UNIVERSITI PUTRA MALAYSIA

DESIGN AND DEVELOPMENT OF THE ARCHITECTURE AND FRAMEWORK OF A KNOWLEDGE-BASED EXPERT SYSTEM FOR ENVIRONMENTAL IMPACT ASSESSMENT

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BY

MONEEF MOHAMMAD ABDEL-KAREEM JAZZAR

Thesis Submitted in Fulfilment of the Requirements
for the Degree of Doctor Of Philosophy
in the Faculty of Engineering
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DEDICATION

I dedicate this dissertation to my parents,
family, and my wife and daughter.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Doctor of Philosophy

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Chairman : Associate Prof. Mohamed Daud, Ph.D., MBA, P.Eng.

Faculty : Engineering

The development of the architecture and framework of a knowledge-based expert system (ES) named "JESEIA" for environmental impact assessment (EIA) was developed using the C Language Integrated Production System (CLIPS) that incorporates relevant expert knowledge on EIA and integrates a computational tool to support the preparation of an EIA study. The research was based on the conceptualization and development of the architecture and framework of a knowledge-based expert system that demonstrates the feasibility of integrating the following aspects: Expert knowledge-based system approach, Object-oriented techniques and rules structuring as knowledge modeling paradigm, database management system as a repository connection between domain knowledge sources and the expert system kernel, and finally EIA as a significant knowledge domain and incremental approach as a development model. This work describes the functional framework

of combining shared knowledge from various experts as knowledge sources through the implementation of a blackboard system approach that organizes the solution elements and determines which information has the highest certainty to contribute to the inference solution. The rules, in the rule base, were developed according to the environmental component classification characteristics with attributes in an object-oriented technique. The developed system considers the robustness, expandability and modularity throughout its development process. The raw knowledge and database were kept in a supportive database developed in the system for further reference or updating through the developed expert system as a built-in functionality as well as through a connection to an external database environment through an open database connectivity mechanism.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah.

REKABENTUK DAN PEMBANGUNAN SENIBINA DAN RANGKA KERJA UNTUK SISTEM KEPAKARAN YANG BERASASKAN PENGETAHUAN UNTUK PENILAIAN KESAN PERSEKITARAN

Oleh

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Pembangunan senibina dan rangka kerja sistem kepakaran yang berasaskan pengetahuan yang bernama "JESEIA" untuk penilaian kesan persekitaran telah dibangunkan dengan menggunakan "CLIPS" yang bergabung dengan pengetahuan kepakaran yang berkaitan dengan "Environmental impact assessment (EIA) dan menggabungkan alat pengkomputeran untuk menyokong penyediaan pengajian EIA. Penyelidikan ini berasaskan konsep dan pembangunan senibina serta rangka kerja untuk satu sistem kepakaran berasaskan pengetahuan yang menunjukkan kelenturan dalam penggabungan aspek-aspek berikut: pendekatan sistem kepakaran yang berasaskan pengetahuan, teknik berasaskan objek dan perstrukturan peraturan sebagai paradigma pemodelan pengetahuan, sistem pengurusan pengkalan data sebagai satu penyambungan sumber di antara domain sumber pengatahuan dan kernel sistem kepakaran, dan akhirnya, EIA sebagai satu domain pengetahuan yang penting, dan pendekatan peningkatan sebagai satu model pembangunan. Kerja ini menunjukkan

rangka kerja fungsi yang menggabungkan pengetahuan yang dikongsi dari pada pelbagai kepakaran sebagai sumber pengetahuan melalui pelaksanaan pendekatan papan hitam yang mengaturkan unsur-unsur penyelesaian dan menentukan maklumat berkenan yang mempunyai kepastian yang tertinggi dalam penyumbangannya kepada penyelesaian. Pengaturannya, yang berasaskan pengaturan, telah dibangunkan berdasarkan komponen persekitaran yang berdasarkan pengelasan ciri-ciri dengan atribut dalam teknik berdasarkan objek. Sistem yang dibangunkan mempertimbangkan keupayaan tahan lasak, perkembangan dan pemodulan melalui proses pembangunannya. Pengetahuan dan pengkalan data yang mentah telah disimpan di dalam pengkalan data penyokongan yang dibangunkan di dalam sistem ini. Salah satu fungsinya adalah sebagai rujukan selanjutan dan juga kerja kemaskini yang menggunakan sistem kepakaran yang telah dibangunkan sebagai satu fungsi yang telah dibina-dalam atau dengan menggunakan penyambungan pengkalan data persekitaran luaran melalui satu mekanisma penyambungan pengkalan data yang terbuka.

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LIST OF ABBREVIATIONS

AI	Artificial Intelligence
DE	Domain Expert
DOE	Department Of Environment
EIA	Environmental Impact Assessment
EQA	Environmental Quality Act
ES	Expert Systems
IE	Inference Engine
KA	Knowledge Acquisition
KBS	Knowledge Base Systems
KE	Knowledge Engineer
NEPA	National Environmental Policy Act
ODBC	Open Data Base Connectivity
UTP	University Technology Petronas

CHAPTER I

INTRODUCTION

Motivation

Over the past decade, there has been a remarkable and refreshing interest in the environmental issues and sustainable development worldwide. To develop an area, for example, the important aspect is to make the best use of land and other natural resources while avoiding any damage or deterioration to the environment. Civilization basically depends on ecosystems that are being altered drastically by human actions. Better management of on going activities prior to any project implementation should be conducted in harmony with the environment. Environmental impact assessment (EIA) plays a major role in decision making and careful planning in protecting the environment from being adversely misused.

EIA is essentially a planning tool for preventing environmental problems due to an action. It seeks to avoid costly mistakes in project implementation, either because of the environmental damages that are likely to arise during project implementation or because of modifications that may be required subsequently in order to make the action environmentally acceptable.

EIA was first legislated for in the USA by the National Environmental Policy Act (NEPA) in 1969 (Jain et al., 1977), and since then has become law in many countries including Canada, Japan, Europe and many developing countries. In Malaysia, the environmental management has been implemented over the past two decades (ENSEARCH, 1996), both as an importer as well as an exporter of environmental pollution control technologies and expertise. Currently, environmental impact assessment approval is an essential requirement for most of the development projects to be undertaken in Malaysia under section 34A of the Environmental Quality Act (EQA) 1974 (DOE, 1995a). EQA provides the power to the Minister of Science, Technology and Environment to prescribe, by order, any activity that may have significant environmental impacts as a prescribed activity. Therefore, a report describing the impact(s) of such activity on the environment has to be submitted to the Director General of Environmental Quality (DOE, 1995a, 1995b). The activity can be approved only if the Director General of

Environmental Quality is convinced that the activity has no damaging impact(s) on the environment.

The Environmental Quality (Prescribed Activity) (Environmental Impact Assessment) Order, 1987 lists nineteen categories of activities as prescribed activities for which an EIA report is required to be submitted to the Director General in order to obtain an approval (DOE, 1995a, 1995b). The problem is that there are no computerized standard procedures, followed by consultants, in preparing the EIA. More problems had to be encountered by the Department of Environment (DOE) in evaluating (to approve, reject or approve with conditions) the report. If the report is approved, yet the DOE is facing a lot of problems, due to the shortage on manpower to verify that the developer or the project manager is actually complying with the approved guidelines.

Based on the recent literature review, there is no computerized system done to produce EIA reports. Expert systems (ES) and knowledge based systems (KBS) are intended to help in solving problems that are traditionally solved by using expert human judgement and experience. The kind of knowledge for solving such a problem, which is dealt with in the ES and the KBS, therefore is non-algorithmic, subjective and rare. The two main human resources involved in the development of the expert system consist

of Domain Experts (DE) and the Knowledge Engineer (KE). The knowledge engineer's role is to glean the "appropriate knowledge" either from the domain expert or through the combination of domain expert knowledge and field research results, and transform that knowledge into a form that is suitable to be used for the ES. The methodology of combining interviews with field experts and formal field research that was successfully developed by Daud (1994) entitled "*An expert system for predicting distribution and consumption of irrigation water in a paddy irrigation scheme*" has been used as the basis in developing the ES.

What is an expert system? Definitions of expert systems are varying. Some definitions are based on functions. Some definitions are based on structures. Some definitions have both functional and structural components. Many early definitions assume rule-based reasoning. Professor Edward Feigenbaum of Stanford University has defined an expert system as "... an intelligent computer program that uses knowledge and inference procedures to solve problems that are difficult enough to require significant human expertise for their solution" (Giarrantano and Riley, 1994). In other word, an expert system is a sophisticated computer program that emulates the decision-making ability of a human expert. The term emulates means that the expert system is intended to act in all respects like a human expert.

Problem Statement

The main objective of environmental impact assessment is to ensure that potential problems are foreseen and addressed at an early stage in the project planning and design. For the proposed development projects, EIA is used as a management tool for project initiators as well as project approving authorities to make decisions on the project. In Malaysia, there is no computerized standard procedures followed by consultant in preparing EIA reports. The lack of information exchange and expertise are the major problems in preparing the EIA reports. Those problems formulate good reasons to look into the use of computers, and in particular into the new technologies like expert systems and knowledge based systems.

Information derived from an EIA should be used to design economically and environmentally sustainable projects. As such, EIA should not be viewed as an obstacle. The basic objective of using expert systems and knowledge-based system approaches to environmental impact assessment is to incorporate expertise into a computerized system. Expertise is normally obtained from data collection, knowledge and heuristics that are relevant to an EIA study. EIA deals with many complex procedures that draw on numerous disciplines. It requires, in fact, a multidisciplinary team of experts. A knowledge-based component for such an EIA system