



**UNIVERSITI PUTRA MALAYSIA**

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

**MONEEF MOHAMMAD ABDEL- KAREEM JAZZAR**

**FK 2000 50**





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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  
Universiti Putra Malaysia**

**August 2000**



## **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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**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**

**MONEEF MOHAMMAD ABDEL-KAREEM JAZZAR**

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**Pengerusi : Profesor Madya Mohamed Daud, Ph.D., MBA, P.Eng.**

**Fakulti : Kejuruteraan**

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 perstruktur peraturan sebagai paradigma pemodelan pengetahuan, sistem pengurusan pengkalan data sebagai satu penyambungan sumber di antara domain sumber pengetahuan 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 berkenaan 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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I certify that an Examination Committee met on 8 August, 2000 to conduct the final examination of Moneef Mohammad Abdel Kareem Jazzar on his Doctor of Philosophy thesis entitled "Design and Development of the Architecture and Framework of a Knowledge-Based Expert System For Environmental Impact Assessment" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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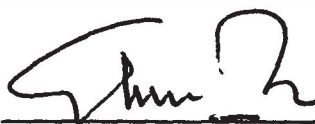
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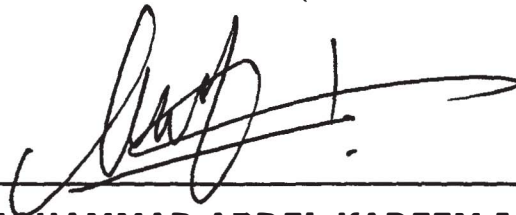
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## DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.



**(MONEEF MOHAMMAD ABDEL KAREEM JAZZAR)**

Date: 27/9/2000

## TABLE OF CONTENTS

		Page
<b>DEDICATION</b>	.....	ii
<b>ABSTRACT</b>	.....	iii
<b>ABSTRAK</b>	.....	v
<b>ACKNOWLEDGEMENTS</b>	.....	vii
<b>APPROVAL SHEETS</b>	.....	viii
<b>DECLARATION FORM</b>	.....	x
<b>LIST OF TABLES</b>	.....	xiii
<b>LIST OF FIGURES</b>	.....	xiv
<b>LIST OF ABBREVIATIONS</b>	.....	xvi
<b>CHAPTER</b>		
<b>I</b>	<b>INTRODUCTION</b> .....	1
	Motivation .....	1
	Problem Statement .....	5
	Research Objectives .....	7
	Scope and Limitation of the Study .....	9
<b>II</b>	<b>LITERATURE REVIEW</b> .....	11
	Environmental Impact Assessment .....	11
	Computer Application That Support Environmental Studies .....	19
	Knowledge-Based Expert Systems and Problem-Solving .....	22
	Expert System Methodologies and Strategies .....	34
	Knowledge Elicitation .....	39
	Knowledge Representation and Modeling ... The Choice of an Expert System	43
	Development Tool .....	48
	Conclusion .....	52
<b>III</b>	<b>METHODOLOGY</b> .....	53
	Expert Domain Knowledge .....	54
	Knowledge Acquisition and the Modeling Process .....	56
	Knowledge Database Management .....	62
	Expert System Module Integration .....	66
	EIA Matrix Implementation .....	69
	EIA Report Constructing .....	71
	Expert System Prototyping .....	74



<b>IV</b>	<b>EXPERT SYSTEM ARCHITECTURE AND DEVELOPMENT PROCESS .....</b>	<b>79</b>
	Conceptual Framework and Design .....	80
	Knowledge Base and Database Handling ....	86
	Knowledge Representation	
	Techniques .....	88
	Productions and Rules Representation	
	Technique .....	95
	Frames and Object-Oriented	
	Knowledge Representation .....	99
	EIA Database Handling Process .....	110
	The Implementation of Blackboard System	
	Approach .....	115
	EIA Selector Development .....	124
	Designing The System User Interface .....	133
<b>V</b>	<b>RESULTS AND DISCUSSION .....</b>	<b>138</b>
	JESEIA: Expert System For EIA .....	139
	User-Level Security System	
	Implementation .....	146
	EIA Category Selector .....	153
	Project Site Selection .....	169
	EIA Report Generator Start-Up .....	184
	Database and Knowledge Manipulation .....	191
	EIA Matrix Scoring .....	207
	File Management and Recovery System	
	Support .....	215
	Validation and Verification of JESEIA .....	220
<b>VI</b>	<b>APPLYING THE SYSTEM ON THE PROPOSED UNIVERSITY TECHNOLOGY PETRONAS AT TRONOH, MALAYSIA: A CASE STUDY .....</b>	<b>228</b>
	Introduction .....	228
	Project Site .....	229
	Project Description .....	229
	JESEIA's Results on the Proposed UTP .....	233
	Existing Environment .....	236
	Air Quality and Noise .....	248
	Residual Impacts .....	249
	Conclusion .....	249
<b>VII</b>	<b>CONCLUSION AND FURTHER RESEARCH ...</b>	<b>250</b>
	Major Findings .....	255
	Suggestions for Future Work .....	259

<b>BIBLIOGRAPHY</b> .....	261
<b>APPENDIX</b>	
Source Code Listing .....	285
<b>VITA</b> .....	367



## LIST OF TABLES

<b>Table</b>		<b>Page</b>
1	Classes and Objects .....	100
2	Some Environmentally Sensitive Areas .....	133
3	Main Menu Items and Description .....	143
4	User Level Authorization Functions .....	151
5	"Loading" Class - Attributes and Functions .....	155
6	"Category" Class - Attributes and Functions .....	156
7	"CatInfo" Class - Attributes and Functions .....	158
8	"Catsys" Class - Attributes and Functions .....	159
9	"Site" Class - Attributes and Functions .....	173
10	Matrix Score Values .....	208
11	Estimated University Population .....	235
12	24-Hours Wind Percentage Frequency of Various Directions and Speed, (1968 – 1997), IPOH .....	242
13	Streamflow Runoff .....	245
14	Extreme Flows (approximation) .....	245
15	Water Sampling Sites .....	246
16	Water Quality sampling .....	247
17	Air Quality at the Project Site .....	248
18	Noise Levels from the Project Site .....	248





## LIST OF FIGURES

Figure		Page
1	Human Effects .....	13
2	Expert System Main Components .....	26
3	Expert System Meta-Knowledge .....	45
4	Expert System Main Components .....	54
5	Architecture of the Knowledge Acquisition Process .....	58
6	Knowledge Modeling Architecture .....	61
7	Interdependence of ES and DBMS .....	64
8	Module Integration in the Expert System .....	69
9	Beneficial and Adverse Scores in an EIA Matrix .....	71
10	EIA Report Construction .....	72
11	ES Prototype Development Phases .....	77
12	The Framework Architecture .....	83
13	Knowledge Model Development Procedure .....	84
14	Repository Scheme .....	85
15	Human Problem Solving versus Computer Problem Solving .....	91
16	Levels of the Knowledge-Based Systems .....	92
17	A Rule Structure .....	96
18	A Rule Example .....	97
19	A Frame Structure .....	99
20	Main Subject Levels .....	103
21	Object-Attribute-Value (OAV) Representation ....	105
22	OAV Representation with Multiple Attributes ....	105
23	An EIA Class-&-Object Diagram .....	106
24	Class-Object Interconnecting Messages .....	109
25	EIA Components of Object-Class Inheritance ....	112
26	EIA Database Handling .....	114
27	The Basic Blackboard Approach .....	117
28	Blackboard Levels .....	118
29	The Blackboard Architecture .....	120
30	EIA Knowledge-Based System Implementing the Blackboard Approach Architecture .....	123
31	The EIA Selector Architecture .....	126
32	System Interface Design - the Main Window ....	136
33	Direct Manipulation and Control Panel Frame ....	137
34	JESEIA System - Main Module Structure .....	140
35	The Main Flowchart of JESEIA .....	141
36	JESEIA Main Frame Window .....	145
37	JESEIA Main Menu Bar Functions .....	145
38	JESEIA License Agreement .....	150
39	User Authorization Levels .....	150



40	Switch User ID Verification .....	152
41	EIA Selector .....	154
42	A Warning Message for a Selected Category ....	162
43	(A) Category Selection List .....	165
43	(B) Waste Treatment and Disposal Category Panel .....	165
44	Project Site Selection .....	170
45	Site Selection Warning Dialogue .....	182
46	Site Selection Menu - Selecting a State .....	182
47	Site Selection Menu - Selecting a District .....	183
48	Site Selection - Problems Encountered .....	183
49	Site Selection Result Dialogue .....	183
50	The EIA Report Generator Window Screen Shot A .....	185
51	The EIA Report Generator Window Screen Shot B .....	186
52	JESEIA Text Editor Functions .....	188
53	Fetching and Executing Database Commands ...	194
54	The ODBC Connection .....	197
55	Rules For Opening Database Connection .....	198
56	User Selection of JESEIA Database or FoxPro Database .....	199
57	JESEIA Database Connection Interface Window .....	200
58	Database Sources Connected To JESEIA .....	201
59	Database Tables - Invoking "Filter & Show Module" .....	203
60	The External Database Main Window .....	205
61	The External Database Entry Window .....	206
62	<i>About</i> The External Database .....	206
63	EIA Matrix Component Module Selection .....	209
64	Manipulating a Knowledge Chunk in the EIA Matrix .....	212
65	Selecting another Category During a Session ...	217
66	Buffering Results in the Working Window .....	219
67	UTP Location Site, Key Plan .....	230
68	UTP Location Site .....	231
69	UTP Location Site, Master Plan .....	232
70	UTP Project, JESEIA Initial Descriptions .....	234
71	UTP Project, JESEIA EIA Selector Module .....	235
72	Mean Monthly Rainfall (1981 – 1997), IPOH Airport .....	238
73	Mean Monthly Raindays (1981 – 1997), IPOH Airport .....	238
74	Mean Monthly Temperature (1968 – 1997), IPOH Airport .....	239



75	Mean Daily Sunshine Hours (1968–1997), IPOH Airport .....	239
76	Mean Monthly Evaporation (1974 – 1997), IPOH Airport .....	240
77	24 Hours Mean Relative Humidity (1968 – 1997), IPOH Airport .....	240
78	24-hours Wind Rose (1968 – 1997), IPOH .....	241
79	Sg. Kinta Catchement .....	243
80	Drainage Pattern Of the Project Area .....	244



## **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