IDT Series

Legal and Negotiation Decision Support Systems (LDSS 2009)

A Post-Conference Workshop at the 12th International Conference on Artificial Intelligence and Law

Editors:
Marta Poblet
Uri Schild
John Zeleznikow

Barcelona, Spain
June 12, 2009

IDT Series

Series Editors:

Pompeu Casanovas
Núria Casellas
Pablo Noriega
Marta Poblet
Antoni Roig
Joan-Josep Vallbé

Volume 4
Proceedings of the Workshop on Legal and Negotiation Decision Support Systems (LDSS 2009)

Volume Editors:

Marta Poblet
Uri Schild
John Zeleznikow

Acknowledgements: ARCS. 2008-ARCS200028; TSI-020501-2008-131; TSI-020100-2008-134; CSO-2008-05536-SOCI; CEN2008-1018

ISSN: 2013-5017
Legal Deposit:

Also appeared with CEUR Workshop Proceedings Series
(ISSN: 1613-0073, CEUR-WS.org)

Editors' addresses:

Institute of Law and Technology
Political Sciences and Public Law Department
School of Law
Universitat Autònoma de Barcelona
08193 Bellaterra, Spain
marta.poblet@uab.cat

Department of Computer Science, Bar Ilan University,
Ramat Gan 52900, Israel,
schild@cs.biu.ac.il

School of Management and Information Systems
Victoria University
Melbourne, VIC 8000 Australia
john.zeleznikow@vu.edu.au

Publisher:

Huygens Editorial
La Costa 44-46, át.1ª
08023 Barcelona. Spain.
www.huygens.es

Foreword

The Workshop on Legal and Negotiation Decision Support Systems (LDSS 2009) was held in conjunction with the 12th International Conference on Artificial Intelligence and Law, ICAIL 2009 (Barcelona Spain) on June 12, 2009. The workshop follows previous Workshops on Judicial Decision Support Systems in Melbourne (1997), Oslo (1999) and St. Louis (2001) and Online Dispute Resolution in Edinburgh (2003), Bologna (2005), and Palo Alto (2007).

The workshop has been receptive to papers dealing with any topic covering technological and legal aspects of Negotiation and Decision Support Systems in the domains of law and negotiation. Since the late 1970s, Decision and Negotiation Support Systems (DSS, NSS) have been developed to aid decision makers and also support complex negotiation tasks. Over the following years, a significant number of projects, prototypes, and products have been successfully developed. Today, the ubiquitous expansion of latest Web technologies puts new challenges for DSS and NSS researchers, and the domain is among the most vibrant ones in the law and artificial intelligence field.

This year seven papers have been accepted coming from Australia, France, Israel, Poland, Portugal, and Spain. Besides the paper presentations, we had an invited lecture by Jon Bing on the new top level domains and dispute resolution mechanisms at ICANN. We thank the authors for choosing the LDSS09 Workshop to disseminate their latest research activities and for their timely work. And we also thank the ICAIL organization committee and the sponsors for their support in making this event possible within the ICAIL 2009 Conference.

The editors
July 2009

Program Committee

- Brooke Abrahams, Victoria University, Australia
- Emilia Bellucci, Victoria University, Australia
- Arno Lodder, Free University of Amsterdam, Netherlands
- Paulo Novais, University of Minho, Portugal
- Marta Poblet, ICREA–Universitat Autònoma de Barcelona, Spain
- Andrew Stranieri, University of Ballarat, Australia
- Uri Schild, Bar Ilan University, Israel
- Tadeusz Tomaszewski, University of Poznan, Poland
- John Zeleznikow, Victoria University, Australia

Index

Intelligent Evaluation of Traffic Offender Records

Uri J. Schild[1] and Ruth Kannai[2]

Abstract: This paper describes an intelligent computer system giving decision support in the area of sentencing of traffic law offenders. The system evaluates the previous record of a traffic offender, and suggests how to consider that record when passing sentence in a new traffic case.

Keywords: intelligent evaluation, intelligent decision support system (DSS), sentencing, traffic law offenders.

1. Introduction

Previous work by us considered the intelligent evaluation of an offender's previous record in the general area of criminal law [1, 2]. The object of that work was to develop an intelligent decision support system (DSS) to help judges (and perhaps other parties in the legal system) to evaluate the previous, general criminal record of an offender, i.e., a person that had been found guilty of some offence. Such an evaluation would be of help to the judge about to pass sentence on the offender. No other work has been carried out on this particular subject.

During that work we considered the possibility of doing similar work on traffic offenders. Intuitively a DSS for this domain might have a different form, as the issues to consider are different than in the general criminal area, but then, perhaps not. Another question that presented itself was to which extent there is a connection between an offender's general criminal record and his traffic offence record. This paper describes the results of our work on the new DSS for evaluating a traffic offender's previous record.

The purpose of the system is *not* to suggest any kind of sentence for the offence at hand, but to evaluate the offender's previous record, and suggest the weight this record should be given in the sentence in the present case.

2. Background

When the judge is about to pass sentence, he can in theory take many factors into account. In practice he will consider only some of these, namely those

1. Department of Computer Science, Bar Ilan University, Ramat Gan 52900, Israel, schild@cs.biu.ac.il
2. Faculty of Law, Bar Ilan University, Ramat Gan 52900, Israel, kannair@mail.biu.ac.il

that have been salient in the case at hand. These factors will then have an aggravating or mitigating influence on the sentence. One of the factors a judge will often consider is the offender's previous record. It is believed by many that the record is of importance and should carry weight. Thus features like the increase or decrease in the severity of past offences and the time-intervals between consecutive offences ought to bear influence on the sentence in the present case.

What happens in practice in the Israeli courts (and presumably in courts all over the world) is the following scenario: After an accused has been pronounced guilty, the prosecutor hands the judge the "sheet", i.e., the record of previous convictions. This record is a hardcopy printout of the entire record stored in the central Israeli police computer relating to the offender.

There is a practical problem with the previous record: The record is often quite extensive, containing a long list of past offences, which may all be of the same type but often include related types of crimes, or even entirely different types of crimes. The record may also span a considerable number of years. The judge can have great difficulty in acquiring a clear picture of the situation, and he must necessarily devote a lot of time to the interpretation of the record. This time is often not available, and the sentence may therefore not reflect the facts embedded in the past record.

What has been described so far holds for general criminal cases and for traffic offences. There are, however, also some important differences:

1. Traffic offences are usually considered less serious than general criminal offences. The public believes that everybody could be involved and found guilty of a traffic offence, not just professional criminals.
2. The sentences handed out in traffic cases are usually much lighter. Traffic offences only very seldom lead to custodial sentences. The customary sentences are monetary (fines and reparation) and driving disqualification. Often the sentences are deferred (suspended), being applied only in the case of repeated offences within a certain period of time.
3. The public believes that the previous record of traffic offences is of extreme importance. The judges do not all agree, but they are under great pressure from the media. It is a common belief that the previous record ought to have a dominant influence in determining the sentence in the case at hand. The media is happy to publish and point out whenever it is believed that some traffic offender with a large number of previous offences gets off with what is considered too light a punishment.
4. The previous record of a traffic offender submitted in a traffic court exclusively contains traffic offences. Only if the offender has a relevant general criminal record (or perhaps in the case of a professional criminal) will a separate printout of the general criminal record be submitted by the prosecutor.

5. The computer printout of an offender's previous record is very hard to read. It is almost impossible to understand for the uninitiated. This of course is not of great importance, as judges, prosecutors and defense lawyers become familiar with the layout over time.

However, even an experienced judge does not have the time to go through, say 100 previous offence records to see whether how the offender has behaved himself in traffic after receiving previous suspended sentences.

3. Our System: Presentation of Basic Data

From our description of the computer record in the previous section it is clear that the first step in building a DSS must be to present the previous record in a clear manner. This will serve two purposes: (1) It will enable legal practitioners to carry out a speedy overview of the record, (2) It will enable them to proceed to the second step: An intelligent analysis of the record. In order to carry out step (1) we spent a large effort interviewing legal professionals involved in reading such records: Judges, lawyers and police officers.

There is no Artificial Intelligence in this part of the system. Applying basic principles of modern interface design [3] and after several iterations with the legal experts, we have reached a way of presenting the previous record in a way that is easily and speedily overseen.

Figure 0 in the appendix shows the original printout from the police computer. One can imagine how difficult it would be even for a legal professional (a judge, a prosecutor, a defence lawyer or a police officer) to survey such a record if it contains, say, 100 items.

Our assumption is that a user should be able to become familiar with even an extensive past record should take three seconds! Surveying details should take another three seconds. Figure 1 gives brief overview of who the offender is, and what he has done in the past (three seconds). Figure 2 shows what Figure 0 would look like in our system[3] (perhaps another three seconds).The colour code enables the user to get an immediate impression of the different types of offences

If the user has more time - one can imagine a lawyer preparing himself for the present case, or a police officer wishing to estimate the dangerousness of somebody he has stopped on the road - more information is available.

Figure 3 is a graph showing the sentences given in the past: Periods of Disqualification and Fines. Sentences are often combined: Disqualification + Fine, etc. It would be nice if one could present such a combined sentence in one graph. This is impossible, one cannot compare apples and oranges, and

3. Obviously all records, computer printouts and screens are in Hebrew. We hope to have them translated (at least partially) before the workshop.

one cannot say that 3 months disqualification is more serious than, say, a NIS 10,000 (US$ 3,000) fine. So we decided to show two graphs in the same screen.

The system interface was established by asking the experts a set of pre-formulated questions. For example:

1. What is wrong, impractical and/or not user-friendly in the old police output?
2. What are you looking for and in which order?
3. Are there data you would like to see sorted in various orders (e.g. dates)?

We did *not* ask whether there was additional data the experts would like to see, even though this seems to be an obvious question. As mentioned above, the printout of the previous record today includes what is stored about the offender in the police computer. Obtaining additional information would call for a major overhaul of police procedure and perhaps the information systems of the entire justice organisation. It would also raise questions of legality of what information the government should be allowed to keep in its computers, and would certainly necessitate new legislation.

The Knesset (Israel's parliament) is aware of such questions and problems. It has formed an external committee (chaired by one of us - R. Kannai) to consider the kind of questions raised above with respect to all kinds of offenders, traffic and otherwise..

In the theory of expert systems it is well-known that different experts come up with different answers [4]. Sometimes experts outright contradict each other. This phenomenon was indeed observed by us with respect to the layout. The solution was simple (but a bit tricky): We chose the answer that was proposed by the majority. What then invariably happened was that at the next iteration the experts found the solution acceptable - also the ones who initially suggested other approaches.

4. Our System: The Intelligent Component

4.1. Preliminaries

In this section we shall deal with two issues: (1) The complexity of the problem, (2) What kind of system to aim for.

4.1.1. The Complexity of the Problem

The intelligent component of the system aims at analysing the previous record in order to determine the presence and extent of certain factors. These are the factors that influence the decision of the judge in passing sentence in the case at hand.

It was clear to us at the beginning of the project, that a sizable amount of specific domain knowledge would be necessary. The problem of how to evaluate an offender's previous record is far from trivial, even for humans. We shall give just a few examples of the complexity of evaluating a previous record:

1. A person is about to be sentenced for speeding in an urban zone. His past record shows a large number of convictions for parking offences. Should judges take such past offences into account? (A case like this would come to court only in extreme cases).
2. A person is about to be sentenced for speeding in an urban zone. He has but one previous conviction, also for speeding in an urban zone. However, that previous offence was ten years ago. How should that fact bear upon the decision by the judge? This offender has possibly spent the previous nine out of ten years out of the country. Is that information available to the judge?
3. A person is about to be sentenced for driving without a valid licence. His past record shows no convictions for that particular offence, but several quite recent convictions for speeding. How should a judge compare the offences (if at all).
4. A person has been found guilty of driving while his licence was suspended. His past record shows no convictions for this offence, but he has several previous convictions for reckless driving, having been involved in several accidents. Is this situation somehow similar to the one in example 3?
5. A person has been found guilty of reckless driving. He has been found guilty in causing an accident where the other driver was killed. His past record shows that he has several convictions for having neglected to renew his licence and pay the yearly car-tax . How should that fact influence the sentence in the present case? (if at all).
6. Combinations of the above examples occur of course, and complicate matters even further.

4.1.2 The System Architecture

Various system architectures have been used in the past to build DSS in the sentencing domain. In principle we distinguish five kinds of systems: (i) Statistical Systems, (ii) Model-Based Systems, (iii) Case-Based Systems, (iv) Neural Network based system and (v) Rule-Based Systems.

(i) Statistical Sentencing Systems in the general criminal domain have been built in the past [5], [6], [7], but are not in use (except, possibly, for one).

(ii) Model-Based Systems have been proposed, but not implemented.

(iii) A Case-Based Sentencing System like the one described in [8] and [9] is appropriate for a court of appeal. The time span of an appeal case is measured in weeks and months (perhaps even years). A judge at this level has the time to apply a case-based system, convince himself that the retrieved case or cases are indeed relevant, and include the conclusions of the system in his deliberation.

However, our present system is intended for a judge at the lowest level of the judiciary. He often hears several cases a day, he has practically no time for deliberation, and he must hand down his decision the moment counsel and witnesses have had their say. It is therefore clear that a case-based sentencing system would be of no use. The judge simply does not have the time to apply it.

(iv) A neural network based system. Such a system lacks transparency in the sense that the user cannot see clearly how a certain recommendation by the system is derived. Nevertheless, in some legal applications there is a definite place for this kind of system. [10]

(v) A rule-based system is the classical kind of expert system. It uses a knowledge-representation in rule-form and applies logical deduction to the rules. Such a system can be appropriate in our case if:

1. It operates very fast, so the user (judge) receives a qualified answer to a query practically without any waiting time.
2. The output is concentrated and summarised for the user to survey in a moment.

As we shall show below there is no problem in fulfilling both of these conditions. The rule-based paradigm is therefore the appropriate choice for our system. The system is a rule-based system written in Prolog, with the interface (shown in the Appendix) in Visual Basic.

4.2 Deriving and Compiling the Domain (Expert) Knowledge

4.2.1 The Relevant Factors

Having decided on the architecture of the system, we approached the step of compiling the domain knowledge. By this we mean the factors judges use to evaluate an offender's previous record. This is of course where the intelligence is found. Two questions came to mind before beginning interviews with the experts. The first question was to which extent experts would agree among themselves about the factors. The second question was to which extent the relevant factors were different for traffic offences than for general criminal offences.

It appears that experts did not differ in their opinion of what these factors are (or should be). This is both surprising and also a bit disappointing. As developers we would have liked to cope with conflicting opinions.

The factors that judges considered relevant in the general criminal DSS were as follows [1]:

1. Number of Previous Offences (Number of Adult Offences, Juvenile Offences)
2. Seriousness of Previous Sentences
3. Seriousness of Previous Offences
4. Similarity of Offences (Same type of offence, same law paragraph)
5. Frequency of Offences
6. New Offence Committed during Service of Previous Sentence
7. New Offence Committed during Cooling-off Period

The factors that traffic judges found relevant for traffic offences are as follows:

1. Seriousness of previous offences

   The offences are categorised as

   (i) Serious offences:

   Driving causing death, driving under influence of alcohol and/or drugs

   Driving during period of disqualification (i.e. while licence is suspended)

   (ii) Less serious offences (red light, speeding, etc.)
2. Similarity of previous offences
3. Seriousness of previous sentences:

   Custodial, licence disqualification, deferred licence disqualification, fine, deferred fine.
4. Driving causing accidents in the past:

   Bodily damage, damage to property
5. Present offence committed during period of disqualification arising from a previous traffic offence.
6. Present offence committed during period of deferred disqualification arising from a previous traffic offence.
7. Frequency of offences

4.2.2 The Analysis

The four classical approaches to punishment, Retribution, Deterrence, Prevention and Rehabilitation form a classification of punishment commonly used by the judiciary and by criminologists:

“We have thought it necessary not only to analyse the facts, but to apply to those facts the classical principles of sentencing. Those classical principles are summed up in four words: retribution, deterrence, prevention and rehabilitation. Any Judge who comes to sentence ought always to have those four classical principles in mind and to apply them to the facts of the case to see which of them has the greatest importance in the case with which he is dealing" [Lawton L.J., in: Sargeant (1974) 60 Cr. App. Rep. 74 C.A. at pp.77-84].

We note that the traffic-factors from the previous section are quite similar to the ones found for general criminal offences. This leads to the conclusion (confirmed by our experts) that traffic judges apply the same approaches to traffic offenders.

However, we were somewhat surprised to find that one factor found relevant for the general criminal DSS is not considered important: The total number of offences. The reason could be that even a person with a great number of traffic offences is not considered a professional criminal, neither by the public nor by the judiciary.

In the first version of our prototype we simply gave ad hoc definitions of the weight of the factors described above. However this is too simplistic a view of the weighing of the factors against each other by a human.

There seems no particular reason to postulate complex interrelationships among the factors resulting in a non-linear expression for the final result. However, the computation of the individual weights had to been done in a more detailed and intelligent manner, reflecting the views of the experts (judges). Thus, e.g., frequency of offences is measured as a function of the type of offence.

The system analyses the record it obtains as input, determines the various factors, and assigns them a weight according to the built-in rules derived from interviewing the experts. Based on that computation the system issues a recommendation to the judge of how to consider the previous record within the framework of passing sentence in the case at hand. Figure 4 shows the intelligent output of the system.

We have not been bothered by the fact that different experts assigned slightly different weights to the factors. The contribution of the past record to the sentence in the case at hand is never as great as the contribution of the offence at hand, so there cannot be a great sensitivity in the choice of constants.

5. Conclusion

In the introduction we raised the question about the correlation between general criminal offenders and traffic offenders. We have examined records of offenders who committed both kinds of offences, and also searched the literature. A large number of papers in the field of Criminology address this question, without reaching any definite conclusions. It is therefore not surprising that we have not found any correlation.

At this stage the system is undergoing testing by the experts under laboratory conditions, not in the courtrooms. It is not clear to what extent the traffic judges in Israel will actually use this system. We have in the past been involved in building DSS for sentencing of various kinds. All were favourably received by the judiciary, legal practitioners and the police. None of these systems are in actual use. This phenomenon has also been observed by others [11]. This question will be the subject of our future work.

6. Acknowledgements

We want to thank Advocate Hanan Mandel for his great help in carrying out this project in a successful manner.

This work was graciously supported by The Ran Naor Foundation for the advancement of road safety research (resh-gimmel 2006-009). We are deeply grateful for this support, without which the research could not have been carried out.

7. References

1. Schild Uri J., Kannai Ruth, Intelligent Computer Evaluation of Offender's Previous Record, ***Proceedings of the 9th Int. Conference on AI and Law*,** ACM Press, 2003, 206-213.
2. Schild U.J., Kannai R, Computer Evaluation of Offender's Previous Record, *Journal of Artificial Intelligence and Law*, 2005, vol. 13, 373-405
3. Shneiderman, B., Plaisant C., *Designing the user interface: Strategies for effective human-computer interaction (4th ed.)* . Reading, MA: Addison-Wesley Publishing, 2005
4. Wellbank M., *A Review of Knowledge Acquisition Techniques for Expert Systems*. Ipswitch: British Telecom, 1983.
5. Chan J. A Computerized Sentencing Information System for New South Wales Courts. *Computer Law and Practice*,137-150 (1991).
6. Hutton N., Patterson A., Tata C. and Wilson J., Decision Support for Sentencing in a Common Law Jurisdiction. *Fifth International Conference on Artificial Intelligence and Law (ICAIL-95)*, 1005, .pp. 89-95. Washington D.C.: ACM Press.
7. Hutton N., Tata C., Sentencing Reform by Self-Regulation: Present and Future Prospects of the Sentencing Information System for Scotland's High Court Justiciary, *Scottish Journal of Criminology*, 6, 2000, pp. 37-51.
8. Schild Uri J. (1998). Decisions Support for Criminal Sentencing, *Artificial Intelligence and Law*, 6(4): pp. 151-202, Kluwer Publ
9. Hacohen-Kerner Y. and Schild U. J., The Judge's Apprentice, *The New Review of Applied Expert Systems*, 1999, Vol. 5, pp.191-202.
10. Stranieri, A., Zeleznikow, J., Gawler, M. and Lewis, B., A Hybrid rule-neural approach for the automation of legal reasoning in the discretionary domain of family law in Australia. *Artificial Intelligence and Law* 7(2-3), 1999, 153-183.

11. Tata C., Resolute Ambivalence, Why Judiciaries Do Not Institutionalize Their Decision Support Systems, *International Review of Law, Computers & Technology*, 14(3), 2000, pp 293-316.

8. Figures

Fig. 1. Computer printout from Israeli Police computer of an offender's previous record of traffic offences

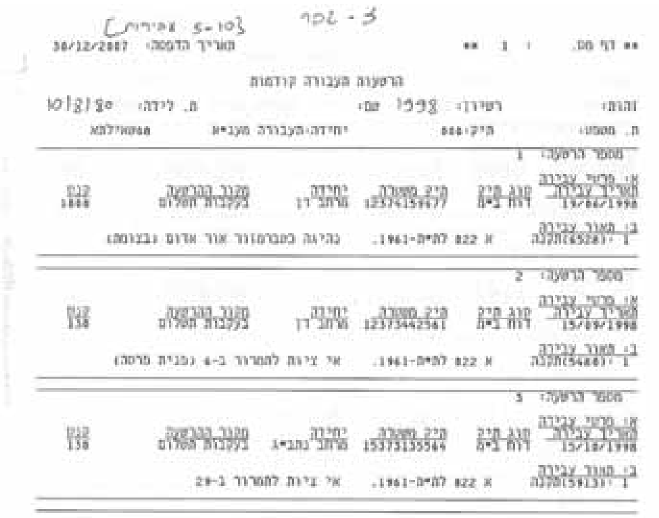


Fig. 2: Short summary of previous record. Same colour-scheme as in Figure 2

Fig. 3. An offender's previous traffic record as it appears in our system (not on scale - in actual system it appears as a full screen). The fields are coloured according to different kind of traffic offences (red light, speeding, invalid licence, etc.)

Fig. 4. Graph showing sentences over time. The upper graph shows sentences of driving disqualification, and the lower graph shows fines (not on scale - in actual system it appears as a full screen). The y-axis indicates months (for disqualification) and sums in NIS (for fines)

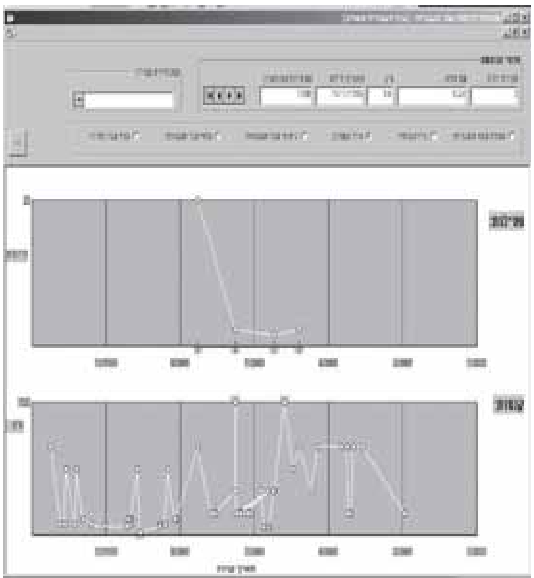


Fig. 5. List and pie-chart showing the relevant factors for weighing traffic offences, summarizing the past record and computing a recommendation. Same color scheme as in Figure 1 (not on scale - in actual system it appears as a full screen)

From Real-World Regulations to Concrete Norms for Software Agents – A Case-Based Reasoning Approach

Tina Balke[1], Paulo Novais[2], Francisco Andrade[3], Torsten Eymann[4]

Abstract. When trying to use software agents (SAs) for real-world business and thereby putting them in a situation to operate under real-world laws, the abstractness of human regulations often poses severe problems. Thus, human regulations are written in a very abstract way, making them open to a wide range of interpretations and applicable for several scenarios as well as stable over a longer period of time. However, in order to be applicable for SAs, regulations need to be precise and unambiguous. This paper presents a case-based reasoning approach in order to bridge the gap between abstract human regulations and the concrete regulations needed for SAs, by developing and using a knowledge base that can be used for drawing analogies and thereby serves as reference for "translating" abstract terms in human regulations.

Keywords: Software Agents, Case-Based Reasoning, Electronic Contracting, Dispute Resolution

1. Introduction

Intelligent inter-systemic electronic contracting is a specific way of forming contracts by electronic means in such a way that contracts are concluded and perfected exclusively by the actuation and interaction of intelligent and autonomous informatics devices capable of autonomous, reactive and proactive behavior, of reasoning, of learning through experiences, of modifying their own instructions and, last but not least, of making decisions on their own and on behalf of others (AI and Law) [35]. In this form of contracting, an important role is played by intelligent software agents (SAs). And these may be fictioned as tools controlled by humans or faced as subjects of elec-

1. University of Bayreuth, Chair of Information Systems Management Bayreuth, Germany, tina.balke@uni-bayreuth.de
2. Universidade do Minho, DI-CCTC, Braga, Portugal, pjon@di.uminho.pt
3. Universidade do Minho, Escola de Direito, Braga, Portugal, fandrade@direito.uminho.pt
4. University of Bayreuth Chair of Information Systems Management Bayreuth, Germany, torsten.eymann@uni-bayreuth.de

tronic commerce, they may be seen as legal objects or as legal subjects [4, 5]. Yet, in any case, it is important to legally consider their own and autonomous will [6]. Thus, within the last years the vision of autonomous software agents conducting inter-systemic electronic contracts on behalf of their principals in the Internet has gained wide popularity and scientists have published a wide number of papers with possible application scenarios [24]. However, when thinking about these scenarios one needs to keep in mind, that the Internet (as an extension of the real-word) and all its users are affected by real-world regulations. Consequently, SAs that act on behalf of their human owners are subject to real-world regulations as well [12]. Neglecting the question of how legal acts by SAs should be interpreted, nevertheless the problem arises that SAs as actors in the Internet need to understand the legal context in which they are acting. Hence when performing legal acts for their principals, SAs need to understand the corresponding human regulations [18] in order to be able to assess when and under which circumstances a regulation is violated and when not and what punishment might follow. One possible relevant issue is the mere consideration of rules and sanctions, especially when considering the communication platforms and the relations between SAs and platforms: if SAs don't abide by the rules, probably they may be put out of the platform and, eventually, they might even be totally destroyed or "murdered" [7]. But another important issue, especially when considering the will of the SA in legal relations, has to do with the consideration of legal rules and the possibility that SAs actually know them and adopt certain standards of behavior according to the legal rules. However, is it reasonable to expect that SAs behave in accordance with legal rules? [13]

This will be especially relevant in situations of on-line dispute resolution, which results in the moving of already traditional alternative dispute resolution "from a physical to virtual place" [11]. This allows the parties not just the ease of litigation, but mainly a simple and efficient way of dealing with disputes, saving both "temporal and monetary costs" [26]. Several methods of Online Dispute Resolution (ODR) may be considered, "from negotiation and mediation to modified arbitration or modified jury proceedings" [21].

Anyway, regardless of the method to be adopted, we must confront ourselves with the existence of different ODR systems, including legal knowledge based systems appearing as tools that provide legal advice to the disputant parties and also "systems that (help) settle disputes in an online environment" [17]. Yet, it is undoubtful that Second Generation ODR in which ODR systems might act "as an autonomous agent" [32] are also on the edge of becoming a way of solving disputes. In considering this possibility, it is not our purpose to question the Katsch vision of the four parties in an ODR process: the two opposing parties, the third party neutral and the technology that works with the mediator or arbitrator [25]. But here, it must be assumed a gradual tendency to foster the intervention of SAs, acting either as decision support systems (DSS) [11] or as real electronic mediators [32]. Surely, this latest role for SAs would imply the use of artificial intelligence techniques through case based reasoning (CBR) and information and knowledge representation. "Models of the description of the fact situations, of the factors relevant for their legal effects allow the agents to be supplied with both the static knowledge of the facts and the dynamic sequence of events" [32]. Of course, representing facts and events would not be sufficient for a dispute resolution, the SA in order to perform actions of utility for the resolution of the dispute also needs to know not only the terms of the dispute but also the rights or wrongs of the parties [32], and to foresee the legal consequences of the said facts and events. Actually, we may well have to consider the issue of software agent really understanding law or, in the way the Dutch doctrine has been discussing about legal reasoning by software agents and its eventual legal responsibility: "are law abiding agents realistic?" [13]

The problem that arises when SAs are to operate under real world conditions is that human regulations are usually written in a quite abstract way and are often open to interpretation [22]. The main reason for this is to cover a large number of cases with the same legal text and to keep regulations stable over a longer period. Thus if being formulated in an abstract way, the same legal text can be applied to several scenarios and only its interpretation needs to be adapted [39]. For instance, German regulations on the obligation in kind, e.g. obligations of a seller who has not sold a specific item, but an item of a certain kind are as follows: (§243 German Civil Code (BGB) [1]):

(1) A person who owes a thing defined only by class must supply a thing of average kind and quality.

(2) If the obligor has done what is necessary on his part to supply such a thing, the obligation is restricted to that thing.

In this case "*average kind and quality*" and "*what is necessary*" are abstract terms/actions that (on purpose) are not properly defined, so that the number of accepted ways for the debitor to fulfill his obligation(s) in kind can be extended without changing existing laws. Furthermore, the study of law itself is not a natural science but is based on hermeneutics where coherence and context are used to solve a given problem. Thus, in the example the fulfillment is linked to the contextual circumstances, leaving more room for interpretation on both sides.

As mentioned earlier, this abstraction and possibility of multiple interpretations that is positive for humans pose severe problems when trying to implement them for SAs where meaning should be precise and unambiguous. In order to tackle this problem, this paper will present a cased-based reasoning (CBR) approach, in which a context depended knowledge-base is set up that can be used for terminological interpretations and comparisons by the SAs. In detail the paper is structured as follows: in order to lay the foundations for the CBR approach, related work dealing with the question of representing knowledge and regulations for SAs will be presented and compared to CBR in chapter 2. Afterwards, in chapter 3.1 CBR and its six steps will be illustrated in more detail. Last but not least, in chapter 3.2 the CBR model will be used to analyze the example just mentioned in the last paragraph. The paper will close with a short summary and conclusion.

2. Related work

After briefly explaining the problem of "translating" abstract human regulations for SAs, in this chapter the related work will be presented. Therefore existing approaches to represent information and rules shall be analyzed. As however, a multiplicity of ways to represent information and regulations exists so far, this paper tries to classify them into 4 categories - namely *rule-based systems*, *ontologies*, *semantic webs* and *case-based reasoning systems* [20] - and will analyze the categories respectively.

2.1 Rule-Based Systems

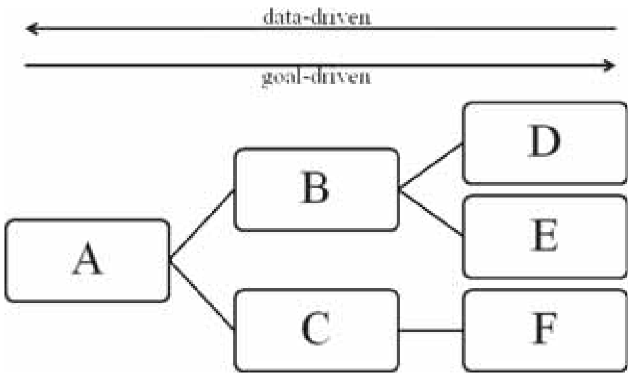
As the name already indicates, rule-based systems are composed of a finite number of rules. These rules normally can be formulated as conditional clauses of the following form:

IF condition *A* holds, *THEN* it can be concluded that statement *B* is true as well. (If *A* then *B*.)

Thereby the "if"-part of the rule is called proposition or left hand side whereas the "then"-formulation is referred to as conclusion or right hand side. Besides these rules, the knowledge base in rule-based systems consists of facts. Facts, in general, are elements that can be described by a finite amount of discrete values [3]. The coherences between the elements are represented by rules. Both components, the rules and the elements, form the abstract knowledge of the rule-based system.

In order to apply the abstract knowledge to a new context, such as in the case of the context-depended "obligations in kind" mentioned in chapter 1, a detailed context description (i.e. concrete or case-specific knowledge) as well as an inference mechanism are required. Depending on the application, the inference mechanism can either be applied data-driven (forward-linked) or goal-oriented (backward-linked). In the first case, the case specific knowledge is used as initial point for the reasoning process. Starting from the fulfilled assumptions, the rules are used to infer about the truth of the concluding rules. Subsequent, the deduced facts on their part are used as initial points for the further inference process. In contrast, the goal-oriented approach uses the opposite conclusion-direction. Thus, the final situation is taken as initial point and all rules are checked by moving backwards, like in a decision tree where starting from the top-node all subjacent edges and nodes are verified (see figure 1).

Figure 1. The tree structure of rule-based systems



When judging the applicability of rule-based systems for the “translation”-problem mentioned in the introduction it has to be noticed, that although they foster a well structured analysis, they do not seem applicable. One reason for this is that in rule-based systems all possible situations (or facts) and rules need to be known in advance, leaving not only the problem of pre-definition, but this invokes such a large number of propositions and rules that need to be defined (if one wants to map everything for the SA) that the systems consistency and transparency are more than in danger.

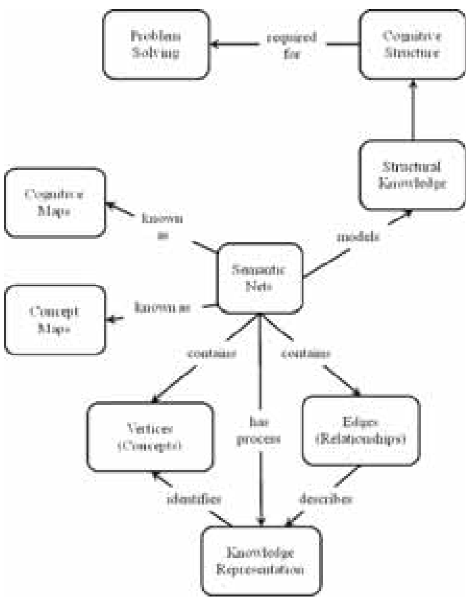
2.2 Ontologies

Another method discussed in literature to move from abstract human regulations to concrete ones for SAs are ontologies (see [39] for example), as their formulation and usage enables programmers of SAs to separate the knowledge of a system (including the terminological knowledge) and the processes. As a consequence of this separation the knowledge can be analyzed, processed and expanded independent of the processes and can be used by SAs for communication purposes. Thereby all knowledge that needs to be used for the communication of SAs needs to be completely represented by the ontology. An ontology itself is a description (like a formal specification of a program) of the concepts and relationships that can exist for an agent or a community of agents. Thus, in the ontology, the individual communication elements correspond to language constructs that are arranged according to a standardized, predetermined form. Besides this integrative form of the communication elements the content of the messages is restricted as well [23]. Although this restriction seems delimiting, it nevertheless ensures that the communication partners use a certain common vocabulary and understand the same terms. This is comparable to the human language: a reasonable communication is only possible if all persons participating associate the same meaning with the same terms. For SAs the establishment of a common ontology means that abstract terms, although having a number of meanings in human interpretations, can be translated to a specific terms that are understood by all SAs the same way, solving the problem of making abstract terms understandable for SAs. Although this idea sounds reasonable and might be applicable for very specific scenarios, as the rule-based systems it brings along complexity problems as soon as these specific scenarios are left. Thus, although ontologies offer standardized text constructs that might be used for negotiation, often these are not being used in the specifications and negotiations (e.g. for reasons of the lack of adaptability of the ontological terms to new situations), but free-text fields are used instead. This however, makes ontologies disadvantageous for bridging the gap between abstract human regulations and specific ones for SAs and illustrates the need for a better concept to solve the problem.

2.3 Semantic Nets

The last group of methods of solution that shall be discussed in this paper - besides CBR approaches - are semantic nets, which were first invented for computers by Richard H. Richens of the Cambridge Language Research Unit in 1956. A Semantic net is net, which represents semantic relations between the concepts. This is often used as a form of knowledge representation. It is a directed or undirected graph consisting of vertices, which represent terms and concepts, and edges that represent the relations between the terms [38] (see figure 2 for example).

Figure 2. Semantic Nets



By using semantic nets for concepts and terminologies, SAs are given the capability to understand and process freely drafted texts by referring to the components of the nets and their structure to one another. Although this solves one problem occurring when applying ontologies, several further problems remain. Thus, although semantic nets are appropriate for specifying fuzzy terms that consist of several elements (i.e. items with vague component specifications), it is difficult to construct semantic nets that help to define single terms that are hardly divisible such as the term "average" when referring to the kind and quality when dealing with obligations in kind.

3. Cased-based reasoning

As a result of the limitations of the approaches presented so far, this paper will present a mechanism that overcomes these limitations and helps to solve the translation problem introduced in chapter 1: the CBR approach. The fundamental idea of this approach is not to try to "translate" abstract terms directly, but - as done in hermeneutics - to use coherence and context to address the problem [8]. Thereby it is assumed that similar cases normally tend to have similar solutions and similar terms normally tend to have similar meanings, even if they emerge against different backgrounds. Consequently the knowledge gained from solving earlier translation problems can be used as a first approximation when new translation problems appear [36]. This idea of cases that are used for drawing analogies is very well known in legal practice [9] and therefore has the advantage of being [10] widely discussed and reasoned about. A concrete case of case-based reasoning at least consists of a description of the problem (i.e. the abstract terms) and the solution found therefore (i.e. the translation in a specific context). In addition the solution to the problems can be associated with a quality assessment or justifications why a specific solution was chosen for a specific case. The individual cases are stored in a knowledge base which can be resorted to when a new problem arises.

3.1 The 6 steps of Case-Based Reasoning

The six step CBR process model that will be used in this paper was first presented by Roth-Berghofer and Iglezakis [34] who expanded the often cited CBR model of Aamodt and Plaza [2]. The model consists of the six steps retrieve, reuse, revise, retain, review and restore that are integrated into two separate phases, the application and the maintenance phase (see figure 3).

Retrieve. Given a target problem, in the first phase of the model, similar cases[5] that are relevant for solving the new problem are retrieved cases from

5. For more information about how to retrieve similar cases and to draw analogies between them see [29] or [14] for example. They, for example, propose to use a memory that organizes expe-

memory. A case consists of a problem, its solution, and, typically, annotations about how the solution was derived. For example, suppose an agent wants to buy a specific complex grid service (that uses CPU time, disk space and memory for its calculations) in the name of his principal. So far, however he has never bought such a service before and is no familiar with the vocabulary applied. Thus, being a novice in this area, the most relevant experience he can recall is one in which he successfully bought some virtual disk space, i.e. a resource that the service he wants to buy now consists of [19]. The procedure he followed for buying the disk space, together with the justifications for decisions made along the way, constitutes the agent's retrieved case.

Reuse. After the retrieval of similar cases, these solutions from the previous cases have to be mapped to the target problem. This is done in the reuse-phase. The mapping itself may involve adapting the solution as needed to fit the new situation. In the grid service example, this would for example mean that the agent must adapt his retrieved solution to focus on complex services instead of "simple" resources.

Revise. Having mapped the previous solution to the target situation, the next step is to test the new solution in the real world (or a simulation) and, if necessary, revise it. Suppose the agent adapted his grid resource solution by adding the costs for the individual resources up in order to have an idea about the price for the service. After this, he discovers that the aggregated costs for the individual resources are much higher than the costs for the complex service and he offered the seller of the service too much money for it, as his cost calculation did not account for this interrelation - an undesired effect. This suggests the following revision: concentrate on market prices when trying to calculate the costs for a service and do not aggregate the costs of the individual resources instead.

By finishing the revision, the application phase (i.e. the actual problem solving) itself can be closed[6]. However for a CBR system to function properly the knowledge base that it is based on, needs to be sustained. This is done in

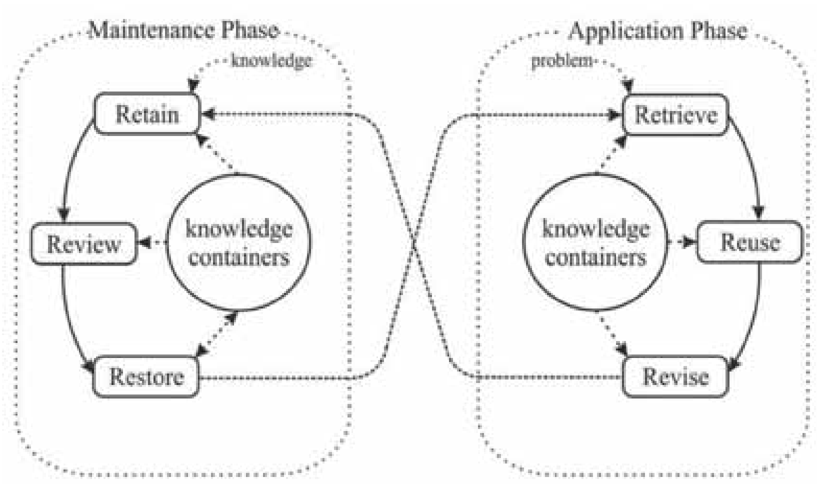
riences (cases) based on generalized episodes. These structures hold generalized knowledge describing a class of similar episodes. An individual experience is indexed by features which differentiate it from the norms of the class (those features which can differentiate it from other similar experiences). As a new experience is integrated into memory, it collides with other experiences in the same generalized episode which shares its differences. This triggers two processes. Expectations based on the first episode can be used in analysis of the new one (analogy). Similarities between the two episodes can be compiled to form a new memory schema with the structure just described (generalization) [28].

6. At first glance, CBR (and especially its application phase) may seem similar to the rule-induction algorithms of machine learning as it starts with a set of cases or training examples and forms generalizations of these examples, albeit implicit ones, by identifying commonalities between a retrieved case and the target problem. The key difference, however, between the implicit generalization in CBR and the generalization in rule induction lies in the point when the generalization is made. A rule-induction algorithm draws its generalizations from a set of training examples before the target problem is even known; that is, it performs eager generalization. In contrast, CBR starts with the target problem and delays implicit generalization of its cases until testing time.

the maintenance phase which consists of the three sub-phases retain, review and restore.

Retain. After the solution has been successfully adapted to the target problem, together with the resulting experience, it should be stored as a new case in the memory i.e the knowledge base. The agent, accordingly, records his newfound procedure for buying grid services, thereby enriching his set of stored experiences, and better preparing him for future grid service transactions. A second purpose of the retain step is to modify the similarity measures by modifying the indexing structures. However, modifications like this should only be implemented in case-based reasoning if it is possible to track the changes or better measure the impact of those changes.

Figure 3. The six steps in CBR



Review. The review step considers the current state of the knowledge containers and assesses their quality. For this purpose appropriate measures need to be found. In literature two fields of corresponding kinds of measures can be distinguished: syntactical measures (i.e. measures that do not rely on domain knowledge) like minimality, simplicity, uniqueness, etc. [33], and semantical measures (i.e. measures using domain knowledge) which check whether the cases are (still) relevant for example [37].

Restore. Finally, the last phase comes into play in case in the review phase it was identified that the quality level of the cases is not as desired. In this case measures to lift the quality level above the critical value are suggested and if approved are being implemented [34].

After having had a look at the CBR model and its six steps in general, in the next chapter, the model shall be applied to the obligation in kind example given in the introduction in order to show the CBR potentials for helping to make abstract terms understandable for SAs. Thereby special focus will be on the potential prerequisites and problems within the six steps as well as potential solutions to these.

3.2 Applying the Case-Based Reasoning Approach

After explaining the general CBR approach, the question arises how it can help with "translation" abstract legal terms for SAs. Therefore the example given in the introduction (concerning the "obligations in kind") shall be recalled. One example where this regulation applies is the domain of cloud computing. The term cloud computing describes the idea that similar to other services - such as electrical power, the telephone, gas or water, in which the service providers seek to meet fluctuating customer needs, and charge for the resources based on usage rather than on a flat-rate basis - IT-services are sold over the Internet [15]. Examples of such IT-services are storage space, server capacity, bandwidth or computer processing time. Cloud computing envisions that in contrast to traditional models of web hosting where the web site owner purchases or leases a single server or space on a shared server and is charged a fixed fee, the fixed costs are substituted by variable costs and he is charged upon how much he actually uses over a given period of time. The negotiation of the cloud services is performed by SAs that automatically react to changes in the resource needs and buy the additional resources needed. The contracts thereby do not concentrate on specific resources (e.g. a specific part of a certain server as storage space or a specific processor that shall be used for the calculations) but feature obligations in kind (i.e. only the general "storage" service, etc. is fixed in the contracts). The reason for this is that the service suppliers try to optimally use their capacity and therefore allocated and reallocate all services continuously depending on the total demand in the network. That's why in cloud computing contract normally service-packages are offered, leading to problems in the comparability for software agents. This problem is intensified by the fast development in the IT sector, leading to a steady increase in the possible component that can be used for a cloud service.

So how could CBR help to solve this translation problem, i.e. how can SAs learn to reason about very general legal terms such as "average kind and quality" and "what is necessary", etc.? To start the explanation, we would like to recall the general CBR-idea: namely the usage of coherence and context to address. As mentioned in chapter 3.1 it thereby is assumed that similar cases normally tend to have similar solutions and similar terms normally tend to have similar meanings, even if they emerge against different backgrounds. This means that in order to be applicable for the "translation"-example, the SA needs a knowledge base that is filled with at least a few cases. If no similar cases exist, the SA first of all needs to be trained, meaning that it has to pass the decision to his principal who then makes that decision and gives the result to the SA who then is able to fill his knowledge container. As the cases are the fundamental elements of CBR and everything else is based upon them, the case-definition is a first very important step to look at. For practical reasons, normally all cases have a particular name, a set of empirical circumstances or facts, and an outcome representing the results of the problem for the decision, solution or classification it poses [16]. These characteristics of a case are then written down in a systematical structured way, such as in form of tables or vectors, etc. Looking at the cloud example, the set of facts might include the original contract formulations (including the related juristic paragraphs and their formulations), the services requested delivered and some quality criteria of the services (e.g. availability or speed), whereas the outcome description could comprehend in how far the measured quality criteria represent the expected ones and whether any difference can be attribute to the obligation in kind. Once, a knowledge based with a few cases exists, the reasoning process can be started, i.e. the SA has to find a similar case and needs to go on by analyzing which decisions were made in this case and why. A very general scheme for the deduction step was presented by Ashley [9]:

Start: Problem description.

A: Process problem description to match terms in case database index.

B: Retrieve from case database all candidate cases associated with matched index terms.

C: Select most similar candidate cases not yet tried.

If there are no acceptable candidate cases, try alternative solution method, if any, and go to F.

Otherwise:

D: Apply selected best candidate cases to analyze/solve the problem. If necessary, adapt cases for solution.

E: Determine if case-based solution or outcome for problem is successful.

If not, return to C to try next candidate cases.

Otherwise:

F: Determine if solution to problem is success or failure, generalize from the problem, update index accordingly and Stop.

Based on this general algorithm, in literature five paradigmatic approaches comparing the existing knowledge base with new cases can be found; these are: statistically-oriented, model-based, planning / design-oriented, exemplar-based, and adversarial or precedent-based approaches7.

Out of these five, for the cloud example, the model-based paradigm is of special interest, as this paradigm, cases are examples explained in terms of a theoretical model of the domain task. Thus, if the SA is confronted with a new case, it has to determine, if the past explanations (e.g. of the legal terms) apply [30]. Similar cases in the cloud computing-”translation” example

7. For a detailed description of the paradigms see [9].

might for example be transactions about IT services that included §243 of the German Civil Code which the SA has concluded before. Starting from these similar cases, in the next step, the SA is to analyze the similarities between his new problem and the old cases. Thereby he has to include the context of the cases in its reasoning. Finally, if a decision is made concerning the interpretation or the translation of the new terms, the mapping needs to be tested in reality. This can either be done by the software agent sending its decision to its principal for validation purposes or by closing the deal and waiting for the outcome (which is then checked against the expected outcome). Finally, after the "translation"-problem is being solved and the outcome is clear in a next step, the quality of the new solution needs to be assessed. This is either done by comparing the achieved result with the expected one or by transferring the evaluation to the principal who can make more elaborated decisions. Afterwards the SA can decide whether to include this new case in the knowledge base or not. Normally it will choose to do so if the new case expands its knowledge base in a sensible way, e.g. if it has not stored any cases concerning the vocabulary of §243 of the German Civil Code before. This knowledge adaptation is completed by maintaining the knowledge base. Thus in the legal context it might happen that a paragraph or a law is changed or interpreted differently in the course of time.

4. Conclusions

As mentioned in the introduction, when wanting to move to electronic environments where intelligent software agents not only conclude contracts on behalf of their human owners but also may participate in dispute resolution, many challenges need to be overcome. One of them is the problem of the abstractness of human regulations. The paper presented several approaches that can be found in literature (e.g. ontologies, etc.) trying to tackle the problem, which however have several drawbacks and consequently may not be the best choice. That is why the paper presented the CBR reasoning concept and explained how it could help to solve the problem. In contrast to many other approaches, CBR has the advantage of being applicable even to the new problems to be solved (e.g. the understanding of new abstract terms)[8] if the problem is badly structured or described incompletely, if the knowledge base starts with a relatively small number of cases or if the rules between the different components are not all known [27, 31]. For this reason and due to its relative simplicity, in the view of the authors, it is well suited for addressing the "translation"-challenges lying ahead and should be researched in more detail.

8. Although CBR reasoning can be applied if only a small knowledge base is available, the more cases it can build on the better it tends to work.

5. Acknowledgements

The work of Paulo Novais and Francisco Andrade described in this paper is included in TIARAC - Telematics and Artificial Intelligence in Alternative Conflict Resolution Project (PTDC/JUR/71354/2006), which is a research project supported by FCT (Science & Technology Foundation), Portugal.

5. References

1. German civil code (bgb). DTV-Beck, September 2008. 62nd edition.
2. Aamodt and E. Plaza. Case-based reasoning: Foundational issues, methodological variations, and system approaches. AI Communications, 7(1):39-59, 1994. IOS Press.
3. Abraham. Rule-based expert systems. In P. H. Sydenham and R. Thorn, editors, Handbook of Measuring System Design, pages 909-919. John Wiley & Sons, 2005.
4. F. Andrade, P. Novais, J. Machado, and J. Neves. Contracting agents: legal personality and representation. Intelligence and Law, 15(4):357-373, 2007. ISSN 0924-8463.
5. F. Andrade, P. Novais, J. Machado, and J. Neves. Intelligent contracting: Software agents, corporate bodies and virtual organizations. In Establishing The Foundation of Collaborative Networks, volume 243, pages 217-224. Springer Boston, 2007.
6. F. Andrade, P. Novais, and J. Neves. Divergence between will and declaration in intelligent agent contracting. In ICAIL 2007 - Eleventh International Conference on Artificial Intelligence and Law, Stanford University, Stanford, California, USA, June 4-8 2007, pages 289-290. ACM Press, 2007. ISBN 978-1-59593-680-6.
7. M. Apistola, F. M. T. Brazier, O. Kubbe, A. Oskamp, J. E. J. Prins, M. H. M. Schellekens, and M. B. Voulon. Migrating agents: Do sysadmins have a license to kill? In Proceedings of the 3rd International SANE Conference (SANE 2002), 2002.
8. K. D. Ashley. Arguing by analogy in law: A case-based model. In D. H. Helman, editor, Analogical Reasoning, pages 205-224. Kluwer Publishers, 1988.
9. K. D. Ashley. Case-based reasoning and its implications for legal expert systems. Artificial Intelligence and Law, 1(2-3):113-208, 1992.
10. K. D. Ashley. An ai model of case-based legal argument from a jurisprudential viewpoint. Artificial Intelligence and Law, 10:163-218, 2002.

11. E. Bellucci, A. Lodder, and J. Zeleznikow. Integrating artificial intelligence, argumentation and game theory to develop an online dispute resolution environment. In ICTAI-2004 - 16th IEEE International Conference on Tools with Artificial Intelligence, pages 749-754, 2004.
12. G. Boella, L. van der Torre, and H. Verhagen. Introduction to the special issue on normative multiagent systems. Autonomous Agents and Multi-Agent Systems, 17:1-10, 2008.
13. F. M. T. Brazier, O. Kubbe, A. Oskamp, and N. J. E. Wijngaards. Are law-abiding agents realistic? In Proceedings of the workshop on the Law of Electronic Agents (LEA2002), pages 151-155, 2002.
14. M. H. Burstein. A model of learning by analogical reasoning and debugging. In Proceedings of the National Conference on Artificial Intelligence, Washington, D. C., 1983.
15. N. G. Carr. It doesn't matter. Harvard Business Review, pages 41-49, May 2003.
16. Chorley and T. Bench-Capon. Agatha: Using heuristic search to automate the construction of case law theories. Artificial Intelligence and Law, 13:9-51, 2006.
17. De Vries, R. Leenes, and J. Zeleznikow. Fundamentals of providing negotiation support online: the need for developping batnas. In Proceedings of the Second International ODR Workshop, pages 59-67, Tilburg, 2005. Wolf Legal Publishers.
18. F. Dignum. Agents, markets, institutions, and protocols. The European AgentLink Perspective, pages 98-114, 2001.
19. T. Eymann, M. Reinicke, W. Streitberger, O. Rana, L. Joita, D. Neumann, B. Schnizler, D. Veit, O. Ardaiz, P. Chacin, I. Chao, F. Freitag, L. Navarro, M. Catalano, M. Gallegati, G. Giulioni, R. C. Schiaffino, and F. Zini. Catallaxy-based grid markets. Multiagent and Grid Systems, 1(4):297-307, 2005. IOS Press.
20. O. Geibig. Agentenbasierte Unterstützung Öffentlicher Ausschreibungen von Bauleistungen unter Verwendung von Methoden der Künstlichen Intelligenz. PhD thesis, Universität Duisburg-Essen, 2008.
21. J. Goodman. The pros and cons of online dispute resolution: an assessment of cyber-mediation websites. Duke Law and Technology Review, 4, 2003.
22. D. Grossi and F. Dignum. From abstract to concrete norms in agent institutions. In Lecture Notes in Computer Science, volume 3228. Springer, 2005.
23. T. R. Gruber. Toward principles for the design of ontologies used for knowledge sharing. International Journal of Human-Computer Studies, 43(5-6):907-928, November 1995. Academic Press, Inc., Duluth, MN, USA.

24. R. H. Guttman, A. G. Moukas, and P. Maes. Agent-mediated electronic commerce: a survey. The Knowledge Engineering Review, 13(2):147-159, 1998.
25. E. Katsch and J. Rifkin. Online dispute resolution - resolving conflicts in cyberspace. Jossey-Bass Wiley Company, 2001.
26. L. Klaming, J. Van Veenen, and R. Leenes. I want the opposite of what you want: summary of a study on the reduction of fixed-pie perceptions in online negotiations. - „expanding the horizons of odr". In Proceedings of the 5th International Workshop on Online Dispute Resolution (ODR Workshop'08), pages 84-94, 2008.
27. J. Kolodner. Case-Based Reasoning. Morgan Kaufmann Publishers, San Mateo, 1993.
28. J. Kolodner, R. Simpson, and K. Sycara. A process model of case-based reasoning in problem solving. In Proceedings of the Ninth International Joint Conference on Artificial Intelligence, pages 284-290, 1985.
29. J. L. Kolodner and R. L. Simpson. Experience and problem solving: a framework. In Proceedings of the Sixth Annual Conference of the Cognitive Science Society, pages 2-9, Boulder, CO., 1984.
30. P. Koton. Using Experience in Learning and Problem Solving. PhD thesis, MIT, 1988.
31. D. Leake. Cbr in context: The present and future. In D. Leake, editor, Case-Based Reasoning: Experiences, Lessons, and Future Directions, pages 1-30. AAAI Press / MIT Press, 1996.
32. G. Peruginelli and G. Chiti. Artificial intelligence in alternative dispute resolution. In Proceedings of the workshop on the Law of Electronic Agents (LEA 2002), 2002.
33. T. Reinartz, I. Iglezakis, and T. Roth-Berghofer. Review and restore for case based maintenance. In E. Blanzieri and L. Portinale, editors, Advances in Case-Based Resoning, pages 247-259. Springer, 2000.
34. T. Roth-Berghofer and I. Iglezakis. Six steps in case-based reasoning: Towards a maintenance methodology for case-based reasoning systems. In H.-P. Schnurr, S. Staab, R. Studer, G. Stumme, and Y. Sure, editors, Professionelles Wissensmanagement: Erfahrungen und Visionen (Proceedings of the 9th German Workshop on Case-Based Reasoning (GWCBR)), pages 198-208. Shaker-Verlag, 2001.
35. S. Russell and P. Norvig. Artificial Intelligence - A Modern Approach. Prentice Hall, 2002.
36. R. Schank. Dynamic Memory: A Theory of Learning in Computers and People. Cambridge University Press, 1982.
37. Smith and M. Keane. Remembering to forget: A competence.preserving case deletion policy for case-based reasoning systems. In Proceedings of

the 13th International Joint Conference on Artificial Intelligence, pages 377-382, 1995.

38. J. F. Sowa. Semantic networks. In S. C. Shapiro, editor, Encyclopedia of Artificial Intelligence. Wiley, 1987.
39. J. Vázquez-Salceda, H. Aldewereld, D. Grossi, and F. Dignum. From human regulations to regulated software agents‘ behavior. Artificial Intelligence and Law, 16(1):73-87, 2008. Kluwer Academic Publishers.

Linking the Semantic Web to ODR: the Ontomedia project

Marta Poblet[1], Pompeu Casanovas[2], José Manuel López Cobo[3]

Abstract. Despite the conceptual vagueness of definitions, both Web 2.0 and Web 3.0 are opening up for ever-growing communities of users new forms of online interaction and customization of information. In this article we explore some of the critical features of Web 2.0 and 3.0 developments applied to different conflict domains, and then present some of the basic components of the Ontomedia platform. The Ontomedia project aims to provide mediation experts and users with a semantically enriched mediation platform where they are able to interact, mediate, and retrieve useful information on related cases in an effective and friendly way.

Keywords: Online Dispute Resolution (ODR), Semantic Web, Web 3.0, Web 2.0, ontologies.

1. Introduction

Nearly at the end of the second decade of the Web, the boundaries delimiting the notions of Web 2.0, Web 3.0, and the Semantic Web are not clearly drawn. To some people, Web 2.0 and 3.0 are buzzwords, blanket terms or marketing concepts [1, 2]. To some others, they are shortcuts to refer to the second and third decades of the Web, respectively [3]. And to many, Web 2.0 is equivalent to the Social Web, since a crucial aspect of its present development is about users (or prosumers, to use another trendy word) creating and sharing contents within social networks. As regards Web 3.0, there is no similar consensus yet on what is it all about, although the notion already resonates with openness (of protocols, standards, data, etc.), intelligent applications, or semantically enriched contents. Spivack forecasts that "the focus of this decade is going to be about enriching the structure of the Web and transforming the Web from something that today is very much like a file server into something that is more like a database" [3]. To MacManus, "Web 3.0 is about open and more structured data, which essentially makes the Web more 'intelligent'" [4].

1. ICREA Researcher at the Institute of Law and Technology
2. Institute of Law and Technology, Universitat Autònoma de Barcelona, Facultat de Dret, 08193 Bellaterra, Spain
3. Ximetrix Network Thoughts {Marta.Poblet, Pompeu.Casanovas}@uab.cat ozelin.lopez@ximetrix.com

And, then, the Semantic Web comes into play as a distinctive set of technologies and languages whose functionalities are perceived in different senses: adding structure to Web 2.0 as to make it evolve to Web 3.0 [5,6,7], letting machines to get the meaning of information to transform, organize or synthesize data intelligently [2], or, more generally transforming the Web into a Giant Global Graph [8].

Now, how ODR services may benefit from the advancements and opportunities of Web 2.0, Web 3.0, and the Semantic Web? For fifteen years now, ODR services have evolved in parallel to the extension of the Web. In 2006, Colin Rule predicted that "ODR will be one of the biggest beneficiaries of these new technologies, because they are squarely aimed at ODR's core functionality areas: communication, collaboration, and interactivity" [9]. Yet, experts have also warned that ODR services may be lagging behind the curve of both Web 2.0 and Semantic Web recent developments [9,10]. In the pages that follow we will try to offer some answers by providing some recent examples and describing our particular contribution to the field, the Ontomedia project.

2. New approaches to ODR

For roughly two years now, new horizons and opportunities for ODR have incredibly expanded with the emergence of new web tools and services focusing on conflict prevention, conflict tracking, debate, or negotiation. For the sake of clarity, we will distinguish here two different sets of tools: open source platforms and mashups. Even though different in nature and purpose, they all have in common featured aspects of state-of-the-art Web 2.0: open source software, free access, multiplatform facilities, and crowdsourced data.

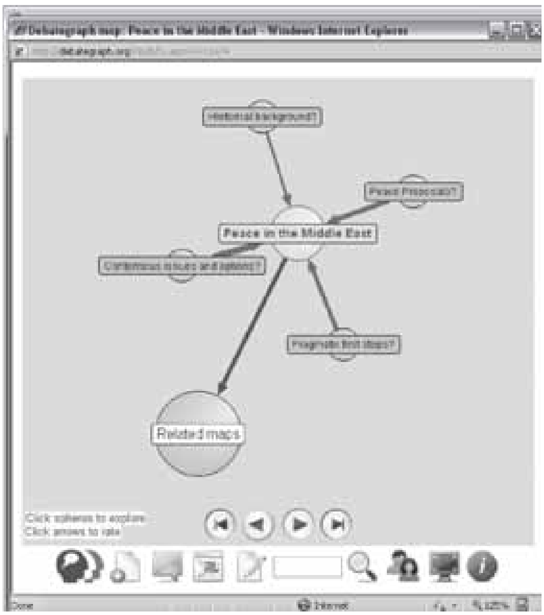
2.1 Open source platforms

- *Ushahidi*—"testimony" in Swahili—is a free, open source platform that allows its users to gather distributed data via SMS, email or web and visualize it on a map or timeline.[4] Through Ushahidi people report real time information of events such as political disruption or natural disasters and the platform aggregates this incoming information for use in a crisis response. The website was created at the beginning of 2008 as a simple mashup, using user-generated reports and Google Maps to map reports of violence in Kenya after the post-election fallout. Ushahidi has recently released the open Beta version of its platform and has been used in different projects in India, Congo, and South Africa.

4. http://www.ushahidi.com/

- *Swift* is a free and open source toolset for crowdsourced situational awareness.[5] The first use of Swift has been as a complement to Ushahidi to monitor the Indian 2009 Elections. Swift embraces Semantic Web open standards “such as FOAF, iCal, Dublin Core, as well as open publishing endpoints such as Freebase” to add structure to crisis data and make them shareable.
- *RapidSMS* is an open source web-based platform for data collection, logistics coordination, and communication developed by the Innovations and Development team of UNICEF.[6] With the RapidSMS web interface, multiple users can simultaneously access the system to view incoming data as it arrives, export new data-sets, and send text messages to users (UNICEF Innovation, 2009).
- *Debategraph* is a web-based, Creative Commons project that has developed a wiki visualization tool to participate in already existing debates or create new ones. The tool includes editing options to raise new points or rating others’ arguments and proposals, and RSS feeds to share, monitor or reuse the debate maps. The first featured debate in Debategraph is “Peace in the Middle East”, which evaluates the contentious issues and potential paths to long-term, sustainable peace in the Middle East.

Fig. 1. Explorer view of a debate in Debategraph



5. http://swiftapp.org/
6. http://www.unicefinnovation.org/mobile-and-sms.php

2.2 Mashups

- *Vikalpa* is a Sri Lanka citizen journalism initiative that in May 2008 launched a micro-site on Twitter with short reports on election related violence and malpractices. Reports were generated by the citizen journalist network in the Eastern Province of the country.[7] The microblogging initiative was complemented with a Google Maps based solution for the Centre for Monitoring Election Violence (CMEV) to locate election related incidents on a map [11].
- *WarViews: Visualizing and Animating Geographic Data on Conflict*. WarViews is a project of The Swiss Federal Institute of Technology that has developed an interface for the exploration of GIS data on conflict. WarViews is offered in two different versions: a static version that runs in a web browser and allows the user to switch between different data sets, and a dynamic version based on Google Earth that can time-animate geographic data such that the development over time can be monitored [12]. WarViews targets both researchers and practitioners in the conflict management and resolution domains.
- *WikiCrimes* is an initiative at the University of Fortaleza (Brazil) that allows posting and accessing criminal occurrences in a Google map.

Fig. 2. Map of election violence in Sri Lanka (10th May 2008)

3. The Ontomedia project

According to Spivack, "there is in fact a natural and very beneficial fit between the technologies of the Semantic Web and what Tim O'Reilly defines Web 2.0 to be about (essentially collective intelligence)" [13]. From these cross-roads

7. http://www.vikalpa.org/archives/category/languages/english/

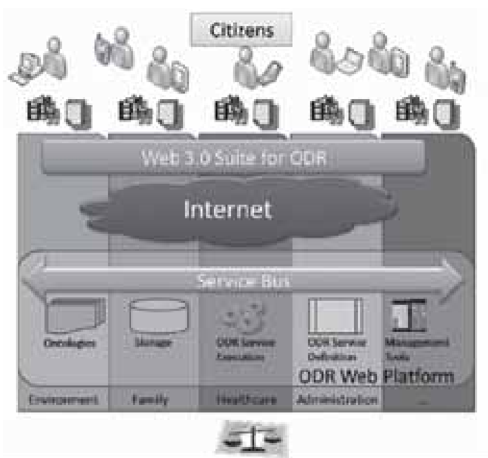
between Web 2.0 and the Semantic Web emerges what is currently known as Web 3.0. Web 3.0, therefore, is about bringing the "connective intelligence" against the already established "collective intelligence" brought by the Web 2.0 [14]. Or, to put in Spivack's words, "about connecting data, concepts, applications and ultimately people" [13]. The use of semantic technologies allows the connectivity through devices, multimedia elements, text and any other Web resource by means of the hyperdata.[8] The Semantic Web is a collective effort led by the W3C in which an evolved Web describes data in a shared and formal format as to be useful for people and machines alike, allowing data to be shared and reused across applications, enterprises, and community boundaries.

The Ontomedia project combines some of these trends and technologies to provide a set of functionalities to a broad community of both professionals of the mediation domain and end-users of mediation services.

From the Ontomedia standpoint, we believe that Web 3.0 technologies can make significant advances into the ODR field, helping professionals in gathering valuable resources relevant to the mediation services they are providing, and helping users as well to share and contribute to harness the connective intelligence about ODR that can be found on the Web.

To some extent, ODR is to ADR what blogs are to newspapers. In that sense, we are talking not only about texts but mainly about videos (mobile or webcam taken), speech, images and pictures. As Web 2.0 implied the massive contribution of content from people, in Web 3.0 people will still be contributing with content, but this content will be automatically annotated to its further use by software agents, connecting one resource to another as the expression of a relationship described in a formal model, known as ontology.

Fig. 3. Conceptual Architecture of Ontomedia



8. Hyperdata is about data that links to other data, as opposed to hypertext which is text linking to other text.

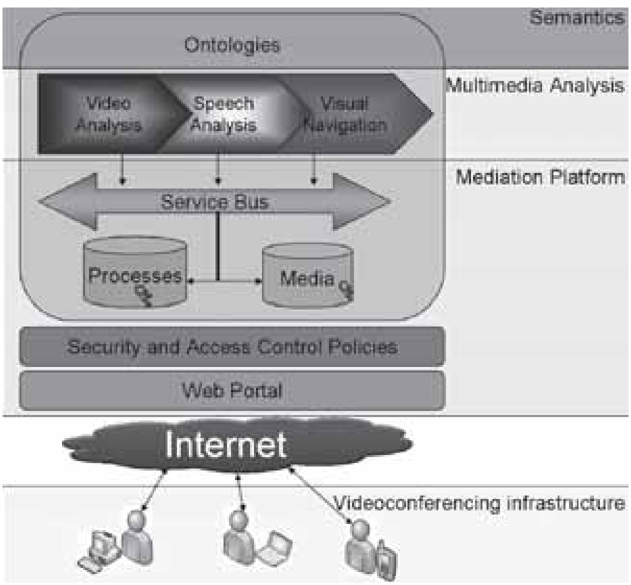
In a nutshell, Ontomedia will allow users and professionals to meet in a community-driven Web portal where contents are provided by users and annotated by the ODR Web Platform. The ODR Web platform is generic, and can be tailored to be effective in several domains such as family, health care, labour, environment, etc.

Citizens (both professionals and users of mediation services) can use any kind of devices to access the portal (computers, mobiles), and in any format suitable to their purposes (text, speech, video, pictures). Users will therefore be able to participate in online mediation services as they do in a face-to-face basis, but with the advantages of distributed and even remote access.

In Ontomedia we also foresee the application of mediation services as tasks within a mediation process that will be formally described by means of both process ontologies and mediation ontologies [15]. These services will be described, stored and made accessible through a service bus that will ensure end to end communication between consumers and providers, as well as a semantic execution engine that takes care of the execution of semantically enhanced mediation processes.

Ontologies will be used to annotate all kind of contents and also to help analyze multimedia content (see Fig. 5). The multimedia analysis is devoted to enhancing the information a mediator possess during a mediation session, capturing mood changes of the parties and any other psychological information inputs that can be useful for mediators, just as if they were in a room with the users of the mediation service. All types of metadata will be automatically extracted and stored to be further used within the mediation process.

Fig. 4. Layered Diagram of Ontomedia Mediation Platform



The access to the portal will be secured and private, and contents will be shown only to profiles of users holding required authorizations. However, if content is authorised to be made available, both users and professionals will have a huge case repository where obtains valuable information concerning a similar case.

Ontomedia will also develop tools to encourage users to exploit the advantages of sharing information and experiences with others. In this way, users will be able to tag and store content that are useful or interesting to them, and to find similar cases. In doing so, they will be able to create social communities of people with common interests.

Related with those initiatives mentioned earlier, Ontomedia will provide a mashable suite of features that will allow users to find in a map similar cases to theirs. The semantic geoposition of those cases and its representation in a map is a trivial feature. What seems more interesting from the user perspective is the posibility to have tag clouds of concepts related with each case and a timeline of concepts against a case.

The set of Web 3.0 features that will be enabled and accesible to users of the Ontomedia platform can be summarised here:

- Annotation of all types of contents. With this feature, a user can easily know if another case has some conceptual similarity with hers. Given a case, a useful visualization feature is the representation of those concepts more relevant in a case as a tag cloud. Just clicking in one concept or other in the tag cloud will show you a set of cases that also are related to that concept.
- Jointly with the annotation, some metadata extraction is automatically conducted, including geoposition of cases, time location and named entity recognition.

  With geoposition, users can see in a map cases similar to theirs, given the set of concepts related to the issues. The tagcloud will always show the concepts that are relevant to cases appearing in the map. Categorization and segmentation will be possible by means of several icons and with just a glimpse the user of the platform will have a powerful tool for visualization and conceptual identification.

  With time location, users will have a timeline. Timelines can show the location of cases against time with respect a particular concept (the aparition of a case related to a concept in a particular time). With this feature, users will be able to see the evolution of the frequency of cases where a concept is concerned.

  Where NER (Named Entity Recognition) is concerned, the platform will be able to detect where well-known entities are mentioned. In Ontomedia, well-known entities are concepts that trascend domain Ontologies like person names, organizations, dates, places, figures and some others. The power behind this feature is that doing so, we will be able to connect well-know entities with well-know facts as those defined with the LOD (Linked Open Data) principles [16]. Where the name of a person is mentioned, if it exists, we will retrieve her FOAF[9] profile. Where a place is mentioned, we will extract the GeoName[10] information available, and so on. This information can be used within Ontomedia to add formal restrictions and reason over it.

– Each concept, each piece of information, each resource is susceptible to have a comment from any user. Users are encouraged to participate within the platform and to build it jointly with other users.

5. Conclusions and future work

Despite the conceptual vagueness of the definitions, both Web 2.0 and Web 3.0 developments offer new forms to interact with the Web that are most relevant to ODR. To be sure, some of their critical features—openness, standardization, free access, connectedness, crowdsourcing effects, etc.—make it possible to enrich ODR services in a wider perspective. The Ontomedia project attempts to learn from these innovations so as to provide an easy-to-use web platform for both mediation domain experts and end-users. A distinctive aspect of Ontomedia, nevertheless, is the application of Semantic Web technologies to enhance online mediation processes. On the one hand, Ontomedia will use ontologies to annotate any kind of content (either textual or multimedia) to help users to participate in the process and search any useful information on related cases. On the other, a semantic execution engine will take care of the execution of the semantically enhanced mediation processes. At the present moment we are developing a mediation core ontology [15] and mediation domain ontologies. Future work also includes semantic geoposition of cases and Named Entity Recognition.

6. Acknowledgments

The research presented in this paper has been developed within the framework of two different projects: (i) ONTOMEDIA: Platform of Web Services for Online Mediation, Spanish Ministry of Industry, Tourism and Commerce (Plan AVANZA I+D, TSI-020501-2008, 2008-2010); (ii) ONTOMEDIA: Semantic Web, Ontologies and ODR: Platform of Web Services for Online Mediation (2009-2011), Spanish Ministry of Science and Innovation (CSO-2008-05536-SOCI)

9. FOAF. Friend of a Friend. http://www.foaf-project.org/
10. Geonames. http://www.geonames.org/about.html

7. References

1. Schmidt, E. Web 2.0 vs. Web 3.0. http://koreacrunch.com/archive/eric-schmidt-web30. (2008) (accessed 7 May 2009)
2. Boutin, G., The definitive definition of Web 3.0, http://www.semanticsin-corporated.com/2008/10/the-definitive-definition-of-web-30.html (2008) (accessed 12 May 2009).
3. Spivack, N. http://thenextweb.com/2008/06/03/video-nova-spivack-ma-king-sense-of-the-semantic-web/ (2008)
4. MacManus, Understanding the New Web Era: Web 3.0, Linked Data, Semantic Web (2009) http://www.readwriteweb.com/archives/understan-ding_the_new_web_era_web_30_linked_data_s.php
5. Greaves, M., Mika, P.: Semantic Web and Web 2.0. Web Semantics: Science, Services and Agents on the World Wide Web, Vol. 6 (1), pp.1–3 (2008)
6. Gruber, T. Collective knowledge systems: Where the Social Web meets the Semantic Web. Web Semantics: Science, Services and Agents on the World Wide Web 6, Vol. 6(1), pp. 4–13 (2008)
7. Hendler, J. Web 3.0 emerging. Computer, IEE, pp. 88-91 (2009)
8. Berners-Lee, T. Giant Global Graph http://dig.csail.mit.edu/breadcrum-bs/node/215 (2007)
9. Rule, C. "ODR and Web 2.0" available at http://www.odr.info/colin/smu/odr%20and%20web%202.doc (2006) (accessed 11 May 2009).
10. Hattotuwa, S.: The Future of Online Dispute Resolution (ODR): Technologies to Keep an Eye On. In 2008 Online Dispute Resolution Forum, June 22, 2008, http://ict4peace.wordpress.com/2008/06/
11. Hattotuwa, S. Maps of election violence and malpractices in Eastern province elections, 10th May 2008, http://ict4peace.wordpress.com/2008/05/10/maps-of-election-violence-and-malpractices-eastern-province-elections-sri-lanka-10th-may-2008/.
12. Weidmann, N.B., Kuse, D. WarViews: Visualizing and Animating Geographic Data on Civil War. International Studies Perspectives, Vol. 10(1), pp. 36-48 (2009)
13. Spivack, N. "The Semantic Web, Collective Intelligence and Hyperdata", available at http://novaspivack.typepad.com/nova_spivacks_we-blog/2007/09/hyperdata.html (2007) (accesed 13 May 2009).
14. O'Reilly, T. "Web 2.0 Compact Definition: Trying Again", available at http://radar.oreilly.com/archives/2006/12/web-20-compact.html (2006) (accessed 12 May 2009).
15. Poblet, M., Casellas, N., Torralba, S., Casanovas, P. "Modeling Expert Knowledge in the Mediation Domain: A Mediatio Core Ontology", in N.

Casellas *et al.* (eds.) *Proceedings of the 3rd Workshop on Legal Ontologies and Artificial Intelligence Techniques (LOAIT'09)*, forthcoming

16. Berners-Lee, T. Linked Data http://www.w3.org/DesignIssues/LinkedData.html (2006)

Intelligent Negotiation Technology

Pamela N. Gray[1], Xenogene Gray[2], John Zeleznikow[3]

Abstract: There have been many decision support systems that provide advice for resolving disputes. However, little effort has been devoted to dispute avoidance. Through the use of the intelligent eGanges shell, this work expands on interest-based negotiation support systems, to develop dispute avoidance ontologies and software for negotiation planning systems. It is suggested that intelligent negotiation technology may add to alternate dispute resolution techniques and further diminish litigation.

An example eGanges application that blends minimax contractual transaction strategy and forward planning of a cohabitation agreement, is used to explain the potential of negotiation planning to avoid commercial and domestic conflict.

Keywords: Dispute Avoidance, Legal Expert Systems, Legal Ontologies, Negotiation Planning, Negotiation Support Systems

1. Background for intelligent negotiation technology

In writing about the Vanishing American Trial, Galanter (2004) argues that, whilst litigation in the United States is increasing, the number of trials decided by US judges has declined drastically; litigants are using alternative forms of Dispute Resolution. Galanter claims that in the federal courts, the percentage of civil cases reaching trial has fallen from 11% in 1962 to 1.8% in 2002. In spite of a five-fold increase in case terminations, the absolute number of civil trials was 20% lower in 2002 than it was 40 years earlier. The use of intelligent negotiation technology to prevent legal conflict may further diminish litigation.

Most negotiations in the legal domain are often conducted in the shadow of the Law i.e. bargaining in legal domains mimics the probable outcome of litigation. Mnookin and Kornhauser (1979) introduced the concept of bargaining in the shadow of the trial. By examining divorce law, they contended that

1. Centre for Research in Complex Systems, Charles Sturt University, Bathurst, NSW 2795, Australia +61 2 6338 4278 pgray@csu.edu.au
2. Grays Knowledge Engineering Sydney, Australia +61 4 0501 9832, xen@grayske.com; www.grayske.com
3. School of Management and Information Systems. Victoria University, Melbourne, VIC 8000, Australia, +61 3 9505 3323. john.zeleznikow@vu.edu.au

the legal rights of each party could be understood as bargaining chips that can affect settlement outcomes.

The shadow of trial model now dominates the literature on civil settlements. Bibas (2004) argues that the conventional wisdom is that litigants bargain towards settlement in the shadow of expected trial outcomes. In this model, rational parties forecast the expected trial outcome and strike bargains that leave both sides better off by splitting the saved costs of trial.

The provision of intelligent legal decision support requires tools to provide advice about negotiation; the practice of law requires knowledge of negotiation as well as knowledge of law. Because most negotiation in law uses the potential decision of the judiciary as a starting point, it is important to know the potential legal outcome of a dispute. Indeed, Lodder and Zeleznikow (2005), in their development of a model for Online Dispute Resolution, determined the order in which online disputes are best resolved. They suggested the following sequencing:

1. The negotiation support tool should provide feedback on the likely outcome(s) of the dispute if the negotiation were to fail.
2. The tool should attempt to resolve any existing conflicts using dialogue techniques.
3. For those issues not resolved in step two, the tool should employ compensation/trade-off strategies in order to facilitate resolution of the dispute.
4. If the result from step three is not acceptable to the parties, the tool should allow the parties to return to step two and repeat the process recursively until either the dispute is resolved or a stalemate occurs.

If a stalemate occurs, arbitration, conciliation, conferencing (or any other Alternative Dispute Resolution technique), or litigation can be used to reach a resolution on a reduced set of factors. The number of issues in dispute can be narrowed to reduce the costs and time taken to resolve the dispute.

Principled negotiation (Fisher and Ury 1981) promotes deciding issues on their merits rather than through a haggling process focused on what each side says it will and will not do. Amongst the features of principled negotiation is knowing your *BATNA* (*B*est *A*lternative *T*o a *N*egotiated *A*greement). Knowing one's BATNA is important because it influences negotiation power. Parties who are aware of their alternatives will be more confident about trying to negotiate a solution that better serves their interests.

The Lodder-Zeleznikow model of Online Dispute Resolution suggests that the important first step in dispute resolution is the provision of BATNA advice. In this paper, we shall focus upon how an expert System Shell, eGanges, can provide intelligent BATNA advice.

Bellucci and Zeleznikow (2006) and Zeleznikow and Vincent (2007) consider how to provide negotiation decision analysis techniques whilst Lodder and Zeleznikow (2005) examines the issue of argumentation for providing intelligent negotiation decision support. However, as Gray et al (2007) point out, even better than providing negotiation support for dispute resolution is providing negotiation support for planning to avoid disputes.

There has been limited research on how to develop negotiation planning support systems which help avoid conflicts. In the domain of family law, (Bellucci and Zeleznikow 2006) have focused upon building negotiation support systems to help resolve marital conflict. Zeleznikow (2004) discusses how the Split-Up system of Stranieri et al (1999) can be used to provide advice about BATNAs in Australian Family Law.

Condliffe (2008) argues that some conflicts cannot be resolved at all, and certainly not easily; thus it is all the more important to avoid conflicts. Blum (2007) argues that protracted armed rivalries are often better managed rather than solved, because the act of seeking full settlement can invite endless frustration and danger, whilst missing opportunities for more limited but stabilising agreements. Once again, all the more reason to avoid conflicts arising. Similarly, rather than resolve a family dispute, should we just manage it so that minimal conflict or disruption occurs?

Eventually, the dispute might be more easily resolved or due to the progress of time, the dispute may no longer exist – such as when dependant children become adults; avoidance of these conflicts may improve the quality of family life for its duration. Dispute avoidance ontology may assist conflict avoidance; if disputes can be anticipated, it is more intelligent to avoid them.

2. Negotiation planning and cohabitation agreements

There is minimal research on building decision support systems which help avoid conflicts. The development of pre-nuptial and co-habitation agreements may avoid domestic conflicts; they can help avoid future disputes about financial resources. The considerations which are necessary for the development of a cohabitation plan, should lead to an increased possibility of a successful relationship.

Gray (1973) proposed a modern cohabitation contract that is negotiated between the intending spouses, as a framework for planning to avoid conflicts. Ancient cohabitation contracts dating back to the Babylonian laws of Hammurabi written in stone (c.2081 B.C.), were negotiated between the parents of the intending spouses.

Cohabitation agreements became enforceable in the state of New South Wales, Australia, under the De facto Relationships Act 1984 NSW; they offer an alternative to marriage and the avoidance of the traumas that can arise in bitter disputed divorce settlements. Such contracts do bring benefits to the relationship. They indicate how a couple intend to conduct their relationship and if the partnership eventually dissolves, appropriate dispute resolution mechanisms.

Although negotiation support systems have been extensively researched over the past twenty years, there has been little research on negotiation and conflict ontologies. Tamma et al (2005) discuss ontologies for supporting automated negotiation. They note that interest in automated negotiation in multi-agent systems has been stimulated to a great extent by the vision of software agents negotiating with other software agents to buy and sell goods and services on behalf of their owners in a future Internet-based global marketplace.

Because most negotiations are domain dependent, very little research has been conducted on developing ontologies to support human negotiators. Stolarski et al (2008) consider a practical example of developing negotiation ontologies for risk management in the travel insurance industry. Gray et al (2007) considers an amalgamation of integrative bargaining and negotiation planning, and develops a prototype negotiation support system that helps avoid domestic conflicts. Considerations in the ontology of possible cohabitation conflict may assist formation of pre-nuptial and cohabitation agreements, and lead to an increased likelihood of a successful arrangement, with ease of renegotiation as circumstances change, and ease of termination. With other appropriate potential conflict ontologies, such as in commerce, environmental use, industrial and cultural relations, inter-governmental matters, and war, similar negotiation support systems might be constructed.

The knowledge structures that are useful in negotiation can be derived from relevant conflict ontologies which may have some conjunctions and some disjunctions. eGanges' can represent clearly these sort of knowledge structures and process them through epistemological heuristics.

3. Intelligent negotiation aid

eGanges (Gray and Gray, 2003), an expert system shell, designed primarily for the domains of law, quality control management, and education, is especially helpful where negotiation requires consideration of a great many possible conflicts, and complex combinatorial reasoning in respect thereof. The shell can provide a visualisation for the management of the conflict ontology as a system of knowledge, and automated intelligent processing of that knowledge.

Choices and their consequents are made clear in the visualisation, and can be freely and randomly navigated and selected for processing. Selections can be made and are processed cumulatively, so that the complex reasoning about the ontology of conflict is automated by way of assistance throughout the negotiation process.

Students in law learn what is required for the formation of a contract whereas, for commercial negotiation purposes, it might be prudent to negotiate a contractual transaction by planning the most advantageous bargain but also by having predetermined acceptable compromises for a fallback contract. At the same time the commercial perspective will predetermine when it is best to avoid the formation of a contract. Where domestic agreements are negotiated, the same realities apply: each party may have preferred bargains, fallback compromises and criteria for avoidance.

The eGanges River visualisation of conjunctions and disjunctions clearly express criteria and alternatives, relative to each other. The fine-graining of negotiation ontology in hierarchical tributaries of conjunction and disjunction introduces intelligent refinement to the negotiation.

In an eGanges map, a soccerball node indicates even finer negotiation pathways. For instance, the initial map of an eGanges application to achieve the Final result of a minimax contractual transaction (Gray and Gray, 2008) is shown in Figure 1, in the Rivers window of the eGanges interface. In the main stream, the first antecedent node is *Minimax conclusion to formation stage*. There are three alternative ways of achieving this antecedent: by *Minimax contract formed*, by *Fallback contract formed*, or by *No contract formed*. The soccerball node *Minimax contract formed* has the submap shown in Figure 2. The soccerball node in Figure 2, *Binding form of negotiation to effect agreement*, also has a submap of further details. This nesting of submaps may be as deep and detailed as the knowledge requires.

Negotiation may require levels of varying ontological depth. The use of theoretical and factual antecedents in negotiation rules may vary within any particular rule or any system of rules; negotiation may be concerned with factual or abstract antecedents, and the factual particularisation of abstract concepts may assist in the negotiation.

The user of an application may freely navigate the eGanges River system, and provide input anywhere in the River system at any time, in whatever order the user chooses. Only the eGanges epistemological processing of the River premises will qualify the effect of random input.

The intelligence features of the eGanges shell make up an epistemology commonly used in the legal domain. There may be other epistemologies also used by lawyers, particularly in the analysis of evidentiary conflicts and gaps. The eGanges epistemology is also suitable for quality control, so that an eGanges application may amount to quality control teaching of law, legal strategy, or a compliance adviser.

The eGanges shell uses intelligent knowledge representation and intelligent processing of that representation through an intelligent communication system. The following are the intelligent features of eGanges that are adopted in an application:

1. Knowledge representation. The largest window in the interface of the eGanges communication system, shown in Figure 7, is the Rivers window, where applications are constructed or consulted. The Rivers window shows a visualisation of a system of interlocking hypothetical

premises that may be nested as far as required by the complexity and extent of the knowledge.

The River graphics in the legal domain are the rules of law or expertise used in the application. They are also the negotiation tributaries or pathways in a legal dispute. The interlocking of antecedents and consequents where they are common to separate rules, creates the hierarchical tributary structure of the River.

2. Through its intelligent communication system, eGanges collects input via its question window which shows the question for the current node under consideration and the answer buttons which show 3 alternative answers for each question. The answers are placed on buttons which are labelled according to the Final conclusion they support. Sometimes all possible answers support a positive conclusion to the negotiation; this is why there are a total of five answer buttons, shown in Figure 7, three of which are all positive.

As answers are selected, the label of the node is recoded as the user's categorical premise in the appropriate adversarial feedback window. Thus the communication system is intelligent. It allows for contradictory categorical premises, although the River visualisation does not show the corresponding contradictory hypothetical premise that is applied. A visualisation of additional contradictory and uncertain hypothetical premises requires a three dimensional graphic (Gray, 1990, 1997).

Once the user has provided the answer input as the categorical premises of the user's case, then eGanges will automatically and cumulatively carry out the combinatorics to give effect to the hierarchy of mixed hypothetical and categorical syllogisms of the negotiation ontology. The combinatorics of the syllogisms are deductive, according to the multiple mixed hypothetical and categorical syllogisms. At any point in a consultation, the current result may be displayed in the Current result window, by pressing the Current result button. Sometimes the Current result is the Final result; sometimes it is a *pro tem* result.

Legal expertise uses and requires four valued logic for automation. This is because, in practice, lawyers must provide for uncertainties in the client's categorical premises. In the cumulative processing of a user's case, the programmer must provide for incomplete instructions. If a Current result is to be given at any point in a consultation, then that result may be the fourth value, unanswered.

Combinatoric automation is only valid if there is a finite set of premises; otherwise Godel's theorem invalidates the processing. The fourth value, unanswered closes the boundaries of the premises for automation. The heuristics of eGanges make provision for the expert and programming four value logic, and implement the prioritisation of consequents in accordance with eGanges' four value de Morgan rules.

For instance, in Figure 6, if the answer to *Co-ed* is negative, indicating that one or both of the parties do not agree to send the children to a co-ed school, then "(neg) Co-ed" will appear in the positive window list indicating a negative disjunction; provided the *Same sex* node is either unanswered or positive. If the *Same sex* node is also answered negative, indicating that the parties can not agree to send the children to a same sex school, then as all options to establish *Sex mix* are negative so *Sex mix* will be established as negative; thereby establishing the nodes *School identity*, *Schools* and *Arrangements for both parties' child(ren)* as negative, regardless of any other node's answers. If *No children of both parties'* is also answered negatively, i.e. there are children, then by deductive flow down the river system it will be established that *Parenting partnership specific* will be negative, i.e. the sex mix of the children's school will be a risk of conflict in the cohabitation.

If instead, *Same sex* is answered as uncertain, and *No children of both parties'* is either negative or uncertain, then uncertainty will propagate down to *Parenting partnership specific*. If *Same sex* is answered as uncertain, and *No children of both parties'* is either unanswered or positive, then "(unc) Same sex" will appear in the positive window list along with "(neg) Co-ed" as these problems won't matter until it is established that the parties have children, but the (neg) and (unc) labels indicate they may become a concern.

The *pro tem* reporting of (neg) and (unc) in the positive adversarial window ensures that the alternatives of a disjunction are available until they are exhausted. Following a four value extension of de Morgan's laws, the negation of a positive disjunction is a negative conjunction that will not be satisfied until the positive disjunction is exhausted.

The de Morgan laws, the Godel validation of the combinatorics with unanswered finiteness, and the four-value logic for uncertainty and incomplete instructions, complicate the processing heuristics but extend the intelligence of the negotiation aid. The extended intelligence may provide validation of the negotiation, and ensure its success.

Static eGanges glosses of inductive and abductive negotiation premises, available as data for retrieval at relevant points in the deductive River system, allow a mix in as non-monotonic without being processed as non-necessary reasoning. This may assist agreement and construction of the negotiation River, and selection from the communication system.

Glosses may be used to list pros and cons of a negotiation rule; this may allow acceptance of a compromise rule as negotiation knowledge. They may also introduce ethics to the negotiation process as well as inductive, abductive, and non-monotonic reasoning and issues.

Where the knowledge River has to be agreed by the parties as part of the negotiation process, the construction of the eGanges application precedes its consultation, and may be ongoing. Godel's theorem requires completion of the knowledge before the eGanges combinatoric processing is valid; it may be said that the knowledge must be holistic for the time being. However, potential ontologies may be always emerging as problematic (Gray, 2007).

4. How eGanges supports cohabitation agreements

The negotiation between cohabitees of an agreement to minimise the risk of domestic conflict, can be located in the framework of a minimax contractual strategy that is for the avoidance of commercial conflict. Thus, a richer appreciation of the bargaining aspects of the cohabitation agreement can be gained. Some aspects of cohabitation planning are commercial.

This calls for a review of social evolution that might be suited to an international civilisation in the age of science and technology. Negotiations for domestic and commercial agreements could rest on survival needs and wants of the parties, as well as, or rather than, individual attributes such as physical beauty, sexuality, emotional reactions, and social relationships that might be more tenuous.

What negotiation derives from technological aids such as eGanges provides for (1) an overall objective (Final result), sub-goals (Consequents), and targets (Antecedents), (2) the quality control detailing of means to the objective, goals, and targets, including provisions for choices, and (3) the logical processing for consistency in selections. These characteristics of intelligent technology may both support and characterise negotiation.

Figure 3 (Gray et al, 2007) is the Initial map of the Cohabitation application, originally prepared prior to and separately from the Minimax contractual application shown in the sample maps of Figures 1 and 2. The processing of the River knowledge requires clear specification of its logical characteristics and potential for automation. Each stream in the tributary structure of an eGanges River represents a formalised rule or conditional proposition. Thus, in Figure 3, which is the Initial map of the eGanges cohabitation application, the mainstream signifies the following hypothetical premise: if duration, nomenclature, property, finance, children, chores, personal matters, variation and termination are agreed on, then there will be minimized risk of conflict in cohabitation. The formalisation is: if (antecedent(s)), then (consequent).

Secondary streams arise from antecedents in the mainstream also as rules or conditional propositions; tertiary streams may arise from an antecedent in a secondary stream as rules or conditional propositions, quaternary streams arise as rules or conditional propositions from an antecedent in a tertiary stream, and so on. At some point a sub-map may be required to further the particularisation, due to the limits of screen size and cognitive map design. Thus the ontology is laid down in its hierarchy of specifications. The eGanges application is finite; it is only as accurate as its River knowledge.

In the specification of the eGanges River hierarchy, the rules of the negotiation that are formalised are also the hypothetical premises in a mixed hypothetical and categorical syllogism. The hierarchy of tributaries represents the hierarchy of such syllogisms. In law, unlike science, the truth of the hypothetical premises is presumed. The exercise of law-making power in making rules obviates the need to establish the truth of the hypothetical premise scientifically.

In the processing of an eGanges application, each antecedent must be established by user input as the categorical premise for the syllogism. Each antecedent node has a question with three alternative answers; the selection of an answer provides the user's input, which is then reported as feedback in the appropriate adversarial window. Like the adversarial windows, each answer is labelled as positive, negative or uncertain to indicate the adversarial window in which the answered node label will, prima facie, be reported.

Thus it can be seen in Figure 1 that, in order to manage a contractual transaction so that risks and losses are minimised and gains are maximised, the first requirement is the *minimax conclusion to formation stage*. If a cohabitation agreement conforms to this requirement, it can be assumed that a minimax cohabitation contract provides minimisation of the risk of domestic conflict. The domestic arrangement then rests on compelling commercial soundness. However, with social studies, the commercial framework may be shown not to be sound for domestic agreements.

If the eGanges application limited to the Final result of *Minimised risk of conflict in cohabitation*, separately posed by Gray et al (2007), is to be reconciled with the minimax contract application, then the Final result of Minimax contractual transaction will broaden and subsume the Final result of *Minimised risk of conflict in cohabitation*. In the amalgamation, Figure 1 can serve as the initial map without change. Effectively, the domestic emphasis shifts from pacifying partners to mutual satisfaction by sharing and exchange of benefits and detriments. The commercial framework brings equality to the negotiation; prima facie, the domestic is dominated by the commercial.

The mainstream antecedents in Figure 3 will then be relocated as either *Selection of consideration* or *Selection of terms* in the stream establishing *Minimax preparations for negotiation of contract* in Figure 2. *Property*, *Finance* and *Chores* are known in commercial consideration; children are not. *Children* belong in terms. *Duration*, *Nomenclature*, *Variation* and *Termination* are also matters of terms, similar to *Commercial terms*. *Personal matters*, depending on what they are, may be matters of consideration or matters of terms. Figures 4-6 suggest reconciliations in the amalgamated application, called here, the Commercial and Domestic Minimax Agreement Negotiation (CDMan) application. Figure 6 replaces the *Children* sub-map indicated in Figure 3, with a sub agreement of *Parenting partnership specific*.

The two applications, reconciled as one, may then employ the same AI techniques of processing input on the particularised hypothetical premises of the substantive negotiation.

5. Future research and conclusion

Current research of negotiation systems have focused upon resolving disputes once they have occurred. But it is easier to avoid disputes, rather than satisfactorily resolve them.

Our research has focused upon designing improved negotiation support processes. On this basis, further measures could be developed for legal fairness in interest based negotiation support systems in family mediation, plea bargaining and housing and condominium disputes.

In this article we have explored the need for intelligent negotiation planning to avoid rather than resolve disputes. The eGanges software has been used to assist development of cohabitation agreements that can help avoid conflicts before and following the breakdown of relationships.

Anti-Violence Worker, Shalini Kumari of the Cumberland Women's Health Centre, in Sydney, has undertaken the development of an eGanges River with the Final result, Minimization of the risk of violence, in which she will encapsulate an ontology of domestic violence that she has formulated over the past 5 years from her 23 years of experience in India and in Australia, working with victims of violence. eGanges allows whole River systems to be pasted into an existing application. When the violence River is completed, consideration will be given to where it might expand the CDMan application.

6. References

1. Bellucci, E. and Zeleznikow, J. (2006). Developing Negotiation Decision Support Systems that support mediators: a case study of the Family_Winner system, *Journal of Artificial Intelligence and Law,* 13(2), 233-271.
2. Bibas, S. (2004). Plea bargaining outside the shadow of the trial, *Harvard Law Review*, 117:2464-2547.
3. Blum, G. (2007). *Islands of Agreement: Managing Enduring Armed Rivalries*, Harvard University Press, Cambridge MA.
4. Condliffe, P. (2008). *Conflict Management: A Practical Guide*, 3rd ed, Lexis Nexis, Sydney
5. Fisher, R. and Ury, W. (1981). *Getting to YES: Negotiating Agreement Without Giving In*, Boston: Haughton Mifflin
6. Galanter, M. (2004). The Vanishing Trial: An Examination of Trials and Related Matters in State and Federal Courts, *Journal of Empirical Legal Studies* 1(3): 459-570.
7. Gray, P.N. (1973). A New Lease of Life. Precedent for a Cohabitation Contract, 123 *New Law Journal*, 591, 596.
8. Gray, P. N. (1990). Choice and jurisprudential systems, LL.M. thesis, University of Sydney, Sydney, Australia.
9. Gray, P. N. (1997). *Artificial Legal Intelligence*, Dartmouth, Aldershot, England
10. Gray, P. N. (2007). Ontology of Legal Possibilities and Legal Potentialities in *Proceedings of the Workshop on Legal Ontologies and Artificial Intelli-*

gence Techniques, International Conference on Artificial Intelligence and Law, Stanford University, ACM. (http://ftp.informatik.rwth-aachen.de/Publications/CEUR-WS/Vol-321/paper1.pdf)

11. Gray, P. N. and Gray, X. (2003). A mapbased expertfriendly shell, in D. Bourcier,(ed.), Legal Knowledge and Information Systems, IOS Press, Amsterdam, Holland.
12. Gray, P. N. and Gray, X. (2008). The chair of Artificial Legal Intelligence, 4th AIJA (Australasian Institute of Judicial Administration) Law & Technology Conference, in Proceedings CD.
13. Gray, P., Gray, X. and Zeleznikow, J. (2007). Decision Negotiating Logic: For richer or poorer. Proceedings of *Eleventh International Conference on Artificial Intelligence and Law*, ACM Press, Palo Alto, Ca., USA. R.Winkels (ed), 978-1-59593-680-6, 247-251.
14. Lodder, A. and Zeleznikow, J. (2005). Developing an Online Dispute Resolution Environment: Dialogue Tools and Negotiation Systems in a Three Step Model. *The Harvard Negotiation Law Review*. 10:287-338.
15. Mnookin, R. and Kornhauser, L. (1979). Bargaining in the shadow of the law: The case of divorce, *Yale Law Journal*, 88: 950-997.
16. Stolarski, P., Tomaszewski, T., Zeleznikow, J. and Abramowicz, W. (2008). A Description of Legal Interpretations in Risk Management with the Use of Ontology Alignment Formalisms, *Expanding the Horizons of ODR: Proceedings of the 5th International Workshop on Online Dispute Resolution*, M. Poblet (ed.) CEUR Workshop Proceedings Series (CEUR-WS.org), Vol. 430, Florence, Italy, December 13 2008, 73-83.
17. Stranieri, A., Zeleznikow, J., Gawler, M. and Lewis, B. (1999). A hybrid—neural approach to the automation of legal reasoning in the discretionary domain of family law in Australia. *Artificial Intelligence and Law* 7(2-3):153-183.
18. Tamma, V., Phelpsa, S., Dickinson, I. and Wooldridge, M. (2005). Ontologies for supporting negotiation in e-commerce, *Engineering Applications of Artificial Intelligence*, 18 (2) 223–236
19. Zeleznikow, J. (2004). The Split-Up project: Induction, context and knowledge discovery in law. *Law, Probability and Risk*, 3: 147-168.
20. Zeleznikow, J and Vincent, A. (2007). *Providing Decision Support for Negotiation: The Need for Adding Notions of Fairness to Those of Interests*, University of Toledo. Law. Review 38:101-143.

7. Figures

Figure 1. Initial map CDMan

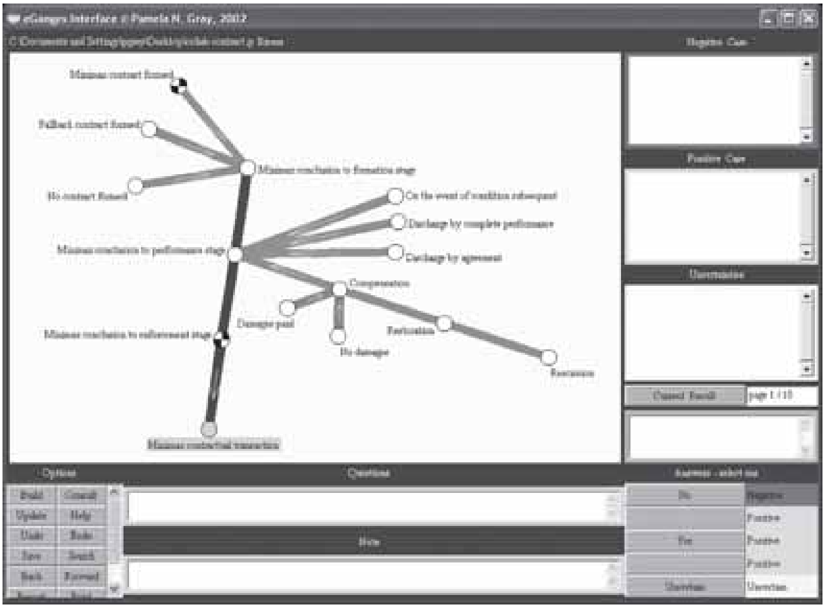


Figure 2. Submap - Minimax contract formed

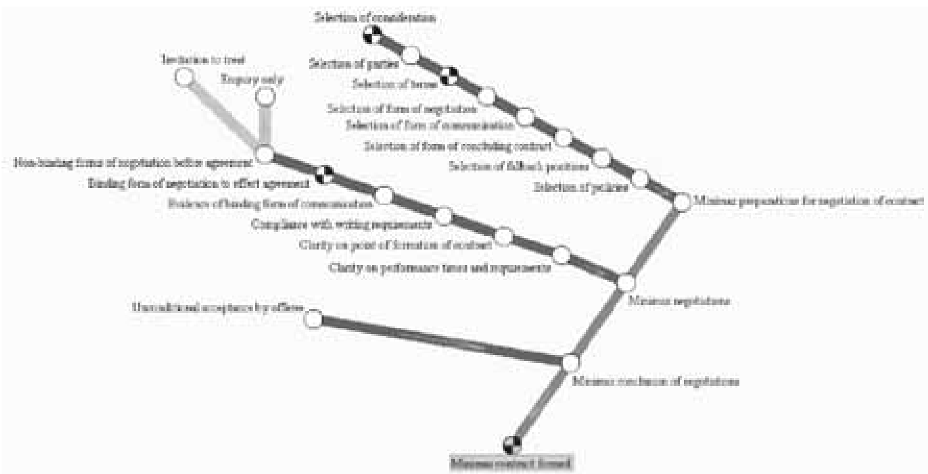


Figure 3. Initial map - Cohabitation application (2007)

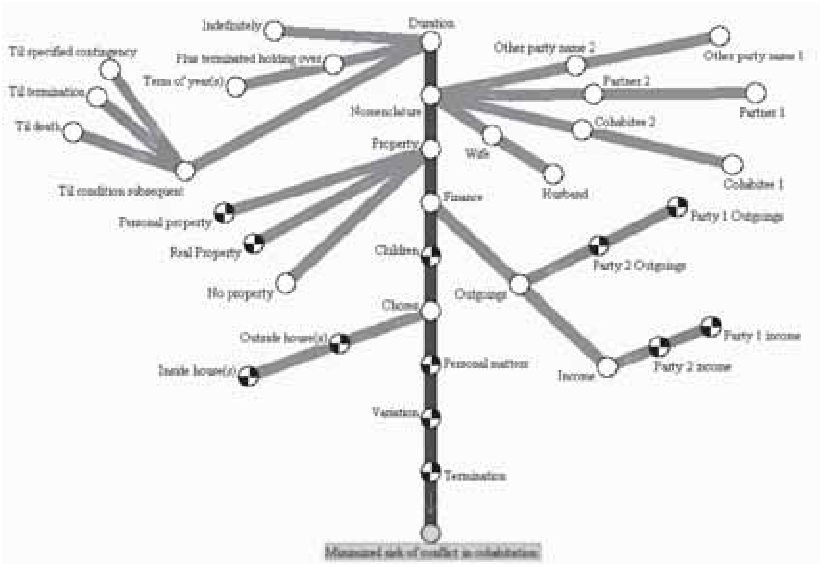


Figure 4. Submap - Selection of consideration

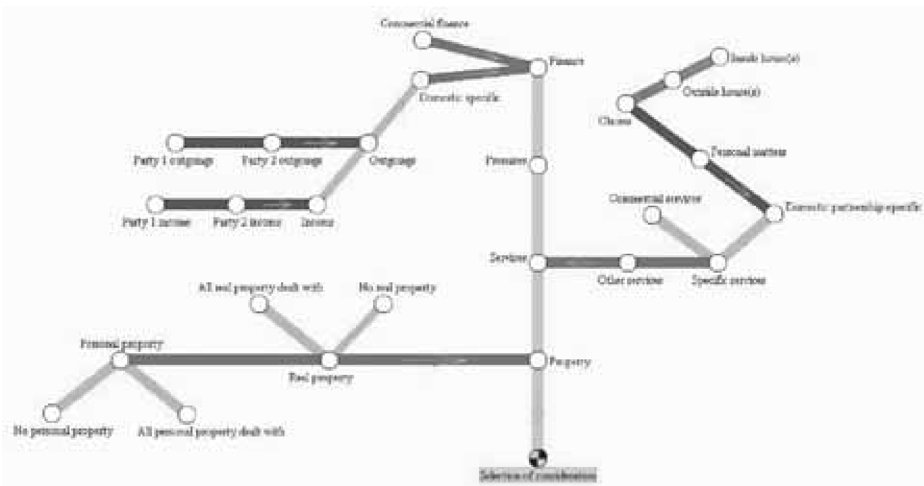


Figure 5. Submap - Selection of terms

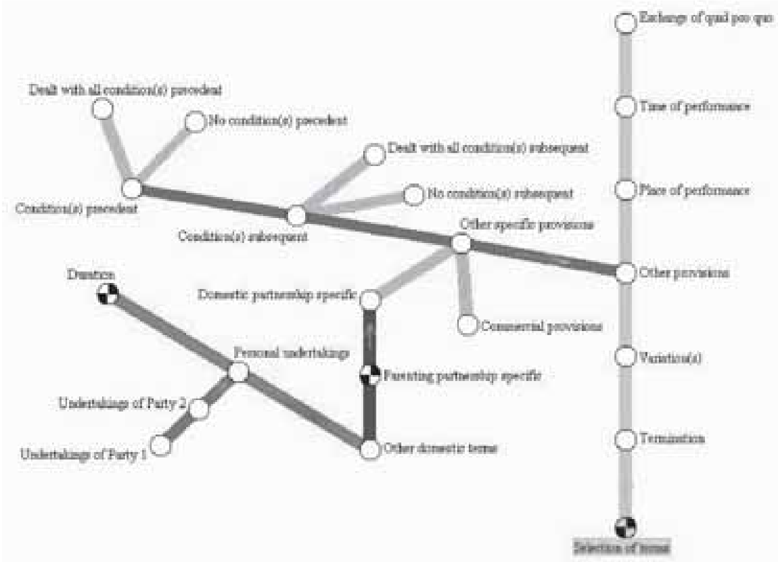


Figure 6. Submap - Parenting partnership specific

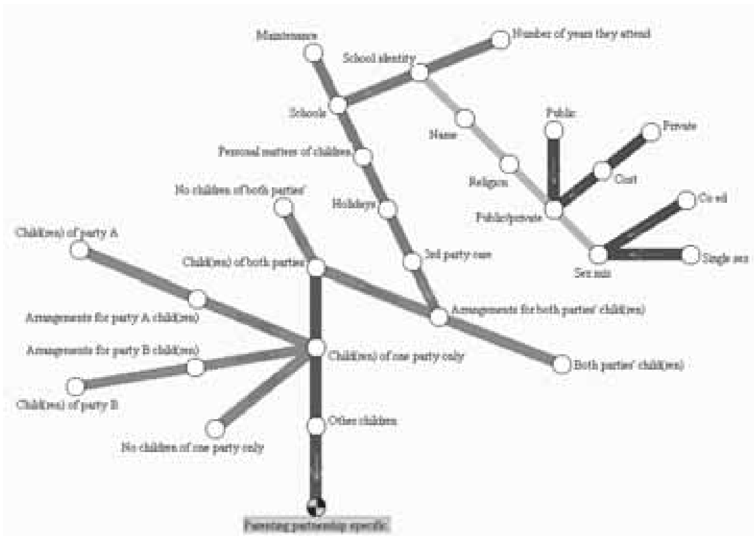
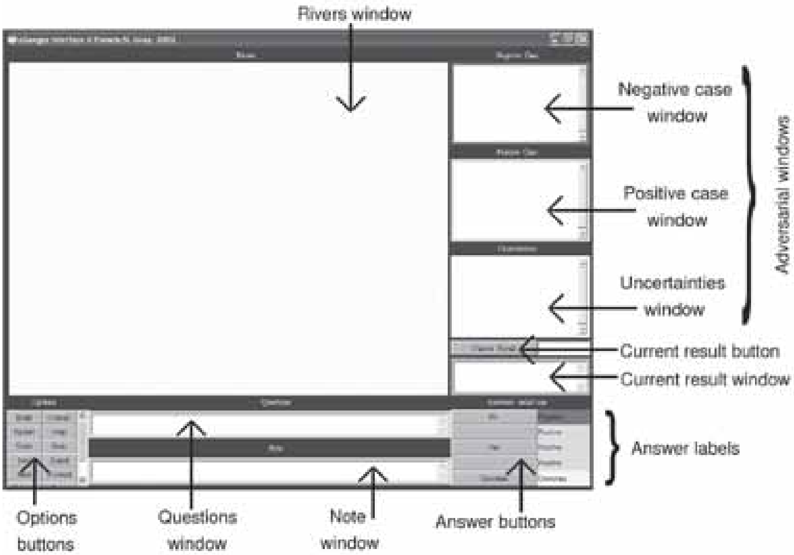


Figure 7. eGanges interface



Software Developed for Use in Family Mediation – AssetDivider

Emilia Bellucci[1]

Abstract: This article describes research into software that supports Family Law mediation. Most divorcing couples enter into mediation to resolve the decisions in who is allocated items from the common pool of assets. AssetDivider supports this task by asking parties to assign ratings to the items in question. The software takes this information and from it develops a list of allocations to each party. This list is developed with knowledge of an ideal "percentage split" that has been set by mediators. The system has been tested informally by our contacts at RAQ, and we now look forward to extensive testing and evaluation by mediators at RAQ in the near future.

Keywords: Negotiation Support Systems (NSS), Family Law Mediation

1. Introduction

The focus of this research is in extending our work in interest-based negotiation to developing research into systems for use in mediations. We have developed several Negotiation Support Systems (NSS) including DEUS, Split_Up and Family_Winner [1]. As a direct result of extensive media interest in Family_Winner [2], we were contacted and have been in negotiations with Relationships Australia Queensland (RAQ). Relationships Australia is a relationship support service, which conducts support services across numerous areas, including family mediation, parenting courses, pre-marriage counselling, and special support services such as counselling to families affected by drought and flooding. We have been in contact with RAQ to develop a new theory of decision support for family mediation.

Negotiation is a process by which two or more parties conduct communication or conferences with the view of resolving differences between them [1]. We believe cooperation between parties as paramount to ensuring both parties are satisfied with the outcome of the negotiation. Their involvement in the decision-making process encourages agreement with the settlement. Mutually satisfying resolutions [3] describe settlements arrived at by the interaction

1. School of Management and Information Systems, Faculty of Business and Law Victoria University. Emilia.Bellucci@vu.edu.au

and input of disputants. Mediators agree with the need for mutually satisfying agreements and are willing to use a NSS if it can support the realities of the negotiation in the domain. We know this because RAQ are eager to use our software.

AssetDivider's predecessor is Family_Winner [2]. The underlying principle of each system is in their use of interests. The theory which best supports our definition of negotiation support is Principled Negotiation [4], developed under the Harvard Negotiation Project. It emphasizes parties look for mutual gains and focuses on the underlying values (or interests) that justify a disputant's position, as opposed to attempting negotiation solely from their positions.

Family_Winner takes a common pool of items and distributes them between two parties based on the value of associated ratings. Each item is listed with two ratings (a rating is posted by each party), which signify the item's importance to the party. A rating in Family_Winner is a number in value from 0- 100 (0 being of no importance; 100 to signify absolute importance). The algorithm to determine which items are allocated to whom works on the premise that each parties' ratings sum to 100; thereby forcing parties to set priorities. The program always checks this is the case, and if not, it realigns ratings to ensure all sum to 100. The basic premise of the system is that it allocates items based on whoever values them more. Once an item has been allocated to a party, the ratings of the remaining items are modified (according to the actions of trade-offs) to ensure the items (and their associated ratings) are ready for the next round of allocation [1].

Family_Winner was evaluated by a number of family solicitors at Victoria Legal Aid (VLA). Whilst the solicitors were very impressed with the way Family_Winner suggested trade-offs and compromises, they had one major concern – that in focusing upon negotiation, the system had ignored the issues of justice [2]. For example, Family_Winner simply allocates property to parties based on their interest in the item. It does not allow for monetary values to influence the allocation process. The dollar value of items is important to the dispute because each party wants to be allocated the right or 'just' amount of money. This concept contrasts with linking an interest value to an item, which is intrinsically different. An interest is an evaluation based on the significance of the item to a person. For example, party A may be very fond of a lamp that has been passed down throughout the generations, and consequently they give it a rating of 50. The remaining items are not as important to party A, and so are given much lower ratings. Whilst using interests to negotiate is a very interesting exercise, it does not in any way reflect the dollar value of the item. This is where Family_Winner fails to support the mediation process effectively. Whilst Mediators from RAQ consider the way Family_Winner supports interest-based negotiation by setting priorities as useful; they are also concerned with the missing influence of monetary values. Hence, our new theory of negotiation support (implemented in AssetDivider) incorporates the basis of

Family_Winner's allocation and trade-off strategy by utilizing both interests and an item's monetary value.

Section 2 will detail this new theory of negotiation support, while Section 3 will discuss the presentation of a family law case to AssetDivider. We are in the process of organising the evaluation of AssetDivider at RAQ, and expect this to occur in the near future.

2. Negotiation Concepts

Early decision-support negotiation systems primarily used Artificial Intelligence techniques to model negotiation. LDS [5] used rule-based reasoning to assist legal experts in settling product liability cases. SAL [6] also used rule-based reasoning to help insurance claim adjusters evaluate claims related to asbestos exposure.

NEGOPLAN [7] is a rule based system written in PROLOG which advised upon industrial disputes in the Canadian paper industry. Mediator [8] used case retrieval and adaptation to propose solutions to international disputes, while PERSUADER [9] integrated case based reasoning and decision-theoretic techniques to provide decision support to United States' industrial disputes.

Negotiation Support Systems (NSS) were primarily responsible for tracking past preferences and informing disputants about progress being made towards a solution to a conflict. We refer to these systems as template systems. Template systems assume disputants take on a passive role after the initial intake of preferences and issues, since they fail to implement any strategies that incorporate change. Modelling the dynamic properties of negotiation infers the incorporation of decision support into a traditional negotiation support system. DEUS [10], INTERNEG [11], CBSS [12], Negotiator Pro and The Art of Negotiating [13] are all template based systems.

We are mostly interested in extending the primary role of a template based NSS to a system capable of providing decision support. We have classified these as Negotiation Decision Support Systems (NDSS). A Negotiation Decision Support System (NDSS) supports negotiation by modelling the properties of a template NSS as well as applying functions to interpret the goals, wants and needs of the parties to provide advice on how disputes can be settled.

Our earliest NDSS was Family_Negotiator [14]. It utilises a hybrid rule-based and case-based system to provides disputants with advice on how to best resolve the issues in an Australian Family Law dispute. Whilst evaluating the Family_Negotiator system, we discovered that Family Law negotiation was not an appropriate domain in which to apply either Case-based or Rule-based Reasoning, due principally to the open textured nature[2], of the domain. Nor did

2. Open textured legal predicates contain questions that cannot be structured in the form of pro-

the overall framework of Family_Negotiator provide in-depth solutions expected from real-life negotiations.

AdjustWinner [15], uses a utility function to achieve equal distribution of the common pool. The algorithm used in the system was the Adjusted Winner procedure [16]. AdjustWinner resolves a dispute by dividing issues and items among disputants, through a mathematical manipulation of numeric preferences. Although not classed as a NSS, AdjustWinner provided the framework for decision-making support that was later incorporated into a NSS to form Family_Winner.

Family_Winner is a negotiation decision support system that allocates items to one of two parties in the dispute. Family_Winner's method of decision support involves a complex number of techniques, including the incorporation of an Issue Decomposition Hierarchy, a Compensation and Trade-off strategy, and an Allocation strategy. The trade-offs pertaining to a disputant are graphically displayed through a series of trade-off maps, while an Issue Decomposition Hierarchy enables disputants to decompose issues to any required level of specification.

Mediator, Persuader, NEGOPLAN and Family_Negotiator are considered to be intelligent systems since they can generate solutions using the system's internal knowledge as well as users input. All incorporate some level of negotiation support, together with the ability to provide users with a resolution to the current problem.

Artificial Intelligence techniques such as case-based, rule-based and hybrid reasoning have had mixed degrees of success in providing negotiation support. The Mediator proved quite successful in its retrieval and adaptation of previous cases. NEGOPLAN used rule-based reasoning to successfully model Canadian industrial disputes, while PERSUADER successfully modeled US industrial disputes through the use of a hybrid case and rule-based methodology. Family_Negotiator however, did not perform to its initial expectations, primarily due to its relatively simple modeling of the domain.

Apart from AdjustWinner, most of the systems surveyed above do not make allowances for measuring the fairness or justness of the settlement. Further, most of the systems discussed are rarely based on theories derived from practice or empirical studies. For example, INSPIRE [11] and SmartSettle [17] use Pareto Optimisation techniques to suggest optimal solutions. Our goal is to provide feasible suggested solutions to the conflict that are acceptable to the user, rather than searching for optimal solutions.

AssetDivider is our latest development in negotiation support systems. It extends on Family_Winner by modifying its' decision making theory to provide advice based on interests and the monetary value of items. Family_Winner provides advice based only on interests (known in the system as ratings). The

---

duction rules or logical propositions and which require some legal knowledge on the part of the user in order to answer rest of the paper will discuss the architecture and theory behind Asset Divider and in Section 3 we will illustrate how AssetDivider operates though an example.

3. Theory implemented into AssetDivider

This section will discuss the theory used to develop AssetDivider. The main principles behind AssetDivider were derived from theories developed and implemented in Family_Winner. [18] gives a thorough comparison of the similarities and differences between AssetDivider and Family_Winner.

3.1. AssetDivider's input and output

Family_Winner takes a list of issues (items for distribution between two parties) and allocates them based on ratings given by the parties in dispute. Two sets of ratings are provide, one for each party in dispute. This rating (a numerical value between 0 and 100) does not represent the monetary value of the item, instead it symbolises how important the item is to the party. We assume a party wants to keep an item they feel is important to them.

AssetDivider accepts a list of items together with ratings (two per item) to indicate the item's importance to a party. In addition it also accepts the current monetary value of each item in dispute. We assume this dollar value has been negotiated (if necessary) before AssetDivider is used[3]. Hence, only one dollar value is entered per item. The proposed percentage split is also entered; this reflects what percentage of the common pool each party is likely to receive in the settlement. The system is not capable of determining the percentage split; this figure has to be derived from the mediator's knowledge in past cases or from computer systems such as SplitUp [19], which can provide a percentage split given certain characteristics and features of divorce cases.

AssetDivider's output consists of a list of items allocated to each party. All of the items (except one) on the allocation lists were provided in the intake screen by the disputants. The additional item is a "payout" item, which reflects the amount of money a disputant would need to pay the other party for the items they have been allocated and collectively are valued greater than the percentage split offers them. For example, party A have been allocated a total value of $100,000 in assets, and party B $115, 000. Under a 50/50 % split, party B will need to pay $15,000 to party A to satisfy the percentage split.

3. Sometimes the parties cannot agree on the monetary value of the item. In this case, mediators would reference standard objective tables and the like to reach a consensus. For example, if parties are arguing over the value of a car, then mediators may access websites that gave independent valuations, such as redbook.com.au.

3.2 AssetDivider's Allocation Strategy

The order by which issues are allocated is of paramount importance in a negotiation. Professional mediators have indicated issues attracting little disputation should be presented foremost for allocation, so as to help foster a positive environment in which to negotiate. By summing the ratings of issues to 100, the level of discourse surrounding an issue can be measured by calculating the numerical difference between the ratings of an issue assigned by each of the parties. For example, if two parties assign the same high rating to an item, then it is expected the level of disputation surrounding the issue to be substantial (because both parties want the item), whereas large differences between the ratings of parties indicate the issue will be resolved much more quickly. AssetDivider uses this strategy in deciding the order by which items are presented for allocation.

Asset_Divider allocates items to parties according to whoever values them the most. Once an item has been allocated to a party, the remaining ratings (of items still in dispute) are modified by trade-off equations. These modifications attempt to mimic the effect losing or gaining an item on the rest of the items still in dispute. The equations directly modify ratings by comparing each against that of the item recently lost or won (each party's set of ratings are modified as a result of an allocation). The equations update ratings based on a number of variables - whether the item allocated was lost or gained, the value of the allocated item in relation to items still in dispute and the value of the item whose rating will change as a result. The allocation strategy described above is similar to that implemented in Family_Winner. It describes the extent to which ratings were modified as determined through an analysis of data we collected from mediation cases provided by the Australian Institute of Family Studies. These are detailed in [1].

AssetDivider's allocation strategy works by provisionally allocating an item to the party whose rating is the highest. It then checks the dollar value of items it has allocated previously (that is, their current list of items), the dollar value of the item presently allocated and the dollar amount permitted under the percentage split given by mediators. If by allocating the item in question the party exceeds its permitted amount, the item is removed from its allocation list and placed back into negotiation. In this case, the item has not been allocated to a party. If the dollar value of the item was within the limits of the amount permitted under the percentage split rule, then the allocation proceeds. Once an allocation has occurred the 'losing party' is compensated by the trade-off equations modifying ratings.

The equations used to modify ratings depend on a number of variables. One of these is the rating of the issue allocated. The following table (Table 1) lists the ratings and corresponding the equations that apply.

Table 1: Rating ranges and corresponding equations

Rating range of issue allocated	If this issue is lost
<= 10	GraphLose0
11 to 20	GraphLose1
21 to 35	Graphlose 2
36 to 55	Graphlose3
> 55	Graphlose4

The following pseudo code gives the reader an understanding of the equations fired and under what conditions. Where RR = Rating(issue in dispute) – Rating(issue lost).

```
if party has lost the issue
  If issue's rating was <= 10 then  /* graphlose0 */
        If RR between -10 and 0 then %change is 0.5* RR + 5
        if RR is between 0 and 10, then %change = 5
        If RR is between 11 and 25 then %change = -2/15*RR + 6
        If RR is between 26 and 100 then   %change = -5/75*RR + 7
  Endif

  if issue's rating was between 11 to 20 then  /* graphlose1 */
        If RR is –20 to 0 then %change = 5
        If RR is between 0 and 89, then   %change = -5/89RR + 5
            Endif

  if issue's rating was between 21 and 35 then  /* graphlose2*/
        if RR is between –40 and –10, then %change is -5/30 *RR + 3
        if RR is between –10 and 0 then %change is 5/10RR + 10
        If RR is between 0 and 15 then % change = -5/15RR + 10

        If RR is between 15 and 44 then %change = -5/29RR + 8
        Endif

        if issue's rating was between 36 and 55 then  /*graphlose3*/
        If RR is –55 and –25, then %change = 15%
        If RR is between –25 and –20 then %change = -RR -8
        If RR is between –20 and 0 then %change = 5/20RR + 15
             If RR is between 0 and 70, then %change = -15/70 + 15
       Endif

        if issue's rating was above 55, then /*graphlose4 */
              If RR is between –100 and 0 then %change is 15%.
              Endif
```

```
        endif /*if item was lost*/

        elseif /*item was won*/
No change
EndIf
```

3.3 User Interface Issues

We have tried to focus on good usability when designing the user interface of the software. Since the software will be used by non-technical and persons not directly involved in the project, it is important the screens are self explanatory, model actual decision making and are helpful. For instance, there is space on screen for users (we presume will be mediators) to enter additional information about the case. We have also added reporting services, which in one case, will print case details such as case identifiers (case number), initial ratings given by users, ratings upon allocation and a final summary of the solutions arrived at by the system. This summary will include, for each solution, the allocation list for each party and the monetary value of each 'allocation list'.

The system has been designed so users can print a number of percentage split scenarios very easily. Once the information pertaining to a case has been entered, the user can press the back button on the screen to arrive at the screen where the user can change the percentage split, and then press the 'allocate' button on the next screen to see the results. A mediator from RAQ commented they would this a useful feature as it would allow clients to view allocation lists based on different percentage split scenarios.

4. An example using AssetDivider

This section will review the process and outcome of a Family Law case on AssetDivider. The aim of this exercise is to demonstrate AssetDivider's operation in practice.

The case description of this real-life divorce scenario and the relative point allocations have been extracted from [16] page 105. The case Jolis v Jolis, began on December 5th, 1980, and concluded on October 30th, 1981. The case was heard in New York City, at a time when a new law subjecting all martial property to a 50 –50 split was being introduced. The couple had been married for 41 years, of which 33 they spent together. The Wife had given up her early and successful career to care for the couple's four sons. The couple had lived together in substantial wealth, primarily due to the expansion of the Husband's diamond business.

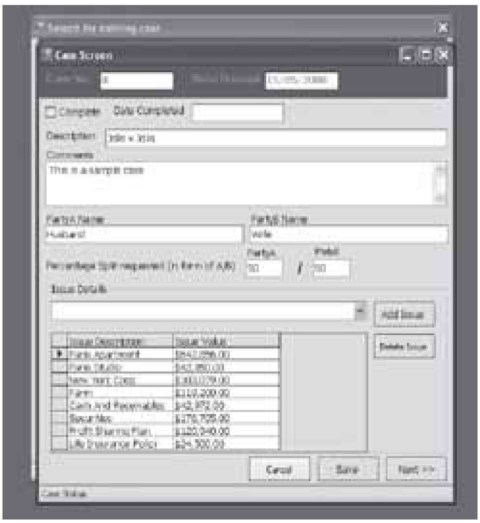
There are both real estate and liquid assets to be divided. The Husband's diamond business is not treated as marital property as its growth was primarily due to market forces, especially the diamond boom of the 1970's. The children's welfare is not included as an issue as they are no longer considered minors at the time of separation.

Table 6.1. Point allocations and dollar valuations [16], page 105

Issues	H's ratings	W's ratings	Dollar value of asset
Paris Apartment	35	55	$642,856
Paris Studio	6	1	$42,850
New York Coop	8	1	$103,079
Farm	8	1	$119,200
Cash And Receivables	5	6	$42,972
Securities	18	17	$176,705
Profit Sharing Plan	15	15	$120,940
Life Insurance Policy	5	4	$24,500
Total	100	100	$1,273,102

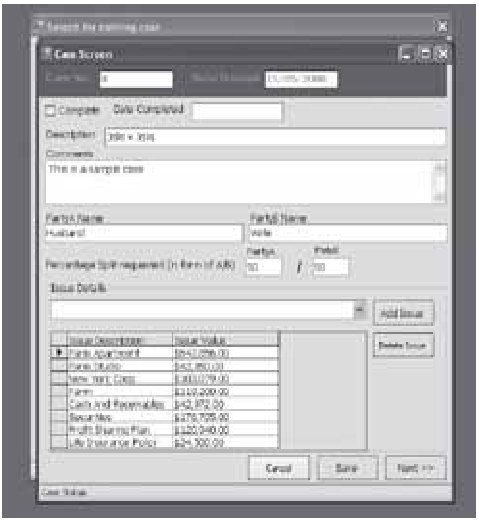
The relevant case information is entered in screen 1.

Screen 1: Intake screen for negotiation



The next screen (screen 2) that appears lists the issues in dispute, their ratings and the allocation summary, which is filled in appropriately when the user clicks button "Calculate allocations". In the Allocation Summary table, we can see that the ratings for Husband (party A) and Wife (party B) are scaled to add to 100 in columns ComputedValuePartyA and ComputedValuePartyB respectively. It is then these ratings that are used to drive the allocation.

Screen 2: Final screen of AssetDivider. It gives the user the allocation list for each party; which includes a payout figure allocated accordingly



According to AssetDivider, the preferred outcome, taking into account each party's' priorities (ratings) and percentage split indicates as follows:

Table 3: Allocation list for Husband (party A) and Wife (party B) using AssetDivider

Husband (Party A)	Value of	Wife (Party B)	Value of
Farm	\$119,200	*Paris Apartment*	\$642,856
New York Coop	\$103,079	*Cash and receivables*	\$42,972
Paris Studio	\$42,850	*Profit Sharing Plan*	\$120,940
Life Insurance Policy	\$24,500		
Securities	\$176,705		
Payout	\$170,217		–\$170,217
Total:	\$636,551	*Total:*	\$636551

In analysing the case, we can see that both parties wanted the Paris Apartment above all else; though Wife (party B) valued it more than the husband (Party A). As a consequence, both parties gave the rest of the items relatively low values. On the whole, both parties received the items they valued considerably (except for Party A's loss of Paris Apartment to Party B – since she valued it much greater). The only item valued equally by the parties was profit-sharing plan (15). It was given to Party B. Party B also need to pay out Party A the amount of 170,217 to ensure the split is exactly 50%.

5. Conclusion and future work

This article describes AssetDivider as a new Negotiation Decision Support System (NDSS) in family law mediation. The software is one of many developed by our lab at Victoria University, including Family_Winner. Family_Winner was developed from the theories in the author's PhD, and AssetDivider represents an improved version, following advice from our industry partners, Relationships Australia (Queensland).

AssetDivider uses the interest (rating given to symbolise the importance of the item to the party) to temporarily assign the asset to a party. AssetDivider tests whether the asset's dollar value exceeds their allowable amount (given by the percentage split set by the mediator).

We are currently assessing AssetDivider via the CCCF System Operational Context Checklist [20]. As a result of this evaluation, we expect to compose questionnaires that ask uses to comment on the operation and use of the system. In order to evaluate successfully, we need to understand how the program is likely to be used. During recent discussions, we believe RAQ would use the software to move clients away from trying to attain a particular percentage of the value of the common pool. Often lawyers or family friends may have provided this advice. There may also be issues with a 'loss of face' if they do not fight for a percentage they consider fair. The program used in this way will help clients see what items make up the given percentage split. They may move their position if they see what items (including the associated payout) they are likely to receive.

The software can also be used to provide mediators with confidence to effectively mediate property-related issues. Most family law mediators have degrees in social work or law. Their expertise lies in mediating child-related issues such as visitation schedules, primary care and other child related issues. If AssetDivider were to be used in child related mediations, it is expected both child-related and property issues could be resolved in one set of session (with mediators); thereby reducing their reliance on lawyers and of course often exuberant associated costs.

AssetDivider has not been extensively evaluated at this point in time. It is expected mediators at RAQ will test and evaluate the system in the near future. We are expecting results from testing to indicate further improvements to the decision making module and in particularly to the user interface. Our research has revealed a lack of negotiation support systems used in family law. We hope our collaboration with RAQ will enable AssetDivider to be used in their organisation, being the first negotiation support systems to do so.

6. References

1. Bellucci, E. (2004), “Developing Compensation Strategies for the construction of Negotiation Decision Support Systems”. PhD thesis, La Trobe University, Bundoora 3086, Victoria, Australia
2. Bellucci, E and Zeleznikow, J., 2006. “Developing Negotiation Decision Support Systems that support mediators: a case study of the Family_Winner system”, Journal of Artificial Intelligence and Law, 13(2), 233-271
3. Bui, T. and Shakun, M. F. 1997. Introduction to the Negotiation Support Systems Minitrack, In Thirtieth Annual Hawaii International Conference on Systems Science - Mini track on Negotiation Support Systems IEEE, Hawaii.
4. Fisher, R. and Ury, W., 1991. Getting to Yes: Negotiating Agreement without Giving In., Boston: Haughton Mifflin.
5. Peterson, M. and Waterman, D. 1985. Evaluating Civil Claims: An Expert Systems Approach to Evaluating Product Liability Cases. In Computer Power and Legal Reasoning (Ed, Walter, C.) West Publishing Company, pp. 627 - 659. Waterman et al 1986
6. Matwin, S., Szpakowicz, S., Koperczak, Z., Kersten, G. E. and Michalowski, G. 1989. NEGOPLAN: An Expert System Shell for Negotiation Support, IEEE Expert 4:50-62
7. Kolodner, J.L. and Simpson, R. L., 1989. The Mediator: Analysis of an Early Case-Based Problem Solver, Cognitive Science, 13:507-549.
8. Sycara, K. 1993. Machine Learning for Intelligent Support of Conflict Resolution, Decision Support Systems, 10:121-136
9. Zeleznikow, J., Meersman, R., Hunter, D. and van Helvoort, E. 1995. Computer tools for aiding legal negotiation. ACIS95 — Sixth Australasian Conference on Information Systems, Curtin University of Technology, Perth, Western Australia: 231-251. Kersten 1997
10. Yuan, Y., Rose, B. J., Archer, N. and Suarga, H., 1998. A Web-Based Negotiation Support System, EM - Electronic Markets, 8.
11. Eidelman, J.A., 1993. Software for Negotiations, Law Practice Management, 19(7): 50-55.
12. Bellucci, E. and Zeleznikow, J. 1997. Family-Negotiator: an intelligent decision support system for negotiation in Australian Family Law. Proceedings of the Fourth Conference of the International Society for Decision Support Systems, Lausanne, International Society for Decision Support Systems: 359-373.
13. Bellucci, E. and Zeleznikow, J., 1998. A comparative study of negotiation decision support systems, In Thirty-First Hawaii International Conference

on System Sciences IEEE Computer Society. Los Alamitos, California, pp. 254 - 262.

14. Brams, S. J. and Taylor, A. D., 1996. Fair Division, from cake cutting to dispute resolution. Cambridge University Press, Cambridge, UK
15. Thiessen, E. M. and McMahon, J. P., 2000. Beyond Win-Win in Cyberspace. Ohio State Journal on Dispute Resolution, 15: 643
16. Bellucci, E. (2008b), “AssetDivider: a new mediation tool in Australian Family Law”, to appear in the proceedings of HuCom 2009.
17. Stranieri, A., Zeleznikow, J., Gawler, M. and Lewis, B., 1999. “A hybrid—neural approach to the automation of legal reasoning in the discretionary domain of family law in Australia. Artificial Intelligence and Law 7(2-3), 153-183.
18. Hall, M. J. J. and Zeleznikow, J., 2003. A method for evaluating legal knowledge-based systems based upon the Context Criteria Contingency guidelines framework, In Proceedings of the Ninth International Conference on Artificial Intelligence and Law ACM Press, Edinburgh, Scotland, pp. 274-283.
19. Bellucci, E. and Zeleznikow, J. 2001. “Representations for decision making support in negotiation”. Journal of Decision Support, 10(3-4), 449-479
20. Mnookin, R., Peppet, S. R. and Tulumello, A. S., 2000. Beyond Winning: Negotiating to Create Value in Deals and Disputes, The Belnap Press of Harvard University Press.

Towards a Platform for Online Mediation

Pablo Noriega and Carlos López

Artificial Intelligence Research Institute (IIIA-CSIC), Campus UAB, 08193 Bellaterra (Barcelona), Spain

{pablo,clopez}@iiia.csic.es

Abstract: In this paper we describe a prototype for a generic platform to support actual on-line mediation. The immediate purpose of the prototype is to provide working examples of the computer artifacts that may be implemented to support current and foreseeable mediation practices. The ultimate objective, however, is to facilitate the deployment of appropriate ODR environments. The proposal is motivated by the production of the *White Book on Mediation in Catalonia* commissioned by the Catalan Government. This paper illustrates how different ODR processes–such as negotiation protocols of different types, arbitration or non-intrusive mediation–plus the preparatory and ancillary sub processes–like convening the parties, caucuses, anonymous proposal registration, mediator selection–may be specified and then assembled into more or less elaborate mediation support systems tailored to the needs and preferences of each mediation provider. This proposal is based on the notion of electronic institution and is being implemented using the IIIA's EIDE platform.

Keywords: Mediation, electronic institution, multiagent systems.

1. Introduction

There is widespread agreement about the need of alternative dispute resolution procedures to address the overflow of litigation that is received by courts. There is also agreement about the convenience of supporting some of these ADR procedures through on-line dispute resolution technologies. This paper explores these two matters through the design of a generic mediation platform that may be tailored to the specific needs of different mediation domains and modalities. The platform we propose is based on the notion of electronic institution and assembled through the EIDE tools developed in the IIIA.[1]

The paper is organized as follows. We first sketch the type of IT technology that is currently being used for on-line mediation and explain the mediation environment that motivates the proposal. In Section 3 we give a brief descrip-

1. http://e-institutions.iiia.csic.es

tion of the "Electronic Institution" framework that we use to specify the prototype presented in section 4. We finish with a brief discussion of the salient features of the prototype.

2. Background

In this paper we will talk mostly about mediation that is IT-supported to some extent and focus on a subset of ODR that includes the type of agreement mechanisms usually associated with mediation, namely, standard non-intrusive mediation, arbitration and some forms of negotiation –mediated or not.

The motivation of our proposal lies in the on-going Catalan regional government effort to produce the *White Book on Mediation in Catalonia*.[2] This White Book includes a chapter on technology for mediation with a description of the state of the art of IT technology in applied mediation and guidelines for appropriate uses of technology in the Catalan mediation environment. As part of that reflection, we are developing the prototype we report on in this paper.

A quick survey of active on-line mediation services shows interesting variations from an IT perspective. There is a group of services that limit their IT content to the use of conventional asynchronous communication to activate, acknowledge or keep track of mediation landmark stages, or support documentation of the mediation process. In any case, the IT uses in this group are so undifferentiated that aside from the fact that there is a website to inform and in some cases to establish contacts with parties in conflict one can hardly say they are IT supported mediations. A second group uses IT to control the mediation flow process and make available on-line, to the mediated parties, some sort of "agreement device" such as a bracketed text, a structured complaint form or a synchronous meeting place or caucus possibilities (chats, IP video conferencing). Finally there is a third group of mediation services that rely on a fully automated system in which the process flow is IT mediated, party interventions are IT mediated as well, and even in some cases, some agreement devices are IT enabled (for instance, simple blind bid-crossing, anonymous "brain-storming" records, iterated negotiation or even automatic last resource arbitration). From a business-model point of view, services range from those with a very focalized mediation domain to the quite generic; some service providers build their model around a software platform while other use such platforms as a support for their core business. None of the service providers reviewed seems to have truly sophisticated ODR technologies like the ones reported in academic *fora*.

Technological maturity is rather uneven in the Catalonian government mediation instances, and although some have functional mediation case-ma-

2. http://idt.uab.cat/llibreblanc/

nagement and archiving, and rather mature IT corporate environments, others provide mediating services within considerably rudimentary IT conditions. The prototype we are developing is intended, thus, to be flexible enough to adapt to a wide range of sophistication levels and to, ideally, all mediation domains; and rich enough to provide thorough support to most activities involved in the mediation process. We claim electronic institutions are an appropriate technology to use for this purpose.

3. An Electronic Institution approach to an on-line mediation environment

Electronic institutions are computational artifacts that correspond to a given extent to what traditional institutions are. They are, first of all, a collection of artificial constraints imposed on the behavior of individuals, or *agents,* who participate in a collective activity. They are also the entity that enforces those conventions and, thirdly, they are software systems that facilitate interactions among those participating agents. That is, they are a means to establish, enact and enforce "the rules of the game", so that that game may be played on-line. Because electronic institutions embody prescriptive and governance features, and these may be applied to activities involving software or human agents that may be independent, autonomous and self-motivated, electronic institutions may be reified as a form of regulated open multi agent systems.

Although these intuitions are more or less shared by different technical proposals we will adhere to the specific electronic institutions framework developed in the IIIA which we shall refer to as EI from now on. The EI framework includes a *conceptual model* to describe an institution, a *computational model* that explains how an institution is enacted and a *pragmatic model* that establishes how it is implemented. For the purpose of this paper we will only be concerned with the conceptual model, that we shall quickly describe here and note that the EI framework includes software tools to specify and run arbitrary electronic institutions.[3] Those are the tools we use for this prototype.

In the EI conceptual model we assume all interactions are among autonomous agents and all interactions among agents *within the EI* are speech acts (that *count as* actions in the world). We further assume that interactions are repetitive and thus may be structured as one would organize the scenes of a play. We further assume that agents may be humans or software agents who are able to use and react to the institutional acts.

With these assumptions in mind, we may specify an electronic institution through three components:

3 The EIDE platform, available at http://e-intitutions.iiiia.csic.es.

1. The *dialogical framework* that specifies the content and interpretation of the admissible speech acts. It defines a *set of roles* agents may play in the institution, the *domain ontology* involved in illocutions and the *information model* on which institutional actions are based.
2. The *performative structure* that specifies how the interactions are organized within the institution. It is formed by a network of *scenes*, (or conversations agents may participate in), that are joined through *transitions* (that state how agents may change scenes, or more precisely, the causal and temporal interdependencies among scenes). Scenes are conversation protocols or dialogue games, which are specified as directed graphs where arcs are labelled by speech acts schemata and nodes thus institutional states.
3. The *rules of behaviour* that put *constraints* on the actions (illocutions) that individuals who are playing a given role may take at some point in the enactment of the institution. More prosaically, these rules are *pre-conditions and post-conditions* associated with each arc, speech act, of a scene or a transition. More formally, these rules establish the normative positions of commitments that arise from agent interactions.

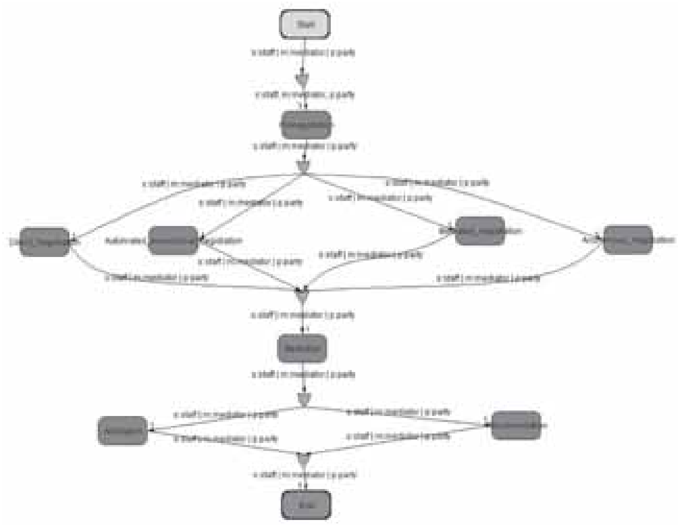
The EI framework includes a graphical specification language, ISLANDER, which may be used to specify electronic institutions whose run-time versions may be enacted by agents. Agents interact in the institution through a middleware layer, AMELI, on top of JADE or similar agent communication platforms.

4. A prototype for a mediation institution

Using the EI framework we are defining a prototype institution that we believe may be appropriate for customizing mediation support environments to the needs of the different mediation instances of the Catalan initiative.

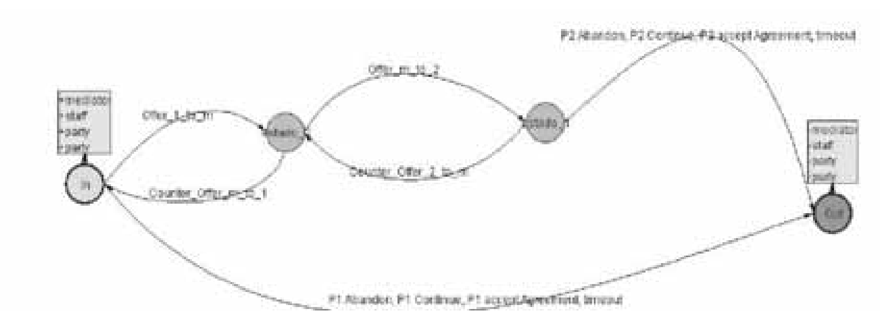
Figure 1 shows the complete *performative structure* of a mediation institution. Boxes correspond to scenes. In this case the eight dark boxes correspond to mediation activities --- a scene where the claimant chooses the type of negotiation she wants to use, four different negotiation conventions, a scene for standard non-intrusive mediation and two ensuing scenes for arbitration and recommendation. The two light boxes are scenes that are needed in every electronic institution as a device to start and terminate enactments. Lines connecting boxes (and widgets) indicate transitions. These transition lines are labeled with the roles that may move from one scene to another. In this institution there are only three roles: *party* (involved in a mediation), *staff* (responsible for institutional functions like time-keeping, record handling, etc.) and *mediator* and they all intervene in all the scenes.

Fig. 1. Performative structure of a mediation institution



Scenes as the one in Fig. 2 are graphical depictions of interaction protocols. In this case it shows a protocol for mediated negotiation. Circles correspond to states of the negotiation and boxes indicate those states where certain roles may enter or exit the scene. Arcs are labelled with illocutions. In this case the scene involves two parties that exchange offers; however, parties do not talk to each other, they talk to the mediator who after the intervention of one party may decide either to pass that communication to the other party or request the original party for a modification of the original communication. Parties may agree or defect and staff keeps track of time so that if a "timeout" period has elapsed without acceptable offers and counteroffers the scene is terminated.

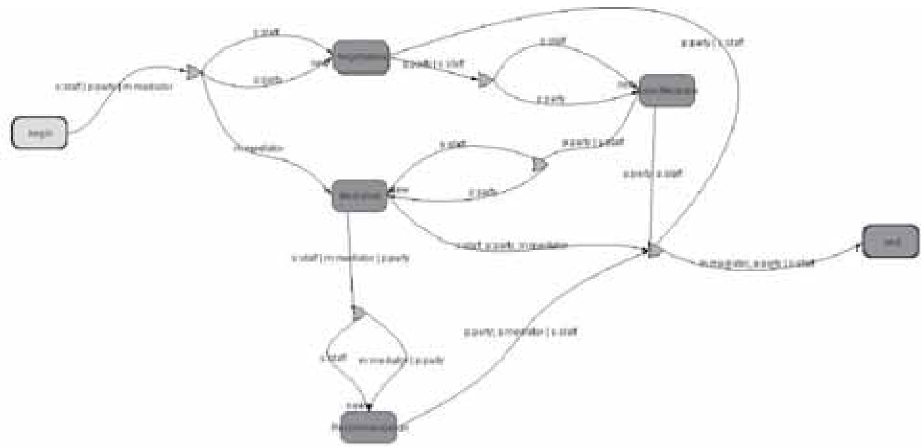
Fig. 2. Mediated negotiation protocol



Thus, for example, the top leftmost arc abbreviates the illocution where party one communicates the mediator and offer, the next line (top, leaving *estado_0*) indicates that the mediator communicates the standing offer to party 2. From that *estado_1*, there are five possible actions, one in which party 2 communicates a counteroffer and four that bring the scene to an end: that party 2 decides to abandon the mediation process, that he decides to leave this negotiation scene but embark into another form of mediation, that he agrees on the standing offer, or that the staff agent declares the scene is over because a deadline ha been reached without agreement among the parties.

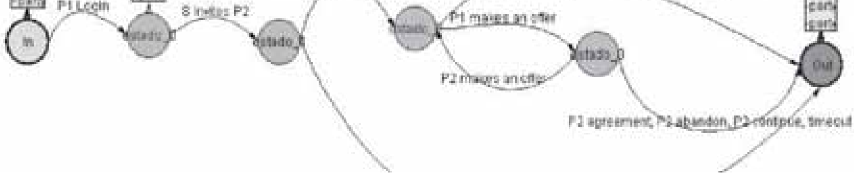
Figure 3 shows the performative structure of another mediation institution, in this case, one that is mirrored after the EcoDir model (http://www.ecodir.org). We have the same three roles as before but a simpler structure of four non-trivial scenes.

Fig. 3. Performative structure of an EcoDir-like institution



Now let's illustrate what happens when we have agents interacting in this electronic institution by looking at the actual display of a run-time monitor. Figure 4 shows the protocol of the *Negotiation* scene and figure 5 a partial screen shot of those interactions taking place in that scene.

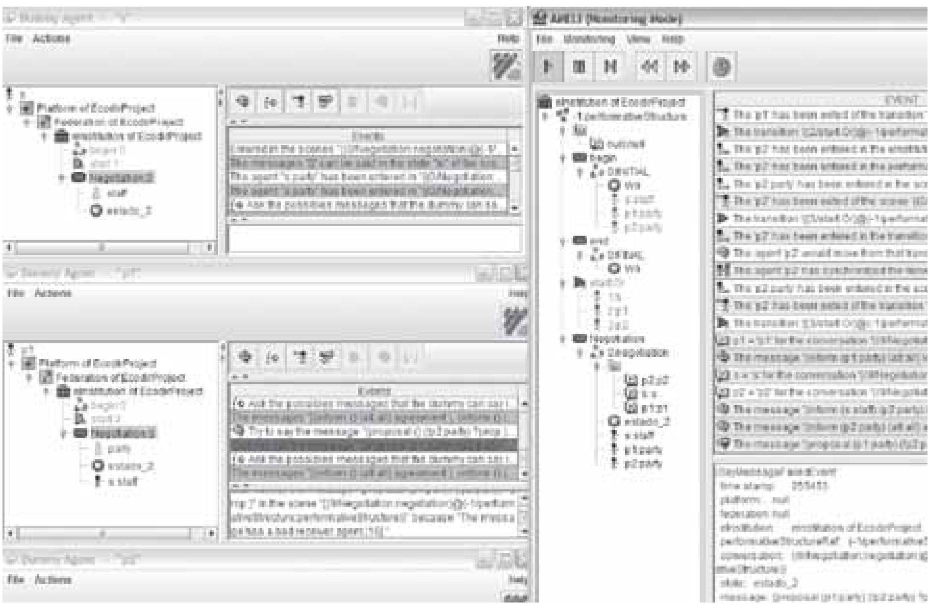
Fig. 4. EcoDir negotiation scene



One may distinguish three main regions in Fig. 5. The one on the right corresponds to the electronic institution as a whole, that is why it shows (on the far right) a list of all the actions that are taking place since the start of the execution and (on its left) a graph of the main actions in the performative structure; for instance that the latest actions are happening in state *estado_2* of the *Negotiation* scene.

The leftmost top region displays what the staff agent *S* sees and does and beneath the same for agent *P1*. In both cases there is their private view of the performative structure on the left and the messages each one hears and attempts to communicate to the institution. What is worth noting is that these two agents are in fact humans that use the rather primitive interface to test the specifications. There is, obviously, a convenient interface for software agents.

Fig. 5. Screenshot of the enactment of the EcoDir-like institution



5. Concluding remarks

What we have presented here is an exercise in the design of a mediation environment.

We have illustrated how to use the EI conceptual model and tools to describe the main processes involved in mediation and specify the details of the conventions that govern those processes. We have shown two examples of mediation models to give an indication of the flexibility of this approach and how these ideas may result in software programs that automate computer supported mediation. But aside from the software engineering advantages, what are the salient features of this approach for developing ODR environments?

The EI framework is well adapted to deal with interactions that are reducible to compact, univocal, formal messages like those involved in economic transactions and in that case it is a powerful way of implementing systems where software agents are involved, sine these may be focussed to the decisional aspects of the mediation and not to the interpretative or rhetorical ones. There are ODR applications where this conciseness and the use of software agents are a plus.

Notwithstanding this last remark, the EI framework may also work with human agents–as we intended to show with figure 5–and in that case, the need for terse messages may be dismissed altogether. A richer semantics allows for simpler interaction protocols but a richer performative structure may then come handy, for one may conceive innovative ways of facilitating agreement that may be at hand for mediators to use when appropriate. While the total automation may be unlikely and probably unadvisable, having an automated due process that may be documented and used on-line may be quite desirable and, as we tried to illustrate with the crude mediation models, quite easy to accomplish with the EI framework.

6. Acknowledgements

Research in this paper has received funding from the Departament de Justícia de la Generalitat de Catalunya, UAB through Project Llibre Blanc de la Mediació a Catalunya and from the Consolider Program of the Spanish Ministry of Science and Innovation through project AT (CSD2007-0022, INGENIO 2010).

Advisory System for the Agricultural Tax Law

Tomasz Zurek[1], Emil Kruk[2]

Abstract. The authors of this study attempted to develop an advisory tool functioning in the scope of the Agricultural Tax Act. The focus of the authors in this study was on presenting the outcome of the efforts connected with building the ontology which would allow for representing individual cases. This study will also outline the structure and concept of the system in question.

Keywords: Legal expert system, agricultural tax law, ontology building

1. Introduction

The law regulating the life of man in society has become so complex that for the average person it is extremely difficult to understand its letter even when considered solely at the basic level of legal social functioning. Nowadays, the old Roman rule stipulating that the lack of legal knowledge cannot be the excuse to anyone sounds almost like a mockery. Therefore, an IT tool advising on certain legal acts could be very useful both to the average 'users' of law, as well as to the state administrative bodies

The authors of this study attempted to develop an advisory tool functioning in the scope of the Agricultural Tax Act [12]. The authors seek to create a tool which would provide the agricultural tax payers and officers with comprehensive advice in the scope of their rights and obligations. The choice of this Act was inspired by its specificity. The authors' primary emphasis was on the legal act being as deterministic as possible, as it would allow for considerably restricting the interpretation leeway which in the case of other legal acts is very wide. Another reason behind this choice stemmed from the fact that fiscal law calls for linguistic interpretation and utilisation of other ways of interpretation of law is not recommended (for example *a contrario*) or strictly forbidden (for example *per analogiam*). Legal acts of this kind significantly facilitate the development of advisory systems, reducing, though not fully eliminating, the impact of interpretation difficulties.

1. Institute of Computer Science, Maria Curie-Sklodowska University, Plac Marii Curie-Sklodowskiej 5, 20-031 Lublin, Poland. zurek@kft.umcs.lublin.pl

2. Institute of Administration and Public Law, Maria Curie-Sklodowska University, Plac Marii Curie-Sklodowskiej 5, 20-031 Lublin, Poland. emil.kruk@wp.pl

The Agricultural Tax Act governs such issues as tax calculation, tax rates, classification of taxpayers and farm land under various taxation classes, tax breaks and reliefs, payment conditions, land class changes, and the like. As the system is entirely based on the Polish statutory law, the Agricultural Tax Act, along with other statutory provisions of a more detailed nature serves as the only source of knowledge. So far, there has been no need to refer to any other legal acts although general legal expertise has often proven imperative to properly construe individual provisions.

The focus of the authors in this study was on presenting the outcome of the efforts connected with building the ontology which would allow for representing individual cases, and dealing with cases not expressly regulated by law. This study will also outline the structure and concept of the system in question.

2. Legal Act

Agricultural Tax Act [12] regulates the issues of agricultural tax calculation, maximum tax rates, classification of taxpayers and farm land under various taxation classes, tax breaks and reliefs, tax payment conditions, land class changes, and the like. As the system is entirely based on the Polish statutory law, the Agricultural Tax Act, along with other statutory provisions of a more detailed nature, serves as the only source of knowledge. So far, there has been no need to refer to any other legal acts although general legal expertise has often proven imperative to properly construe individual provisions.

Agriculture in Poland is not only one of these sectors of economy where the number of employees is still relatively high, but it is also very fragmented (with plenty of relatively small agricultural farms). Therefore, the number of agricultural tax payers is huge. As intended by the authors, the advisory tool, providing legal information on the rights and obligations of the agricultural tax payers, will come in handy not only for the taxpayers but also for the officers dealing with agricultural matters. It can facilitate and speed up the law interpreting process, cutting down the number of frauds.

3. System structure

Rules are the major carrier of legal expertise in the system developed by the authors. However, unlike in the classic expert systems, they are “incorporated” into certain elements of ontology, which allows for a case to be described. The ontology thus forms an interpretation “background”. Particular instances of the ontology elements, i.e. input and output elements (conditions and conclusions) of the rules, make it possible to describe specific cases, and to introduce certain semantic aspect into the static knowledge (describing the reality). Apart from the classic legal rules, regulating changes to the legal status (e.g. deontic features), the system also contains more general rules which govern cases not expressly defined in the letter of law.

The JAVA language was selected as the system implementation tool, considering the ease it offers in representing and shaping such structures.

In turn, the PROLOG language was applied for pre-modelling the basic legal relations, especially those connected with the cases not expressly regulated by law. This choice was inspired by the huge possibilities in the scope of representing various logical relations, including the pretty complex ones, offered by PROLOG. Finally, the full version of the system also makes use of the JBOSS RULES engine, highly flexible and compatible with JAVA. As the JBOSS RULES knowledge representation is rule-based, the model developed in PROLOG was extremely useful in creating the system. The JBOSS RULES engine is based on the RETE algorithm, and the authors believe that it is particularly predisposed to operate together with the JAVA-implemented ontology

The real-life situations were expressed as instances of individual classes. Part of the procedural knowledge (e.g. the mechanisms used for calculating conversion hectares) was defined in the class-specific methods.

4. Ontology

Any problem encountered by lawyers is highly specific, and this specificity must be properly accounted for to become interpretable in the context of the existing legal regulations. Several authors have made attempts to create more or less complex ontologies to represent legal acts [1, 2, 9, 13]. In consequence, the authors suggest the use of ontology for expressing the legal aspect of cases analysed. Further details concerning ontology can be found in [16]. It was implemented within the system as a structure comprising interfaces and classes, where an instant case is expressed through individual class instances. For example, if Mr. Bilbo Baggins is the owner of land in village Hobbiton, the description comprises the following class instances:

- Location ("The Hill")
- Land ("Bag End"), class have attribute: Location. Value of the attribute: "The Hill"
- Village ("Hobbiton") class has collection of attributes: Location. Value of the one of them: "The Hill"
- Natural Person ("Mr. Bilbo Baggins")
- Ownership ("Ownership of Mr. Baggins"). Attribute: Owner, value: "Mr. Bilbo Baggins", attribute property: "Bag End"

Naturally, each class consists of several attributes, some of which allow for making connections between individual instances. For example, "Location" is one of the attributes of the *Land* class instance, and the *Location* class instance serves as its value.

5. Deontic logic

When analyzing legal interpretation, it is hardly possible to neglect deontic logic, defined as the field of logic which is concerned with the formal relation between the following deontic concepts—obligation, prohibition, and permission. Lawyers frequently apply these basic laws of deontic logic more or less intuitively. Some examples of implementations of deontic logic in legal expert systems were described in [14]. These laws facilitate interpretation of the least complex cases not expressly regulated by law.

Deontic logic revolves around three principal concepts, namely the concept of *permit*, *prohibited* and *obligatory* (some authors advocate one additional concept— indifference, but this study will be confined to the three principal concepts mentioned) [15]. Implementation of one of the basic deontic rules, stating that any actions obligatory are also permitted, proved indispensable in this study. This was modelled using the PROLOG language:

permitted(Action,Performer):-obligatory(Action,Performer),action(Action), person(Performer).

Other principles stating, inter alia, that any actions prohibited are neither permitted nor obligatory, and – on the contrary – that any actions permitted and obligatory are not prohibited, should result from the structure of the knowledge base of the system.

There is one more issue to be focused on as regards deontic logic. Namely, the proper choice of ontology makes it considerably easier and very often possible at all, to represent the reality in which a given act functions. However, at the same time, the maker of the system has to face the necessity to somehow adjust the deontic logic to the actual ontology. Generally, ontologies take the form of a hierarchical structure of beings, and the place of such concepts as obligation, prohibition, and permission in this structure is of key importance.

Assuming that action B constitutes a sub-group of action A, we may infer that:

- permission to do A also means permission to do B, unless separate provisions stipulate otherwise, i.e. that B is forbidden
- obligation to do A does not mean obligation to do B; for instance, we are obliged to pay taxes but we may not necessarily be obliged to pay the agricultural tax (provided that we do not conduct agricultural activity but we work, for instance, at university).
- a prohibition on A means a prohibition on B, unless separate provisions stipulate otherwise, i.e. that B is permitted.

6. Rules

Rules are the major carrier of conditional legal norms in the system. In authors' opinion these rules should mirror legal principles, avoiding free interpretation of the act, as much as it is possible. Interpretation principles and reasoning should be separated from general knowledge base. Example of one of the rules is presented below:

```
rule „tax payer - owner”
when
land : Land();
person : Person();
ownership : Ownerhip(who == person && what == land && taxPayer ==
false);
      not possessor : Possessor(what == owner.what);
      not rent : Rent(what == owner.what);
      not user : User( what == owner.what );
then
ownership.setTaxPayer(true);
update(owner);
end
```

The above rule states whether the owner of the land is an agricultural tax payer. The first three provisions in the conditional part of the rule state that there should be a person who owns an instance of the class Land. The next three conditions exclude situations which defeat the rule. There are no other possibilities of defeasing this rule and theory of law forbids creating the new defeasing conditions out of any ways of interpretation (especially out of analogy).

Conclusion of the above rule changes the state of value of the attribute TaxPayer from false into true.

7. Interpretation of cases not expressly regulated

The legal theory and practice has given rise to a wide array of methods to deal with cases not expressly regulated by law, some of which were used by the authors. Implementation of one of the basic deontic rules, stating that any actions obligatory are also permitted, received top priority. In general, deontic logic is connected with the rules of instrumental obligation, and prohibition, and permission. Of these three, the rule of instrumental permission was the only one to be considered relatively unquestionable, and thus was implemented. The authors further considered the possibility to apply the *a contrario* interpretation method. The problem of interpretation of cases not expressly regulated by law is discussed wider in [17]. The subject of deontic logic is widely discussed i.a. in [6, 10, 14] instrumental reasoning and *a contrario* is mentioned in [5, 6, 8].

8. Conclusions

Expert systems were among the first computer tools applied to support legal expertise. Given their specificity, they were mainly used in modelling the statute law rather than the common law. Following the initial enthusiasm, they became the object of vivid criticism. Critical judgements concerning the viability of rule-based systems as a tool supporting legal expertise usually focused on the difficulties related to representing unclear and exceptionally complex definitions or to converting some of the most complicated relations into rules. This criticism is by no means groundless. However, it should be emphasised that the level of detail differs among specific legal acts, thereby requiring different ways of interpretation. In certain cases, the theory of law requires very strict precision and grammatical interpretation.

The authors of this study have attempted to develop an advisory tool functioning in the scope of the Agricultural Tax Act. The principal goal of this is to provide automatic legal advice. Implementation of certain mechanisms which allow for advising on cases not expressly regulated in law is what makes this project exceptional. The system comprises three levels of representation of legal knowledge: the level of ontology, level of procedural knowledge and the level of rules. The ontology developed by the authors to allow for representing specific cases serves as the basic representation level, making it possible to describe the strictly legal concepts, as well as the commonsense-based concepts.

Elements of ontology serve as the conditions and conclusions of the rules which form the dynamic part of legal knowledge stored in the system. Apart from the rules which directly reflect the provisions of the legal act, the system also comprises a range of rules of a more general nature. The latter mirror the principles of legal interpretation, including the basic rules of deontic logic, and the rule of instrumental permission.

The elements implemented so far include the ontology and part of the deontic legal principles. The system is well capable of providing correct answers to the cases which clearly fall within the scope of the knowledge already implemented, as well as to certain questions not expressly defined in the provisions.

Future works will focus on implementing further provisions and on developing the module supporting interpretation of cases not expressly regulated in law. The authors envision introducing a distinction between various rules, based i.e. on the results of studies [10, 11], and are also going to focus on the more formal representation of legal knowledge. This distinction would aim to expand and to crystallize the possibilities related to interpreting some of the cases not expressly regulated by law. The authors are also going to focus on representation of consistency constraints in a knowledge base.

9. References

1. Benjamins V. R., Casanovas P., Breuker J., Gangemi A. (ed.): Law and the Semantic Web: Legal Ontologies, Methodologies, Legal Information Retrieval, and Applications. Springer: Berlin/Heidelberg (2005)
2. Breuker J. Valente A., Winkels R.: Legal Ontologies in Knowledge Engineering and Information Management. Artificial Intelligence and Law, no. 12, pp. 241--277, Springer (2004)
3. Gordon T.: Some Problems with PROLOG as a Knowledge Representation Language for Legal Expert Systems. Yearbook of Law, Computers & Technology. (ed.) C. Arnold, pp. 52--67 London (1987)
4. Greinke A.: Legal Expert System: A humanistic critique of Mechanical Legal Interface, http://www.murdoch.edu.au/elaw/issues/v1n4/greinke14.txt (1994)
5. Hage J.C.: Reasoning with Rules: An Essay on Legal Reasoning and Its Underlying Logic. Springer Berlin- Heidelberg (1997)
6. Leszczynski L.: Issues of theory of application of law in Polish Zakamycze (2001)
7. Popple J.: A Pragmatic Legal Expert System. Dartmouth, Aldershot, (1996).
8. Roth B.: A Typology of Moves Involved in Case Comparison. Proceedings of 8th International Conference of Artificial Intelligence and Law. St Luis, pp. 129—138, ACM New York (2001)
9. Sartor G. Rubino R., Rotolo A.: An OWL Ontology of Fundamental Legal Concepts in: Legal knowledge and information systems, JURIX 2006, the Nineteenth Annual Conference, Amsterdam, pp. 101--111, IOS Press (2006)
10. Sartor G., Shiner R.A., Rottleuthner H., Peczenik A.,Pattaro E.: A Treatise of Legal Philosophy and General Jurisprudence. Springer, Berlin-Heidelberg (2005)
11. Sartor G.: Fundamental Legal Concepts A Formal and Teleological Characterisation. http://cadmus.iue.it/dspace/bitstream/1814/4351/1/LAW%202006.11.pdf (2006)
12. The Journal of Laws of the Republic of Poland
13. Visser P.R.S., Bench-Capon T.J.M.: Ontologies in the Design of Legal Knowledge Systems; Towards a Library of Legal Domain Ontologies. http://citeseer.ist.psu.edu/64358.html (1999)

14. Wieringa R.J., Meyer J.J. CH: Applications of Deontic Logic in Computer Science a Concise Overview se overview in Deontic Logic in Computer Science: Normative System Specification, John Wiley and Sons (1993)
15. Ziembinski Z.: Logika praktyczna (Practical Logic). PWN Warsaw (1990)
16. Zurek T.: Knowledge Base Ontology in Legal Expert System. Polish Journal of Environmental Studies vol. 17, No 3B, pp.575--580 Olsztyn (2008)
17. Zurek T., Kruk E.: Supporting of Legal Reasoning for Cases which are not Strictly Regulated by Law Proceedings of 12th International Conference of Artificial Intelligence and Law. Barcelona, pp. 220—221, ACM New York (2009)

Environmental, Social and Normative Networks in the MAELIA Platform

Romain Boulet[1], Pierre Mazzega[1], Bertrand Jouve[2]

Abstract. The MAELIA project consists in modeling the socio-environmental impacts of norms designing the management and governance of renewable natural resources and of the environment. In this paper we present the MAELIA project and in particular its network-like structures: several sub-systems of different nature (environmental, social, normative sub-systems) emerge and interact in a complex manner. This network point of view on the MAELIA platform will allow to use and to develop tools relying on graph theory and network analysis in order to understand the structures of these different interacting complex systems, to construct a platform taking into consideration these interactions and to build various scenarios for the analysis of the social and environmental coupled system sustainability.

Keywords: environmental norms, water management, resources, multi-agent system, impact assessment, social network, institutional networks, graph theory, simulation.

1. Introduction

The water is a resource for many different uses. The withdrawal of water volumes from resource pools and the possible change in the water geochemistry and quality induced by some uses might change the resource availability for other uses. Consequently uses of water in a given ecological or environmental context are competing. They are also often interdependent, sometimes in a non trivial way. For example, water can be stocked in dams and used for the hydroelectric production. This water is not immediately available for irrigation in the downstream areas. But irrigation is generally using some electric devices for extracting water from the groundwater or surface water reservoirs. At the basin scale, the consumption of electric power for irrigation can significantly rely on the energy power plants, and in particular on dams. In this case the hydroelectric production and irrigation are not only competing uses but they are also interdependent, asking for some arbitration in the priority affected to

1. Université de Toulouse; UPS(OMP). CNRS IRD, LMTG Toulouse 14 av. Belin 31400 Toulouse, France. {boulet, mazzega}@lmtg.obs-mip.fr

2. Institut de Mathématiques de Toulouse. Université de Toulouse II. 5 Allées Machado, 31058 Toulouse. jouve@univ-tlse2.fr

the different uses (these priorities are usually changing with the environmental seasonality and inter-annual variability).

The *agents* (a very abstract notion as will be seen here below) responsible for the uses, the exploitation or the valorization of the water resources, are somewhat indirectly interacting through the conjugated impacts of their (interdependent) actions on the resource. They also directly interact through cooperation or competition mechanisms (among others). These mechanisms in turn can be non-formal or formally institutionalized. Many different norms exist that tend to regulate these direct and indirect interactions, being socially *bottom-up* emergent, or – at least tentatively – enforced by some legal authority. More specifically, legal norms can have many different types and expected mode of affecting the agents' actions in order to obtain some targeted results (e.g. water quality, or water availability for all in case of resource shortage, etc.). In particular we find all the classical categories that deontic logic intends to analyze and to formalize (e.g. [1]) and a large spectrum of softer instruments like incentive policy or directives, etc., proposing general guidelines to be implemented at different organizational levels of the society.

However when designing or implementing new normative frames, or when norms are self-emerging, the question is raised on the expectations that can be formulated about their capacity to effectively regulate the coupled dynamics of the resource and ecological systems with the social systems. In this paper we briefly show in the context of the basin-scale water resource management, how the effectiveness and efficiency issues associated to the normative frames are intimately related to the underlying network structure of the ruled system. We also expose a few concepts (and tools) developed in Graph Theory that we plan to use in order to bring some understanding on the structural complexity of these socio-environmental systems and on their normative regulation.

2. The MAELIA Project

2.1 The Context of the Basin-Scale Water Management

Planetary environmental changes are affecting the water resources at the scale of river basins. Ecosystem dynamics is modified. The uses, access and perceptions of the resources are changing. But also new institutions are adapted or crafted in order to regulate the social versus ecological interactions for a sustainable development, creating the conditions for legitimate collective actions [2]. Many studies strongly suggest that the way these political, economical and social institutions (organizations, legal and social rules, incentives, etc.) are functioning is a key issue for the long term evolution of socio-environmental systems [3], pushing them to overuse and decline, or maintaining the fragile dynamical equilibrium between development and sustainability. At the same time it is now understood that no universal solution exists for reaching such balance in different context [4], [5], and that – like biodiversity – institutional diversity might be a key patrimony to be preserved too [6].

The systems of water resource management at the basin scale, as developed since decades in France [7] and now in Europe, tends to be a worldwide spread model. This approach is contrasting with strategies of sectorial and/or local water resource management. Whatever the chosen policy, the actors in charge of the management of this resource are asked to take decision or to help designing policy orientation faced to intricate problems with nearly no scientific tools supporting the evaluation of the evolving situations in a globally to locally changing context. In the MAELIA Project we start building some scientific integrative simulation tool for supporting policy-making and decision-taking for the water management.

2.2 The Objective of the Project and Main Issues

The MAELIA Project[3] (started in 2009) consists in developing a multi-agent system for the assessment of the impacts of the environmental norms, with some strong focus on issues related to the basin-scale water resource management. By environmental norms, we mean all the norms that are susceptible of having some environmental dimension or target. The impacts are sought on the water resource (quality and quantity), on the social practices related to the resource uses, exploitation and valorization, on the functioning and structures of the institutions and organizations directly or indirectly related to water management issues, or to the related production sectors (individual or industrial). The design and building of the platform is done in three main (parallel) steps: a) we perform an interdisciplinary analysis of basin-scale water management systems as observed in different environmental and political / national contexts; b) from these analyses we abstract some generic scheme summarizing a stylized view of how the environmental and social co-evolving systems are functioning, with some special attention given to the regulation brought by the normative embedding system; c) a generic platform structure and implementation is developed that is mirroring the schemes obtained in the previous step, and that allows interoperability between the multi-agent layers, the layers of some geographic information system gathering information on a given river basin, and some classical partial differential model(s) describing the physical and bio-geochemical dynamics of the water, soils and biological (from phytoplankton to vegetation and higher levels of the trophic web) interacting compartments.

3. In its initial stage, the MAELIA Project is involving four main groups: the LMTG, several teams for the Maison des Sciences Humaines et Sociales from the University of Toulouse 2 – among which a team of the Institute of Mathematics of Toulouse, the Research Institute of Computer Sciences of Toulouse IRIT, and a laboratory of the National Institute of Agronomy INRA/AGIR. See http://www.iaai-maelia.eu

Equipped with the simulation platform we shall consider three central questions: 1) what are the impacts of a given normative system in different socio-economical and environmental contexts? 2) What are the impacts of different normative systems in a given socio-economical and environmental context? 3) Are these impacts consistent with the expectations of the legislating authorities or participating social groups? The first two questions require that on one hand the formal representation of the functioning of the environmental plus social coupled systems, and on the other hand the representation of the normative system, can be easily plugged and unplugged in the platform. Moreover several representations of socio-environmental coupled systems and of normative systems must be prepared in order to contrast their respective effects or reactions to the rest of the whole integrative system (including among others, external large scale environmental forcing or economical forcing, the agent and action layers, etc.). The third question is related to the choice of some explicit criteria allowing to test the validity of the functioning and design of the integrative platform and the simulations that will be performed. This issue is far to be trivial for two reasons: 1) we are going to assess the impacts of norms that point towards "*what should be*" and not towards "*what is*"; 2) we shall build scenarios of evolution of complex systems, projecting their trajectory in the future. On both aspects we generally have no direct data, observations or even narrative description that would allow applying the usual criteria of modern science for testing the validity of the model. Comparing the platform outputs with some external and independent expectation is a possibility that we are exploring.

3. A System of Complex Sub-systems

The approach chosen for building the integrative platform is based on cognition in the sense that we clarify and formalize the partial building blocks of knowledge provided by the different scientific disciplines and then build the schemes for their coordinated and integrative functioning[4]. One possible way to present the integrative platform is to present it as a network of several complex sub-systems, each sub-system presenting an underlying network-like structure. The corresponding mathematical object is a graph, say basically the pair constituted by a set of vertices and a set of edges linking some of the vertices two by two. We now briefly illustrate the network structures of the resource, social, action and norm sub-systems.

3.1 A Sub-system of Resources

The conceptual representation of several kinds of ecological systems or sub-systems is often relying on networks: box models for the water bio-geochemistry,

4. At this level of description, these expressions should be taken in a very loose interpretation.

trophic webs, population dynamics, elements energy and matter cycles, etc. [8], [9]. In the MAELIA Project we are interested in ecological dynamics because it is producing resources or services. The physical and geochemical dynamics of water is ruled by hydrological processes and interactions (atmosphere, rainfall, soils, rocks, etc.) but also by interactions with other components of the biosphere (bacteria, phyto- and zoo-plankton, vegetation, etc.) [10]. In these models, the vertices are not directly resources, but physical, chemical or biological variables (biomass density, population density and cohort spectra, etc.) which values represent the instantaneous state[5] of the water resources and of the other resources (soil, usable vegetation, livestock, etc.). The edge between two vertices represents a functional link often itself formed of the superimposition of different processes with their own space-time dynamics. All these models are generally developed in the form of (stochastic) ordinary or partial differential equations non linear coupled systems, or in the form of agent-based models. They exhibit a rich spectrum of dynamical regimes that are mostly analyzed and characterized in the Dynamical System Theory [11], [12].

3.2 System of Social and Organizational Agents

The physical, biological and ecological entities just mentioned are resources only once some agents are using, exploiting or valorizing them. Basically the agents are themselves entities able to a) have various perceptions of their environment (including on the time varying and distributed states of the resources); b) undertake and realize actions; c) make decision, with regard to the actions they undertake, their possible coordination with the other agents, the communication and information exchange they perform with the others. We broadly distinguish two large classes of agents: institutional agents that have the responsibility of managing the resources (or ensuring the conditions for such management: for example Water Agencies, Regional Councils, etc.) and non institutional agents that mainly use, exploit or valorize the resources and ecological services: for example farmers (using water for irrigation, developing livestock farming, forestry, etc.), rural or urban inhabitants but also firms from the public or private sectors, associations, etc.

The analysis of the water resource management is central in our modeling for identifying these agents (e.g. [13]). The analysis of water governance also gives a view of the links existing between all these agents [14], [15]. We are building a typology of these links. Indeed different kinds of relationships exist between agents: inter-institutional links are often formalized (possibly as a legal norm); institutions might interact with non institutional agents in the form of incentives, or in creating the conditions for participatory forums to be held, enforcement of (legally legitimated) decisions, etc. The mode of interaction will

5. In distributed system, these variables are also depending on some spatial independent variables (geographical coordinates, altitude or depth, etc.).

be also different between individuals, and between a “collective” agent (for ex a firm, an NGO, etc.) and individuals. Of course not all possible links are represented in the platform. For example if in some context the familial links have no role in the use or management of the resources, they will not be represented. With this example we also see that modeling decisions have to be taken also in the sense of discarding some components of the real systems[6]. In summary in this sub-system, vertices are agents and edges links between them.

3.3 A Sub-system of Actions

Every agent has the capacity to perform different actions on the resources. This set of actions can be shared by all the agents of the same social group. The platform comporting different groups or types of agents, there will be several, non-necessarily disjoint, sets of actions. In this sub-system, the vertices of the underlying structure are elementary actions. Several such actions can be composed in order to form more complex actions, or series of actions. Such composition is represented as a path linking several consecutive elementary actions in a sequence. Not all actions can be composed together or in an arbitrary order. In other words not all links (and paths) are possible in the graph of actions.

Dependencies between actions are of two types. The first one is given by the conditionality of an action: the action a_i can be performed by agent A_j if and only if action a_k has been previously realized (possibly by another agent A_l). The link is representing the conditional dependence of the action a_i on the action a_k. Of course such conditionality can be set on several actions, the conditioned action being the source for several edges oriented towards the conditioning actions. The second kind of link concerns the consequence of an action, performing an action involves another action; that yields a directed network of actions.

The existence of a link between actions may be dependant of the intensity of the actions. For instance pumping water may involves, if this pumping exceeds a given threshold, the action of opening the floodgates of a dam. This is surely important in the design of the platform: a link that represents the fact that a given action has some impact on the course, magnitude or effect of another action. If an action magnitude or spec-time extension is parameterized, the effect of another action can be obtained by changing the scalar values of the parameters. However the main difficulty is probably not here. It is in the possibility to design modular actions, and to be able to compose them in a coherent way. Such objective requires the ongoing development of a meta-theory of action [16].

6. Note that the capacities of perception, decision-making, strategic evaluation, as well as many attributes are encapsulated in the agents themselves.

3.4 A Sub-systems of Norms

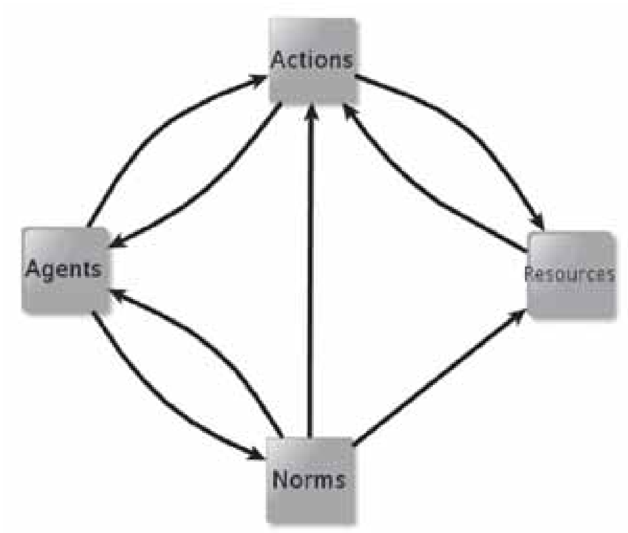
In the MAELIA project we distinguish two large classes of norms: social norms and legal norms. The first kind of norms is embedded in the social tissue and is more or less regulating the interweaving of agent interactions. These norms might be non-explicit though known or shared by most of the agents. As for actions, social norms can present some conditionality interdependency or (mutual) impacts or effects, one norm changing or modulating the way another norm will regulate the behavior and actions that are under their own domain. The class of legal norms, their types, modes of implementation, efficiency and effectiveness are receiving much attention from lawyers, sociologist, political sciences, etc. The results of these approaches must be analyzed for building another typology of normative links. Such links can be found between legal norms in particular through their inter-citation and hierarchical system [17], [18].

They are also found when considering the occurrence of some fundamental concepts in legal texts: for example the notion of “water resource” will be found in many legal texts like the European Water Framework Directive, the French law on water and aquatic environments of 2006, etc. or in sub-parts of these texts, exhibiting some cognitive patterns, the strength of which can be quantified using information functions [19]. Mining large corpuses of legal norms in search for some notions that are central in an ontology design for water resources, will clearly exhibit this organization of the “water norm system”.

3.5 Connecting Sub-systems

To each sub-system just described is associated a representation as a set of entities (vertices: resources, agents, actions, norms) related by different types of functional links (edges between some pairs of vertices). For the sake of clarity, in Figure 1, these sub-systems are represented as vertices of a kind of meta-network that encompass all the platform items; the links represent classes of links that in fact should be detailed, and that connect not only large sub-systems, but some vertices contained in the sub-systems. Let us give an illustration of the possible interpretation of these classes. Some of them get an apparently trivial interpretation. Each agent has the capacity to perform various actions on the resources (link “agent to action”). At this stage, the actions considered in the MAELIA Platform directly affect the resources (link “action to resource”). Many norms are regulating actions (link “norm to action”) with respect to their potential impact on the resource (link “norm to resource”), or conversely modify the possibility of action because of some particular state (water quantity or quality) of the resource. Some norms give a mandate or the power to some agents (link “norm to agent”) to realize some action. Some of these agents are also giving the right to create new legal norms (link “agents to norms”).

Fig. 1. A meta-network representing the MAELIA platform. "Agents" stands for the sub-system of individuals and institutions linked by various social and institutional ties; "Actions" stands for the sub-system of actions, "Norms" stands for the sub-system of legal and social norms and "Resources" stands for the sub-system of the water resource and other natural resources all linked by ecological or environmental dynamics. Arcs describe the different interactions which are detailed in the text



We have also shown previously that some actions are related to other actions because of some conditional dependence (links internal to the sub-system of actions). But some conditional dependences exist also between some actions and agents: for example when an action performed by an agent requires one or several other agent to be available for cooperation. Some links between action and resources also exist: the production of hydro-electricity is possible if and only if some water is in the dam. The representation of such conditionality is included in the Figure 1, with the link oriented from the action to the agents, and the link from the resource to the action. Here we do not intend to give an exhaustive illustration of all the possible links that will be represented in the MAELIA Platform. This will be presented in another study.

Of course this representation as a complex network composed of sub-network defined on the basis of the knowledge that we have in different disciplines on the regulation of the environment and resources with norms, does not encapsulate all the complexity of the system. Indeed the different parts of the platform must be carefully instantiated and the information flux controlled.

4. Networks and Scenarios Building

The complex system represented in Figure 1 can be studied, from a mathematical and computer science point of view, by graphs and more precisely by weighted directed graphs with different kinds of edges.

4.1 Network Design

The approach we are developing allows us to use and develop tools from graph theory and network analysis to study the structure of this complex system. We briefly describe now some tools used in network analysis; the purpose of such an analysis is to better understand the structure of a graph [20].

A first step in network analysis is to compute some indices on the graph that are some quantitative measurements well adapted to characterize network structures. This measures are for instance the density of the graph (the ratio between the number of edges in the graph and the total number of possible edges), the local clustering (the probability that two vertices are linked knowing that they are already linked to a common vertex) or the global connectivity (how many intermediaries are necessary to connect any two vertices in the graph). A well-known structure may emerge from the analysis of the given graph such as a small-world structure.

An interesting feature is highlighting important vertices, respectively to the considered network it can be an important agent, an important action, an important resource or an important norm. However this notion of importance must be defined. In graph theory there are mainly three such notions called *centrality* [21]. The *degree centrality* is just defined as the number of links incident to a vertex; more the vertex is connected with other vertices, more important is this vertex. The *betweenness centrality* measures the number of shortest paths going through a vertex; a typical vertex with a high betweenness centrality measure is a vertex with a low number of links but linking two almost-disjoint groups. The *proximity centrality* is computed from the mean distance from a vertex to other vertices; an important vertex for this notion of centrality is a vertex able to reach quickly other vertices.

A fundamental aspect of network analysis is the research of communities. The notion of community, quite natural in a social network, can be extended to any kind of network as a group of vertices highly interconnected. Finding communities permits to have an overview of the network by aggregating the vertices into communities, therefore it permits to better understand the network structure, and also to draw an intelligible representation of the network [22]. These analyses can be first performed on each sub-system of our platform by adapting the classical notions exposed above to weighted directed graphs with different kinds of links. Then, the dynamic aspect of these systems should be taken into account; by measuring the evolution of centralities and other measures on the network; these evolutions may help us to construct dynamic models of the considered systems.

The analysis of the whole system drawn in figure Fig.1 and involving four different sub-systems exposed in Section 3 may reveal important and hidden features like communities. Indeed the sub-systems of resources, agents, actions and norms can be considered somewhat as homogeneous groups of entities linked by specific relationships and formed during the cognitive process of the model design. It is an analytical view of the water management system regulated by some normative system that is very pertinent when conceiving and implementing the platform, or when analyzing real water management systems. But we are not a priori guaranteed that these groups are also communities in a graph or network theoretic sense, when considering the whole system of Fig. 1. Even if the definition of a community in such a system is far to be obvious, it will be interesting to search for and find heterogeneous communities, that is the ones which gather vertices from several kinds of sub-networks and thus going through the predefined organization in four sub-networks. Though we already suspect that such hidden community exists, we would like to bring some evidence of their existence in such complex system and analyze their content. Equipped with the network approach and analysis we can potentially achieve this goal.

4.2 Scenarios and Social Engineering

An important purpose and a cornerstone of the MAELIA platform concerns the building of various scenarios by modifying a part of the system like addition/deletion of edges or vertices in its underlying network structure. These vertices or edges are chosen following two competing procedures: they can be chosen according to their centrality measures or they can be chosen at random, the latter one permitting to evaluate the real impact of the former one. Let us give two examples of scenarios that will be explored.

We shall first focus on the normative sub-system since one of the objectives of the MAELIA project is to simulate and assess the impact of different normative systems designed for the water resource management on the same socio-environmental system (see the end of Sec.2.2). A way to control some perturbation of the normative system is to change its network structure (for example removing or adding some links of a definite type). In other words, what are the impacts of a modification of the normative sub-system and/or links between its components and the other parts of the whole complex system? Is this perturbed normative sub-system inducing some better performances in terms of social development or resource sustainability (all concepts to be precised, even if competing definitions are retained)?

We also plan to consider governance issues. A very abstract and abridged way of representing the governance is to draw the set of agents (in our case public agencies and authorities, stakeholders, etc.) linked by different types of relationships of interest for the governance of the water resource at basin scale. In a top-down controlling system of the decisional power, no link will go from the bottom vertices (agents with no recourse for participating in any decision) to the upper vertices, say to agents having a real capacity to take decisions concerning the management of the resource. Adding a few link going bottom up, or even directly creating a kind of short cut, from the bottom most stakeholders to the powerful decision-makers, should deeply change the various centralities of all the agents and consequently the effective mechanisms of decision-taking. Such idea have been for example analyzed in the case of the environmental governance [23] but not analyzed with mathematical tools and quantitative measures as we plan to do in the MAELIA Project.

5. Conclusion

In the MAELIA Project we are building a multi-agent platform for assessing the impact of environmental norms on the environment, water resources and socio-economical dynamics. We here proposed an architecture of the MAELIA platform based on a meta-network structure. The understanding of the functioning of this complex system passes through the study of network dynamic measures and the research of heterogeneous communities. In this paper we explain the various analysis and scenarios building that will be now possible. Several hard problems found in the theory of organization, in the analysis of environmental and resource governance, in the impact assessment of legal norms, etc. can be addressed in a rigorous way using this particular approach.

6. Acknowledgments

The authors warmly thank Prof. M. Poblet and Prof. P. Casanovas for the opportunities they gave to present different aspects of the MAELIA Project in international, interdisciplinary and inter-institutional forums. R. Boulet benefits from a post doctoral grant of the *Institut National des Sciences de l'Univers* (CNRS, Paris). This study is funded by the RTRA *Sciences et Techniques de l'Aéronautique et de l'Espace* (http://www.fondation-stae.net/) in Toulouse (MAELIA project - http://www.iaai-maelia.eu/).

7. References

1. Sartor, G.: Legal reasoning – a cognitive approach to the law. A treatise of legal philosophy and general jurisprudence, vol. 5, E. Pattaro (ed. in chief), Springer, Berlin (2007)
2. Young, O. R., King, L. A., Schroeder H.: Institutions and Environmental Change. The MIT Press, Cambridge (2008)

3. Ostrom, E.: Governing the Commons: The Evolution of Institutions for Collective Action. Cambridge University Press, Cambridge MAS (1990)
4. Brock, W. A., Carpenter, S. R.: Panacea and diversification of environmental policy, *PNAS* Sept. 25, 104 (39), pp. 15206--15211 (2007)
5. Ostrom, E, Janssen, M. A. and J. M. Anderies, J. M.: Going Beyond Panaceas Special Feature: Going beyond panaceas. *PNAS* Sept. 25, 104 (39), pp. 15176--15178 (2007)
6. Ostrom, E.: Understanding Institutional Diversity. Princeton University Press, Princeton (2005)
7. Nicolazo, J.-L., Redaud, J.-L. : Les agences de l'eau – Quarante ans de politique de l'eau. Ed. Johanet, Paris (2007)
8. Coquillard, P., Hill, D.: Modélisation et simulation d'écosystèmes. Masson, Paris (1997)
9. Treuil, J.-P., Drogoul, A., Zucker J.-D. : Modélisation et simulation à base d'agents. Dunod / IRD, Paris (2008)
10. Sigg, L., Behar, Ph., Stumm, W.: Chimie des milieux aquatiques. 4^{e} ed., Dunod, Paris (2006)
11. Wiggins, S.: Introduction to applied nonlinear dynamical systems and chaos; Springer, Berlin (1990)
12. Lasota, A., Mackey, M. C.: Chaos, fractals and noise – stochastic aspects of dynamics. Springer, Berlin (1994)
13. Videira, N., Kallis, G., Antunes, P., Santos R. (eds.) : Integrated evaluation for sustainable river basin governance, European Commission, Community Res., IWA Publ., London (2007)
14. Timmerman, J. G., Pahl-Wostl, C., Moltgen J.: The adaptiveness of IWRM – Analysing European IWRM research, EC Community Res., IWA Publ. (2008)
15. Wallace, J., Wouters, P. (eds.) : Hydrology and water law – bridging the gap, IWA Publ., London (2006)
16. Herzig, A., Varzinczak, I.: Metatheory of action: beyond consistency. Artifical Intelligence, 171(16-17), pp. 951--984 (2007)
17. Bourcier, D., Mazzega P.: Codification law article and graphs. Legal Knowledge & Inf. Systems, JURIX A.R. Lodder and L. Mommers (eds.), IOS Press, pp. 29--38 (2007)
18. Mazzega, P., Bourcier, D., Boulet, R.: The Network of French Legal Codes, Proc. Inter. Conf. Artificial Intelligence & Law ICAIL'09, Barcelona, pp. 236--237 (2009)
19. Mazzega, P., Bourcier, D., Bourgine, P., Nadha, N., Boulet, R.: A complex-system approach: legal knowledge, ontology, information and networks,

Approaches to Legal Ontologies, Sartor, Casanovas, Biasiotti & Fernández Barrera eds., Springer, *submitted.* (2009)

20. Boulet R.: Comparaison de graphes, applications à l'étude d'un réseau de sociabilité paysan au Moyen Age, PhD thesis (2008)
21. Freeman, L.C. Centrality in social networks: Conceptual clarification. Social Networks, 1(3) pp. 215--239 (1979)
22. Boulet R., Jouve B., Rossi F., Villa N.: Batch kernel SOM and related Laplacian methods for social network analysis, Neurocomputing 71(7-9), pp. 1257--1273 (2008)
23. Trustnet-In-Action: TIA Final Report, 66 pp. http://www.trustnetinaction.com (2007)