eGanges: computational legal pedagogy

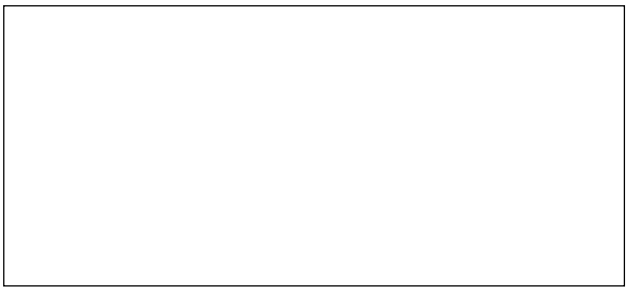
Pamela N. Gray
Law Lecturer,
Faculty of Commerce,
Charles Sturt University,
Bathurst, NSW 2795, AUSTRALIA
Tel: +61 2 6338 4278
Email: pgray@csu.edu.au

Xenogene Gray
Computational Physicist
Grays Knowledge Engineering
Sydney, NSW 2795, Australia
www.grayske.com
Tel: +61 2 9872 2557
Email: xen@grayske.com

ABSTRACT
Students are more clearly instructed on legal method and substantive law if they are taught a generic legal epistemology that has the precision necessary for automation. eGanges was designed on the basis of a generic computational legal epistemology as a new generation user-friendly shell offering interactive visualisation with game characteristics. It permits faster, more efficient learning, suitable for hand-held devices such as PDAs and mobile phones. Applications of the shell could be used by students, legal professionals or the general public. The scientific precision of the epistemology permits learning of legal method as well as substantive fields of law.

Categories and Subject Descriptors
D.1.5 [**Object-oriented Programming**]
D.1.6 [**Logic Programming**]
D.1.7 [**Visual Programming**]
D.2.2 [**Design Tools and Techniques**]: Flow charts, User interfaces
D.2.6 [**Programming Environments**]: Graphical environments, Interactive environments
D.3.2 [**Language Classifications**]: Very high-level languages (eGanges)
H.5.2 [**User Interfaces**]: Graphical user interfaces (GUI), Natural language, Standardization
I.2.1 [**Applications and Expert Systems**]: Law, Natural language interfaces, Office automation
I.2.4 [**Knowledge Representation Formalisms and Methods**]: Representations (procedural and rule-based)
I.2.5 [**Programming Languages and Software**]: Expert system tools and techniques
I.2.6 [**Learning**]: Concept learning, Knowledge acquisition
I.2.7 [**Natural Language Processing**]: Discourse

General Terms
Management, Documentation, Performance, Designn, Standardization, Languages, Theory, Legal Aspect



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, rule maps, transparency, user-friendliness.

1. INTRODUCTION

Computational legal epistemology is a new pedagogy for teaching the law, and programs that implement it are dynamic aids for teaching the computational pedagogy. Computation takes epistemology [1] into the realms of pedagogy. eGanges (**e**lectronic **G**lossed **a**dversarial **n**ested **g**raphical **e**xpert **s**ystem) was designed in 2002 as a user-friendly legal expert system shell, based on the computational epistemology of 3d legal logic [2][3][4][5] (See also [6][7][8][9]). In the design of eGanges, this epistemology was adapted to suit fast, efficient, learning and management of extensive, complex systems of legal logic that are implicit in the law. The interactive visualisation and object-oriented programming of eGanges employ the logic objects (cf. [10]), of the epistemology of 3d legal logic.

2. COMPUTATIONAL EPISTEMOLOGY

McCarthy and Hayes [11], pioneers of artificial intelligence, explicitly acknowledged that epistemological adequacy was required for intelligent programs; they saw knowledge representation as the focus of epistemological adequacy. A thoroughly sound generic legal epistemology is provided in the design of the eGanges shell. This generic epistemology has the following three features:

(1) Knowledge structures
(2) Knowledge processing structures
(3) Functionality

Rather than algebraic formulae, the knowledge structures are geometric maps of systems of rules, procedures or strategies, called river maps; these maps are like Ishikawa fishbone diagrams [12] that were developed in Japan for quality control management. (See also [13]). River maps are extrapolated from the spherical logic objects of the epistemology of 3d legal logic, as cognitively optimal for interactive visualization. The maps may be nested as a series of sub-maps if they represent extensive complex systems, too large to be easily navigable. The nature of the maps will be

discussed below as concrete learning objects. Arrows are shown on the rivers to indicate a processing structure.

The knowledge processing structures that are shown in the eGanges interface are the Question and Answer facilities, three adversarial windows (Positive case, Negative case and Uncertainties) and a Current result button and window. These processing facilities allow for input and output. The user's case is shown in adversarial windows progressively, as input is given through the Question and Answer facilities. The current result button can be used at any time during a consultation of an application, in order to see the Current result in the Current result window. The Current result may be an interim or Final result, depending on the User's case as entered.

The determination of the output is carried out by the functionality of the inferencing strategy. This is derived from the epistemology of 3d legal logic; even though two dimensional objects are used in the graphics window of the eGanges interface, the knowledge processing structures and the functionality of the shell ensure that the three dimensionality of legal logic is given full effect in the most user-friendly way. The knowledge processing structures and the functionality are explained more fully as the eGanges' legal game of inferencing strategy.

3. Concrete learning objects

An example of an eGanges rule map is set out in Figure 1. This rule map represents the Australian Environment Protection and Biodiversity Conservation Act 1999 (Cth) s.18(1) which states:

A person must not take an action that:

(1) has or will have a significant impact on a listed threatened species included in the extinct in the wild category; or
(2) is likely to have a significant impact on a listed threatened species included in the extinct in the wild category.

Civil Penalty:

(a) for an individual - 5,000 penalty units;
(b) for a body corporate - 50,000 penalty units.

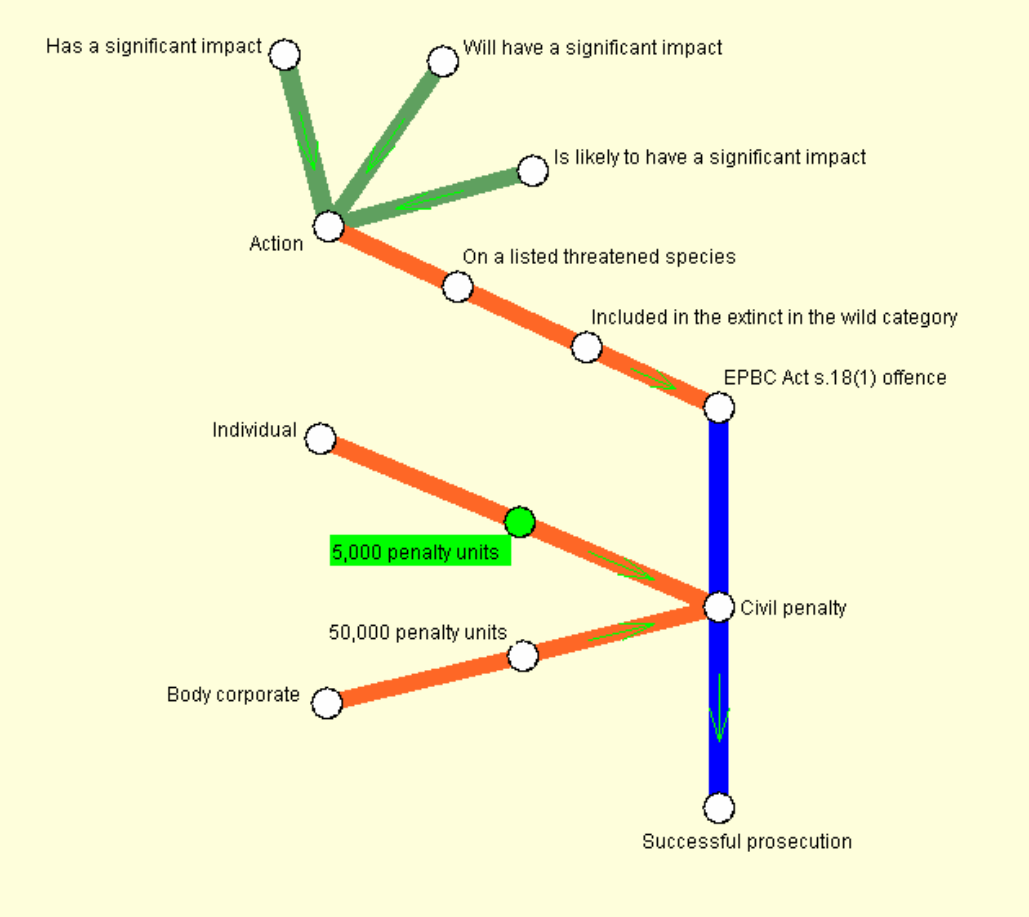


Figure 1: EPBCA s.18(1) – Successful prosecution map

One Final Result implicit in the text of the section is: Successful prosecution of Environment Protection and Biodiversity Conservation Act 1999 s.18(1) offence (abbreviated as EPBCA s.18(1) offence). Alternatively the Final Result may be: No successful prosecution of EPBCA s.18(1) offence. A choice must be made from the available Final Results. In Figure 1, the final result selected is Successful prosecution.

In the Figure 1 rule map, each node is labelled to indicate a concept that is an antecedent or a consequent in a rule. A rule is a premise in legal argument that takes the logical form of a conditional proposition, namely if (antecedent(s)) then (consequent). A rule map is a system of premises for extended deductive legal argument; it represents the tributary structure of a system of fully formalised rules of law. The rules of law must be fully formalised in this way if they are to be systematically used as premises in an extended argument that produces a valid legal expert opinion. The formalism is sufficiently precise for automation.

Rules of law belong to a tributary system if they can be formalised according to the paradigm set out in Figures 2 and 3. In Figure 2, there is a geometric representation of algebraic formalisations of conditional propositions. Instead of a string of letters representing antecedents, followed by an arrow and then the letter representing the consequent, the geometric river is a string of labelled nodes, representing antecedents, connected by lines signifying conjunction, with the last line containing the algebraic arrow followed by the last node representing the consequent. The geometric substitute for the algebraic expression, provides objects that make object-oriented processing possible. These objects have the structure of a river because the arrow represents the flow of antecedence to consequence. The order of antecedents in the flow may have some temporal or other significance. For instance, in contract law, there cannot be an acceptance until there is first an offer.

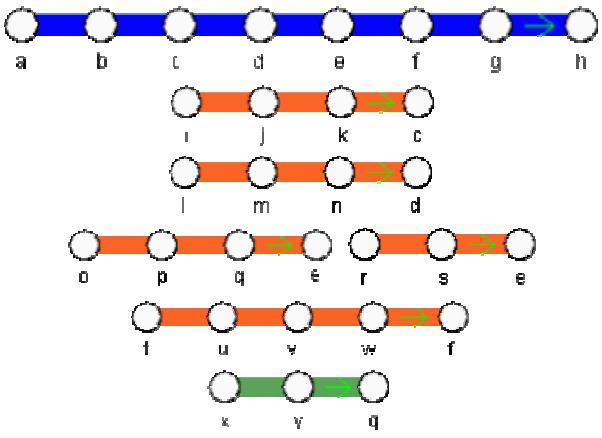


Figure 2: Wholly formalised rule streams

In each rulestream listed in Figure 2, all nodes, except the last, are antecedents in conjunction; the last node is the consequent. The flow of a stream is shown by the arrow that symbolizes 'then' in the rule format 'if (antecedent(s)) then (consequent)'. The arrows on the streams take the place of the arrows in an algebraic representation of a rule. In the mainstream, that is listed first with nodes a-h, the antecedent c is also the consequent of the secondary stream that is listed second; similarly, d, e and f are antecedents in the mainstream and consequents in other secondary streams. The last river, which is a tertiary stream, particularises q, which is an antecedent in the third listed secondary stream. River systems are streamlined hierarchies with some common points.

Interlocking the seven streams in Figure 2 at common points where they overlap, the tributary structure in Figure 3 is produced with the Final result, h. The interlocked tributary structure allows each node to be unique.

Sometimes an antecedent in one rule is also a consequent in another rule; these rules can be seen to overlap or interlock at the common point. For example, in Figure 1, 'EPBC Act s.18(1) offence' is the consequent of a secondary rule and also the first antecedent in the mainstream rule.

The two secondary rules in Figures 2 and 3, that share the common consequent e can be understood as a fan that represents a Boolean 'or'. For example, in Figure 1, there are three alternative ways of establishing the required 'Action' for the offence, namely, if it has a significant impact, if it will have a significant impact, or if it is likely to have a significant impact. In any of these cases, there is the required 'Action'; this is a fan with three fanstreams. Fans are Boolean structures in the knowledge that indicate alternatives and choice; their streams may be mutually exclusive or non-mutually exclusive.

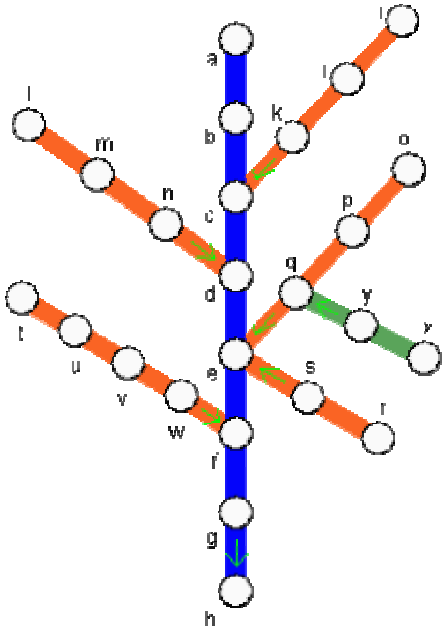


Figure 3: eGanges river map

Different structures distinguish the 'and' and the 'or' aspects of the deductive premises. In the river hierarchy, the more upstreams that an antecedent has, then the more particularised or abstract it is. Many fields of law have extensive, complex river systems.

Concrete learning in the eGanges shell is achieved by the two dimensional rule maps. The famous legal construct of the reasonable person, the man on the Clapham omnibus [14] understands the bus route; this level of urban intelligence is all that is required for students to understand rule maps.

With eGanges applications, people might better be able to understand how to obey the law and, in return, receive its benefits; an exchange of benefits for obedience is a social contract that is likely to increase the effectiveness of a legal system. This social reasoning which is implicit in the legal system, is part of the epistemology of the legal domain; it necessitates user-friendliness or a user-friendly communication system. The fairness of specific exchanges of *quid pro quo* might also be brought within this epistemology, to secure optimum effectiveness and efficiency in the system of rules. The precise specification of substantive law as rule maps assists its evaluation in terms of fair exchange, justice, effectiveness, and efficiency; rule maps clearly reveal legal choices and provide frameworks for creative legal strategies.

Flow of interlocked rules is always downstream; this downstream flow characterises the river flowchart. The user will not be lost in a forest of trees with a river system; the flow always leads to the Final result. Where the consequent in one rule becomes an antecedent of another rule, then the flow downstream in that one rule joins the flow downstream in the other rule. The user can navigate upstream and downstream.

The river flows represent the chaining paths implicit in extended deductive arguments. The antecedents on all streams must be established to reach the Final result, except for fan alternatives, only one of which must be established. A river representation portrays alternative, overlapping sets of necessary and sufficient conditions that are not otherwise easily managed in formal logic. The river map is a user-friendly representation of complex logic, because it uses the familiar structure of a major river system and is in map form; thus it requires only urban street map intelligence for comprehension. The visualisation is suited to concrete learners to whom the program epistemology is only apparent as a game.

3.1. DEDUCTIVE PREMISES

The tributary structure represents the premises of law that can be used in an extended deductive argument [15][16]. The representation manages the alternative overlapping sets of necessary and sufficient conditions that establish the Final result. There are other deductive premises that can be used as argument pathways to the failure of the Final result (Uncertainties) or the contradictory Final result (Negative case). These are the pathways of the opponent's legal argument. They are not shown in the visualisation, but they are implemented in the knowledge processing structures and the inferencing strategy of the shell functionality.

3.2. INDUCTIVE AND ABDUCTIVE PREMISES

Inductive and Abductive premises for legal argument are made available through the gloss facilities of eGanges. The inductive premises are provided for in the spectrum gloss and the abductive premises are provided for in other types of glosses. The iteration of inductive instances in the spectrum gloss, permits a semantic evaluation of whether an argument is available by virtue of analogous instances, authoritative iteration, or both.

A spectrum gloss has three sectors: negative, positive and uncertain. In each sector, entities may be listed to detail what is available to establish the node (positive sector), what is available that will not establish the node (negative sector) and what is not certain to establish the node (uncertain sector). A dissimilar entity may or may not support an argument that the node is not established, depending on the spectrum sector in which it is located.

Case and legislative authorities can be given in a text gloss, for each antecedent and for its location in the tributary structure; these authoritative statements may be used as abductive premises. Abductive premises may be interspersed at the appropriate point in the extended deductive legal argument, to lend weight or otherwise to the argument. For instance, the development of the action in negligence in Donoghue v Stevenson [1932] AC 562, 1932] All ER 1, was based on the commandment to love thy neighbour; this was a strong reason for the duty of care. However, it is not a defence to an action in negligence that the defendant loved the plaintiff.

Other gloss options are link options whereby an antecedent may be linked to another antecedent in a different river in the same tributary structure, or to another antecedent in a different or parallel tributary system. For instance, it may be useful, in the contract tributary system to link mistake and misrepresentation for a direct comparison of the two, in order to better understand where and how the distinction between them is sometimes fine, as well as the significant difference in their respective consequents. Also, it may be useful to link parallel rivers where related areas of law are relevant considerations; for instance, a contract application might link to an equity application at appropriate points. An eGanges application can also be linked at the appropriate point to any other files, programs or websites.

In abductive glosses, abductive premises may be set out singly or as part of their own deductive argument or system. What characterizes abductive premises is that they are outside the deductive river system; yet they might lend weight to the extended deductive argument of the river system, although they do not carry deductive necessity in the river argument.

4. GAME OF INFERENCING STRATEGY

The rule map visualisation can be freely navigated by the user of an application, expanding to gloss information, or contracting to the deductive map alone. In addition, eGanges allows a user to provide input that will establish how the rules in the map apply to the user's case. Functionality gives effect to the eGanges inferencing strategy that is based on computational epistemology of 3d legal logic; this provides the eGanges game characteristics. The functionality is threefold:

1. Sorting answers into Case windows

2. Showing the Final result in a Case window when the necessary and sufficient conditions are established to do so

3. Showing the Current result in the Current result window in response to clicking the Current result button.

4.1. Sorting answers into Case windows

Each node has a question that can be answered by the user by selecting one of the three available answers. The questions appear in natural language in the Questions window and there are five answer buttons where three possible answers may be placed by reference to the sense of the natural language of the question. The reason there are five answer buttons and only three available answers is that each node may be one of two types of antecedent: (i) ordinary antecedent or (ii) neutral antecedents.

Available answers to questions that establish neutral antecedents require different treatment to ordinary antecedents. A neutral antecedent is one that is inconsequential to the Final result. The answers to ordinary antecedents will determine whether or not the Final result is established. For example, in contract law, an enquiry as to the meaning of an offer is a neutral antecedent; whether or not an enquiry is made, or there is uncertainty that it has been made, does not affect the Final result of formation of a valid contract. For the enquiry question, there will be three alternative answers, yes, no and uncertain, all of which will be on the three positive answer buttons

The five possible answer buttons are labeled so that one is Negative, three are Positive and one is Uncertain. Answers such as yes, no and uncertain may be placed so that uncertain may be on the Uncertain button or a Positive button, yes may be placed on the Negative button or a Positive button and no may be placed on the Negative button or a Positive button. Where an antecedent is inconsequential to the Final result, all three available answers are placed on the three Positive buttons. For an ordinary antecedent, the answer uncertain is placed on the Uncertain button and the answers yes and no are placed on either of the Negative and Positive buttons depending on the natural language sense of the question.

The labelling of the answers *prima facie* indicates in which Case window the label of the node answered will be reported. Thus if an answer is labelled Positive, then the node's label will be reported in the Positive case window. However, in order to accommodate fans, Negatives and Uncertains may be treated as Positives, and Negatives may be treated as Uncertains, until all the alternative rivers in the fan are answered decisively. To indicate the Negative or Uncertain fan status in the Positive or Uncertain adversarial windows, the antecedent node label is preceded by (Neg) or (Unc) as appropriate.

If a fan is answered decisively so that no Positive alternative is established, any Negatives or Uncertains that have been temporarily listed in the Positive window, will be automatically moved to their next location as appropriate. The next location of a temporary Negative will be the Uncertainties window if an Uncertain fan stream has been satisfied or the Negative case window if all fan streams are established as Negatives.

A fan stream which has more than one antecedent becomes Negative if only one antecedent is Negative; a fan stream with more than one antecedent becomes Uncertain if only one antecedent is Uncertain and there are no antecedents that are answered Negatively.

The adversarial windows list sorted answers. Each list represents the user's premises that are available to complete the user's extended deductive argument. The user's premises may not always lead to the Final result preferred by the user; however, they will lead to the only Final result that the rule system allows in the user's situation.

The significance of an uncertainty requires further processing according to the rules of burden of proof. eGanges does not offer this processing but a module could be developed to accommodate the effect of the rules that determine who has the burden of proof in respect of each antecedent, and the nature of the burden (civil or criminal).

4.2. Showing the Final result in a Case window when the necessary and sufficient conditions are established to do so

The tributary structure shown in the Rivers window represents the Positive tributary structure; its Final result is the Positive Final result. All antecedents, except where there are fan alternatives, must be established in order to reach the Positive Final result; at least one fan must be established. As soon as the Positive result is reached, its label is shown at the top of the Positive case window.

Notionally, the Positive tributary structure is part of the spherical logic structure of the epistemology of 3d legal logic, in which there is a Negative tributary structure corresponding to the Positive tributary structure and an Uncertain tributary structure corresponding to the Negative tributary structure. Both the Negative tributary structure and the Uncertain tributary structure respectively give rise to pole structures. The pole structures represent the premises that any Negative antecedent establishes a Negative Final result and any Uncertain antecedent establishes an Uncertain Final result.

As soon as a Negative Final result or an Uncertain Final result is established, respectively, it will be shown at the top of the appropriate adversarial window. If an Uncertain Final result is established before a Negative Final result, it will be reported at the top of the Uncertainties window. However, if a Negative Final result is subsequently established then the Uncertain Final result is removed from the Uncertainties window and the Negative Final result is reported at the top of the Negative case window

The spherical logic indicates the complexity of the possible Cases covered by the system of rules. The pathways of the alternative sets of necessary and sufficient conditions may proceed through the three dimensional space of the sphere to reach one of the five possible Final results: (i) Positive Final result, (ii) Wholly negative Final result, (iii) Partially negative but conclusive Final

result, (iv) Wholly uncertain Final result, or (v) Partially uncertain but conclusive Final result. These five possible Final results allow for combinatorial explosion of alternative overlapping sets of necessary and sufficient conditions that include not just the premises that lead to the Final result in the Positive rule map that is shown in the Rivers window of the eGanges interface, but also the failure (Uncertainties) and contradictory (Negative) premises that are not shown in the interactive visualisation.

Although the eGanges epistemology gives an Uncertain fan stream priority over a Negative fan stream in the assessment of user fan premises, as soon as a Negative Final result is established, the Negative Final result overrides any Uncertain Final result. Other epistemologies might operate with other priorities. Games can be played by the user with hypothetical fact situations to learn the functionality of the epistemology; for example neutrals in fans can be tested for prioritisation of Final results.

4.3. Showing the Current result in the Current result window in response to clicking the Current result button.

During a consultation, the user may obtain the Current result by clicking on the Current result button. The Current result will then appear in the Current result window. A Current result may be an interim result or a Final result. If a Final result has been reached, then the Final result label will already be shown in the window of the successful Case. The interim result that is shown when no Final result has been listed in an adversarial window is called 'unanswered'.

The Current result is shown according to the result that has been reached at the time the Current result button has been pressed. The interim Current result, namely unanswered, is given when no set of necessary and sufficient conditions has been established for a Final result. Whenever a set of necessary and sufficient conditions are established, its Final result is reported as the Current result.

Nesting, as explained below also raises the understanding of direct and indirect logical implications. The failure of a deeply nested positive antecedent will implement the automated domino effect on rulestreams through to the Final result.

5. ART OF MNEMONIC SHAPES

Due to the eGanges sub-mapping facility, the maps can be hewn into mnemonic shapes best suited for human memory. Sub-mapping is illustrated in Figures 4 and 5. Figure 4 shows the Initial map of the United Nations Convention on Contracts for the International Sale of Goods, known as the Vienna Convention in

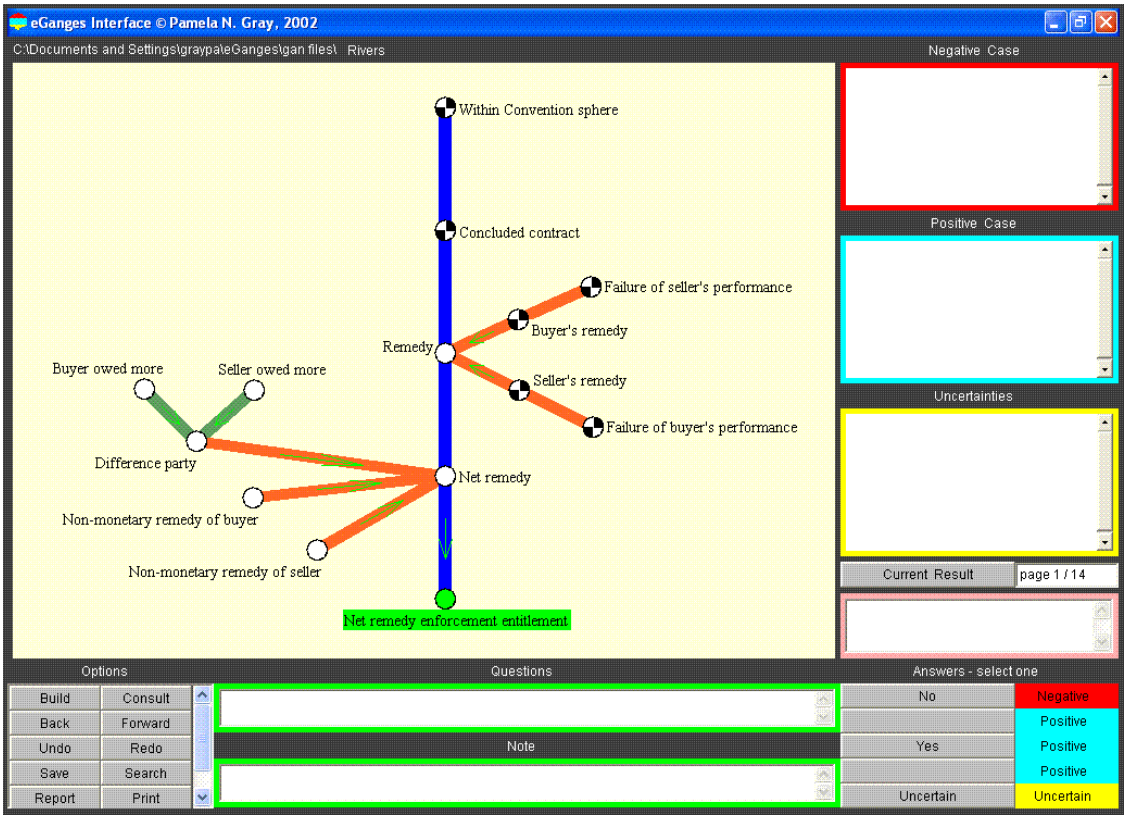


Figure 4: Initial map of the Vienna Convention

the Rivers window of the eGanges interface. This Convention is an extensive and complex system of rules. In the Initial map there are numerous soccerball nodes, indicating sub-maps. Figure 5 shows the submap for the Concluded contract node on the primary river of the Initial map. It can be seen that Figure 5 also contains soccerballs that indicate further levels of submaps. An application builder may choose where to nest the rules, so that each screen will have a cognitively comfortable volume of information and mnemonic shapes. eGanges facilitates easy construction of maps and allows the repositioning of streams in angles and lengths required by the builder. The maps in Figures 4 and 5 are clearly distinguishable. The creative skills of cognitive and mnemonic art may be developed to further enhance the computational pedagogy of the eGanges shell.

6. MOBILE SUITABILITY

eGanges is written in Java so that it is independent of any hardware and operating system. Java Runtime Environments (JREs) are available for PDAs and mobile phones, as well as 32 and 64 bit versions of Windows, Linux, Unix and Apple Macs. In short, Java programs, such as eGanges, can be run on any mobile computer with a JRE; all JREs are available for free download from the web.

The size of eGanges suits small devices; it is less than 0.25 MB. Although it offers interactive visualisation, its applications are also minimally sized and can be expected to be less than 1MB.

Mobile learning software must suit the technical limits of hand-held devices such as Personal Digital Assistants (PDAs) and mobile phones. It must also encapsulate a pedagogy that is epistemologically sound and swift for the particular domain of learning. eGanges does both. A glance at a map can be sufficient for learning the complexity of the knowledge that it represents.

The epistemology 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 [17].

eGanges applications may be constructed quickly and during variable small periods by an expert using a hand-held device; it is cost effective.

7. FAST AND EFFICIENT INSTRUCTION

Transparency makes for fast and efficient learning. The colour-coding and labels of the five answer buttons correspond to the three case windows. *Prima facie*, if the user selects the Negative answer, then the node label for that question automatically and immediately appears in the Negative case window. Likewise, if any of the three Positive answer buttons is hit, the node label is reported in the Positive window, and if the Uncertain answer is chosen, the node label appears in the Uncertainties window. 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.

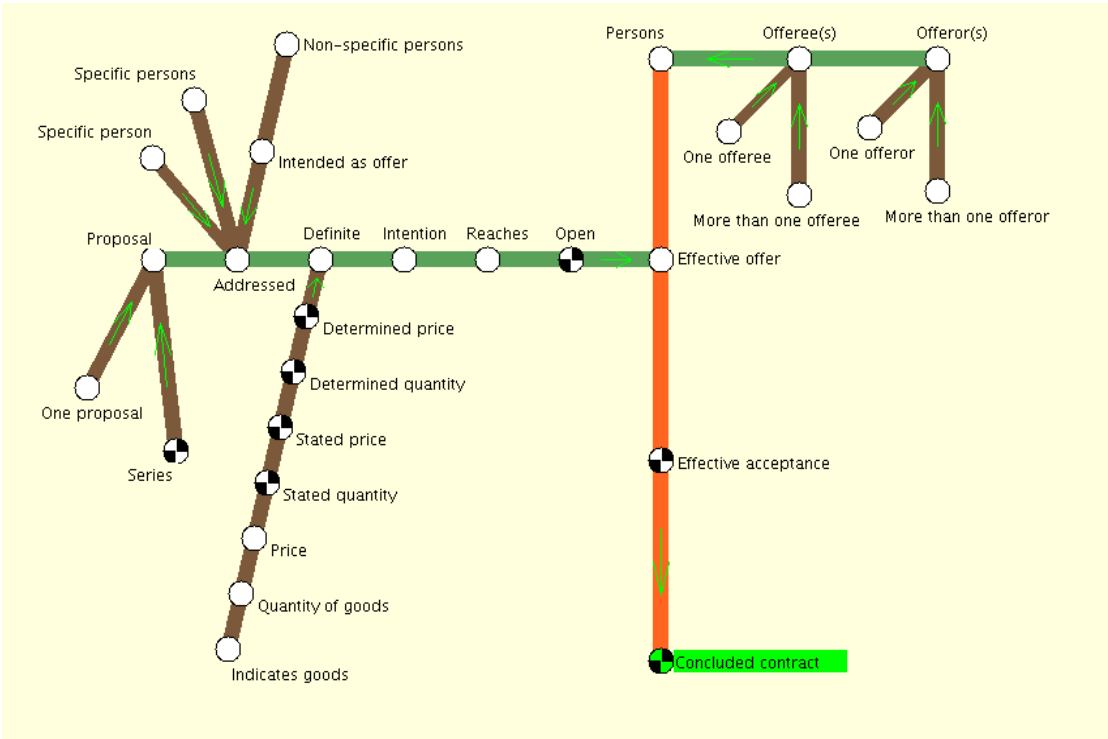


Figure 5: Concluded contract submap - Vienna Convention

Where a node label appears in the Negative window, so too will the Final result label; the Positive case has failed to establish one essential or necessary antecedent. Thus, a Negative pole rule has produced a Final negative result by which the negative case wins. Where nothing is listed in the Negative window, as soon as a label appears in the Uncertainties window, so too will the Final result label; the burden of proof rules or settlement of a gap in the law, will determine who wins. If the Final result label appears in the Positive Case window, there is a final determination on the available input; the negative case cannot win.

The transparency that is achieved by the user-friendly eGanges interface is also in the spirit of open legal systems that are fundamental to the justice system of the law. eGanges resists the use of AI to create new black boxes to govern us.

As mobile software, eGanges requires only one click to select a sub-map, give an informed answer to a node question or see the Current result at any time during a consultation. Maps can be freely navigated; answers can be changed. Deductive processing produces lists of points that support adversarial arguments and interim and Final results. Essential screen information is minimalized to node labels and simple natural language questions; there is an option to expand into the gloss additions. eGanges offers pictures that say a thousand words and computation that manages the combinatorial explosion of choice.

8. CONCLUSION

With eGanges, AI technology has instigated an evolution in logic representation from black box algebraic code to transparent user-friendly geometric symbols. The algorithms of programming are still in code that gives effect to interactive visualisation of the geometric representation in the interface, as part of the communication system. The illusion of transparency in combination with the free navigation of vastly nested maps and the regularity of inferencing processes, contribute to the game quality of this new generation learning aid.

eGanges is a smart shell that assumes acceptance of its epistemology by both the builder and user of an application. Although the eGanges epistemology deals with complex logic, it is both computationally precise and can be managed simply.Once the epistemology is understood and accepted, applications can provide very efficient learning. Inevitably, a paradigm shift is required in the transition to this efficient learning system.

9. REFERENENCE

1. Everson, S., *Introduction,* in Everson, S. (ed.), *Epistemology*, Cambridge University Press, Cambridge, UK, 1990
2. Gray, P. N., *Intellectual Artefacts of Expert Systems Meta-epistemology*. In *Computers and Philosophy 2003*, Weckert, J. and Al-Saggaf, Y. (eds.), Australian Computer Science Communications, Vol 37, pp 51-8
3. Gray, P. N., *Artificial Legal Intelligence*, Dartmouth Publishing Co., Aldershot, England, 1997
4. Gray, P. N., Scaling Up To A Three Dimensional Graphic Trace. In *Verso Un Sistema Esperto Giuridico Integrale*, Ciampi, C., Socci Natali, F and Taddei, E. G. (eds.), Padua, Italy, Cedam, 1995
5. Gray, P. N., *Choice and Jurisprudential Systems*, LL.M. thesis, University of Sydney, Sydney, 1990
6. Samuel, G., *Epistemology and method in law*, Burlington, VT, Ashgate, 2003
7. Conover, M., Applying Three-Dimensional Thinking and Systems Technologies to Jurisprudence and Legal Management. In *Interactive Systems and Law*. Rasmussen, T. (ed.). Lansing, Michigan, Spartan Press, 1988
8. Rourke, N.E., On The Way to Experimental Jurisprudence. In *System Science and Jurisprudence*, T. Rasmussen (ed.), Lansing, Michigan, Spartan Press, 1986, pp.187-219
9. Terrell, T.P., Flatlaw: An Essay on the Dimensions of Legal Reasoning and the Development of Fundamental Normative Principles. Calif. L.R. Vol 72 No. 3 pp. 288-343, 1984
10. Vaihinger, H. (1911, 1965): *The Philosophy of "As if"*, translated by C.K.Ogden, London, Routledge
11. McCarthy, J. and Hayes, P.J., Some Philosophical Problems from the Viewpoint of Artificial Intelligence. In *Machine Intelligence 4*. Meltzer, B. and Mitchie, D. (eds). Edinburgh, Edinburgh University Press, 1969
12. Ishikawa, K., *What Is Total Quality Control? The Japanese Way*, translated by David J. Lu. Englewood Cliffs, N.J., Prentice-Hall Inc., 1985
13. Morgan, T., *Business Rules and Information Systems*, Boston, Addison-Wesley, 2002, pp.122-5
14. Vermeesch, R.B. and Lindgren, K.E., *Business Law of Australia,* Sydney, NSW, Butterworths, 1998, pp.417-8
15. Gray, P.N., Explanatory Rule Maps. *Computers and Law Journal for the Australian and New Zealand Societies for Computers and the Law* 50:11-13, Dec 2002
16. Gray, P.N., The CLIMS (Contract Law Information Management System) Pilot - Automatable Law. In *Proc. of the 4th International Congress on Computers and Law*, Rome, 1988
17. Gray, P.N. and Gray, X., A Map-Based Expert-Friendly Shell. In *LegalKnowledge and Information Systems*. Bourcier, D. (ed.). Amsterdam, IOS Press, 2003