The Importance of Nonmonotonicity for Legal Reasoning

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1. Introduction

Oblog-2 is a nonmonotonic knowledge representation and reasoning system designed for representing knowledge as general rules subject to separately expressed exceptions. Oblog was designed for representing legal domains, for use in legal "expert systems" for example, and its use of general rules and exceptions was influenced by the way laws are often represented in statutes. The Oblog system is described in considerable detail in [7] and [8]. Although these papers do mention reasons for the structuring of normative knowledge as general rules with exceptions, their emphasis is the technical description of the Oblog knowledge representation language and "inference engine". Here, I would like to concentrate on the question of why we have chosen not to use standard first-order predicate logic for representing legal norms in Oblog. In particular, the importance of nonmonotonic reasoning for legal knowledge representation and inference is discussed.[2] We also contribute to the ongoing debate on the relevance of logic for knowledge representation.

We begin with a brief definition of nonmonotonicity and then describe its relation to reasoning in the presence of incomplete or imperfect information. Nonmonotonic reasoning has become an active field of interest because of attempts within Artificial Intelligence (AI) to understand common sense reasoning. We argue that although legal reasoning is a kind of common sense reasoning, it has special requirements due to its normative and conflict resolution roles.

There is a continuing discussion within AI regarding the appropriateness of logic for various knowledge representation tasks. Surprisingly, perhaps, there does not seem to be a commonly accepted definition of "logic". Although many advocates of logic do indeed promote the use of standard first-order predicate logic, others are primarily criticising the failure of many system designers to give their knowledge representation language a precise semantics. lt is important to distinguish between logic and formal reasoning in general. The term "logic" has long been used to describe formal systems of reasoning which do not have the standard semantics of first-order predicate logic. Nonmonotonic logics are of this type. But such systems are logics only in a broad sense of the term. However broad a definition of logic one may find acceptable, for the purpose of representing the law so as to facilitate its normative goals, we argue that standard logic, at least, is not a suitable representational formalism.

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1. Many thanks to Christoph Lischka and Reinhard Linz for their helpful discussions on logic.

2. Another paper [6] also deals in a general way with the issues to be discussed here, but does not use the term "nonmonotonic reasoning" or mention the Artificial Intelligence literature on the subject.

2. Nonmonotonic Reasoning

Standard propositional and predicate logics are *monotonic*. That is, if a proposition is logically implied by some set of propositions, then it is also implied by every superset of the initial set.[3] Another way of describing monotonicity is to say that once something is determined to be true, it remains true. No additional information can cause conclusions to be modified or withdrawn. There is no way to presume something to be the case until there is information to the contrary. There are no rules of thumb, or general rules, which allow conclusions to be drawn which may be faulty, but are nonetheless better than indecision. Classical logic offers no theory about when to prefer one belief to another in general, and provides no language for stating which beliefs to prefer given that certain things are known in a particular case.

The subject matter of classical logic is truth, not decision making. The central concern of logic is *logical consequence*: which propositions are necessarily true given that other propositions are true. Monotonic logic is very useful when we want to know what must be the case *if* something else is known to be true. It is less useful when we know very little about some domain with certainty, or can discover the facts only by extending resources, if at all. Monotonic logic alone provides us with an infinite number of conditional statements of the form "this would be true if that is true", which is of little help in making decisions when we are unable to establish with certainty the truth or falsity of the alternative premises.

These limitations of classical logic have caused a number of AI researchers to believe it to be unsuitable for representing and reasoning about *common sense* knowledge. There have been a number approaches to the problem. Several proponents of logic have developed nonmonotonic logics [10, 11, 13, 14]. *Reason maintenance* researchers have designed machinery for keeping and using various kinds of information about how particular theorems are deduced, so as to allow the set of theorems to be continuously updated as the set of axioms change, e.g. [4]. Finally, others have developed knowledge representation formalisms, not based on standard logic, which include ways of expressing, e.g., defaults. "Frame" languages are of this type, e.g. [3, 5]. Oblog also fits into this latter category.

The various approaches to common sense reasoning are not necessarily incompatible with one another. They address different, but overlapping, aspects of the problem. Nonmonotonic logics aim to provide a rational basis for choosing one belief over another in those cases where classical logic would leave us undecided for want of adequate information. They do so, however, at the expense of the standard interpretation of "truth" and do not help us to decide which theorems to retract when axioms are deleted. Reason maintenance provides methods for keeping a consistent

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3. Monotonicity is principally a mathematical term used to describe functions on partial orders. A function, f: A $\Rightarrow$ B, is said to be monotonic if $\forall$ x, y. x $\supseteq$ y $\Rightarrow$ f(x) $\supseteq$ f(y), where x $\in$ A and f(x) $\in$ B. For standard logic, the function mapping a set of axioms into the set of propositions logically implied by the axioms has this property. We will be using the term "nonmonotonicity" in a much less technical way in this paper, however, to describe all approaches to the problem of reasoning with incomplete information and a changing set of beliefs.

set of theorems when axioms are added and deleted, and does not require nonstandard logic, but offers no help in deciding which default conclusions to make. Nonlogical languages for knowledge representation aim at providing tools which are intuitive and practical for supporting and actually doing common sense reasoning.

3. Why Nonmonotonicity for Legal Reasoning?

The need for nonmonotonicity in common sense reasoning arises from the lack of perfect information, or knowledge, about the state of the world. Classical logic does not take into account the pragmatic aspects of reasoning about problems in time, where for example it may be necessary to make a decision based on incomplete knowledge of the facts, only to discover at a later time that our assumptions had been incorrect.

Like common sense reasoning in general, legal reasoning takes place in time and is subject to the pragmatic limitations of incomplete information about the world, especially at the time decisions must be made. Legal reasoning, however, has particular features which distinguish it from the general case.

Restricting ourselves to civil cases, law has at least two purposes: the guidance of behavior according to legislated norms so as to avoid conflicts and provide the means for achieving goals which are deemed socially desirable (such as the creation of binding contracts), and the settlement of disputes after they have arisen (such as breach of contract).[4] The normative and conflict resolution roles of the law set it apart from common sense reasoning in general, where these aspects are usually not given explicit consideration.

The law must be represented in a way which admits and supports nonmonotonic inference to achieve these two goals, but for different reasons in each case. In order to promote the normative purpose of the law, persons who are not particularly knowledgeable of, or interested in, the law must be capable of learning and applying the law when planning their affairs. The settlement of civil disputes according to law, the second goal, is possible only to the extent that the legal system provides a means of resolving legal issues which is sensitive to the value of a decision to the parties involved. In the following sections we will explore these considerations in somewhat more detail.

4. To some extent the second purpose of the law is an admission that it is incapable of completely satisfying the first.

3.1. Normative Purpose of Law

The law is a normative system. One of its fundamental purposes is to guide the behavior of those persons who are subject to it. Criminal law, of course, aims at preventing certain acts. Other laws are intended to encourage behavior, as is the case with certain credits and deductions provided by tax laws. And other laws provide the means for achieving particular objectives, which usually involve the creation of a bundle of rights and obligations. Laws regulating contracts and marriage are of this type. This is all common sense, perhaps. But the achievement of these goals presupposes that ordinary persons are able to learn and apply the law with some success. Given the complexity of modern legal systems, systems which even lawyers have great difficulty in learning, it is reasonable to ask how we can fairly expect ordinary citizens to know the law. This difficulty is reduced significantly by the observation that no one needs to know all of the law, at least not all at once. The problem is finding a way of expressing the law which allows persons to quickly find that portion of the law which is relevant to the problem at hand. It should be possible to quickly acquire a rough sketch of some area of law, an overview, and to fill in the details of this sketch as the need arises. That is, the law should support various depths of understanding. A useful, if shallow, understanding of legal rules and principles should be easy to learn. This shallow knowledge should then be able to be deepened, on an incremental basis.

There are a number of techniques which can be used for the purpose of managing complexity in the law, but I will discuss just two, abstraction and general rules subject to exceptions, both of which have been traditionally used to draft legislation.[5] By using a procedure called, in computer science circles, "topdown refinement", laws can be described in terms of very highlevel concepts. These concepts can be given more precise, and perhaps technical, meaning at the next, lower, level of abstraction. Terms at that level can be refined still further at the next level, and so on. Thus, the same law can be described at various levels of detail. Users run the risk, when restricting their attention to some level of description, of misinterpreting the law. It may be, for example, that a term used at one level of description is defined in a technical, nonintuitive way at the next level: But this risk is more than balanced by the possibility of quickly getting a rough picture of the law.

Abstraction, however, is not enough. No matter how abstractly a rule is stated, standard logic requires the rule to state sufficient conditions for its conclusion. If intuitive terms are used at the most abstract level of description, then the logical structure of these conditions is in general much too complex to be quickly grasped and applied. Of course, any complex set of conditions can be represented abstractly by a single technical term or symbol, such as "A contract is valid if it is enforceable.",

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5. The problem of organizing large bodies of law is related to the problem of organizing large software systems. Techniques for data and procedure abstraction and for modular programming, are well-known [1]. Nonmonotonicity has also been used to control complexity in software systems, although I am not aware that it has been discussed in these terms. Object-oriented programming languages, for example, allow classes of objects to be associated with default behavior, which can be overridden in specialized classes.

where enforceability is a complex technical concept to be defined at lower levels, or worse "A contract is valid if the conditions of § 978 are satisfied", but such rules are not useful, because they define unknown complex concepts in terms of equally unknown and complex concepts.

A better approach is to use general rules subject to exceptions to supplement abstraction. It is just such systems of rules that nonmonotonic logic is intended to formalize. There may be a rule, for example, stating that contracts are valid, which is subject to an exception for contracts with minors, which in turn is subject to further exceptions. As with abstraction, this technique introduces a kind of risk, in this case that a relevant exception will be overlooked. But when laws are even slightly complex, this risk is outweighed by the advantage of being able to remember and apply general rules. Knowing a general rule is better than knowing none at all.

Implicit in our discussion so far is the conviction that a law must not only be understandable when we have the text of some statute in front of us, it must also be possible to remember the law. Persons must be able to make legal judgments and plan their affairs without having to consult their law books (or computers). When someone needs to decide whether and how long he has an obligation to remain at the scene of a traffic accident, for example, his only source of legal advice will be his recollection.

3.2. Economics of Deciding Cases

When the efforts of the law to guide behaviour break down and conflicts do arise, then we turn to the law to determine liability. In civil cases, at least, the parties involved decide, effectively, whether or not to bring their dispute to the courts. There is usually the possibility of settling the case out of court, and indeed most cases, I believe, do not proceed to judgment. Such settlements are not usually reached because one party finally acknowledges the validity of the legal argument made by his adversary, but because the parties have weighed the costs of pursuing the case further against the gains to be expected from a favourable judgment, taking into consideration the risk of an unfavorable judgment, and have determined that settlement is the least expensive alternative. Other factors do play a role here (we are not always as rational as economists would like us to be); but this is nonetheless a fair first approximation of the process.

Whether or not out of court settlements are socially desirable or not is irrelevant for our purposes here. The point is only that parties do take the costs of litigation into consideration, and that the courts will be used in some case only if procedures are available for reaching a decision which is sufficiently inexpensive.[6]

How does nonmonotonicity bear on the issue of the cost of reaching judicial decisions? General rules with exceptions are one way of dividing up burden of proof. The party interested in showing that some legal conclusion is satisfied need only show that the conditions of the general rule are satisfied. It is the burden of the opposing

6. The substantive law on some matter does play a role in deciding whether or not to settle, so it is not necessarily true that the law is ineffective when cases are not brought to the courts. But if it is difficult for the parties to estimate their rights under the relevant law, or even to determine which law is relevant, then the role of law here may be limited to a simple decision to ignore it.

party to show that one of the exceptions to the rule is applicable. If the opposing party does not care, or remember, to make an issue out of one of the exceptions, then the question is decided without having to consider the exceptions.

To show that some condition of a legal rule is satisfied, evidence must be discovered and introduced. Such "discovery" is a major expense of trials. It should be remembered that neither the courts nor the attorneys involved usually have first-hand information about the facts of the case. Everything needs to be discovered. By dividing up the burden of proof, with general rules and exceptions for example, the costs of discovery can be distributed among the parties. Each party can decide, based on whatever partial information is available, whether to make an issue out of some exception. By allowing certain "facts" to be assumed unless put at issue by an interested party, the costs of proving some issues can be avoided altogether.

Contrast this state of affairs with a legal system based on standard logic. Every possible "exception" would be made an issue. It may not be necessary to introduce evidence with respect to each issue, the parties may be permitted to agree to the facts, but every possible issue would at least have to be brought to the attention of the parties and the courts. No stone could be left unturned. It may be thought that, in the interest of justice, such thoroughness is necessary. Justice can be served, however, at lower cost. In a system with exceptions, the exceptions will be raised just in those cases where the parties are not willing to agree to the facts. And if the parties are willing to agree, then a system with exceptions permits them to do so implicitly without having to suffer the costs of a formal checklist. This analysis assumes that exceptions are well documented.

One final point might be made here. It deserves greater attention, but for the purposes of this paper, a comment will have to suffice. A fundamental aspect of legal controversies is that they must be decided. Subsidiary questions may be left open if alternative arguments for deciding the case are found which do not depend on their resolution; but the "top-level" issue of a case must be conclusively decided. In a criminal case, for example, a judge's duty is not satisfied by a judgment that the defendant is "guilty or not guilty". If important information about the case is lacking, standard logic and the substantive law alone may very well leave us in this state of indecision. Thus the law uses nonmonotonic reasoning to express a preference for one alternative or the other. How it is that law-making bodies decide, or should decide, to favor a particular judgment is an interesting and important topic in its own right.

4. Some Thoughts about Logic

Many AI knowledge representation languages, and Oblog is no exception, are ad hoc; they do not have a formal semantics. A continuing debate within the AI community concerns the suitability of standard logic, by which is usually meant first-order predicate logic, for knowledge representation [9, 12]. The main advantage of standard logic is that it has a well-known model theoretic semantics and proof theory. As we have argued, however, standard logic alone appears to be insufficient for decision-making in domains where there is incomplete information, such as law. Proponents of logic for knowledge representation may be primarily advocating greater rigor and the

use of formal methods. For example, in his "Defence of Logic" paper [9], Pat Hayes argues persuasively that standard logic has an advantage over ad hoc knowledge representation formalisms; but he explicitly acknowledges that nonstandard "logics" may be useful for reasoning in domains for which the notion of "world" used in the model theory of standard logic is "too simple". The nonmonotonic logics which have been proposed, such as McDermott and Doyle's Non-Monotonic Logic I [11], do have a fomal semantics. Such systems are logic, however, only in a broad sense of the term. A proper semantics alone is not enough to earn the title of "logic". Whatever the merits of our position about terminology here, standard logic, at least, is not be the most appropriate formalism for the task of representing and reasoning with norms.

4.1. Relation of Logic to Formal Systems

Sometimes arguments in favor of logic for knowledge representation are principally arguments in favor of a formal approach to knowledge representation, as opposed to the ad hoc approach so common in AI. Although standard logic does meet these demands for formality, there are arbitrarily many systems we can construct which are equally rigorous. It appears unlikely that there exists one system which is suitable for all knowledge representation tasks. In any event, as we have argued, standard logic is certainly not such a system.

Whatever the merits of formal methods, a logic itself can be an *informal* object. Theories of logical reasoning, that is theories concerned about which propositions are implied by other propositions, *solely by virtue of their form*, need not themselves be "formalized". We can *describe* a logic using formal mathematical methods, by constructing a suitable mathematical structure, but we need not do so in order to sensibly refer to it as a logic. There are less formal methods of description which are suitable for some purposes.

Logicians are apparently more careful that AI researchers when talking about a logic and a calculus for it; a logical *calculus* is a formal system for deriving theorems. A formal system has been defined only when we have specified a precise grammar for formulating sentences in some language, and inference rules for *deriving* sentences from other sentences. It is the calculus which is at issue, for example, when such topics as *correctness and completeness* are being addressed. That is, issues such as correctness only makes sense in the context of a particular semantics for the formal system.

4.2. Is Nonmonotonic "Logic" Logic?

We have been careful in this paper to speak of nonmonotonic reasoning rather than nonmonotonic logic when discussing approaches to the problem of common sense reasoning in general. But is it useful to classify non-monotonic "logics", such as McDermott and Doyle's "Non-monotonic Logic I" [11], as logics? Just as there seems to be no accepted definition of "artificial intelligence" there also seems to be no consensus about what is, or is not, "logic".

Logic should not be identified with formal systems for doing logic, as discussed above. What are the core properties an object should have before we can sensibly

refer to it as a logic? R.C.Moore defines logic as "a language ... with either a formal inference system or a formal semantics (or both)." [12]. This definition is quite loose and misleading. Logic is not a language but a set of *concepts* concerning such matters as truth and implication. These concepts can only be described or defined, however precisely, in language, of course. An arbitrary formal "inference system", if by this we mean transformation rules for generating expressions from other expressions in some language, need not have a particular relationship to logic. The lambda calculus, for example, is a formal system, but not a logic. Moreover, a language can be given a formal semantics without being, or becoming, a logic.[7] The programming language Scheme, for example, has been given a formal denotational semantics, but Scheme is not a logic.

One might want to insist that a theory be concerned with the concepts of *truth* and *entailment* or *consequence*, as is the case for predicate logic, the prototypical modern logic, before it may be called a logic.[8] There can be alternate or exotic conceptions of these ideas, but the theory must be an earnest attempt to deal with these subjects. Nonmonotonic "logic", however, does not appear to be principally concerned with truth and entailment, but rather such matters as belief and decision-making.[9] In Non-monotonic Logic I, for example, McDermott and Doyle's definition of "truth" makes reference to provability. Rather than straining the meaning of truth in this way, would it not have been clearer to define the semantics directly in terms of belief?

As for Oblog, in its informal semantics, rules do not have truth values, unlike statements or formulas in a logic. For example, an Oblog rule to the effect that contracts are valid, with another rule for the exception that contracts with minors are not valid, is neither true nor false. It does not state that all contracts are valid, which would be false, but rather that an agreement satisfying the formal requirements of contracts is presumed to be valid. If we were to give Oblog a formal semantics, we might begin by constructing a mathematical structure to describe such concepts as presumption more precisely, and then define the various constructs of the Oblog language, such as rules, in terms of the components of this structure.

Clearly, a great number of systems in philosophy and AI are called logics which do not fit the narrow definition given here. It is not necessary to quibble over terminology, so long as writers are clear about which sense of a term is intended.

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7. The term "language" has a technical sense in logic, meaning a particular set of predicate and function symbols. Here we are using "language" in the sense of programming languages and knowledge representation languages.

8. More precisely, we might define logic as a structure of three components <P,i,|=> where P is the domain of propositions, i is an interpretation function of type $P \rightarrow B$ (where B is the domain of truth values), and |= is a relation defining entailment or consequence and is of the type $2^P \rightarrow 2^P$ (where 2^P is the power set of P). The entailment relation, |=, defines which propositions are true by virtue of the form of some set of propositions assumed as axioms. This relation must be *truth preserving*. Propositional logic and predicate logic are instances of this structure. The domain of truth values has been left unspecified to allow for nonstandard logics such as multivalued logics.

9. It may be that a theory of nonmonotonic reasoning will include, as a subcomponent, a theory of truth and necessity.

4.3. Logic vs. Knowledge Representation

Even if we assume that, for some application field, formalization is a promising route, it does not follow that the formalization should use a logical language. An obvious example of this is arithmetic. If ever there was a formal system which has gained wide use and acceptance it is arithmetic. But when we add two and two, we are not doing logic. The expression 2+2 does not represent a proposition, i.e. it is not true or false. The rules of arithmetic allow us to replace this expression by the symbol 4, which directly represents our solution, the number four.[10]

Logic can be used to represent formal theories about common sense reasoning, as McCarthy has done with his theory of circumscription.[11] There is an important difference between constructing an adequate theory about common sense reasoning and designing a formalism in which to do common sense reasoning, as we have tried to do with Oblog. A theory about common sense reasoning, however formal and adequate it may be for the purpose of explaining common sense reasoning, may not be suitable as a language for expressing and using common sense knowledge.

The use of general rules with exceptions to express norms mixes declarative and *control* aspects of knowledge, contrary to recommendations of the proponents of logic for knowledge representation. But the mixing of control and declarative information can be desirable when thc purpose of the representation is not a precise specification of knowledge, but rather the charting of an approach to solving a particular class of problems using the knowledge. When we are representing the law, it is more important to find a representation that makes the law useable for planning and the resolution of conflicts, as discussed above, than it is to make the logical structure of the law transparent.

These issues are well illustrated by Layman Allen's work on the "normalization" of statutes [2]. Allen has long argued that statutes contain unnecessary and undesirable "structural ambiguity" which can be eliminated by expressing the law in a modified form of propositional logic. An important ambiguity is the intended meaning of words such as "unless" or "except". Although "normalization", as proposed by Allen lessens, if not eliminates, this structural ambiguity, it does so at the expense of more important goals, such as keeping general rules from being buried beneath the detail of secondary exceptions. Rather than translating uses of "unless" into propositional logic, what is required is an adequate (formal) knowledge representation language, with a well-defined semantics, which preserves the advantages of general rules with separate exceptions for reasoning with incomplete information.

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10. This problem can be, of course, easily represented in a predicate logic language with equality. But we don't usually do arithmetic this way for the simple reason that it would be more cumbersorne to do so.

11. McCarthy, however, uses second-order predicate logic to formalize circumscription, not "standard" logic.

5. Conclusion

"Oblog" is an acronym for "object-oriented logic". It is no longer, however, either object-oriented or logic. Why Oblog is not an object-oriented language will have to be left for another day. Here we've focussed on the issue of the appropriateness of logic, at least standard logic, for representing legal norms. At the beginning of our work in expert systems in law, we were excited about the prospects of using logic as a knowledge representation language, particularly because of the success of Prolog. The idea had been to represent some area of law as a set of Horn clauses, just as this has now been done by a number of research teams. The Imperial College formalization of the British Nationality Act is probably the most familiar of these efforts [15]. But it was soon clear that the legal texts we had wanted to represent with Horn clauses were stated, for the most part, as general rules with textually separate exceptions. The conviction that we were attempting to use a representational tool, standard logic, for a domain for which it was never intended, developed as we tried to collapse hierarchies of general rules into a flat collection of Horn clauses. It seemed natural to try to find a knowledge representation language which admitted and supported this structure. The nonmonotonic logics we were familiar with do not support rule hierarchies in the manner we envisioned. Lacking adequate theoretical support, we decided nonetheless to build an expert system shell for legal applications, however ad hoc, which directly supports rule hierarchies similar to those used in legislation.

A working prototype implementation of Oblog now exists. For the most part the system does seem to capture our intuitions about reasoning with general rules and exceptions. But the idea needs to be elaborated; a formal model theoretic semantics for partially ordered rules would be an interesting task to attempt.

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