ iff it satisfies the following constraints:*

1. *$r(m_1) = P$;*

2. *if $i > 1$ and $r(m_i) = P$ then $a(m_i)$ was not earlier moved in d by $pl(m_i)$ and*

   (a) $a(m_i)$ strictly $a(m_i)$-defeats $a(m_{i-1})$ or

   (b) $a_{m_{i-2}}$ strictly $a(m_i)$-defeats $a_{m_{i-1}}$ or

   (c) $a(m_i) =$ "$\texttt{burden}(\overline{p}, \varphi)$ since S" where $a(m_{i-1})$ weakly $\emptyset$-defeats $a(m_{i-2})$ on φ;

3. *if $i > 1$ and $r(m_i) = O$ then*

   (a) if $pl(m_i) = \pi$ and $r(m_{i-1}) = O$ then $a(m_i)$ was not earlier moved in d by $pl(m_i)$; and

   (b) a_{m_i} $\emptyset$-defeats $a_{m_{i-1}}$.

Theorem 4.5 is now reformulated as follows.

Theorem 4.7 *For any ALIS theory R with defeasible priorities it holds that if S is the set of ALIS- justified arguments of R then S is the set of LIS-justified arguments of the LIS theory with defeasible priorities (R, b_π^S, b_δ^S).*

PROOF. The proof is the same as for Theorem 4.5. □

5 EXAMPLES

In this section we first illustrate the technical features of the ALIS formalism with some formal examples and we then apply it to two actual legal cases. Recall that ALIS (as the IS system, see Section 2) is not intended to be a model of actual legal dialogue but a dialectical proof theory for a nonmonotonic logic. We therefore do not claim that the debates below are adequate models of how debates between the adversaries in a legal dispute could evolve. All we claim is that our dialogue game draws the correct defeasible inferences from the ALIS theory consisting of all rules and facts that are listed below.

Below we only list rules and regard it as obvious how they can be used to build the relevant arguments. Furthermore, we leave the strict rules of Definition 4.1 implicit. Apart from this, in all examples the set R of rules consists of all and only the listed rules and facts.

5.1 Formal examples

The first example illustrates what happens when only defensible arguments on the burden of proof can be constructed. We write 'c since $\{p_1, \ldots, p_n\}$' to denote an argument with conclusion c and premises $\{p_1, \ldots, p_n\}$. The literal argument premises are unconditional default rules.

$$\pi_1(P): \quad q \text{ since } \{p \Rightarrow q, p\}$$
$$\delta_1(O): \quad \neg p \text{ since } \{r \Rightarrow \neg p, r\}$$
$$\pi_2(O): \quad p \text{ since } \{s \Rightarrow p, s\}$$
$$\delta_2(P): \quad \texttt{burden}(\pi, p) \text{ since } \{t \Rightarrow \texttt{burden}(\pi, p), t\}$$
$$\pi_3(O): \quad \texttt{burden}(\delta, \neg p) \text{ since } \{u \Rightarrow \texttt{burden}(\delta, \neg p), u\}$$

At this point condition (2a) of Definition 4.6 disallows δ from repeating δ_2 so she loses. At first sight it would seem that π has a wining strategy. This would be undesirable, since it would seem that π can thus always escape the burden of persuasion for his main claim. However, this is not the case, since δ could at δ_2 have repeated δ_1:

$$\pi_1(P): \quad q \text{ since } \{p \Rightarrow q, p\}$$
$$\delta_1(O): \quad \neg p \text{ since } \{r \Rightarrow \neg p, r\}$$
$$\pi_2(O): \quad p \text{ since } \{s \Rightarrow p, s\}$$
$$\delta_2'(O): \quad \neg p \text{ since } \{r \Rightarrow \neg p, r\}$$
$$\pi_3'(P): \quad \texttt{burden}(\delta, \neg p) \text{ since } \{u \Rightarrow \texttt{burden}(\delta, \neg p), u\}$$
$$\delta_3'(O): \quad \texttt{burden}(\pi, p) \text{ since } \{t \Rightarrow \texttt{burden}(\pi, p), t\}$$

Note that after δ_2' condition (3b) of Definition 4.6 disallows π from repeating π_2 so π is forced to start the meta-debate as proponent. In fact, this is always the case; the proof of Theorem 4.5 makes this precise in case 1. The conclusion that can be drawn from this is that plaintiff by default has the burden of persuasion for his main claim, unless he can provide a justified argument why this is otherwise.

We next note that the first moment at which a metadebate could start is after δ_1, since the rules for p and $\neg p$ have contradictory consequents and no rule priorities are stated. The dialogue would then develop as after π_3' above.

Continuing the example, we finally illustrate that debates about the burden of persuasion can be nested any number of times. Suppose π can still reply to δ_3' (in his argument, r_1 names $u \Rightarrow \texttt{burden}(\delta, \neg p)$ and r_2 names $t \Rightarrow \texttt{burden}(\pi, p)$):

$$\pi_4(P): \quad r_2 \prec r_1 \text{ since } \{v \Rightarrow r_2 \prec r_1, v\}$$
$$\delta_4(O): \quad \neg v \text{ since } \{w \Rightarrow \neg v, w\}$$
$$\pi_5(O): \quad v \text{ since } \{x \Rightarrow v, x\}$$
$$\delta_5(O): \quad \neg v \text{ since } \{w \Rightarrow \neg v, w\}$$
$$\pi_6(P): \quad \texttt{burden}(\delta, \neg v) \text{ since } \{y \Rightarrow \texttt{burden}(\delta, \neg v), y\}$$

And so on. The move π_4 states a rule priority that makes π_3' strictly π_3'-defeat δ_3' but in the debate about this priority argument a new issue arises about the burden of proof.

5.2 Ownership of Archaeological Goods (Italy)

Our first example illustrates the interplay between presumptions and burdens of proof, in both private and penal law. According to an Italian statute (n. 364 of 1909), all archaeological items found on the Italian territory become directly inalienable property of the Italian State. However, this only applies to items found after this statute came into force, namely, after 1909: the property of archaeological items found before 1909 could legitimately be acquired by private people (the owner of the land where the items were found and their finder, according to general rules of the

Italian civil code), and their property could be transferred to others (after 1909 only though inheritance). These provisions belong to private law, but they have a significance for penal law too: by establishing when a good belongs to the State they provide a precondition for the application of penalties against archaeological theft, namely, against getting possession of archaeological goods belonging to the State (as established by legislative decree n. 490 of 1999).

The double significance of this provision has recently emerged in an Italian case, concerning a certain Mr. L., who had been found in possession of certain archaeological items. Against Mr. L. first a penal procedure was started. The central issue of the criminal process was whether such items belonged to the State, this being a precondition for condemning Mr. L. for archaeological theft. In Italian criminal law there are two approaches with regard to this issue, both approaches being supported by conflicting decisions of the Italian Court of Cassation (Corte di Cassazione). According to one approach, which was dominant until recently, archaeological goods are considered to be State property unless the accused citizen proves to have legitimately acquired their property. According to the other approach, a citizen can be convicted for archaeological theft only if prosecution proves that the items possessed by the citizen belong to the State. Following the latter approach, however, the citizen has the burden of justifying his or her possession of such items, which entails indicating circumstances explaining why he or she, rather then the State, owns such items. However, once such circumstances are indicated, prosecution must convince the judge that they did not take place (so that the items can indeed be considered State property), in order to obtain conviction.

Using our conceptualisation we may say that in Italian criminal law there are the following views on how State ownership of archaeological items is to be proved: according to one view both the burden of production and the burden of persuasion (that the items possessed do not belong to the State) falls upon the possessor; according to the second view, the burden of production (that the items do not belong to the State) falls upon the possessor, while the burden of persuasion (that the items belong to the State) falls upon the State. The penal judge who decided the case of Mr. L. adopted the second view and acquitted him, on the basis of the following reasons: (1) L. claimed that the items had been unearthed before 1909 and consequently privately appropriated (and transmitted to him through inheritance), and (2) at the end of the proceedings, "absolute uncertainty remained concerning the time of the unearthing".

Let us try to provide a formalisation of the debate in these criminal proceedings (rather than precisely reproducing the sequence of the acts of the parties, we shall provide a narrative which emphasises the aspects we want to focus on).

Let us first consider the main argument by prosecution (π), viz. that the accused citizen (δ) is an archaeological thief since δ took possession of the archaeological item (i) owned by to the state (s). Let us assume that the prosecution moves in proponent role (P) as is usually the case in criminal law, and that therefore it has the burden of persuasion with regard to the constitutive elements of the crime. Prosecution's argument is based upon two rules: the first (r_1) indicates the conditions constituting the crime of archaeological theft, the second (r_2) states that archaeological good discovered in the Italian territory belong to the state.

$\pi_1(P)$

r_1: ArchaeologicalItem$(x) \wedge$ PossessedBy$(x, y) \wedge$
      OwnedBy$(x, s) \wedge y \neq s$
      $\Rightarrow$ CommitsArchaeologicalTheft(y)

r_2: ArchaeologicalItem$(x) \wedge$ FoundInItaly(x)
      $\Rightarrow$ OwnedBy(x, s)

f_1: $\rightarrow$ ArchaeologicalItem(i)

f_2: $\rightarrow$ FoundInItaly(i)

f_3: $\rightarrow$ PossessedBy(i, δ)

Let us assume that there is incontestable evidence for the facts that i is an archaeological item (f_1), found in the Italian territory (f_2), and that δ possesses i (f_3), so that they can be taken by the parties as indisputable facts, rather than as disputable hypotheses (as expressed by prefixing them with the connective $\rightarrow$, rather then with $\Rightarrow$).

The accused citizen δ challenges prosecution's argument by affirming that the archaeological item he possesses was privately appropriated before 1909 (PrivateBefore1909), so that rule r_2 does not apply to the finding of i (not being in force yet when it took place). He does that playing the opponent's role:

$\delta_1(O)$

r_3: PrivateBefore1909$(x) \Rightarrow \neg$ appl(r_2, x, s)

d_1: $\Rightarrow$ PrivateBefore1909(i)

Note that the citizen has provided no evidence for private ownership before 1909: this is a disputable hypothesis, on which the parties are likely to disagree.

Prosecution replies by providing the presumption that archaeological items were not private before 1909, a presumption which prevails upon the assertion that the items had already become private property. In fact the law usually assumes that conditional presumptions prevail over unsupported negations of their conclusion, though they are strictly defeated when specific grounds leading to a contradictory conclusion are provided. This is how the law deals with the so-called rebuttable legal presumptions (*praesumptiones juris tantum*), while nonrebuttable legal presumptions (*praesumptiones juris et de jure*) cannot be defeated by arguments contradicting their conclusion.

$\pi_2(P)$

r_4: ArchaeologicalItem$(x) \Rightarrow \neg$ PrivateBefore1909(x)

p_1: Presumption $(x) \wedge$ UnSupportedAssertion(y)
      $\Rightarrow y \prec x$

f_4: $\rightarrow$ Presumption(p_1)

f_5: $\rightarrow$ UnSupportedAssertion(d_1)

The citizen could attack this presumption directly (rejecting the idea that archaeological goods can be assumed not to have been privately appropriated before 1909). However, this move is not the most effective way of replying to prosecution, since Italian judges have upheld this presumption in various instances, affirming that the possessor of an archaeological item will lose on this point unless he provides any justification (any argument) for the private ownership. Thus δ chooses a subtler reply: he accepts this presumption but only insofar as it impacts on the burden of production (only insofar as it concerns the burden of *allegazione*, as Italian lawyers call it): the presumption is valid but it become useless as soon as it is attacked by a defensible argument. Thus δ needs first to attack the presumption by indicating some plausible circumstances in which the item could have become private property. In case this argument were contested (as will actually happen in the continuation of the dispute) δ will argue that prosecution has the burden to

persuade the Court that the indicated circumstance did not obtain or could not operate. On the basis of this allocation of the burden of persuasion, he will argue that since prosecution fails to provide persuasion, he must be acquitted.

Here is the first step of this strategy: to defeat the presumption, δ argues that an ancestor of his (from which he inherits) acquired ownership by finding the archaeological item before 1909.

$\delta_2(O)$
r_5: `FoundBefore1909`$(x) \Rightarrow$ `PrivateBefore1909`(x)
d_2: $\Rightarrow$ `FoundBefore1909by`(i)

Assume that prosecution does not find any specific argument supporting the conclusion that the item was found since 1909. However, prosecution rejects the citizen's statement concerning the fact that the item was found before 1909, and affirms that the citizen possessing an archaeological item has the burden of persuasion with regard to the fact that the item was private property before 1909.

$\pi_3(P)$
d_3: $\Rightarrow \neg$ `FoundBefore1909`(a, i)
r_6: `ArchaeologicalItem`$(x) \wedge$ `PossessedBy`(x, y)
    $\Rightarrow$ `burden`$(y, PrivateBefore1909(x))$

If this argument were accepted (so that the citizen had the burden of persuasion with regard to private appropriation before 1909) then δ would lose the case and be convicted for archaeological theft. In fact, at this stage δ has not provided a justified argument (as required for satisfying a burden of persuasion) that the items were private before 1909 (the precondition of this conclusion, namely finding i before that date, is the object of conflicting unsupported claims). Hence the presumption that the archaeological item were not privately appropriated remains unchallenged.

However, the penal judge (following certain precedents of the criminal sections of the Court of Cassation) accepted the following objection to rule r_6: according to the principle of the presumption of innocence an accused person x cannot have the burden of persuasion with regard to any fact φ which may prevent x's conviction (`PreventsConviction`), like the fact that a found the item before 1909, a fact which could indeed prevent δ's conviction. This requirement is stated in the Italian Constitution, so that it prevails over civil law presumptions (according to preference rule p_2).

$\delta_3(O)$
r_7: `PreventsConviction`$(\varphi, x) \Rightarrow \neg$ `burden`(x, φ)
f_6: $\rightarrow$ `PreventsConviction`$(PrivateBefore1909(i), \delta)$
p_2: `OrdinaryLaw`$(x) \wedge$ `ConstitutionalLaw`(y)
    $\Rightarrow x \prec y$
f_7: $\rightarrow$ `OrdinaryLaw`(r_3)
f_8: $\rightarrow$ `ConstitutionalLaw`(r_7)

On the basis of this procedural argument, the Italian State lost the criminal case and Mr. L., the owner of the archaeological item, was acquitted.

Immediately after the end of the criminal proceedings, the Italian State, s, filed a civil lawsuit against Mr. L., δ, demanding that a civil court should establish that the archaeological items possessed by δ were owned by the s, and consequently order δ to deliver them to the s. This demand was accepted by the Tribunal of Rome, the Appeal Court of Rome, and finally the Italian Court of Cassation (Corte di Cassazione, Sezione Prima Civile, 10 February 2006, Decision n. 2995), so that δ, though having won the criminal proceedings lost the civil ones.

The central argument in the civil proceedings was again the proof of State ownership. The possessor δ affirmed, as he had done in the criminal process, that the State s had the burden of persuading the Court that the archaeological items i, possessed by δ, had not been privately appropriated before 1909, on the basis of the fact that the s according to Italian law has no privileged position over private parties. However this argument was rejected by the Court, which on the contrary accepted s's argument that δ, besides having the burden of indicating facts which allegedly determined the private ownership of the item before 1909, also had to prove (to "provide full demonstration" of) such facts.

Here is how the Court of Cassation states this argument:

> The State when affirming the ownership of archaeological items can use a presumption of State property. This presumption is supported, besides by what usually happens (*id quod plaerunque accidit*), by a "normative normality." . . . Consequently, since the citizen provides in opposition an exceptional circumstance, capable of defeating the presumption, he must prove it, . . . giving full demonstration that the item was found before 1909."

In this statement we can distinguish two lines of reasoning. First a backing is provided for the presumption (r_3) that archaeological items were not privately appropriated before 1909: there is a high statistical probability, P^h, that if the presumption's antecedent is true (something is an archeological item) also its consequent is true (private appropriation before 1909 has not taken place). Then it is affirmed that once a backed civil law presumption is satisfied (namely, once the antecedent of the presumption has been established) there is a burden of persuasion with regard to the complement of the presumption's consequent. By combining these two lines of reasoning an argument is provided why δ has the burden of proving that the archaeological items were privately appropriated before 1909:

$\pi_4(P)$

b_1: $\texttt{CivilPresumption}(r) \wedge P^h(cons(r) \mid ant(r))$
       $\Rightarrow \texttt{Backed}(r)$

r_8: $\texttt{CivilPresumption}(r) \wedge \texttt{Backed}(r) \wedge ant(r)$
       $\Rightarrow \texttt{burden}(x, \overline{cons(r)})$

f_9: $\rightarrow \texttt{CivilPresumption}(r_3)$

$f_1 0$: $\rightarrow P^h(cons(r_3) \mid ant(r_3))$

Here P^h indicates high statistical probability (likeness) and $\overline{cons(r)}$ denotes the complement of $cons(r)$ (the complement of a strong literal is its strong negation if the literal is an atom, otherwise it is the atom formed by removing the strong negation). Since δ could not find a satisfactory reply to this argument (according to the Court of Cassation) he lost the case. In fact, δ has the burden of persuasion with regard to the complement of r_3's consequent, namely, private appropriation before 1909. By failing to provide a justified argument to this effect, he fails to defeat the presumption that there was no prior appropriation, so that the judge can conclude for State property. Note that δ now could not refer to r_7, namely, to the fact that one cannot have the burden to prove something that could prevent one's conviction, since in civil proceedings no conviction is at stake.

This example shows the distinction between burden of production and burden of persuasion and the role of presumptions in satisfying such burdens. Both in the criminal and in the civil proceedings the presumption that there was no private appropriation before 1909 could be used by the State to fulfill its burden of production. However, the burden of persuasion is a separate issue, which was approached differently in the criminal proceedings (according to the so-called presumption of innocence) and in the civil ones, which led to different outcomes.

5.3 Individualised Education Programs for Disabled Children (USA)

Our second example, the American case Weast v. Schaffer, 41 IDELR 176 (4th Cir. Md., 2004) directly addresses the burden of persuasion for a certain proposition, without taking presumptions into account. The parents of a disabled child sued their school district to seek reimbursement for private school tuition on the grounds that the individualised education programme (IEP) for their son provided by the district was inappropriate. The statute governing this issue (IDEA) is silent on the burden of persuasion. The parents claimed that the schoo district had the burden of proving that that the offered IEP was appropriate. A district court agreed with the parents but in appeal the majority of the 4th US circuit Court of Appeals held that the parents had the burden of proving that the IEP was inappropriate. The Supreme Court 546 U.S. (2005) confirmed this decision on the following grounds. It began with the "ordinary default rule" that the party seeking in an administrative procedure has the burden of proof, and it argued that in this case there was no exception since there was no reason to believe that the legislator intended otherwise. The Court then rejected the parents' arguments to the contrary. Their first argument was that putting the burden of proof on the school district will encourage schools to put more resources into preparing IEPs and preparing their evidence in procedures, which will ensure free appropriate public education, which is a purpose of the IDEA. The court, though agreeing that this might be the case, rejected this argument on the grounds that these effects will also lead to increased administrative and litigation costs, while the legislator had repeatedly amended the act to reduce such costs. A second argument of the parents was that fairness demands that facts that are peculiarly within the knowledge of a party must be proven by that party. The court rejected this argument on the grounds that the IDEA contains various safeguards and rights for parents to obtain the relevant information about IEPs.

Our formalisation will combine the substantial debate on who must pay the parents' costs for private tuition with the procedural debate on who has the burden of persuasion. Since the case law reports do not contain enough information to reconstruct the substantial debate, we have to make our own reconstruction. Below the parents are plaintiff (π) and the school district is defendant (δ). Suppose the parents start in proponent role, arguing that they should be compensated since they were offered a program (i) which was not appropriate as a IEP.

$\pi_1(P)$
r_1: `OfferedIEP`$(x, y, z) \wedge \neg$ `Appropriate`$(x) \Rightarrow$
    `MustCompensate`(y, z)
f_1: $\rightarrow$ `OfferedIEP`(i, s, p)
d_1 $\Rightarrow \neg$ `Appropriate`(i)

In these rules x, y, z are variables while i, s, p are constants denoting, respectively, the IEP, the school district and the parents. This argument concludes that the school must compensate the parents (`MustCompensate`(s, p)).

The school replies in opponent role with the following argument for the appropriateness of the offered program.

$\delta_1(O)$
r_2: `Grounds`$_1 \Rightarrow$ `Appropriate`(i)
f_2: $\rightarrow$ `Grounds`$_1$

The parents think that the school district has the burden of persuasion that the IEP is appropriate and therefore now choose opponent role, moving an argument which weakly defeats the school district's argument based on r_2 (by denying the appropriateness of the program).

$\pi_2(O)$

   r_3:   `Grounds`$_2 \Rightarrow \neg$ `Appropriate`(i)

   f_3: $\rightarrow$ `Grounds`$_2$

Note that π_2 weakly $\emptyset$-defeats δ_1 since r_2 and r_3 have complementary consequents. The school district disagrees that it has the burden of persuasion and therefore starts a procedural debate by arguing in proponent role that the parents have the burden of persuasion with respect to the claim that the offered IEP scheme is inappropriate (denoted below with the term $\neg$ $Appropriate(i)$). Defendant's argument is in fact the Supreme Court's main argument based on the ordinary default rule that a party seeking administrative relief on a certain ground has the burden of proving it.

$\delta_2(P)$

   r_4:   `SeeksReliefOn`$(x, \varphi) \Rightarrow$ `burden`(x, φ)

   f_4: $\rightarrow$ `SeeksReliefOn`$(p, \neg Appropriate(i))$

The parents try to counter this argument by providing an argument why in the present case the general allocation of the burden should be overridden by specific reasons why burden of persuasion should be on the school. Firstly they argue that this should be the case since the school has peculiar access to information on the issue at state (the appropriateness of the offered IEP).

$\pi_3(O)$

   r_5:   `PeculiarlyWithinKnowledgeOf`$(x, \varphi) \Rightarrow$
      $\neg$ `Appl`(r_4, x, φ)

   r_6:   `PeculiarlyWithinKnowledgeOf`$(x, \varphi) \Rightarrow$
      `burden`(x, φ)

   d_2: $\Rightarrow$ `PeculiarlyWithinKnowledgeOf`$(s, Appropriate(i))$

The antecedent of both r_5 and r_6 is provided as a default instead of as a fact, since it is contested on the basis of the fact that access to information was ensured to the parents by legislative safeguards, an argument which was accepted by the Supreme Court. Such an acceptance can be expressed by including fact f_6 in the following argument, which makes it strictly δ_3-defeat π_2.

$\delta_3(P)$

   r_7:   `AccessSafeguardsFor`$(\overline{x}, \varphi) \Rightarrow$
      $\neg$ `PeculiarlyWithinKnowledgeOf`(x, φ)

   f_5: $\rightarrow$ `AccessSafeguardsFor`$(p, Appropriate(i))$

   f_6: $\rightarrow r_6 \prec r_7$

The parents' second main argument is a practical value-based argument, saying that the burden of proof should be put on the school since doing so has some desirable consequences. The formalisation of such arguments has recently received considerable attention in the literature. For work within AI & law see e.g. [9; 5; 6; 1]. Since this topic is not the central focus of this paper, we adopt the method of [9] for the pragmatic reason that it was developed within the IS logic. In this method, first the two arguments on whether the legislator intended an exception are formalised and then their conflict is decided as a priority argument on the relative importance of the values advanced by these arguments. The parents argue that the reason why rule r_4 should not be applied to the proof of the non-appropriateness of burdens (r_8) and why the burden of persuasion should be put on the school (r_9) is that this makes it likely that the school will dedicate more resources to IEPs. (P_h B | A indicates that the stated conditional probability is high, namely, that the happening of A makes it likely that B happens too).

$\pi_3'(O)$

r_8: $P^h(\texttt{ResOnIEPs} \mid \texttt{burden}(x, Appropriate(y))) \Rightarrow$
$\neg\,\texttt{Appl}(r_4, \overline{x}, \neg Appropriate(y))$

r_9: $P^h(\texttt{ResOnIEPs} \mid \texttt{burden}(x, Appropriate(y))) \Rightarrow$
$\texttt{Burden}x, Appropriate(y))$

f_7: $\rightarrow P^h(\texttt{ResOnIEPs} \mid \texttt{burden}(s, Appropriate(i)))$

The school's counterargument is based on the idea the reason why the burden of persuasion should be put on the parents is that this will discourage them from starting legal actions, which leads to lower litigation costs.

$\delta_3'(P)$

r_{10}: $P^h(\texttt{LessLitCosts} \mid \texttt{burden}(x, \neg Appropriate(y))) \Rightarrow$
$\texttt{Burden}(x, \neg Appropriate(y))$

f_8: $\rightarrow P^h(\texttt{LessLitCosts} \mid \texttt{burden}(p, \neg Appropriate(i)))$

Note that the school's argument was moved in proponent role. Therefore, according to Definition 4.6 the court has to combine it with a priority argument making his argument strictly defeat the parents' argument. In the method of [9] this can be done by first stating which values are advanced by the various rules and then stating which value is more important. The method then contains axioms which imply the desired priority conclusions. Below, *fpe* stands for the value of free appropriate public education while *lc* stands for the value of lower litigation and administration costs.

$\delta_3'(P)$ **(continued)**

f_9: $\rightarrow \texttt{Advances}(r_9, fpe)$

f_{10}: $\rightarrow \texttt{Advances}(r_{10}, lc)$

The supreme court in fact based its rejection of the parents' argument on the observation that the legislator had amended the IDEA various times to reduce the litigation and administrative costs. This can be formalised as the reason why the value of lower litigation and administration costs is more important than the value of free appropriate public education.

$\delta_3'(P)$ **(continued)**

r_{10}: $\texttt{LegislAmendedForLC}(x, y) \Rightarrow fpe \prec lc$

f_{11}: $\rightarrow \texttt{LegislAmendedForLC}(x, y)$

When the court's rules in δ_3' are combined with the axioms of [9], an argument results for the conclusion $r_9 \prec r_{10}$, so that δ_3' strictly δ_3'-defeats π_3'. To conclude this example, note that it is based on the ALIS theory consisting of all facts and rules put forward in the dialogue plus the three strict rules of Definition 4.1. The dialogue is in fact a winning strategy for defendant on the basis of this theory: defendant can win whether plaintiff chooses for π_3 or for π_3' and plaintiff has no other choices at any point in the dialogue. It would be different if the theory also contained a priority argument for the conclusion $r_2 \prec r_3$: then plaintiff could adopt proponent role in π_2 and combine this priority argument with main argument in π_2. However, the text of the Supreme Court decision does not warrant the inclusion of such a priority argument in the theory.

We finally illustrate Theorem 4.7. The set S of justified arguments of the ALIS theory includes δ_2 but not π_3 or π_3' so the corresponding LIS theory (R, b_π^S, b_δ^S) is such that $b_\pi^S = \{\neg\texttt{Appropriate}(i)\}$ while $b_\delta^S = \emptyset$.

6   CONCLUSION

In this paper we have presented an argument-based logic in which distributions of the burden of persuasion over parties in a dispute can be explicitly represented and reasoned about. The logic

extends the one of [8], in which distributions of the burden of persuasion can be expressed but are fixed and undisputable. That logic modified the dialectical proof theory of our system of [10]. While in the 1996 system one side always has the burden to justify and the other side merely the burden to interfere, in the 2001 version this may be different for different subissues of an issue.

Our current system retains from the 2001 system the lack of an extension-based semantics in the style of [2]. As noted in [8], this raises important questions concerning the adequacy of 'mainstream' nonmonotonic logics for representing legal reasoning. However, this issue is outside the scope of the present paper.

To our knowledge, ALIS is the first nonmonotonic logic that models reasoning about the burden of persuasion. Of course, different ways to model the burden of persuasion will lead to different ways to model reasoning about it. There is one other inferential model with much attention for issues related to burden of proof, viz. the Carneades system of [3]. This system is parametrised by 'proof standards', some of which are defined in detail. In [3] it is not discussed how the three proof burdens can be expressed in Carneades but a method for this has in recent joint work been developed by Gordon, Prakken and Walton in [4].

In [12] a protocol for persuasion dialogue is presented in which the participants can debate the burden of proof: when one party challenges a claim of the other party, that party can challenge the challenge after which a metalevel dialogue can start about whether the challenged claim or its negation must be backed with an argument. The aim of this work is not to model defeasible inference but to model rational natural dialogue. It is not discussed whether the metadialogues concern the burden of persuasion or production. We think they concern the burden of production but this should be further investigated.

More generally, more research is needed on the integration of our inferential account of burden of proof with dialogical and procedural models of legal argument.

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