Ontology and Epistemology in Legal Knowledge Engineering

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Abstract

For optimum use in legal knowledge engineering, legal ontologies have to be understood in relation to legal epistemologies. The relationship between legal ontology and legal epistemology is examined in the light of the requirement for epistemological adequacy posed by McCarthy and Hayes and specified by Reichgelt, and in the light of epistemological soundness achieved in the eGanges project by using a meta-epistemological methodology in which legal ontology is located; eGanges is a new generation smart, user-friendly expert system shell that is cost-effective. Some of the legal ontology of the United Nations Convention on Contracts for the International Sale of Goods, known as the Vienna Convention, is shown governed by the epistemology of eGanges, to demonstrate the relationship between legal ontology and legal epistemology. When ontology and epistemology are used in relation to each other as legal knowledge engineering methodology, the technology brings new clarity to redefine these major metaphysical concepts.

Keywords: abductive legal reasoning, computational domain epistemology, deductive legal reasoning, epistemological adequacy, generic legal reasoning, inductive legal reasoning, interactive visualisation, interface, legal epistemology, legal logic, navigation, legal ontology, rule maps, transparency, user-friendliness.

Introduction

The relationship between legal ontologies and legal epistemologies determines how each may be used in legal knowledge engineering methodology. The technology clarifies the relationship so that legal metaphysics may be redefined for optimum use in the design and construction of legal expert systems. This can be demonstrated by reference to the criteria for epistemological adequacy posed by Reichgelt and development of the eGanges shell with an application of it in the field of international conventions.

It is assumed that ontology and epistemology constitute the study of metaphysics.

Ontology is concerned with what exists; what exists can be known. Thus knowledge may presuppose existence (Everson, 1990). Epistemology is concerned with how what exists is known, how what might exist is known, and how what will exist is known. Known existences, potential existences and future existences in law are matters of legal epistemology; it is the existences that are known in law that are matters of legal ontology.

Perspective Knots

The three perspectives for determination of the scope of ontology and epistemology in legal knowledge engineering can be summarized as follows:

1. Perspective of Law as social epistemology; law is the means of effecting social organization. Social organization itself may be studied ontologically; one way in which it is achieved is through law.
2. Perspective within law: the law has epistemological plans that include social ontologies. When social ontologies are set as legal concepts by way of social epistemology, they become legal ontologies.
3. Perspective of program design and construction: the way of designing and constructing software is a matter of software epistemology. Software epistemology must take account of perspectives 1 and 2.

The two Greek words that make up epistemology are *episteme*, meaning knowledge, and *logos* meaning plan; epistemology is the plan of knowledge. Similarly, ontology is the plan of existence, methodology is the plan of method, and software technology is the plan of the art or craft of programming. Thus, epistemology is the plan of knowledge of the plan of existence: the epistemological plan includes the existential plan, as well as the plans of hypotheses, that is, the plans of what might and what will exist.

Within the framework of these perspectives, intelligent software must represent the domain epistemological plan, and a methodological plan can ensure that this happens. There is an overlap or connection of epistemology, technology and methodology. Methodology and technology may be regarded as applied epistemology.

Accordingly, a legal ontology is the plan of existences in law; a legal epistemology is a plan of legal knowledge of a plan of existences in law, as well as other plans of legal hypotheses. Applied legal epistemology includes legal method and the art of legal reasoning or legal processing. Theoretical and applied legal epistemology must accommodate legal ontology; a legal expert system must be designed accordingly to be sound.

Epistemological adequacy and ontology

McCarthy and Hayes (1969) explicitly recognized the requirement of epistemological adequacy in the construction of artificial intelligence; they saw knowledge representation (KR) as the focus of epistemology. In relation to KR, Reichgelt (1991, pp10-11), set out four criteria for epistemological adequacy:

1. Natural organization of domain information e.g. the use of rules in law.
2. Modular representation to facilitate change of knowledge. For example, if all the information is buried in program code, the whole program would have to be changed; non-modularity is not epistemologically adequate.
3. Suitable granularity for storage of fine facts or conceptual chunks as required and permitted by the domain.
4. Actual primitives in a KR language must allow for appropriate choice of domain concepts. For example, a framework which insisted that HAS-PART be a conceptual primitive may not be epistemologically adequate for a domain.

These four criteria confirm that an intelligent program is epistemologically adequate if it suits domain epistemology that accommodates domain ontology. Reichgelt was concerned to evaluate KR languages that were popular at the time. He listed six types of KR languages, each characterized by its major epistemological feature, as follows:

1. Logic
2. Production rules: most popular for expert systems where expert digressions from logic may be accommodated in rule system
3. Semantic networks
4. Frames and frame-based object-oriented programming
5. Parallel distributed processing, connectionism or neural networks
6. Combinations of any of the above

KR languages provide some epistemological assumptions and some flexibility to add further expert epistemology not otherwise assumed. However, following the work of McCarthy and Hayes, in many domains, such as law, the expertise was difficult to acquire adequately in order to specify further epistemological refinements that were necessary for epistemological adequacy. The Feigenbaum bottleneck prevented rapid ascendency of expert systems technology for the remainder of the twentieth century. The KR languages *per se* were not epistemologically adequate for the legal domain; they had evolved from limited generic intelligence rather than expert epistemology.

Ontological solution

In the 1990s, ontology was resorted to in legal knowledge engineering as a possible

solution to the Feigenbaum bottleneck. It was thought that if the ontology, the plan of existences of the law could be determined, this would be the solution to the problem of acquiring expert knowledge in order to automate it. It was not thought that legal ontologies would provide epistemological refinements. However, as legal ontologies in substantive law were studied, they revealed knowledge structures for knowledge processing that did not readily suit existing KR languages or shells (Gray, 1988). Epistemological refinements were required as a matter of expert knowledge acquisition, in order to process a legal ontology.

Ontology in the legal domain

In the legal domain, the concept of ontology is useful because it distinguishes what exists that can be established by evidence as facts, from what is a socio-legal construct or legal concept that is a material fact. In law, some facts also may be treated as material facts, that is, as if they were socio-legal constructs. Antecedents and their consequent in a rule of law are generally material facts. The nicest concepts in law are socio-legal constructs: agreement (contract), trust, ownership, good faith, duty of care, legal tender, marriage, guardianship, right and justice. There are also socio-legal constructs that spell trouble: *mens rea*, breach (of contract, of trust, of duty), negligence, false pretences, larceny, defamation, trespass, debt, liability, penalty, and fine. Further, there are socio-legal concepts that carry uncertainty, a tenuous predicament: lessee, will, negotiable instrument, holder in due course, conversion, bailment, bail, remand, jury, and bond.

Lawyers negotiate the definitions of socio-legal constructs in relation to real situations, so that they can be detached from circumstances where it would be unjust to attach them. New situations that bring new factual additions, may require modifications to the definitional significance of facts. The detachment of facts from definitions of material facts is sometimes achieved by lawyers in the management of relevant evidence.

In a sense, socio-legal constructs exist; they are acted on as if they exist. They may be as real as the human mind itself. In the legal domain they are treated as such, be they verified ontologies or not. A legal system is itself a socio-legal construct. However, socio-legal constructs need not exist or be acted on; they are a matter of choice and informed choice is a process that concerns epistemology. Law determines when a socio-legal construct exists or does not exist, and what the law enforcement powers will choose to do about it. Subjects with knowledge of the law may make informed decisions to behave in a certain way, accordingly. In the legal domain, subjects rather than agents are of primary concern.

Certain existences must be established by evidence in order to prove a material fact. The law of evidence is an extensive area of law that largely conforms to empirical standards. Evidence is a term of law and the rules of evidence are a legal epistemology.

For the purposes of legal knowledge engineering, legal ontology may determine the distinction between facts and material facts; facts are established by evidence and material facts are established by facts. In the course of this ontological investigation, knowledge structures and knowledge processing structures may become apparent, whereby arrangements of facts constitute material facts and arrangements of material facts in knowledge processable structures allow informed choice and enforcement (Gray, 1988); these are epistemological structures.

The optimum use of ontology in legal knowledge engineering is in the determination of semantic strings and chunks, as identified by Reichgelt, for processing purposes. In doing this, a knowledge of generic theoretical and applied legal epistemology is useful to ensure there is a match in the plan of legal existences and the plan of legal knowledge. The line between existences and socio-legal constructs may be indicated in a legal expert system as a matter for legal argument. The ontological distinction serves the epistemology of legal argument.

Ontology and epistemological adequacy

Once ontology is used to identify the units of legal information for a legal expert system, the question then becomes: how does this ensure epistemological adequacy? As observed, sometimes the ontological existences reveal certain regularities common to the ontologies of various fields of substantive law. These common structures and processes indicate the realm of generic epistemology that could be the basis for a user-friendly shell rather than a technical KR language. This can be verified in a more direct study of legal epistemology, beginning with Reichgelt's first criteria of rules as normative to the legal domain. Rules of law are epistemological structures that are concerned with what might exist and what will exist; their antecedents and consequents may be based on what has existed or what does exist. In logic, rules are formalized in generic, epistemological regularity as conditional propositions. A rule program is epistemologically adequate if it suits the domain ontology on which antecedents and consequents in rules of law, are based.

How is epistemological adequacy achieved in the legal domain?

In the legal domain, the epistemological plan suits the ontological plan of law. However, there are eight different inter-related epistemologies that are used in the legal domain. These are as follows:

Profession and authority – how power to make and administer law is

distributed

Rules of law – how an expert opinion or judgment is determined
Cases – how precedent cases are given effect in the formulation of expert opinion or judgment
Evidence – how findings of fact are determined (See Wigmore, 1913, 1931 and 1937.)
Litigation – how court orders are obtained
Commercial practice – how benefits of law are obtained
Legal strategies – how gains are maximized and losses are minimized through law
Justice – how justice is achieved in the legal system

Further, as law itself is a social epistemology, when we come to lay out legal ontologies in substantive law, what is disclosed is the epistemology of social organisation. The epistemologies of the legal domain are derived from what lawyers do to give effect to social epistemologies contained in substantive law. Legal ontology is nested in social epistemology which in turn is nested in legal epistemologies, namely the eight types above.

There may be some variations of these epistemologies according to individual expert diversity; individual variations may occur also in the determination of legal ontologies.

When Reichgelt's four criteria are applied to the system of legal epistemologies, it can be seen that his concern is more with program epistemology than with domain epistemology. However, if we employ Reichgelt's first criteria in representing the legal epistemology of rules of law, then the full extent of this legal epistemology can be discovered so that the optimum use of ontology is confirmed. With the exposure of full rule epistemology and the consequent place of ontology, it is then appropriate to consider which of the knowledge representation languages and techniques, if any, is best suited to the requirements of the rule epistemology, so that it can represent the legal ontology of the substantive fields concerned.

Meta-epistemological method

To ensure not just epistemological adequacy, but thorough and sound epistemological requirements of a legal expert system, the totality of legal domain epistemology may be transformed from stage to stage in the process of developing a legal expert system. This is the meta-epistemological method (Gray, 2004). It was used in the development of eGanges (Gray and Gray, 2003), which is a new generation, cost-effective, user-friendly expert system shell with interactive visualisation, suited to the legal domain.

In the eGanges Project, the process which transformed acquired domain epistemology and ontology into a generic shell and applications that are not just epistemologically adequate but thoroughly epistemologically sound and appropriate for legal ontology and social epistemology, five stages of meta-epistemological method were used, as follows:

1. Determination of domain epistemologies
2. Specification of generic computational domain epistemology
3. Design of shell epistemology
4. Determination of shell programming epistemology
5. Determination of application ontology and social epistemology

In the course of proceeding through these five stages, there was some retroduction (Peirce, 1931, p.28),) For instance, in developing the shell epistemology, the generic computational epistemology was adapted to further requirements of the eight-fold domain epistemology in regard to the communication system of the interface. Each of the eight-fold domain epistemologies was not precisely specified until it became necessary to do so in the course of the subsequent stages.

Computational domain epistemology

The specification of the computational domain epistemology was approached by Reichgelt's first criteria in representing the legal epistemology of rules of law. In unravelling rule epistemology in the legal domain, it is possible to uncover objects of generic legal knowledge representation that are suitable for object-oriented programming of a refined domain legal logic. These objects are also suitable for satisfying the requirements of other legal epistemologies that are related to the rule epistemology in the system of legal epistemologies.

The approach by Reichgelt's first criteria in representing the legal epistemology of rules of law, produced the computational epistemology of 3d legal logic (Gray, 1988, 1990, 1995, 1997, 2002, 2004. See also Samuel, 2003, Conover,1988, Rourke, 1986, and Terrell, 1984) which contains objects in the form of generic knowledge structures and generic knowledge processing structures with their generic meta-rules for processing that can be used as generic inferencing strategies. This made it possible to use object-oriented programming to produce the shell. eGanges is a Java object-oriented program with the visualisation of legal logic objects as a major feature of its interface. (Gray and Gray, 2003).

The generic computational domain epistemology was established by pursuing the structure of the natural organization of legal domain information i.e. rules of law, in different areas of substantive law. The user-unfriendly algebraic formalism of conditional proposition was transformed into a geometric formalism, namely lines joining nodes with

a flow arrow, that were called rivers. Rather than trees in a forest where one can become lost in unfathomable density, the rules were streamlined so that the flow maintained orientation to direction. River formalisms revealed that there were overlaps of antecedents and consequents in rule systems, and these overlaps could be locked together as a more complex tributary structure. Law could be treated as a collection of river systems (cf. Vaihinger, H., 1911, 1965). The common paradigm of a system of rules that was established, is set out in Figure 1.

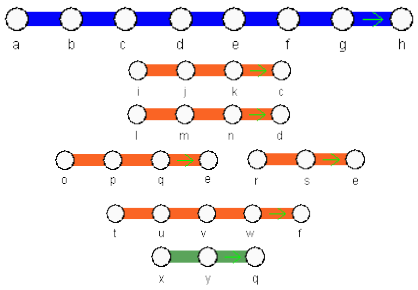

Figure 1: Wholly formalised rule streams

When these rules are locked together at points of overlap, the result is a tributary structure or river system that is like an Ishikawa fishbone (Ishikawa, 1985); this is shown in Figure 2. The tributary structure is an epistemological structure because it represents the scheme of rules. It is also a logic structure because it represents the rules as premises that can be used in an extended deductive legal argument. Finally, it is a knowledge processing structure insofar as its arrows of flow indicate the available paths of necessary and sufficient conditions that can be established in order to establish interim consequents and the Final consequent. A knowledge of this generic epistemology can facilitate the ontological specification of the semantic units that will replace the letters of the alphabet in the construction of an application in a substantive field of law.

As will be shown in the Vienna Convention application, the semantic unit may not always be ontological; it may be a unit of information from one of the other eight legal sub-epistemologies. Ontologies alone do not determine the static epistemological structures of relationships between separate existences, such as conjunction and disjunction; nor do they capture the processing of these relationships in accordance with the flow of antecedence and consequence and the holistic meta-rules that recognize overlaps and manage the cumulative effect of matching actual existences, their contradictories and uncertainties, to the substantive detail of the epistemological

structures in their temporal and contemporaneous constraints.

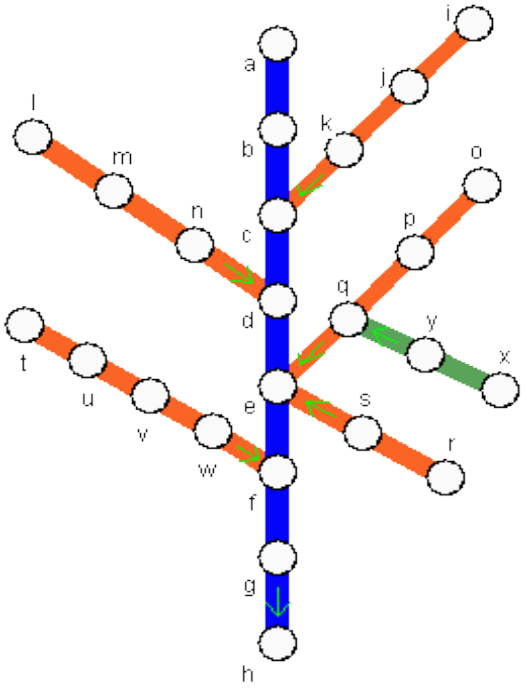

Figure 2: eGanges river map

Ontology governed by generic computational domain epistemology

Figure 3 shows the initial legal ontology of the United Nations Convention on Contracts for the International Sale of Goods, known as the Vienna Convention, represented as a tributary structure in the Rivers window of the eGanges interface.

The legal ontology in the initial map reveals the social epistemology of enforcing a net remedy where there is a breach of a contract for the international sale of goods. It is a social epistemology because it is a method of achieving social organisation. It is to be noted that the nodes that provide for Net remedy are derived from litigation epistemology, rather than the Vienna Convention itself. Further details of the legal ontology and its inherent social epistemology are set out in Figure 4 which is the sub-map (indicated by the soccerball node) of the node Concluded contract in Figure 3. Figures 3 and 4 demonstrate an epistemologically governed ontology.

The rules of law in the Vienna Convention are an extensive system of premises that can be used in an extended deductive argument when the user's situation input establishes which antecedents in the rules apply in the user's case. eGanges deals with negation and uncertainty of the antecedents in the river maps through its three Case windows, where the input premises available in the user's situation are listed according to the labels of the

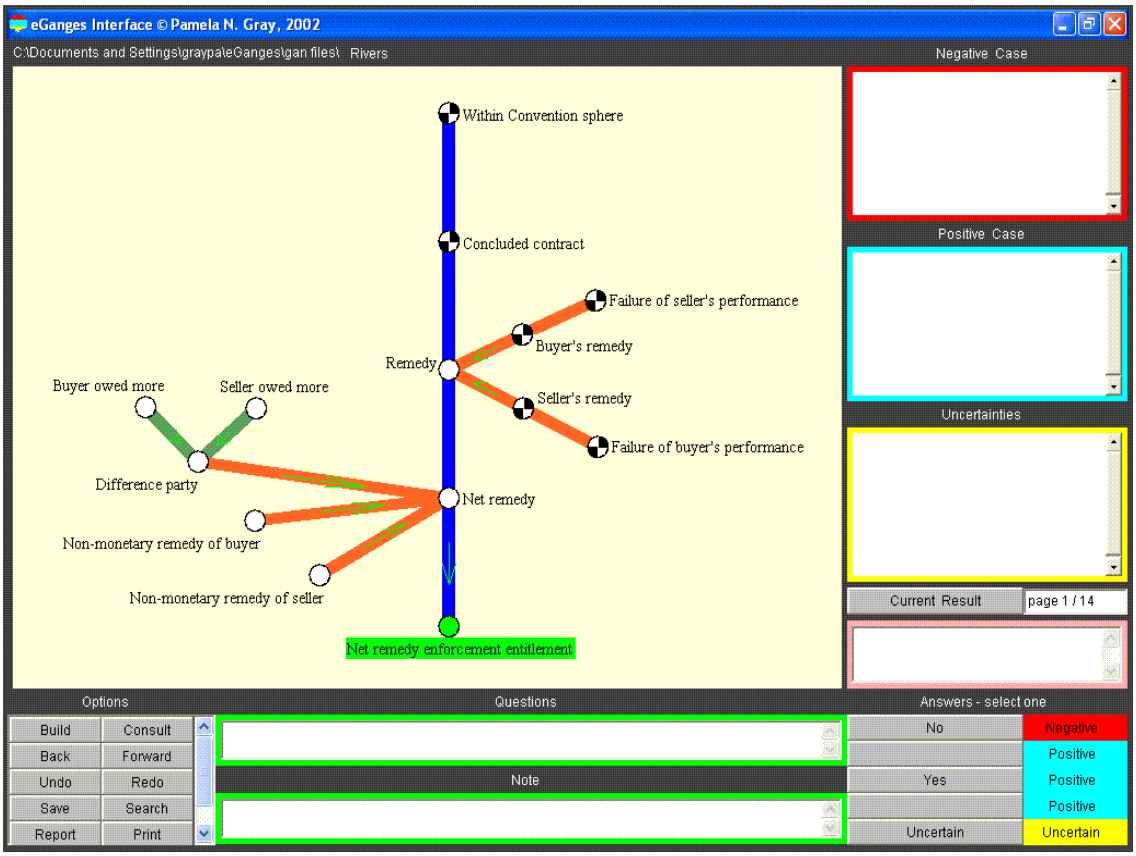

Figure 3: Initial map of the Vienna Convention

five available answer buttons. The epistemological phenomenon of neutral antecedents, that is, antecedents that are inconsequential to the Final result, are managed by the provision of three positive answer buttons that can be used instead of a set of one positive, one negative and one uncertain answers. A processing strategy is used in the sorting of answers, to accommodate Boolean alternatives in the sets of overlapping necessary and sufficient conditions; until all rules in a Boolean 'or' fan of rivers fail, negative answers will be shown as (Neg) in the Positive case window. Similar meta-rules govern the inferencing strategy that handles uncertainties.

Sometimes antecedents are stated in a way that must be converted to a contradictory for inclusion in a river with a certain Final result. This is particularly problematic in determining legal ontologies without an understanding of legal epistemologies. The diversion to failure of the Final result may occur at any point along the river because of the rule that all antecedents on the river must be established in order to reach the Final result, except where there is a Boolean 'or' indicating alternatives.

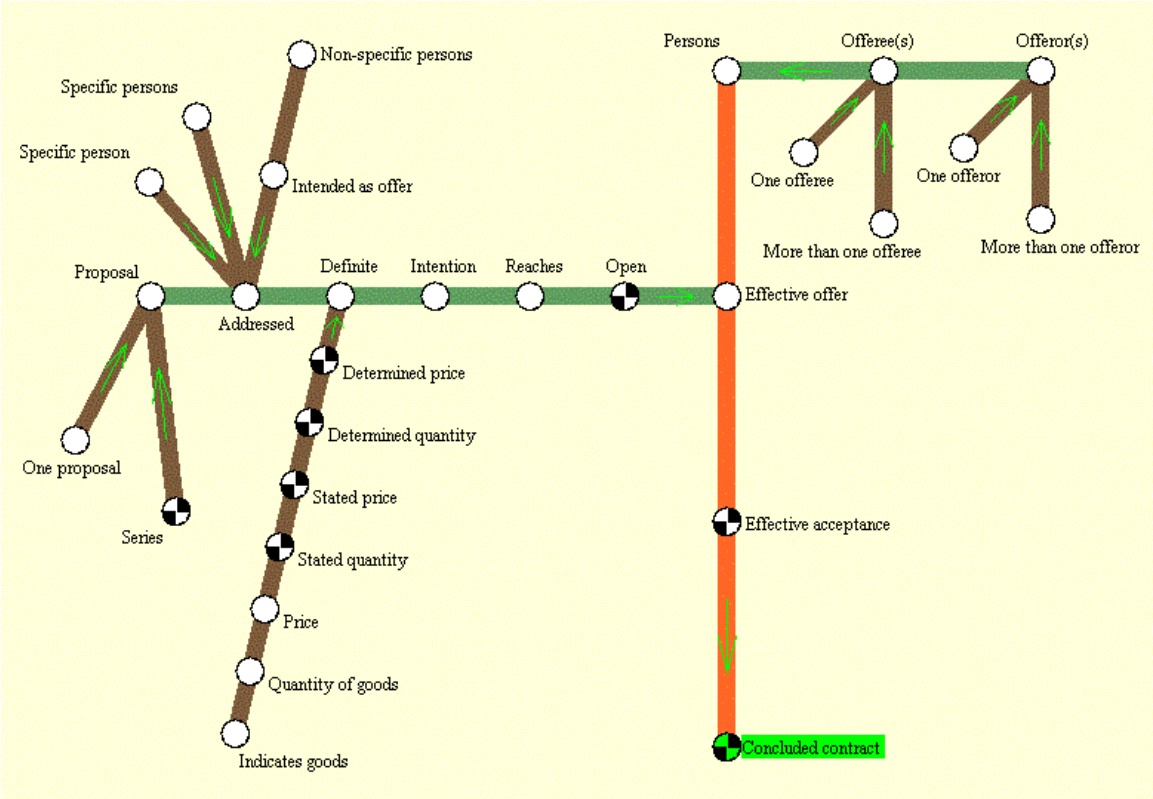

Figure 4: Concluded contract submap - Vienna Convention

The Boolean 'or' rules share a common consequent and appear in the river map as a fan of rivers. Fans produce a major characterization of law as a system of premises for
of rivers. Fans produce a major characterization of law as a system of premises for
extended deductive argument: a system of rules of law consists of overlapping alternative sets of necessary and sufficient conditions that establish the Final result.

The potential for combinatorial explosion is controlled by the epistemology of pole rules, that is, rules each of which share their one antecedent with an antecedent on the

contradictory tributary structure and share their common consequent that is a Final negative result; a similar combinatorial explosion control is provided for uncertain antecedents. Meta-rules manage the prioritization of negative and uncertain accumulation in fan processing and Final result processing.

Conclusion

Epistemological adequacy is concerned with making provision for strings and chunks of semantic information determined by the ontology of substantive law. The eGanges shell that encapsulates sound generic legal epistemology, makes provision for strings and chunks of semantic information as required by the domain but also guides in the location of these chunks and strings in relation to each other in knowledge processing structures that are subject to inferencing strategies; this is crucial where the ontological information falls short of indicating the processing structures and inferencing strategies. eGanges also provides for natural language used in questions to establish the ontology of the user's case, by allowing natural answers to be given appropriate epistemological significance. Sound epistemological matching of legal ontologies in substantive law and the user ontologies of the question and answer logic is thus provided. Ontology provides some epistemological information; however, a sound epistemology ensures the correct location and use of ontological information in the complete construction of a legal expert system.

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