The PARCOM Legal Expert System and Its Hypertext Facilities

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1. INTRODUCTION

Each year the Belgian Labour Department receives approximately 3000 requests for advice with regard to the competence of the Joint Committees. It is the competence of a Joint Committee that determines to what sector of industry a company belongs. Several other governmental agencies, such as the Inspection of the Social Laws or the Social Security, as well as private agencies involved in labour administration, are increasingly confronted with requests for advice in this matter. However, most of the knowledge concerning the competence of the Joint Committees and easy access to the document sources whereupon the knowledge is based, are confined to some experts working at the Labour Department.

The scope of each industry is determined by a large number of Royal Decrees. Over the years, the federal labour administration, responsible for the application of those decrees, has developed a vast body of administrative case law. Decisions of the administration can be overruled by the labour courts. Quite often, determining the competent Joint Committee is a complex process. In Belgian Law the competence of a Joint Committee is mainly based upon company activities. In some cases, however, other criteria as e.g. the geographical site or the amount of personnel employed, may not only be relevant, they may even be decisive. Moreover, parties with conflicting interests (employers, employees, government, etc.) have given different interpretations of the law, which has led to ambiguous results in the past.

The PARCOM legal expert system provides help in determining the competent Joint Committee. The main goals of PARCOM are:

1. to supply a portable system, available to the Labour Department and to other agencies;
2. to provide a bilingual system (Dutch-French);
3. to reduce the amount of time spent by the expert on each consultation;
4. to provide unambiguous, comprehensible, and reliable advice for all parties concerned;
5. to establish a system that can be consulted by experts as well as by lay users without any domain knowledge.

Although the domain knowledge is vast and usually complex, it is clearly defined, thus making the building of an expert system realistic [Oskamp 1990].

The legal expert system PARCOM is supplied with a large bilingual hypertext documentation system. This documentation system was seen as a good way to explicate the knowledge employed by the expert system. It contains state and case law with regard to the legal definitions used in the knowledge base of the expert system.

To ensure its portability, the PARCOM system was developed for use in Windows 3.1 on PC. It needs a 386 processor and 4 MB ram memory. The PARCOM system was implemented by the software house ORIGIN BELGIUM n.v. in cooperation with ICRI (the Interdisciplinary Centre for Law and Information Technology at the Katholieke Universiteit Leuven, Belgium) and ORIGIN/BSO Artificial Intelligence, The Netherlands. We formed a team of four people: three software engineers and one knowledge engineer. We had contacts with the experts at the Belgian Labour Department on a regular basis. The knowledge engineer was engaged in a limited acquisition of the knowledge, and in the implementation of the knowledge in the knowledge base. The experts were responsible for most of the acquisition, the analysis, partial implementation, and the validation of the knowledge. Both the knowledge engineer and the experts accomplished the implementation of the contents of the hypertext documentation system.

An expert system shell was developed, reusing parts of code for the interface and the inference engine of the non-official version for Windows 3.0 of the shell Advisor-2, developed by Expert Systems International n.v. in cooperation with the Technische Universiteit Twente, The Netherlands. As in Advisor-2, the shell is implemented in Prolog-2 for Windows. The shell supports the knowledge representation language we designed, and provides bilingual interfaces. The shell is also supplied with facilities to add extra software to an application. Among this extra software the hypertext documentation system was developed as a help file for Windows 3.1. We linked this system with the expert system in a way that it could be consulted any time from the menu bar. To ensure extra control of the knowledge base we provided the knowledge representation language with the facility to link knowledge rules with relevant pages of the hypertext documentation system.
2. Brief Description of the Expert System

The shell exhibits the structure of a standard expert system shell: it consists of an inference engine, linked to the knowledge base and of two front ends, one to be used by the end user (user interface) and one to be used by the knowledge engineer (developer interface).

2.1. Knowledge acquisition

The knowledge sources primarily consist of statutory legislation (the law of 5 December 1968 and related Royal Decrees). To a lesser extent, the knowledge is extracted from legal cases and authoritative publications. Human expertise was not only helpful in complementing the document sources, but also in providing a method of consulting the knowledge.

2.2. Knowledge representation in the knowledge base

A separate language, the Wet Representatietaal (WRT), was designed to represent legal knowledge. This language imposes a formal structure upon the knowledge. The knowledge engineer is supplied with bilingual keywords or connectives. A parser was developed to translate the WRT statements, written either in Dutch or French, into efficient Prolog code.

The knowledge base is segregated into three parts. The first module controls the realisation of a consultation. Its knowledge manages the sequences, in which screens and advice texts are shown to the user. The second module contains the domain knowledge, represented by means of production rules. The PARCOM system processes about 22,000 lines of production rules. The if-then representation of these rules shows some similarity to human formulating, especially in law, and is convenient for explanatory purposes. Indeed, the domain knowledge in PARCOM, including case studies and knowledge from legal publications, has a regulatory character. The syntax of the WRT language, designed to represent the production rules, resembles the Knowledge Representation Language of the TESSEC expert system [Nieuwenhuis 1989]. As the Knowledge Representation Language of the TESSEC system [Svensson 1990], the WRT language is based on a core of predicate logic. The conditional parts of rules, as well as their non-conditional parts, can be written in whatever combination of conjunctions, disjunctions and negations. The use of existential and universal quantifiers can be simulated. Through the interface, the user has the possibility to view the production rules. The third module of the knowledge base contains
a lexicon, needed for the translation of the production rules into the natural language of the user. Each entry of this lexicon contains the Dutch name of an identifier or identifier value, its French name, and its abstract name, used in the production rules. This lexicon is built by the experts, since they are in the best position to attribute suitable Dutch or French names to the legal concepts. The third module also contains the links with the bilingual hypertext documentation system.

In the PARCOM knowledge base, it is attempted to project each legal rule into one production rule. Also, different legal sources are represented separately and links are built between the different rule sets. In PARCOM, these sources sometimes had a different weight or priority. The source of an applied rule can be detected easily and, if necessary, be added to the advice given. Sometimes, it was necessary to adopt common knowledge into the rules. It seemed reasonable to group this common knowledge and to relate the legal rules to it. So, whenever possible, the isomorphism [Bench-Capon, Coenen 1992] between the original legal sources and the knowledge in the knowledge base is preserved. However, as the domain knowledge is large, it was often necessary to abandon the principle of the one-to-one representation of legal rules and knowledge, and to rewrite the legal rules into an efficiently organised set of non-redundant production rules.

In the PARCOM knowledge base, meta-knowledge was needed for two reasons. Heuristic knowledge (search methods of the experts) is applied to search for a solution in an efficient way (see inference engine). Meta-knowledge is also used to determine priorities of rules or groups of rules, e.g. in the case of different legal sources [cf. Poulin et al. 1993]. When evaluating our knowledge representation language, it is a disadvantage that this meta-knowledge is not represented separately from the genuine domain knowledge. Changing the meta-knowledge would require more or less restructuring the production rules. The intermingled representation of domain and meta-knowledge could also impede the reuse of the domain knowledge in other applications.

2.3. Inference engine

A rule-based system needs a method of inference that calculates which production rule should be applied at each step of the reasoning process. In PARCOM, we used heuristic knowledge (search methods of the experts) to guide the inference process. This kind of meta-knowledge was absolutely necessary because of the vast amount of rules. The final goal of the search is the determination of the competent Joint Committee. The search space
of the knowledge is divided into different search subspaces. The preliminary goal(s) in the search is(are) the determination of the relevant subset of knowledge. Once the relevant subset of knowledge is found, the final goal is proven by means of backward chaining.

2.4. User interface

PARCOM is a knowledge-based, question-answering system. When a consultation is run, the system will ask the user relevant questions to complement its knowledge. The sequence of the questions reflects the practice of questioning by the human expert. Menu options and dialogue boxes show similarity to other Windows applications, thus creating a degree of familiarity.

The system is completely bilingual. The inference engine conducts a dialogue with the user in Dutch or French. The user starts consulting in the language of his choice. Questions, advice, and explanatory information appear in the chosen language. Upon request of the user, the advice can be automatically displayed into the other interface language. When interacting with the user, the system performs multiple translations. With the help of the lexicon, abstract definitions in Prolog code are translated into comprehensible sentences in either Dutch or French.

The user has the possibility to store completed and uncompleted sessions, which can be consulted or completed at a later date. Stored consultations can be consulted in the language in use during the original consultation, as well as in the other interface language. The user has also the possibility to correct given answers. This mechanism can also be used to perform simulation tasks.

2.5. Developer interface

The developer interface is bilingual and comparable to the user interface. It provides additional tools for the implementation, debugging and validation of the knowledge.

An important aspect of legal knowledge engineering is the validation of the knowledge. The purpose of the validation is to control whether the knowledge base truly reflects the present, underlying legal concepts and facts. Knowledge validation is not an easy process, especially when the knowledge is large and complex [Johnson, Mead 1991]. In the past, validation of legal knowledge was done by comparing the solutions, given by the system, with the solutions of the experts [Dupuis et al. 1993].
Hereby, a sample of representative input cases is submitted to the system [Walters, Nielsen 1988]. This method of validation is not very appropriate when validating large knowledge bases.

Because of the intended widespread use of the PARCOM system and the sometimes complex legal reasoning it performed, it was requested that the knowledge could be validated by the experts themselves. It is not uncommon to involve the experts in the validation of legal knowledge bases [Dupuis et al. 1993]. However, for reasons of the efficient organisation of the knowledge base, the interdependence of the production rules is not very clear. When viewing the knowledge base, it is sometimes hard to trace the path the system will follow when searching for a conclusion, especially for the expert who is unfamiliar with knowledge engineering techniques. Therefore, much attention was given to design a validation tool that presents the knowledge and the reasoning process in a format, familiar to the expert. The validation tool formats the rules into clear and comprehensive decision rules and represents them in the format of a decision tree that matches the analysis of the knowledge made by the expert. This representation facilitates the validation of the knowledge by the expert and reflects his working method and way of questioning, when performing an expertise. As an extra control, some irregularities in the decision rules are automatically checked.

3. The Hypertext Documentation System

Not only for the developer of the knowledge base, but also for the user of the expert system, it is important to have a supplementary survey of the knowledge behind the reasoning of the expert system. The lack of means to represent more detailed information on the underlying domain model is often seen as a weakness of rule-based systems. As in the PARCOM system the knowledge is large and based on a variety of sources, the need for complementary documentation is high. Moreover, in the PARCOM knowledge base, much of the transparency of the production rules was lost in order to guarantee the efficiency of the system.

The traditional response to develop transparency of an expert system is the ability of the system to explain and justify. PARCOM provides a hypertext-based explanation facility. The reasoning of the system can be elucidated in a context-sensitive way by information, extracted from an extensive and detailed documentation system. To make this kind of explanation possible, the knowledge engineer builds links between the production rules and
related pages of the hypertext documentation system. At present it is not uncommon to link a legal expert system to a hypertext system containing valuable explanations [Brown 1993; Dupuis et al. 1993; Hafner, Wise 1993].

Besides the explanatory function, the hypertext documentation system can be consulted from the menu bar at any time. In order to have access to the hypertext documentation system, the user is not required to run a consultation of the expert system. In this way, the hypertext documentation system can be seen as a stand alone application and as a tool for storage and management of a document collection. Legal texts are densely correlated (e.g. cases interpret statutes, cases cite cases, etc.), making them particularly suited for hypertext presentation [Greenleaf et al. 1991].

3.1. Description of the hypertext documentation system

Two versions (Dutch and French) of the hypertext documentation system have been developed. Both versions are available through the Dutch as well as the French interface of the system. The structure, the method of consulting, and the contents of both versions are identical.

When activating the hypertext documentation system, a general menu of the hypertext facilities is shown (Fig. 1). The hypertext system can be

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**Fig. 1. General Menu of the Dutch Version of the Documentation System, shown in the French interface**

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consulted as any Windows help file. The user can make jumps from one topic to another by clicking with the mouse on the jump terms (displayed in green and underlined), can browse through the pages of the documentation system, or can find relevant information on a subject by using the search function. Once activated, this function supplies the user with a list of search terms, representing the different subjects covered by the documentation system. The user has the possibility to send a copy of a specific page of the documentation to the clipboard, to add personal notes to specific parts of the documentation, or to define bookmarks in order to easily recover certain pages. The user can always return to pages previously consulted. A hypertext documentation system, used for information retrieval purposes, has many advantages [Tenopir, Ro 1990], among which the fact that the user himself determines the search direction.

The content of the hypertext documentation system is divided into two main parts.

The first part contains the document sources, whereupon the determination of the Joint Committees is based. It includes a lexicon, the description of the law of 5 December 1968 regarding the Joint Committees, a case base, that is chronologically and thematically ordered, and a database with former advises, performed by the Labour Department. The lexicon contains the legal concepts and definitions that are appropriate for determining the competent Joint Committee. Further, there are some additional lists, among which a list of institutions for which the law of 5 December 1968 is not applicable.

The second part of the hypertext documentation system contains general instructions regarding the determination of the Joint Committees. Guidelines are cited for the application of the law. General procedures are described about how a Joint Committee is determined. Special cases are treated, e.g. when a company exercises different activities. Also the composition of the bargaining committees with representatives of the employers and employees, who negotiate the collective labour agreements, is outlined.

3.2. Implementation and maintenance of the hypertext documentation system

As its development is similar to the development of a Windows help file, the implementation of the hypertext documentation system (Fig. 2) is not complicated and easy to learn. As a result, the major part of the implementation task was done by the experts at the Belgian Labour Department. The experts are familiar with the different document sources, the
relations amongst them, and their application with regard to the determination of the Joint Committee. The original form of the document sources is preserved as well as possible. After all, many document sources were scanned into the system. The experts are also engaged in the maintenance of the documentation system. Structuring the documents and constructing or maintaining the links between jump terms are tasks still to be done manually.
The Dutch and the French versions of the documentation are separately developed. We did not provide a control mechanism to ensure that the content of both versions is in accordance.

3.3. Acceptance of the hypertext documentation system

The hypertext documentation system is greatly appreciated by its various users. A fast and easy access to relevant and related pages in the documentation system is guaranteed. The similarity to a Windows help file, regarding the structure and the access methods, enhances the acceptance.

4. Conclusion

The hypertext documentation system of PARCOM can be used as a stand alone application or as an extra explanation facility for the expert system. Because of the vast amount of knowledge and the variety of knowledge sources the PARCOM system employs, this is not a luxury. Especially when the expert system aims to solve in a straightforward way ambiguities in the law or in its interpretation, the extra motivation provided by the hypertext documentation system (description of cases, doctrine) is more than welcome. Also, as a pure source of documentation, disconnected from the use of the expert system, it has outstanding merits. It allows the user to retrieve the information he is interested in. Therefore, the hypertext documentation system has been well received among its various users.

In the future, as research progresses and the knowledge of the legal language improves, it could be possible to construct a hypertext documentation system, as well as a knowledge base in a more automatic way from the original legal documents [Greenleaf et al. 1991; Jacobs 1992], thus reducing the high cost of manual construction and maintaining of these information bases.

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