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December 1998

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Peter Meso  
*Kent State University*

Gregory Madey  
*Kent State University*

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### Recommended Citation

Meso, Peter and Madey, Gregory, "Developing Web-based Agents for Knowledge Management" (1998). *AMCIS 1998 Proceedings*. 64.  
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# Developing Web-based Agents for Knowledge Management

Peter N. Meso  
Gregory R. Madey  
College of Business  
Kent State University

## Abstract

*Can we employ the emerging web technologies to transform expert systems technology so that it can be more readily harnessed for the development of Knowledge Management Agents (KMA)? This paper outlines how web technologies can be combined with an expert system shell to provide the platform for the development of KMA. To demonstrate the applicability of such a platform, a sample inter-organizational credential-analysis system is developed. Implications of combining these two technologies in the creation of web-based KMAs, and the platform's potential applications are then presented.*

## Introduction

In a rapidly globalizing world economy “the one sure source of lasting competitive advantage is Knowledge” (Nonaka, 1991). This realization is causing many organizations to re-examine how they create, transfer, and use corporate expertise for sustainable competitive advantage - a task termed Knowledge Management (Hibbard, 1997). Traditionally, expert systems have been used for capturing expertise. However, expert systems address very narrow scopes of knowledge domains, require tremendous effort to develop and maintain, and updating their knowledge-bases requires the full-time services of a knowledge engineer. These characteristics inhibit their use for developing Knowledge Management Systems (KMSs). However, the ability of expert systems to handle heuristic problems efficiently is a key advantage that needs to be harnessed in the development of KMSs.

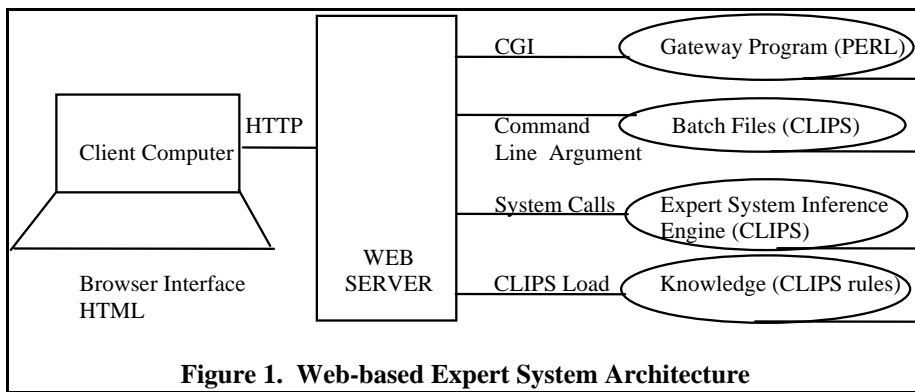
Nine key technologies, now maturing, have the capability to transform the application of expert systems in the solution of business problems, namely: groupware, messaging, web-browsers, document management, search and retrieval, data mining, visualization, push technology, and intelligent agents (Hibbard, 1997). This paper presents one method by which web-browser technologies can enhance the use of expert systems in the development of knowledge management agents. It addresses the question:

*Can we employ the emerging web technologies to transform expert systems technology so that it can be more readily harnessed for the development of Knowledge Management Agents?*

Part two of the paper explains the combination of web-technologies and an expert system shell into a platform for the creation of web-based knowledge management agents. A practical application of the platform in developing a web-based admissions counseling system is presented in the third part. Part four outlines the benefits and limitations of this platform, while part five presents the platform's implications to Knowledge Management Systems. Part six presents the potential application areas for this platform.

## Description of The Platform and Its Application

The platform's design is shown in Figure 1. It is made of: a) an expert system which infers the knowledge, b) user-interfaces that enable users to communicate with the expert system, and c) gateway programs which provide the connectivity between the users and the expert system. The expert system is coded in CLIPS (C Language Integrated Production System), a multi-paradigm programming language that supports rule-based reasoning. CLIPS represents knowledge as facts and rules. Facts are chunks of knowledge about the real world. Rules are cognitive matches of facts and the consequences of those facts. Because CLIPS is a forward chaining system, it is suited for the development of a classification system such as the admissions counseling prototype that we demonstrate in the next part of this paper (Giarratano and Riley, 1994; Watson, 1997). The user interfaces are written in Hypertext Markup Language (HTML). HTML is the programming language used to design web pages. The HTML form syntax is used to capture inquirers' responses to the questions asked by the expert system (Gundavaram, 1996). Gateway programs are written in PERL (Pactical Extraction Report Language). A gateway program converts statements written in one language into equivalent statements of another language thereby providing connectivity between the two languages (Quigley, 1995; Watson, 1997). The PERL programs are responsible for translating HTML code received from the web-browser into the CLIPS code that is then executed by the expert system. They also convert the CLIPS output from the expert system into the HTML output that is transmitted back to the inquirer. The platform employs the Hypertext Transfer Protocol (HTTP) and the Common Gateway Interface Protocol (CGI). HTTP is the transfer protocol used to transmit data between web-sites. The web browser employs HTTP to transmit the HTML inquiry data from the client to the server. The server then uses the CGI protocol to convert this HTML inquiry data into CLIPS input data. CGI is the part of the server that provides the communication between



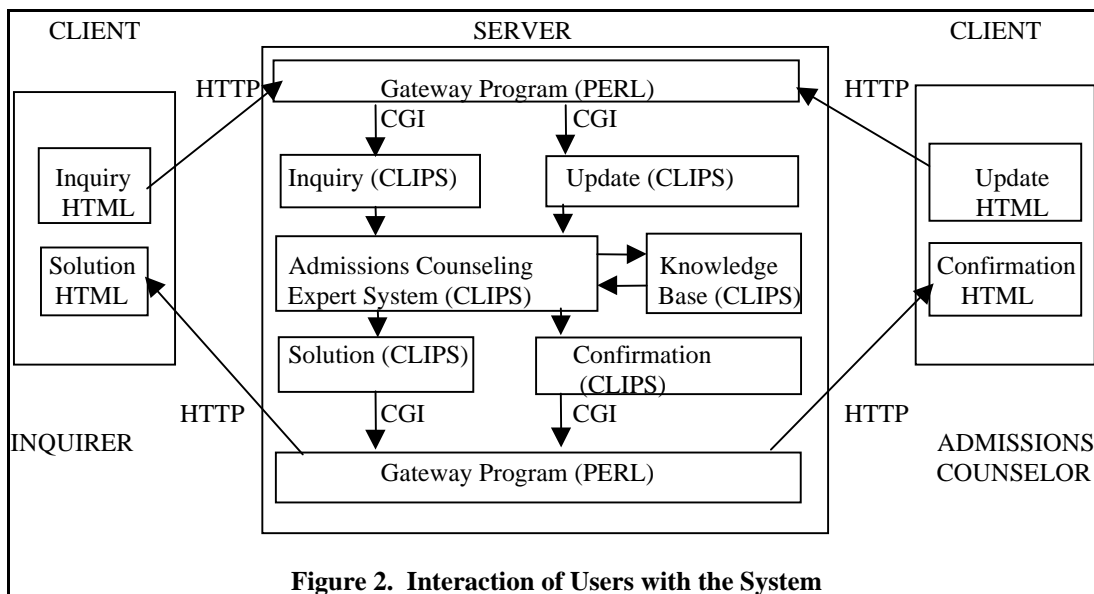
**Figure 1. Web-based Expert System Architecture**

programs running on the client and those running on the server. It allows the server to call up a program needed by the client, pass user-specific data to that program, and pass the response from that program back to the client. PERL employs the CGI protocol (Gundavaram, 1996; Todd, 1996; Quigley, 1995).

### The Admissions Counseling Prototype

Admissions counseling entails classifying inquirers into generic

categories on the basis of specific information. This information will differ from inquirer to inquirer, calling for the use of different rules and ranking schemes (Finlay and King, 1989). The information required for this task is not found on the credentials held by the inquirer. Thus the admissions counselor has to refer to admission guidelines, manuals, and recommendations from such agencies as the Association of Collegiate Registrars and Admissions Officers (AACRAO) in order to make a decision (Haas, 1994). Given the scope and nature of admissions counseling, supporting the function with a knowledge-based system should enhance the efficiency and effectiveness of the service to inquirers. Most inquiries, especially those from foreigners, will be received from persons geographically dispersed from the university. An Internet accessible knowledge-based system solution allows for time and geography independent provision of admissions counseling service to any inquirers (Finlay and King, 1989; Edwards and Bader, 1988). Therefore, the platform's practical applicability is demonstrated via the prototype, as graphically depicted in Figure 2. The inquirers' view is accessible at <http://zeke.kent.edu/~meso/clips/ADMIT.CGI>, while that of the admission counselors is accessible at <http://zeke.kent.edu/~meso/clips/ADNWFAC.T.CGI>.



**Figure 2. Interaction of Users with the System**

### Benefits and Limitations

The following benefits were observed when testing the admissions counseling prototype:

- Easy-to-use interfaces that connect experts (admissions counselors) and users (international inquirers) to a common knowledge base,
- Time and geography independent access to the knowledge base,
- Automation of knowledge engineering by allowing the experts (admissions counselors) to articulate their expertise directly into the knowledge base, and
- Enhanced efficiency and effectiveness of the knowledge work pertaining to admissions counseling.

However, we encountered a number of limitations, the most notable being

- a. Since the platform uses hidden fields to transmit data from the client to the server, a larger number of input screens increases the redundancy in the information transferred and hence the risk of data corruption or loss. This limits to the number of input screens.
- b. The unrestricted access, by inquirers, to the expert-system on the server demands that access security is minimal thereby exposing the server to potential destruction of its data and software; and,
- c. Concurrent update of the knowledge base by experts enhances the problem of truth maintenance.

Further development and enhancement of the platform is required in order to overcome these limitations. The empirical applicability of the platform is currently being tested through a collaborative effort between the authors and the staff of the Admissions office at Kent State University.

### **Implications to Knowledge Management**

The essence of Knowledge Management Systems (KMSs) is to support continued innovation via the iterative processes of articulation and internalization – a process termed organizational learning (Nonaka, 1991). Articulation occurs when an expert’s implicit knowledge is captured as explicit knowledge and internalization occurs when this captured explicit knowledge is then transformed into another person’s implicit knowledge. Innovation results from the articulation and internalization of knowledge. Knowledge work entails four key processes: 1) Finding existing knowledge, 2) Creating new knowledge, 3) Packaging knowledge created externally, and 4) Using existing knowledge (Davenport, Jarvenpaa and Beers, 1996). The platform demonstrated in this paper supports all the processes of knowledge work. Therefore, it enables the process of organizational and inter-organizational learning. By automating knowledge engineering, it eliminates a major impediment of expert system usage in developing KMSs. These findings have major implications on the development of KMSs. First, KMAs can be used to build intelligence into KMSs. Second, KMAs make the commercialization of KMSs on the Internet feasible. Third, powerful expert systems, hitherto limited to specific problem domains, can now be used in a wide array of KMSs. Fourth, KMAs can be used to develop self-learning KMSs.

### **Potential Uses of the System**

Examples of areas in which this platform can be used to develop Knowledge management systems include:

1. Credentials Analysis: The verification of the validity and authenticity of credentials, is the heart of employee selection, recruitment and placement; students admission and placement; accreditation of journalists, diplomats and other professionals; and the accreditation of educational, research, and professional organizations. It is knowledge intensive and requires comparison of many different and sometimes incompatible standards.
2. International legislation: Given the variance in national laws from country to country, a system that interprets the implications of national laws to cross-border trade, providing appropriate advice based on comparisons of these laws is very useful to the international business organizations.
3. Research and development: Research is a knowledge intensive activity that requires a high degree of interaction between the researchers. The richest form of interaction is the face to face interaction. Given that the best researchers may not be located at the same geographic location, the web provides the closest substitute to face to face interaction. This platform enhances the iterative interaction between researchers and allows them to build on each other’s knowledge via the processes of articulation and internalization.

### **Conclusion**

Organizational learning can be supported by a structured Knowledge Management System. Such a system may be developed using web-based knowledge management agents. These agents can be employed to automate knowledge engineering because they allow experts to access and articulate their knowledge directly into a knowledge-base via interfaces that are user-friendly, and time and geography independent.

### *References*

For references, please contact the authors (pmeso@bsa3.kent.edu; gmaday@synapse.kent.edu).