A Map-Based Expert-Friendly Shell

Pamela N.Gray* Xenogene Gray†
*School of Law University of Western Sydney, Parramatta Campus
Parramatta, NSW, Australia
pgray@csu.edu.au
†Grays Knowledge Engineering
Telopea, NSW 2117, Australia
xen@grayske.com

Abstract. eGanges is a map-based, expert-friendly legal expert system shell that allows construction of nested rule or procedure maps, with various glosses of nodes in the maps. Gloss options include links between nodes in the same map and between parallel maps. The shell has facilities to navigate and interrogate maps, as well as functionality in processing interrogation input. A sample of the Vienna Convention is used to illustrate features of an application of the shell.

1 Introduction

A map-based, expert-friendly, legal expert system shell, eGanges (electronic glossed adversarial nested graphical expert system), has a design that is based on a template of rule-oriented or procedure-oriented expertise or intelligence. The template is derived from the jurisprudential model of 3d legal logic [1 - 4]. The theory of 3d legal logic reifies legal logic so that it is suited to object-oriented programming, interactive visualisation of legal logic, and concrete learning. eGanges is an object-oriented Java program.

Although the theory of 3d legal logic was developed as legal knowledge engineering methodology, its jurisprudential model is theoretically independent of computer technology: in its electronic or non-electronic form, it may be useful for understanding, schematising, teaching and managing rule-oriented or procedure-oriented domains. The reification requires notional three dimensional space, but it has permitted eGanges to be designed with simpler, navigable two dimensional graphics. The eGanges interface further simplifies the reification.

Knowledge engineering design graphics, in eGanges, are ostensibly part of the expert system itself. This provides transparency. Navigable River maps with eGanges functionality, permit users to see the precise nature and extent of the expert knowledge, while at the same time seeing exactly how this knowledge is applied to a particular case. The construction and consultation interface is shown in Graphic 1.

2 Construction Task

In order to build a legal expert system using eGanges, a legal knowledge engineer must construct logic graphics in the form of rule or procedure maps in the River window and Questions in the Question window and answers on the Answer buttons. The builder may also detail glosses through the gloss menu or in the Note window. The Build button in the Options menu allows the user to develop: (1) nested tributaries of River rule/procedure maps, (2) questions

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and glosses that pertain to antecedents or procedural points on the rivers, (3) possible answers to the questions, and (4) notes that pertain to the questions.

In constructing an eGanges application, there must be adherence to the jurisprudential model of 3d legal logic. First, the final consequent of a field of rules must be specified. For instance, a final consequent of the rules of United Nations Convention on Contracts for the International Sale of Goods (known as the Vienna Convention) might be 'enforcement entitlement', as in the River window in Graphic 1. The main rule that establishes this final consequent may then be drawn.

Rules are represented in a map by a method of standardisation and then interlocking at identified points of overlap. Standardisation of rules requires the formalisation of each rule as a conditional proposition, i.e. as 'if (antecedent(s)) then (consequent)' statements. Following standardisation, where an antecedent in one rule is the same as the consequent in another rule, or more than one rule has the same consequent or antecedent, there is a point of overlap that identifies how the rules may be locked together. In Graphic 1, 'Net remedy' is both an antecedent in the main rule and the consequent of three secondary rules that particularise buyer and seller remedies respectively. These secondary rules are not mutually exclusive alternatives. Some alternatives are. Graphically, the locking together forms a tributary structure.

Rule maps use nodes to represent antecedents and consequents, or procedural points. The antecedent nodes in a rule are joined by lines that indicate a conjunction relationship between them. Where an antecedent or consequent in one rule is identical to an antecedent or consequent in another rule, one node is used to represent both, as a node where the rules intersect. Every node label must be unique. A good design will keep the label short.

The flow from antecedent(s) to consequent is represented by a directional arrow, as in a logical relationship or a flowchart, giving to the tributary structure, the attribute of a river. No matter how extensive and complex the tributary system, the direction of flow always aids its navigation. Where an antecedent in one rule is a consequent in a second rule, then the flow downstream in that second rule joins the flow downstream in the first rule. Similarly, procedural sequences may be standardised and locked together at overlapping points.

Where several rules share the same consequent, they form a fan of alternative ways of establishing the consequent, as a more complex confluence. The fan captures single or multiple disjunctions, with one or multiple Vs. There may be one or more antecedents in a fan river. If there is more than one, like non-fan rivers, they are connected by 'and' links.

When an antecedent in one rule is identical to the consequent in a second rule, then the second rule effectively defines the antecedent in the first rule. A tributary rule map is hierarchical. Prima facie, what is upstream defines what is downstream. However, this is not always in the sense of general concepts being downstream and particular concepts being upstream toward the watershed. Granularity of the antecedents may be irregular, so that one rule stream may contain general concepts in some of its antecedent nodes as well as particular concepts in some of its other antecedent nodes. The exercise of lawmaking power determines not only the antecedents and consequents of the rules but also the relationships between them, their definitions, and the spread of abstract and concrete terms in the rules.

However, the more upstreams there are for an antecedent, the more particularised is that area of expertise. A rule map may be developed as an hierarchical structure with a primary or main stream, from whose antecedents defining secondary streams may arise; any secondary rule flows into a mainstream antecedent. From the antecedents of such secondary streams, defining tertiary streams may arise, and so on up into the fine detail of the watershed of the system. In eGanges, colour-coding of the hierarchy aid navigation.

In common law, the rules run out at the far reaches of antecedents, the material facts. Beyond that, the facts of precedent cases are examples of how material facts are established.

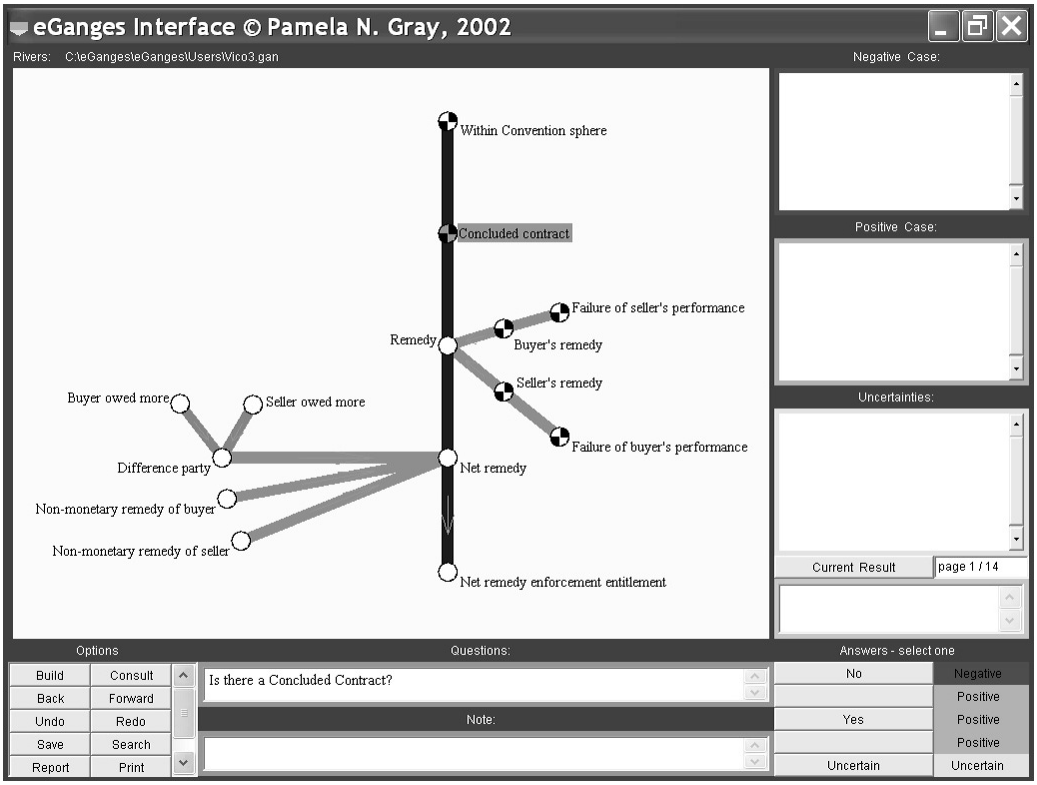

Figure 1:

Examples may be incorporated into the river system with an appropriate text gloss indicating that they are examples only in a fan or spectrum of possibilities. A fan of examples may include a fan to cover unspecified examples, for future specification.

The consequent of the main stream is the final consequent or result of the system. Just as backward and forward chaining indicate the direction of reasoning for a knowledge or decision tree, so a river system may be navigated upstream or downstream. However, rule logic or river procedure logic always flows downstream. All rules or procedural sequences flow directly or indirectly to the final result.

The rules could be represented as an and/or tree, but the river structure is a truer representation of interlocking rules; it also distinguishes the ‘and’ and the ‘or’ aspects of rule logic by different structures. The ‘and’ structure better facilitates labelling of nodes.

If a river system, such as the Vienna Convention, is too vast and complex for the whole of it to be viewed at once, then the solution is to nest the rivers. The Rivers window in Graphic 2 contains a rule map that represents streamlining of some of Part II of the Vienna Convention; it deals with the formation of a contract. This rule map in Graphic 2 is nested, like a sub-system, in the antecedent ‘Concluded contract’ in Graphic 1. Soccer ball nodes indicate a nested sub-map. In the nested map, an antecedent becomes a consequent. Nesting navigation may proceed as a two way system, through many levels of nesting, as a kind of metamorphosis, from an antecedent to its transformed state as a consequent, and back from consequent to antecedent. The deeper the nesting, the higher the streams.

Sometimes a field of expertise is a composite of many rules, and various strands have to be separated for the purposes of building an application. Any implied rules must also be expressly stated to complete the system of rules. Question/Answer processes apply the rules to a user’s situation. Rule maps [1] provide a check list for ensuring all necessary and sufficient antecedents have been presented; they are a basis for identifying where there are alternative ways of establishing an antecedent or a consequent. They are also a basis for

identifying antecedents that are in issue. Comprehensive extended legal arguments, and their sequence for linear presentation, may also be designed from the framework of rule maps.

3 Map Processing - Functionality

A system of adversarial heuristics applies to rule maps. These adversarial heuristics determine the processing of user input in relation to the Questions and Answers associated with the rule maps. In eGanges, the adversarial system is accessible through:

- 3d lists
- question and answer logic and
- current result.

3.1 3d Lists

In an adversarial field, there are two corresponding rivers that represent (1) the positive set of rules that supports the positive case, and (2) the negative set of rules that supports the negative case. This is adversarial correspondence. In a procedural domain, a positive procedure leads to a procedurally positive result and a negative procedure leads to a procedurally negative result.

A simple example of adversarial correspondence (as distinct from conventional logic) that applies in the legal domain, is: if a then b (jurisprudential positive) and if not-a then not-b (jurisprudential negative). Put simply, if there is an agreement then there is a valid contract and if there is no agreement then there is no valid contract. These are adversarial propositions that are both true law by virtue of the lawmaking authority that has pronounced them so, expressly or impliedly.

Legal experts and authorities may state a rule expressly in its adversarially positive or negative form. Whatever is stated expressly in its positive form can be restated in its corresponding negative form. In all the positive and negative rules, if there is more than one antecedent, then the antecedents are linked by ‘and’ connections. Procedural points are similarly linked by ‘and’, to indicate proceeding downstream.

However, some antecedents are neutral. This is represented by the simple example: if c then d and if not-c then d. Usually, neutral nodes are all positive; there is no corresponding adversarial negative rule. Neutral nodes can be represented as a set of single antecedent positive rules in a fan with a common positive consequent. For example, in contract law, an enquiry by the offeree as to the meaning of an offer, is a neutral antecedent. Whether or not such an inquiry has been made, or is uncertain to have been made, the parties are still on foot with the ultimate positive result that there is a valid contract. This is the reason why eGanges has five possible answer buttons: one negative, three positive and one uncertain.

A positive case only wins if all positive antecedents or procedural points in the positive river system are established. There may be inconclusive negative antecedents in a positive case as these may be matters of unnecessary fan alternatives. If there is a positive fan, then all of its streams must fail before the negative consequent arises. A positive rule with conjunctions has a corresponding negative fan of disjunctions. A negative rule with conjunctions has a corresponding positive fan of disjunctions.

Subject to the constraints of any fans that provide the positive case with alternatives, if any negative antecedent is established, then there is a partially negative but conclusive result. Thus, all the antecedent elements of a concluded contract must be present in a particular case

to establish a concluded contract; if one or more of these antecedents is missing, a concluded contract can not be shown.

Every negative antecedent has two possible consequents Severally, the negative antecedents have a common partially negative but conclusive result that can be represented in a pole fan; jointly they have a wholly negative result. If all negative antecedents are established in a particular case, then there is a wholly negative final result. This is illustrated in Graphic 3. A set of negative rules is identified by its pole characteristic. If either the wholly or partially negative case is established, then the negative case wins. The strength of a negative case can be shown by the number of negative antecedents that have been established.

In practice, a user's case, may be hindered by uncertainties. Thus, to complete the model, there is a third set of rules that corresponds in structure to the positive and negative rivers, namely, the uncertain river system. Uncertain antecedents, like negative antecedents, also have two possible consequents, that can be represented in a river that corresponds with the positive river and in a pole fan, respectively. If all uncertain antecedents are established, then there is a wholly uncertain case. However, subject to fan alternatives, if any uncertain antecedent is established, then there is a partially uncertain case. It is possible to show the uncertainty strength in a case by the number of established uncertain antecedents.

In the legal domain, uncertainties are included in settlement advice that might resolve a conflict. For both the positive and negative cases, uncertainties are risks of losing. They are more likely to support the negative case, because the positive case usually carries the burden of proof. For the positive case to win in a civil court action, subject to any fan constraints, every uncertainty must be proved to be positive on the balance of probabilities. In a criminal case, usually the prosecution must prove that every uncertain antecedent is, beyond a reasonable doubt, actually a positive antecedent. As long as the party with the negative case can keep an antecedent uncertain when the standard of proof is applied, the uncertainty will

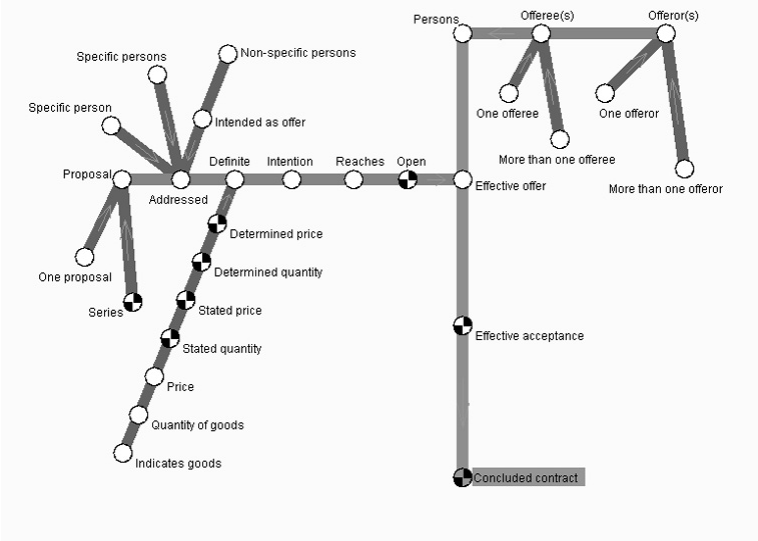

Figure 2:

prevent the positive case from winning, even though no negative antecedent has been established. The party with the negative case wins by virtue of the uncertainties that are not found to be positives.

As illustrated in Graphic 3, notional three dimensional space is required for the symbolic sphere that contains the full adversarial structure of rules. Triad links are used to show the corresponding negative, positive and uncertain antecedents in the negative, positive and uncertain tributary structures; the spectral connection or continuum of the three antecedents is

also represented by the triad link. For example, the negative sector of a triad may have ‘no offer’, the positive sector may have ‘offer’ and the uncertain sector may have ‘quasi-offer’.

The notional north pole represents a partially negative but conclusive result and the notional south pole represents a partially uncertain result. Pole streams connect negative antecedents to their common consequent or negative pole result, and uncertain antecedents to their common consequent, the uncertain pole result. Typically, pole rules have only one antecedent which is also an antecedent in the tributary structure that has a wholly negative or wholly uncertain final result.

In Graphic 3, two presuppositions of the system of rules, are connected by a boundary ring: (1) there is an initial triad, consisting of three alternative antecedents, that is the start of the system and (2) there are five possible end results in the sphere of rules, namely:

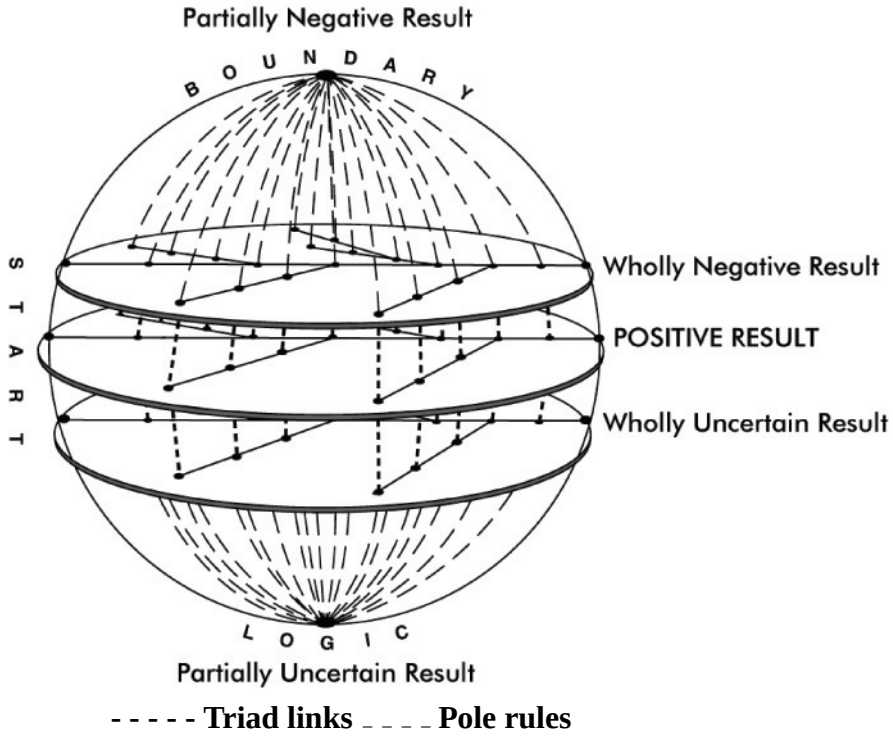

Figure 3: Sphere of river logic

The sphere of rivers confines the combinatorial explosion of possible cases. The positive river system is placed in the central position, as it has no pole streams. It may be larger than the negative and uncertain river systems if it has neutral antecedents.

In eGanges, three dimensional graphics are not used; they are thought to be too complicated for navigation. Instead, there are three windows: Negative case window, Positive case window and Uncertainties window, each of which will list appropriately antecedents that are established in a user’s case. A two dimensional rule map in the eGanges Rivers window indicates the paths for establishing a final outcome of a user’s case; the river to be constructed by the builder of an eGanges application, is effectively the positive river. However this two dimensional river map works *in tandem* with the Case and Uncertainties lists to implement the full system of adversarial rules.

3.2 Question and Answer Logic

In a consultation, a left click of the mouse on an antecedent node in the Rivers window produces, in the question window, a question that can be answered by the user. The eGanges de-

sign distinguishes factual negation from adversarial negative. The answer buttons are aligned to show which factual answer will support which adversarial case: positive, negative, or uncertain. After the user selects an answer, by a left click on the requisite answer button, the antecedent label is listed appropriately, in the Negative Case window, the Positive Case window or the Uncertainties window. These lists indicate the second premises in an extended set of *modus ponens* arguments, where the first premise is the relevant rule.

Once antecedents are established for the user's case, interim and final conclusions, by way of deduction, are available as the current result. At any time during a consultation, the user can see how many points there are, if any, for each adversary or side, and how many uncertainties there are.

Usually, there will be three alternative answers, each positioned appropriately by the application builder, on the negative, positive, and uncertain buttons: yes, no and uncertain. In accordance with the rules of law, sometimes a yes answer will support the positive case, and sometimes it will support the negative case. Likewise, a no answer may sometimes be adversarially positive or negative. To avoid an uncertain answer, the Note window, may have an advice from the builder to answer further questions upstream to clarify the situation; otherwise an uncertain answer produces a node label in the uncertainties list. If a node is neutral, all three alternative answers, yes, no and uncertain, will support the positive case and will appear on the three positive answer buttons.

The order in which antecedents are placed in a rule is sometimes determined by the sense required for questions. A temporal sequence may be required. For instance, an offer comes before its acceptance. A question, "Has the offer been accepted?", presupposes that there has been a question answered positively: "Was an offer made?" If a negative answer has been given to the effect that no offer has been made, so that the current result is immediately a conclusive negative, then, from this time on, questions will assume that no negative antecedent has been established. Further questions may assume that there is an offer even though input has established otherwise. A user may wish to proceed in this way in order to ascertain how strong the negative or uncertain case is.

The label on an antecedent node in the Rivers window is the label that appears in a list following the selection of an answer. The labels are appropriate to the positive case. For example, in a contract application, the label 'Offer' in the negative list, means that there is no offer; in the positive list it means that there is an offer.

For a contract node label, 'No rejection', meaning no rejection of an offer, a direct question will take the negative perspective: Has the offer been rejected? The negative answer is yes and if this answer is given, then the label 'No rejection' will appear in the Negative case window. However, this means that there is a double negative: there is not no rejection, meaning there is rejection. When the user requests a Report on the consultation, then the Report will print beside the label 'No rejection', the question that was asked and the answer that was given.

A user may change an answer that has been given, by selecting the node label from the positive, negative or uncertainties lists. A left mouse click on the requisite node, produces in the Rivers window the rule map that contains that node, and the node question in the Question window with the alternative answers to it on the answer buttons. The selection acts as a back button, so that the lists are also navigation aids that permit the user to reconsider or change an answer. A different answer may then be selected and the list windows will be adjusted accordingly. To move an antecedent from one case window to another, the answer must be changed appropriately.

3.3 Current Result

The Current result button permits the user to obtain confirmation of the current result during the consultation of an application, as follows:

1. If there is a negative antecedent in the Negative case window, then the current result is negative.
2. If there is an uncertain antecedent in the Uncertainties window, and no negative antecedent in the Negative case window, then the current result is uncertain.
3. Until all the necessary and sufficient positive antecedents are established for the positive result, a current result can not be positive. However, the current result may be tenuously positive, with the interim result of 'unanswered'.

If the user does not use the current result button, then the current result is available by understanding the significance of the Case and Uncertainties entries. Negative antecedents or points in the Negative case list produce a conclusive result that overrides uncertainty. Inconclusive fan negatives and uncertainties remain in the Positive Case window until there is a sufficient accumulation of them to activate a pole rule. Then they shift to the appropriate Negative Case or Uncertainties window.

4 Glosses

Glosses or commentary may be added by the builder in two ways: (1) as strata logic or (2) as question notes

A right click of the mouse on an antecedent or procedural node in a river map will permit the user to build or consult glosses associated with that node. Questions may also be glossed through the Note window.

4.1 Strata logic

It is possible to build three types of expert system: (1) rule or procedure systems which apply only rules and/or procedures, (2) expanded rule and/or procedure systems that include inferences from the rules or procedures, (3) critical expanded rule and/or procedure systems that include inferences from the rules or procedures, and further critical information about the rules and/or procedures and/or any inferences from them. In any of these systems, various commentary may be relevant as strata logic. eGanges gloss facilities allow the builder to add strata of commentary about an antecedent node. Available gloss types are:

Text: this information might contain the natural language definition of the selected node's label, the natural language statement of the rule or procedure in which the node is located, and authorities for the definitions and rule statement. Inconsistencies, alternative definitions and statements, critical comment, or reform views, might be included.

Spectrum: the spectral continuum of negative-positive-uncertain triads may set out information about the content of each sector. A triad spectrum may range from negative to positive to uncertain, to reflect the adversarial structure, or it may range from positive to uncertain to negative, to reflect a gradation of quantity or quality. Gradation may clarify adversarial sectors and the location of gaps in the law. For instance a rule that provides for a minimum quantity, such as one peppercorn places 1-n peppercorns in the positive

sector, zero peppercorns in the negative sector and anything between zero and 1 in the uncertain sector. Continuity of a spectrum may be the basis for legal argument.

Inter-node links: sometimes there is a relationship between triads that are on different rivers in the same river system. For instance, in law, the triads of misrepresentation and mistake could be glossed and linked as a double spectrum so that fine distinctions between sectors can be clarified.

Parallel river links: there may be rearrangements of river systems to suit different perspectives or purposes of users. For instance, rivers of contractual strategy may be created from the rules of contract law. A gloss link may be created to permit a consideration of other reconstrued or relevant river systems as a parallel logic.

File links: a gloss link to another file or program may be created. For instance, in tax law, mathematical calculations may be required; at the relevant node, a link to a calculation program might be provided.

Thus related information may be included in an application at a precise point of relevance. The uncertain sector of a spectrum gloss may show possibilities discussed in obiter dicta, or as a matter of speculation based on meaning, common knowledge, empirical observation or hypothesis. Extended legal arguments may have elements of gloss arguments about what the rules mean, why they are rules or what the rules ought to be. Gloss content may be interwoven into the presentation of arguments. Thus gloss information is available for understanding the law, appreciating the nature of a question and its possible answers, and formulating heterostatic argument for judicial or political development of the rule system.

4.2 Question Notes

The Note window may be used in two ways: (1) it may provide output such as advice about questions or the best order for answers, or (2) it allows users to enter data, such as evidence detailing proof of an antecedent.

5 Consult

The Consult button enables the user to consult an application by (1) navigating the nested River tributaries, (2) accessing the glosses, questions and notes, (3) providing input by selecting from the available answers and receiving feedback, following the input, in the Negative Case, Positive Case, Uncertainties and Current Result windows and (4) providing input in the Note window for the purpose of recording the user's evidence or other information for the consultation report. A Report of the consultation lists the antecedent labels that have been recorded in the positive, negative and uncertainties windows together with their questions, the user's answers, Note advice, Note data input, unanswered nodes, and current result. A person consulting an application may be precluded from accessing the build menu, while a builder may be precluded from accessing a particular consultation.

6 Conclusion

The shell is suitable for short or protracted sessions of application construction, maintenance or consultation; applications may be useful pro tem. eGanges satisfies the design criteria

recommended by Meister [5]: its interface is simple, easy to learn and concrete. Yet the ostensible simplicity of eGanges, can capture the three dimensionality of extensive and complex rule-oriented and procedure-oriented expertise. The preparation of a nested map presupposes a science of legal choice.

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