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CONTENTS

USING SET-OF-SUPPORT CONTROL STRATEGY TO DEAL WITH INDETERMINACY IN LEGAL REASONING

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Abstract

Our long-term research objective is to model the process of creating new interpretations in legal reasoning. Our approach is to sketch out an argument, identify the relevant legal factors, and use them in a top-down fashion to guide the search for new interpretations. Here we report on the front-end of this system which generates arguments supporting a given conclusion while taking into account extra-legal factors such as the intentions of the law-makers. We show how the "set-of-support" control strategy can be used effectively to generate multiple arguments for or against a conclusion from an inconsistent knowledge-base. We present some characteristics of set-of-support strategy with regard to inconsistent knowledge-base, and show that only those arguments are generated that are relevant to the given conclusion. We present a detailed example of an actual legal case in which many extra-legal factors played a key role, and then apply set-of-support strategy to generate four different arguments — two each for the plaintiff and the defendant. We compare our work with existing research and then briefly discuss how we plan to use this system to model creative reasoning.

1 Introduction and overview

> *"…The process of argument is not a chain of demonstrative reasoning. It is a presenting and re-presenting of those features of the case which* severally co-operate *in favor of the conclusion, in favour of saying what the reasoner wishes said, in favor of calling the situation by the name which he wishes to call it.* The reasons are like the legs of a chair, not the links of a chain.*"*
>
> – *Wisdom, 1944* (Quoted in Twining and Miers, 1982, p. 268; emphasis added by Twining and Miers.)

The long-term goal of our research is to make a legal-reasoning system to generate multiple arguments to support a conclusion. In particular, we are interested in modeling the process by which *creative* arguments can be generated: that is arguments that call into play new dimensions or categories, or generate new interpretations. This research is motivated from the author's previous work on creative analogies and metaphors (Indurkhya 1992; forthcoming), where it is proposed that a new perspective on some object or situation (a *case* for a legal-reasoning system) can result from applying the higher-level description of one object to the low-level description of another object, and the underlying process is that of change of representation. Importing this idea to the legal domain, it suggests that the high-level factors such as the goals of the user, or the purpose of the law can serve as a strong force to guide and constrain the process of creating new categories or interpretations. So before we can start generating creative arguments, we must identify relevant high-level factors and sketch out the outline of an argument (or several arguments) in terms of these factors. It is this aspect of legal reasoning — a preamble to our long-term research goal — that is addressed in this paper. We would like our "generate argument" module to have the following characteristics:

1. It should be able to take into account the statutory rules as well as various other extra-legal factors such as purpose of the law.

2. It should be able to work with inconsistent information. There may be mutually inconsistent formalizations of statutory rules or extra-legal factors (for example, two different purposes attributed to a law.)
3. It should be able to sketch out arguments for either side of a conclusion: for P or for $\neg P$.
4. It should be able to generate multiple arguments supporting a conclusion.
5. We would like to use some logic-based approach so that the structure of the argument is sound, even though the premises themselves might be defeasible.

Now characteristics 2 and 3 are well-known to the AI and Law research community under the rubric of *indeterminacy*. Though some researchers have felt that they are incompatible with requirement 5 (Berman and Hafner 1987), many other researchers have devised elaborate logical systems to address the indeterminacy problem. These approaches can be roughly divided into two classes. For approaches under one class, the goal is to model the adversarial aspect of legal reasoning. The emphasis here is to compare and evaluate opposing arguments to decide which one is stronger. Some notable progress in this direction has been made in the recent years by Hage (1996), Loui and Norman (1995), and Prakken and Sartor (1996).

The approaches in the other class have focused on generating arguments without trying to evaluate which is the winning argument. It is under this class that our research described here falls. Our goal is to produce multiple arguments that support a conclusion and, in later research, to model creative ways to strengthen those arguments. Our initial study of some examples of creativity in legal reasoning has shown that in such situations the strength of the arguments is a matter of subjective judgment. The arguments tend to be somewhat weak as they involve a new interpretation or a new categorization, but they may be the only argument that the party in dispute maybe able to offer. Moreover, in the spirit of Wisdom (1944) cited above, we believe that if we have the opportunity to produce multiple arguments to support a conclusion, we should generate them all. Therefore at this point, we are merely interested in generating multiple arguments without comparing them or trying to decide which is the winning argument. We will discuss existing research on generating arguments and compare our work with it later in Section 5.

One problem with using some straightforward logical inference mechanism with an inconsistent knowledge-base is that anything can be derived from it. To avoid this pitfall has been, at least in part, the motivation for developing various systems of non-monotonic logics, such as those of Brewka (1991), Poole (1988) and Reiter (1980). While such elaborate systems may be useful to model the adversarial aspect of legal reasoning, we would like to demonstrate here that a rather simple control strategy known as *set-of-support* (Nilsson 1980, p. 167) works well in dealing with an inconsistent knowledge-base: It can be used to generate multiple arguments either for a conclusion or its negation; not every conclusion can be derived from it; and it identifies the relevant factors from the knowledge-base that are the key ingredients to the arguments (which one can try to strengthen creatively, if necessary.)

The organization of this paper is as follows. In the next section we introduce set-of-support control strategy and describe its characteristics with respect to inconsistent knowledge-base. Then, in Section 3, we present an example of a real legal case that involved various mutually inconsistent extra-legal factors. In Section 4, we present a formalization of this example and apply set-of-support control strategy to derive at least four different arguments — two each for the plaintiff and the defendant. In Section 5, we compare our approach with other related research. Finally, in Section 6, we present the main conclusions of this paper and make suggestions for further research.

2 Inconsistent knowledge-base and set-of-support control strategy

Set-of-support control strategy is designed as a way to improve the efficiency of a resolution-refutation theorem-prover. It dictates that while generating a refutation tree for proving a goal, at each step one must ensure that of the two clauses that are being resolved, at least one of them either comes from the negated goal, or is a descendant of the negated goal clauses. Formally, this can be defined as follows: Suppose *T* is a knowledge-base (in the clausal form) and let *g* be the goal. *Ng* is the set of clauses obtained by negating the goal ($\neg g$) and converting it into the clausal form. If φ and ψ are two clauses, then by *Res*(ϕ,ψ) we mean the set of clauses obtained by resolving φ and ψ. Now we can recursively define the nth-level set-of-support resolvents of *T* and *Ng*, namely *RS(T,Ng,n)*, and n-deep set-of-support resolution tree generated by *T* and *Ng*, namely *SS(T,Ng,n)*, as given below (for simplicity, we omit the parameters *T* and *Ng)*:

RS(0) = Ng; SS(0) = Ng T;
RS(n) = {Res(φ,ψ)|φ RS(n-1) and ψ SS(n-1)};
SS(n) = SS(n-1) RS(n).

If ε is the empty clause, and if for some n, ε SS(n), then we say that a set-of-support refutation exists for *Ng* in *T* or that *g* is ss-provable from *T*. In such situation, the *support set* for *g* in *T* is the set of ancestor clauses of ε. (If ξ Res(φ,ψ) then φ and ψ are parent clauses of ξ. The set of ancestor clauses of any clause ξ includes the parents of ξ, the parents of parents of ξ, the parents of parents of parents of ξ, etc.) If we include the parent relation among the clauses in the support-set, then the resulting structure is called the *refutation tree* for *g* in *T*.

It can be proven that the set-of-support control strategy is complete — meaning that whenever a refutation exists then a set-of-support refutation exists also. The intuition behind the proof is that any inconsistency must come from the negated goal *Ng*. But this tacitly assumes that the knowledge-base *T* is consistent.

If the knowledge-base *T* is allowed to be inconsistent, then the completeness of set-of-support strategy can no longer be guaranteed. Obviously, since *T* is inconsistent, a refutation tree exists within *T*. So, for any goal *g*, we can say that a refutation exists for *Ng* in *T*. However, it does not necessarily follow that a set-of-support refutation exists as well. As a trivial example, take *T* to be *{A,¬A}*, and *g* to be *B* (with B≠A) This has a simple refutation tree with *A* and ¬*A* as the two parents, but there is no set-of-support refutation tree, as ¬*B* unifies neither with *A* nor with ¬*A*.

This fact actually makes set-of-support quite useful for applying to inconsistent knowledge-bases. For most refutation trees, there are no set-of-support refutations, so such irrelevant arguments are not generated by set-of-support control strategy. In fact, one can say that only propositions that are *relevant to the goal* and that take into account various legal and extra-legal factors represented in the knowledge base can be derived from this strategy. Moreover, if the clauses in the knowledge-base are in a form that closely resembles the source of the knowledge (Bench-Capon and Coenen 1992), then it is relatively easy for a human user to see the structure of the argument from the refutation tree, as we will show with our example in the next section.

One can also derive the following result for set-of-support strategy applied to inconsistent knowledge-base which we state here without proof:
Lemma: The support-set for any *g* in *T* is always consistent (even if T is inconsistent). This makes our support-sets *justifications* in the sense of De Vey Mestdagh *et al.* (1991).

3 An example of indeterminacy and extra-legal factors

Law books and journals are full of cases where various extra-legal factors such as intentions of the legislators played a key role in the arguments of the lawyers and judges. The example we present here concerns a certain statute in the tax law of the USA: IRS Sections 280A(a) and 280A(c)(1). Section 280A(a) lays down a general rule:

> "Except as otherwise provided in this section, in the case of a taxpayer who is an individual or an S corporation, no deduction otherwise allowable under this chapter shall be allowed with respect to the use of a dwelling unit which is used by the taxpayer during the taxable year as a residence."

Section 280A(c)(1) provides one exception to this general rule:

> "Exception for certain business use: Subsection (a) shall not apply to any item to the extent such item is allocable to a portion of the dwelling unit which is exclusively used on a regular basis: (A) [as] the principal place of business for any trade or the business of the taxpayer, (B) as a place of business which is used by patients, clients or customers in meeting or dealing with the taxpayer in the normal course of business, or (C) in the case of a separate structure which is not attached to the dwelling unit in connection with the taxpayer's trade or business. In the case of an employee, the preceding sentence shall apply only if the exclusive use referred to in the preceding sentence is for the convenience of the employer."

Before presenting the facts of the case, a brief background would be helpful. This statute was part of the IRS reform act passed by Congress in 1976. Before this, Section 162(a) of the IRC (26 U.S.C. § 162(a)) allowed deductions for "all the ordinary and necessary expenses incurred during the taxable year in carrying on any trade or business…". After Section 280 was enacted, there were many test cases brought to the court that sought to clarify the meanings of such terms as "principal place of business", "convenience of the employer" etc. It is the first of these statutory predicate, abbreviated as PPB henceforth, that is of interest to us here.

Until about 1983, the courts used what they referred to as the *focal point test* to determine PPB. According to this test, the PPB for any business is the place where the focal point of the business activity is carried out. A number of cases exemplified the focal point test: For a teacher (professor), the focal point is the classroom; for a judge, it is courtroom; for an airline pilot, it is cockpit; and so on. Then in 1983, the appellate court overturned a tax-court decision to rule that for a concert musician, PPB is the rehearsal room at home. A few other cases followed in a similar vein: For a college professor, PPB is allowed to be the office at home where research is done (1984); for a Laundromat manager, PPB can be the home office where administrative work is done (1986); etc. The rule to determine PPB in these cases was referred to as the *facts-and-circumstances-test* in the legal opinions.

Against this background came the case of *Soliman v. C.I.R.* Soliman was an anesthesiologist who worked at three hospitals but was not provided an office at any of the three hospitals, and who sought tax deduction for maintaining a home office where he did administrative work. Soliman's case went through the tax courts (94 TC 20), appellate courts (935 F.2d 52 (4th Cir. 1991)), and the Supreme Court (113 S.Ct. 701) and generated nine judicial opinions in the process. On analyzing the various opinions delivered on this case, a number of extra-legal factors are easily discerned:

Intent of the Congress

I1: To alleviate administrative burden on the IRS.
I2: To prevent abuses of tax deduction.
I3: Is *not* to force taxpayer to rent outside office space.

Extra-Legal Factors

E1:Tax deductions are a matter of grace and not a right.
E2:Tax deductions ought to be fare.
E3:Tax deductions must not be abused.
E4:Self-employed taxpayers working from home should be encouraged.

4 Applying set-of-support strategy to Soliman case

In this section we formalize the example presented above and apply set-of-support strategy to generate multiple arguments for different conclusions. Though the Soliman case is rich in details, and there are many factors that must be included in a complete formalization, we present here only a partial formalization with enough details to generate four different arguments (two for each side). Also, in our formalization we have tried to stick very close to the legal opinions from which the legal knowledge was derived, thereby incorporating the isomorphism condition of Bench-Capon and Coenen (1992).

In presenting the formalization, we use the first-order logic supplemented by an "is-a" hierarchy represented as a partially ordered set of sorts. Words with lower-case letters denote constants, words with the upper-case first letter represent predicate symbols, and single upper-case letters are variables. When a variable is constrained to be of a certain sort, the sort name is written after the variable (following a colon).

Sort Hierarchy: (A ≤ B means A is a subconcept of B).
- soliman ≤ taxpayer ≤ person.
- anesthesiology ≤ physician ≤ profession ≤ business.
- su-hospital ≤ hospital ≤ place-of-business ≤ place.
- home-office ≤ place-of-business.

Facts:
- F1: Self-employed (soliman).
- F2: Business (soliman, anesthesiology).
- F3: Place-of-business (soliman, su-hospital).
- F4: Place-of business (soliman, home-office).
- F5: Spends-most-time (soliman, su-hospital).
- F6: Sees-clients (soliman, su-hospital).
- F7: Practices-profession (soliman, su-hospital).
- F8: Performs-administrative-functions (soliman, home-office).
- F9: ¬ Rents-outside-office (soliman).
- F0: ¬ Sees-clients (soliman, home-office).

Statutory Knowledge:
- S1: PPB (X: taxpayer, home-office) => Gets-tax-deduction (X).
- S2: ¬ PPB (X: taxpayer, home-office) => ¬ Gets-tax-deduction (X).
- S3: Rents-outside-office (X: taxpayer) => Gets-tax-deduction (X).

Legal Background Knowledge:
- LB1: Focal-point-test => [Business (X: taxpayer, physician) => PPB (X, Y: hospital)].
- LB2: ¬ Focal-point-test => Facts-and-circumstances-test.
- LB3: Facts-and-circumstances-test => Administrative-burden.

General Background Knowledge:
- GB1: Performs-administrative-functions (X: taxpayer, home-office) => Manages-business-from-home (X).
- GB2: Gets-tax-deduction (X: taxpayer) => Encouraged (X).
- GB3: ¬ Gets-tax-deduction (X: taxpayer) => ¬ Encouraged (X).
- GB4: Business (X: taxpayer, anesthesiology) => Business (X, physician).
- GB5: ¬ Rents-outside-office (X: taxpayer), ¬ Gets-tax-deduction (X) => Must-rent-outside-office.
- GB6: home-office ≠ su-hospital.

Intent of the Congress:
IC1: ¬ Administrative-burden.
IC2: ¬ Must-rent-outside-office.
Extra-legal Principles:
EL1: Self-employed (X: taxpayer), Manages-business-from-home (X) => Encouraged (X).
Linguistic Analysis:
LA1: PPB (X: taxpayer, Y: place), (Y ≠ Z: place) => ¬ PPB (X, Z).
General Undesirable Conclusions:
UC1: Practices-profession (X: taxpayer, Y: place), Sees-clients (X, Y), Spends-most-time (X, Y), ¬ PPB (X, Y).

In this formalization, two different arguments can be generated in *favor* of Soliman, shown in Figs. 1 and 2. The arguments are presented in the forms of refutation trees. Notice that each argument uses different extra-legal factors to prove the same conclusion. Moreover, both these arguments mirror portions of the actual legal opinions written by the judges while deciding this case.

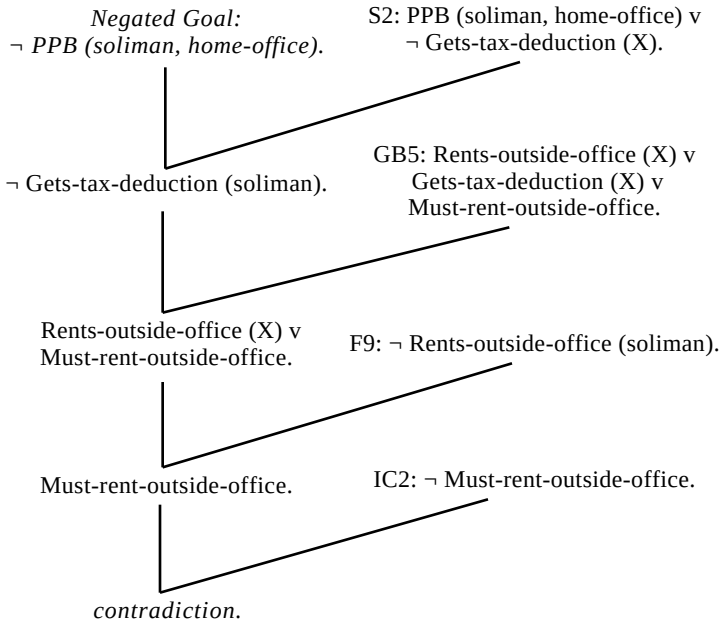

Figure 1: An argument in favor of Soliman

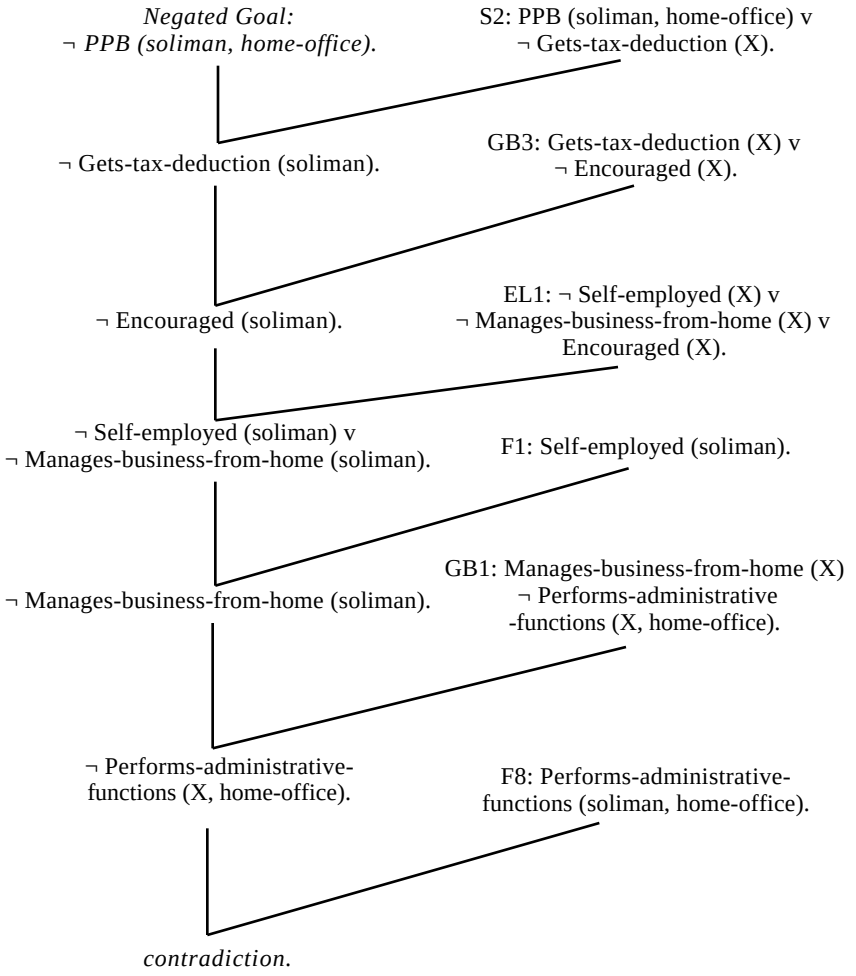

Figure 2: Another argument in favor of Soliman

In Figs. 3 and 4 we show two different arguments *against* Soliman that can be derived from the same formalization. Again, notice that they use different parts of extra-legal factors: different from each other and also, obviously, different from the arguments of Figs. 1 and 2. And again, the structures of these arguments reflect the actual judicial arguments used by the courts.

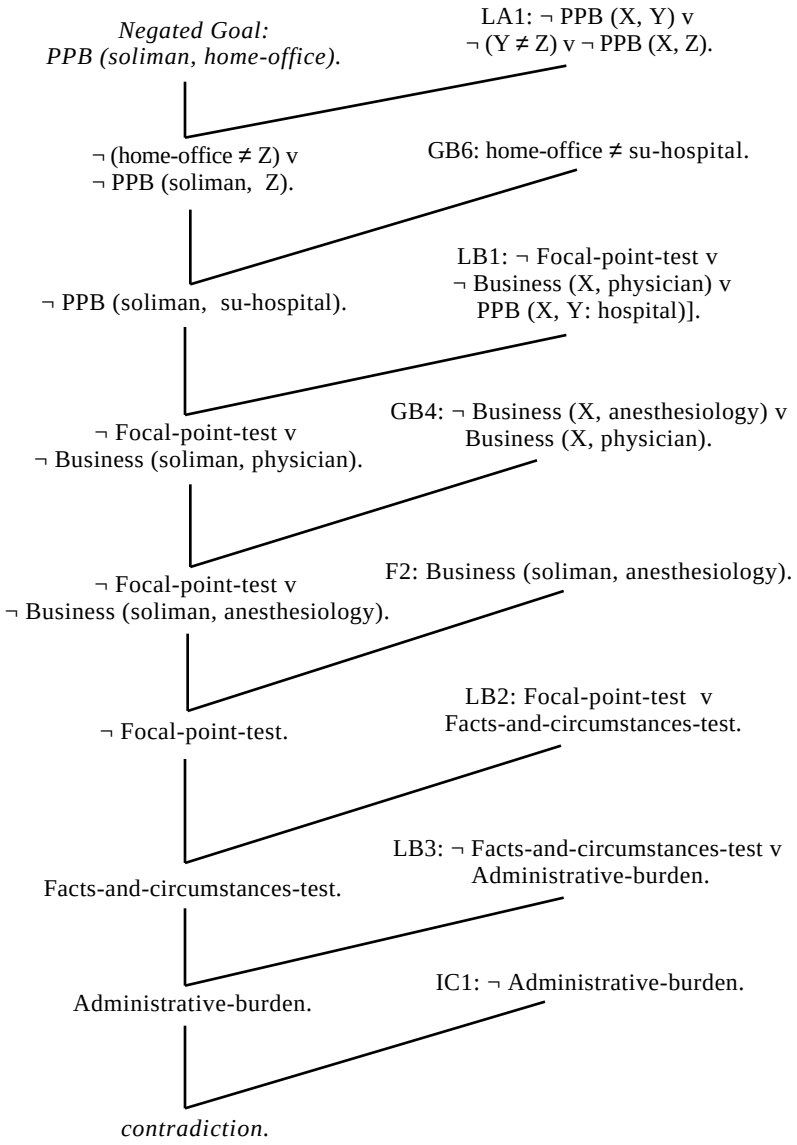

Figure 3: An argument against Soliman

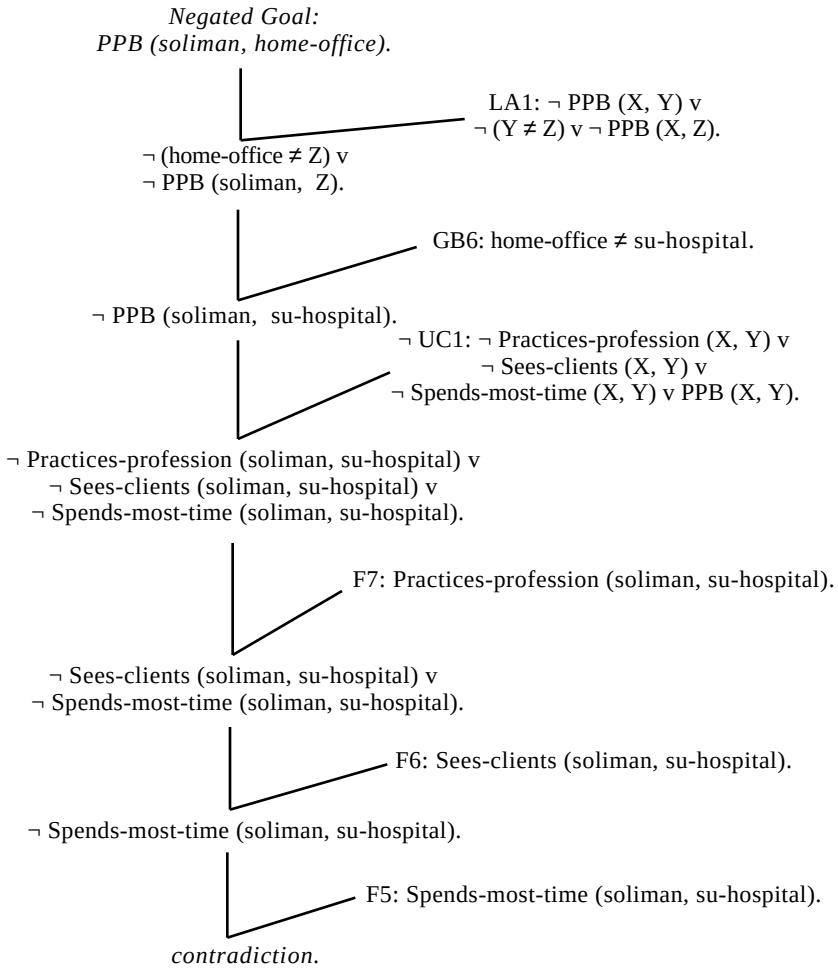

Figure 4: Another argument against Soliman

5 Comparison to related research

There are two existing research projects on generating arguments that are very close to ours in spirit. One is the logic of reasonable inferences proposed by De Vey Mestdagh *et al.* (1991), where the authors present a system for generating all possible arguments from an inconsistent knowledge-base. Their approach is based on finding all maximally consistent subsets of the knowledge-base, which are referred to as contexts. Their system is designed to guide the user to a certain appropriate conclusion, and to offer justification for it.

Obviously, our goal is somewhat different from that of De Vey Mestdagh *et al*. which accounts for the difference in our approaches. For us, it seems wasteful to try to find all possible arguments for reaching different conclusions, because in the system we are designing, the user already has a conclusion in mind, and wants to find out how to generate arguments supporting that conclusion. Moreover, we are interested in the

situation where even when there are much stronger arguments *against* the conclusion that the user wishes to reach, instead of steering the user towards this opposite conclusion, we would like our system to try to come up with some creative ways to strengthen the arguments for the conclusion. Of course, this creative aspect will be the subject of later research, but at this point we would like our system to come up with any argument(s) that it can for supporting a conclusion and to identify the relevant extra-legal factors involved.

The other project with which the research presented here shares a common ground is the dialectical reasoning system built at the University of Montreal in Canada (Poulin *et al.* 1993; St-Vincent *et al.* 1995). Their system architecture consists of an object-level and one or more meta-levels. The substantive legal knowledge is kept as rules at the object-level, which are allowed to be contradictory. The different interpretations of a statute, or different purposes ascribed to it are represented as different object-level rules. The meta-level rules use filtering mechanisms that allows them to choose between different object-level rules while constructing arguments. Their explicit control system allows the user to specify a goal and ask the system to generate arguments for or against it. The arguments are generated in the form of a proof tree.

This dialectical reasoning project comes closest to us in having the same goals, though our approaches are rather different. Our clausal form of representation and resolution-refutation inference mechanism is more general but much less efficient than the rule-based form used by St.-Vincent *et al.* (1995). But as our main interest was in modeling creativity, we were not so much concerned with efficiency considerations at this point in time, but we wanted to keep as much generality as possible. We should also add that we came to know of the dialectical reasoning project only recently, and in principle we can quite easily imagine a system like that being used as a front-end to our planned research on creativity in legal reasoning.

6 Conclusions and future research

In this article we have demonstrated how the set-of-support control strategy can be used to generate arguments from an inconsistent knowledge-base. This method restricts the kind of inferences that can be generated from an inconsistent knowledge-base so that only relevant inferences are generated. A system based on this method can select, from the various conflicting factors represented in the knowledge-base, those factors that are appropriate and helpful for supporting a conclusion and construct an argument for that conclusion.

As mentioned in the introduction, this is merely a preamble to our main research goal of being able to model the process of creativity that requires creating new categories or new interpretations. Once the outline of an argument is sketched and the appropriate legal factors have been identified, these factors can be used to provide top-down pressures to guide the search for new interpretations or new categories. For modeling this aspect, we would like to follow the approach of Rissland and Skalak (1991), except that whereas their system looked at the existing dimensions for analogizing or distinguishing, we would like to be able to create new dimensions or modify existing dimensions as guided by the top-down pressures. Ultimately, we would like the argument generating module and the interpretation module to interact with each other, each influencing the other, to model the real-life argumentation process, as described by Den Haan (1996, p. 19): "The argumentation and interpretation have an influence on one another: an interpretation may support a particular argument, and an argument may concern particular interpretations." As creating new interpretation (or creating new category) usually requires world knowledge, the approach of Den Haan (1996) which maintains a neat separation between world knowledge and normative knowledge is especially appealing to us.

In the long run, we would also be able to incorporate the reduction-graph model proposed by Branting (1993), where a sort-of "theory" of decision is attached to each precedent. We would like to demonstrate that certain aspects of creative reasoning result from using the theory of decision of one precedent to restructure the facts of another precedent, which may have a different theory attached to it.

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