The Development and Rapid Evaluation of the Knowledge Model of ADVOKATE: an Advisory System to Assess the Credibility of Eyewitness Testimony

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Abstract. ADVOKATE, a web-enabled knowledge base application operating in the forensic and legal domain, offers assistance to police and legal counsel in their task of assessing the credibility of potential witnesses. The knowledge model of ADVOKATE is presented in two parts. Directed graph techniques are used to model rule based knowledge and discretionary decisions and argumentation are modeled using a technique derived from Toulmin argumentation. The knowledge was acquired from legal cases, published legal and psychological research and interviews with domain experts.

The model was formatively and rapidly evaluated by using it as the basis for a prototype web deployed application built using the expert system shell, WebShell. ADVOKATE, implemented as a browser accessible application, was made available to forensic experts, lawyers and police who provided feedback to the designers. The knowledge model was iteratively refined and enhanced and is available at http://advokate.bromby.vze.com/.

The paper concludes with a discussion of some knowledge modeling issues demonstrated in the ADVOKATE project and the benefits provided by using a prototyping methodology to conduct a formatively biased rapid evaluation of a knowledge model in projects with limited resources.

1 Introduction

Eyewitness testimony is an important factor in criminal investigation. Many crimes have witnesses who may have observed important details, however often the credibility of a witness is difficult to determine prior to their appearance in Court due to the discretionary assessment of witness reliability by a jury. The two major factors requiring assessment to provide an estimation of witness credibility are the reliability and suitability of the witness.

ADVOKATE is a web-enabled knowledge-based decision support application designed for use in criminal investigations, civil litigation or as a teaching aide for investigative training. ADVOKATE provides an indicative assessment of the credibility of eyewitness testimony. The acronym ADVOKATE is derived from knowledge associated with witness reliability as discussed below. This paper first describes an approach to modelling knowledge,

Michael C. Bromby and Maria Jean J. Hall, 'The Development and Rapid Evaluation of the Knowledge Model of ADVOKATE: an Advisory System to Assess the Credibility of Eyewitness Testimony' in T.J.M. Bench-Capon, A. Daskalopulu and R.G.F. Winkels (eds.), *Legal Knowledge and Information Systems. Jurix 2002: The Fifteenth Annual Conference*. Amsterdam: IOS Press, 2002, pp. 143-152.

with both discretionary and rule-based components, then presents the knowledge model underlying the ADVOKATE system. It continues with a description of a method based on prototyping, used for the rapid formative evaluation of this model. Demonstrating a prototype web-based application to domain experts (police and legal counsel) resulted in feedback, which in turn prompted further refinements to the model. The ADVOKATE knowledge model was thus formatively evaluated through a series of iterative prototypes. The paper continues with a discussion of some knowledge modelling issues identified during this project and concludes with a discussion on the part prototyping can play in the rapid evaluation of a legal knowledge based system.

2 The ADVOKATE knowledge model

The knowledge model supporting ADVOKATE was developed using knowledge acquired from various sources including legal cases, interviews with domain experts and reports in the literature. Empirical research, published and accepted by the scientific and legal communities such as the amount of time the witness observed the perpetrator [1] or the effects of time delay [2], was also incorporated in the model. The knowledge model is presented in two parts, the first dealing with rule-based inferences and the second with knowledge containing some elements of discretionary inferencing. Figure 1 demonstrates how directed graph techniques are used to model rule-based knowledge. The nodes represent ADVOKATE concepts and the possible values for each concept are captured in arcs emerging from the node. Leaf nodes represent the possible outcomes. This simple directed graph demonstrates that the credibility of an eyewitness involves a preliminary assessment of suitability followed by the principal analysis for reliability. Failure in either of the two tests suggests that the eyewitness is not credible and should be rejected.

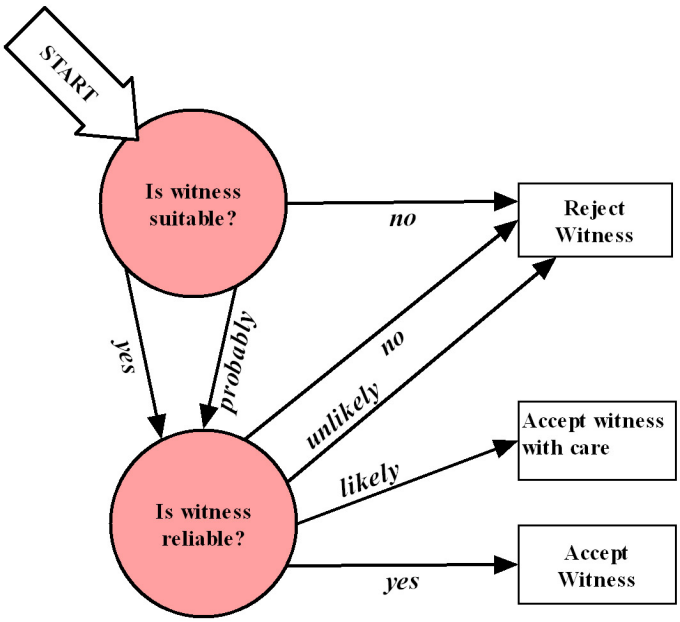

Figure 1: ADVOKATE: Rule-based section of the knowledge model.

The detailed determination of witness' suitability and reliability are not rule-based inferences but rather discretionary decisions where the decision maker, taking account of several input factors, chooses from one of several possible outcomes. Decision makers may arrive at different outcomes, depending on how they choose to inference from their understanding

of the input factors. Thus the ADVOKATE domain can be categorised as a bounded discretionary domain [3]. The factors to be taken into account are known but no norms specified, leaving the decision maker free to weight the factors, as they so desire.

Decisions with some discretionary elements are modelled using a technique derived from Toulmin argumentation and based upon the work of Stranieri, Yearwood and Zeleznikow [4]. An argument tree has nodes representing factors that are claims and leaves representing data items relevant in arriving at a claim. Argument trees are used to further refine the knowledge depicted as directed graph nodes in Figure 1. Figures 2 and 3 show part of the argument tree for witness *suitability* and figure 4 models witness *reliability* argumentation. The Toulmin warrant component is here replaced with inference mechanisms and a reason for relevance [5], however, how the factors are considered and combined by a decision maker when determining a claim, is not depicted in this model.

2.1 Witness Suitability

The Oxford Dictionary defines suitability as *'right for the purpose or occasion'* [6]. Witness *suitability* is questioned from a legal perspective to ensure that the witness can proceed along the pathway of investigation, from initial interview and statement through to giving evidence in a court of law. This is applicable not only to eyewitnesses, but to any witness giving evidence in court. The domain is vast, with much knowledge being taken from existing procedures and tests laid down by case law or legislation as discussed below. The knowledge model created for ADVOKATE is a very simplified test as the main function of the system is to advise the user on the overall credibility of eyewitness testimony. The *suitability* section of the advisory system is an area for future extension as the current ADVOKATE project places more emphasis on witness *reliability*.

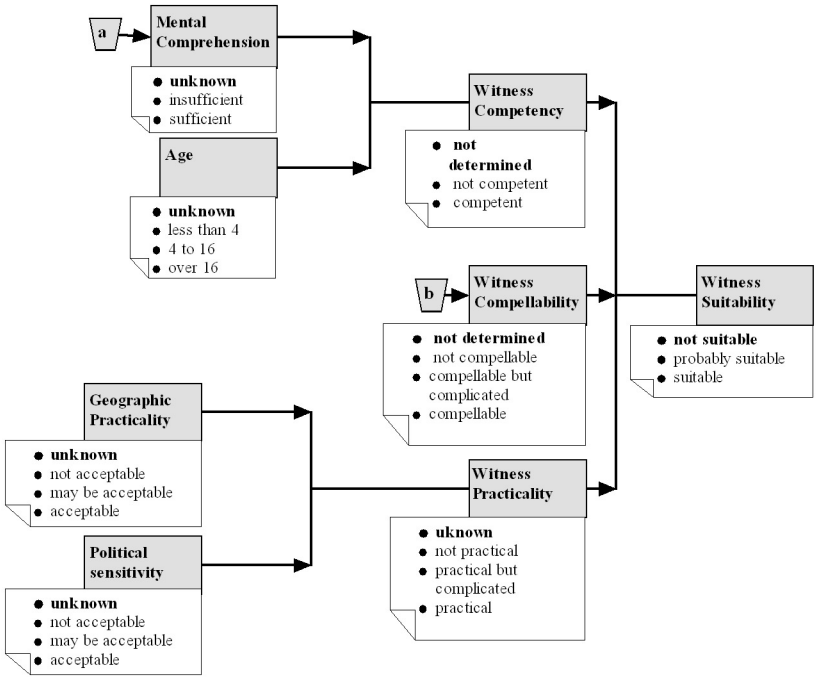

Figure 2: ADVOKATE: Part of the knowledge model of witness suitability.

Suitability is assessed by looking at three core issues: *competency, compellability* and *practicality* as shown in figure 2. The first two areas are well-defined legal terms, the knowledge being readily available in legal cases that have addressed these areas [7]. Practicality

is an issue that may or may not be significant depending on a number of factors such as the number of available witnesses, the significance of their testimony and the contribution made to the totality of evidence in a particular case. There may well be further factors that play a part in determining *suitability* other than the core areas examined in this model depending on whether the advisory system is to be used by the police, the public prosecuting body or as a training aide. Any omissions would be identified during model validation by domain experts or when tailoring ADVOKATE for a particular end user.

Witness *competency* is determined considering two factors: *age* and *mental comprehension.* The key factors are: understanding the difference between truth and falsehood; appreciating the duty to tell the truth; and being able to give coherent testimony as defined in Dickinson's *Evidence* paragraphs 1550 - 1554 [8]. The witness must meet all three of these criteria, otherwise the witness will be deemed to be not competent, which in turn will cause ADVOKATE to infer that the witness is unsuitable.

The *compellability* of a witness is determined by looking at two factors: the *connection* between the witness and the accused; and any *immunity* the witness may have. The general rule is that a *competent* witness is also *compellable* as stated in *McDonnell v McShane* (1967) [9]. The test for witness compellability is shown in figure 3. The model for compellability contains the exclusions to the general rule found in statutes such as section 264(2)(b) of the Criminal Procedure (Scotland) Act 1995 [10] which states that communication between spouses during marriage is privileged and a spouse cannot be compelled to give such evidence. The Diplomatic Privileges Act 1964 [11] and the Consular Relations Act 1968 [12] permits diplomats, their families and staff to give evidence as competent witnesses, but they cannot be compelled to do so.

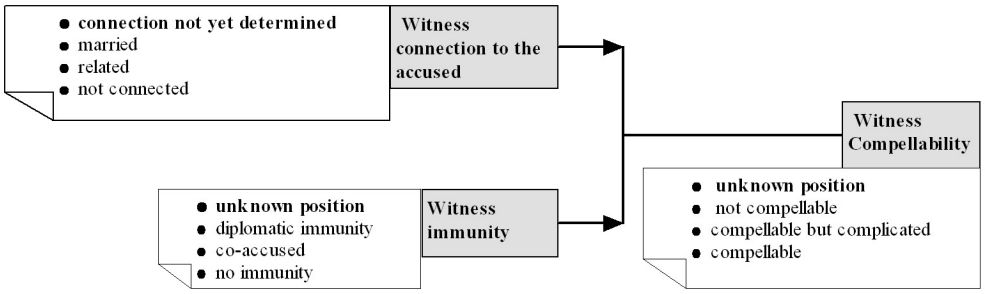

Figure 3: ADVOKATE: Witness Compellability.

The knowledge model for witness suitability determines, before testimony is given, whether a witness is likely to meet the criteria set out by a Court. However, witness suitability will be established ultimately in Court by the presiding judge. This model reflects the areas the judge will consider and predicts what the Court may rule. In situations where multiple witnesses are available, the ADVOKATE advisory system may aid the crime investigators or prosecuting body in deciding which witnesses to use.

2.2 Witness Reliability

The Oxford Dictionary defines reliability as *'consistently good in quality or performance'* [13]. The reliability test employed in ADVOKATE is taken from *R v Turnbull* [14],where the recommendations of the judge have since evolved into a mandatory jury direction that must be addressed to the jury of each case where eyewitness testimony is considered. The relevance of this case is apparent within many common-law jurisdictions. A study [15] of the

references to the Turnbull case found a high frequency of citations, illustrating the widespread acceptance and relevance of this legal test for eyewitness reliability.

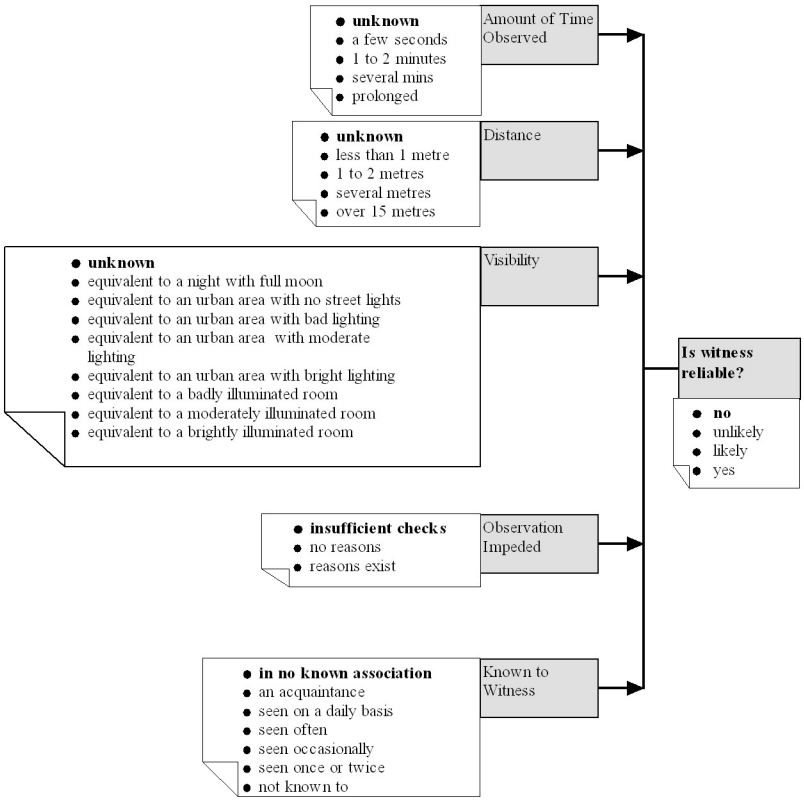

Figure 4: ADVOKATE: Witness Reliability knowledge model

The ADVOKATE acronym refers to the eight witness reliability factors that must be examined to comply with the Turnbull direction. These factors are shown in Figure 4:

A – the **Amount** or length of time the witness observed the perpetrator
D – the **Distance** from the witness to the perpetrator
V – the **Visibility** conditions at the material time
O – whether the line of **Observation** was impeded either partially or temporarily
K – whether the perpetrator was **Known** to the witness in any way
A – if there were **Any reasons** for remembering the event or the perpetrator
T – the **Time** elapsed since the event
E – whether there were any **Errors** in the description of the perpetrator compared to the appearance of the accused.

Witness reliability inferences can be made from certain combinations of these Turnbull factors. Taking into account all the possible input values for each Turnbull factor, there are at least 472,500 possible variations making it too resource consuming to consider the outcomes generated by all of these separately. An expert system provides a suitable way to store and analyse this type of knowledge. From the examination of the domain knowledge, certain factor values are apparent that would cause the eyewitness to be deemed unreliable, irrespective of the values entered for other factors. These are termed *defeating values* and include all the 'unknown' values for each of the eight Turnbull factors, distances over 15 metres and visibility below 15 lux. The latter two values have been shown by psychological research to represent a cut-off value for possible recognition [16].

3 Evaluating the ADVOKATE knowledge model

Evaluation can be summative or formative. Summative evaluation provides methods of assessing and certifying that a preset level of product quality has been reached whilst formative evaluation places the emphasis on iteratively improving each version of the product through seeking feedback. The World Wide Web provides an opportunity for the formative evaluation of decision support systems [17].

The Context Criteria Contingency Evaluation framework for legal knowledge base systems provides a framework for planning an evaluation [18]. It first considers properties of the *contexts* of the system operation and of its evaluation. It then offers a selection of potential evaluation *criteria* covering verification and validation, user credibility, technical infrastructure and impact. Finally, it suggests *contingency* guidelines for the choice of evaluation criteria based on the evaluation and operational *contexts*. The impact of the *contexts* upon the choice of evaluation *criteria* is emphasised.

The resources available for the evaluation of the ADVOKATE model were limited and there was a requirement to conduct an inexpensive evaluation in limited time. This restriction in the evaluation *context* impacted upon the choice of evaluation method and *criteria.* Accordingly this evaluation was designed to concentrate on the validity and usefulness of the ADVOKATE knowledge model. The model became the basis for the construction of a rapidly prototyped web-enabled application, thus demonstrating the usefulness of the model together with its 'correctness' and 'completeness' i.e. there was sufficient knowledge modelled in an appropriate manner to allow the specification and building of such an application.

The ADVOKATE prototype application was developed using WebShell, a web enabled expert system shell [19]. This shell integrates knowledge held as rule-based directed graphs with knowledge exhibiting discretion held as argument trees and provides access to the resulting rapidly prototyped decision support system via a web browser. WebShell offers a developer several methods for inferencing discretionary outcomes. The ADVOKATE prototype was implemented using an inferencing algorithm based on a weighted linear mapping technique with specified exceptions to this general result, such as the defeating values discussed above, coded as exception rules, with the order of their firing impacting upon the outcome [20]. The Application's user interface is shown in Figure 5.

The potential usefulness of the knowledge model to an application developer was confirmed as it provided a viable foundation for developing the ADVOKATE prototype. The process of attempting to implement the prototype prompted changes and improvements to the knowledge model itself. Where simpler or more obvious ways of modelling the knowledge were found, the model was enhanced. The fine scrutiny of the model necessary for implementing the prototype alerted the modeller to ambiguities and duplications, which could then be resolved. Other model enhancements and corrections included reconsidering the sequence of presentation of some of the factors and where possible, stipulating the factors in a way to allow them to impact on the outcome in the same direction (positive or negative). Factor values were also re-ordered from most to least significant.

The ADVOKATE application prototype was made available to a wide audience by deploying it on the World Wide Web. Initial discussions with the Forensic Institute and Procurator Fiscals in Scotland indicated that the ADVOKATE system could be developed into a useful advisory system. The application and its knowledge model were also demonstrated at the Joseph Bell Centre workshop for modelling evidence and intelligence [21] to a multidisciplinary audience of forensic experts, police and lawyers. Resources were limited so this evaluation of ADVOKATE was immediate and informal rather than conducted through experiments and survey questionnaires however this rapid evaluation proved to be of value as the demonstration prompted considerable discussion amongst the audience. The feedback

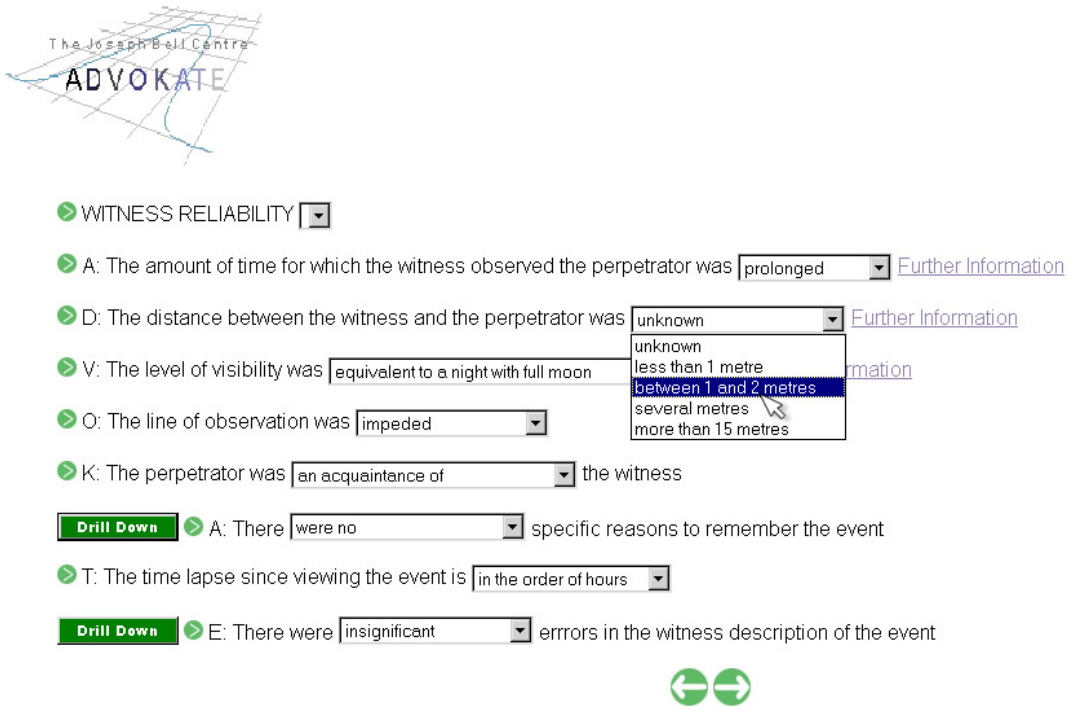

Figure 5: ADVOKATE prototype user interface implementing the eight Turnbull factors modelled in Figure 4

obtained both confirmed the potential usefulness of the tool and prompted revision and extension of the underlying knowledge model, hence contributing to its formative evaluation. WebShell implements a scalable application and it is a simple matter to implement changes and have them immediately available on the World Wide Web. The ADVOKATE knowledge model was protoyped, demonstrated to domain experts, enhanced with the feedback obtained and the knowledge model and prototype application prototype updated, all in rapid succession. The process of modelling the already acquired domain knowledge, implementing the application prototype and receiving and acting upon feedback took less than a man-week of effort, and can be considered a technique facilitating 'rapid evaluation'.

4 Knowledge Modelling Issues

During the ADVOKATE knowledge-modelling phase, concerns arose over what to include in the model and how to include it.

4.1 'Absent' values

The concept of absence or a factor having an 'unknown' value was considered. Three types of factor absence were identified and in some cases these required logical differentiation. For example considering witness compellability (Figure 3) and the one determining factor 'connection to the accused', there are three types of absence of a connection between the witness and the accused and each may have a different impact on determining witness compellability and hence the reliability of the witness: A confirmed absence (e.g. the witness does not know the accused) is represented as 'not connected' whereas 'connection not yet determined' is used in two ways to represent both the situation of absence because a presence has not yet been identified or because checking is incomplete (as an analogy, there is no record of the

witness knowing the accused – ‘interrupt’, or it has not yet been determined whether the witness does or does not know the accused – ‘polling’).

4.2 Intuitive correctness versus pragmatism

In ADVOKATE, as with other legal knowledge base systems developed using WebShell and knowledge supplied by domain experts, inferencing exceptions can be explicitly recorded as rules. This can implement a domain dependent pragmatic outcome, which may seem at first consideration to challenge intuitive correctness. In relation to witness compellability (Figure 3), a witness may be ’in an unknown position as to immunity’, but is ’married’ to the accused so by a coded exception rule is considered to be ’not compellable’ rather than ‘in an unknown position’, even though one of the determining factors has a value of ’in an unknown position’.

4.3 Completeness versus justifiability

During the knowledge acquisition phase, a problem arose, previously observed by one of the authors when modelling other legal knowledge base systems, namely the difficulty in deciding which factors should be included in the knowledge model. The inherent incompleteness of research and the uncertainty of the Law in some areas can be an impediment when attempting to create a knowledge model that is both logically complete and legally justifiable. Legal domain experts are predominantly concerned with what can be justified in terms of the statutes or case law and are reluctant to include factors that cannot be so supported, however this may not give complete coverage. Much of what can be termed ’common sense’ or the ’unwritten law’ does not appear in statute. Heuristics, or rules of thumb are therefore sometimes difficult to justify in the explanation associated with each possible outcome. It may be that broader criteria for inclusion of factors would not rely solely on justifiability under statutes or case law but also, under the guidance of domain experts, incorporate an ethos of ’what is useful’.

5 Conclusion

Knowledge pertaining to the ADVOKATE domain was acquired and a knowledge model constructed using modelling techniques combining rule based directional graphs and argumentation. The ADVOKATE prototype was developed and deployed on the World Wide Web, prompting feedback from domain experts and validating the usefulness of the model both to the domain experts in their witness credibility assessment task and to the application developer.

Future work will include modifying and expanding the ADVOKATE knowledge model in relevant areas and presenting new prototype iterations for further evaluation by interested parties. The prototype versions will eventually evolve into a requirements specification for re-implementation using an alternative, more sophisticated application development tool set. This would allow the inclusion of extra functionality such as data storage and retrieval, and interaction with other databases and on-line resources. Such interaction would allow multiple witnesses to be independently assessed and also create an assessment of the totality of eyewitness evidence. The consistency of witness opinion, synergies, conflicts and gaps in the investigation could be identified. Much of these extra elements could not be included in the WebShell prototype and this was a known disadvantage of using this software. However, the use of an alternative shell might not have supported the prototyping and web-based rapid

evaluation techniques, and for this project, it was considered that these benefits outweighed any disadvantages of the WebShell tool, including its inability to store historical data.

This rapid evaluation of ADVOKATE demonstrates a method for evaluating a knowledge model that could be applied to other legal knowledge base systems developed as research projects with low budgets and limited resources. Prototyping an application using a low cost limited functionality shell such as WebShell and deploying it over the web provides significant benefits. The fine scrutiny of the model that is necessary to code the prototype identifies areas for model improvement and provides the modeller with an opportunity to improve and standardise the model presentation. Constructing a prototype offers a 'proof of concept' that the knowledge is suitable to use as the basis of an application and thus evaluates its usefulness to an application developer. The inexpensive and easy web deployment of the prototype application and its exposure to domain experts prompts feedback to validate the completeness of the model and formatively enhance it. The prototype can also be used to evaluate usefulness and usability for a user. Finally the knowledge model and its prototyped application can become the requirements specification, for an enhanced operational system constructed using a more sophisticated shell.

Evaluations can be wide ranging, detailed and provide useful insight. However they consume resources that would otherwise be available for further development efforts. It is important that evaluations occur but prudent to weigh up the evaluation costs, expected evaluation benefits and the opportunity cost lost of the alternative uses of the expended resources. The method of rapid evaluation of the ADVOKATE prototype is here offered as one solution to this evaluation dilemma.

Acknowledgements

The valuable comments and assistance from the domain experts, the Advisory Board of the Joseph Bell Centre and the delegates of the Workshop on Modelling Evidence and Intelligence are gratefully acknowledged.

WebShell was developed in a research project funded by the Australian Research Council under the Strategic Partnerships with Industry Research and Training initiative with industry partners Victoria Legal Aid Ltd, Software Engineering Australia (Qld) and the Refugee Review Tribunal of Australia.

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