EXPERT DECISION SUPPORT SYSTEM (EDSS)
FOR DOCTOR SELECTION AT EMERGENCY
DEPARTMENT USING CASE-BASED
REASONING TECHNIQUE

SUE QI JIAN

BACHELOR OF COMPUTER SCIENCE
(SOFTWARE ENGINEERING)
UNIVERSITI MALAYSIA PAHANG
ABSTRACT

In real world, emergency always happen and it always needed an immediate action to solve it as patient's treatment duration is very crucial. Besides, there is no expert system to decide which doctor has to handle which emergency case based on expertise and resource allocation. In this project, "Expert Decision Support System" is to come out with the fast decision as it will be implemented to an emergency department and it needs a quick decision. The objective of this project is to design and develop an expert decision support system that able to decide which doctor to be assigned to which case based on type of emergency, prioritize which case should handle first based on stage of emergency. In this project, the proposed method that will be implemented is Case-Based Reasoning (CBR) technique in doctor selection process. By the end of this project, this system will be implemented in emergency department in order to come out with a support decision for doctor selection in each emergency case. This system is designed specifically for medical staff in emergency department.
ABSTRAK

TABLE OF CONTENTS

THESIS DECLARATION i
BORANG PENGESAHAN STATUS TESIS i
STUDENT'S DECLARATION ii
SUPERVISOR'S DECLARATION iii
DEDICATION iv
ACKNOWLEDGEMENTS v
ABSTRACT vi
ABSTRAK vii

TABLE OF CONTENTS viii
LIST OF TABLES xi
LIST OF FIGURES xii
LIST OF ABBREVIATIONS xiv

PART 1 INTRODUCTION 1

1.1 Project Purpose 2
  1.1.1 Problem Statement 2
  1.1.2 Motivations and Objectives 3
    1.1.2.1 Motivations 3
    1.1.2.2 Objectives 3
1.2 Review of Previous Research and Relationship to Current Project 4
  1.2.1 Information Visualization to Support Management Decisions 4
  1.2.2 A Decision Support System for Supplier Selection Process 5
  1.2.3 A Decision Support System for Surgery Sequencing at UZ Leuven's Day-Care Department 6
1.3 Explain the Current System and Its Limitation 7
  1.3.1 Comparison Table 8
1.4 Explanations of Terminology 9
1.4.1 Emergency Medical Communication Response (EMCR) 9
1.4.2 Expert Decision Support System for Doctor Selection 9
1.5 Project Scope 10
1.6 Outline of Material 11

PART 2 REPORT BODY 12

2.1 User Requirement 12
2.2 Design Description 13
  2.2.1 Waterfall Model 13
    2.2.1.1 Planning 15
    2.2.1.2 Analysis 15
    2.2.1.3 Design 15
    2.2.1.4 Development 16
    2.2.1.5 Maintenance 16
  2.2.2 Context Diagram 17
  2.2.3 Flow Chart 19
  2.2.4 Use Case Diagram 20
  2.2.5 Data Flow Diagrams 21
  2.2.6 Entity-Relationship Diagram 25
  2.2.7 Data Dictionary 26

2.3 Methods and Materials Used 28
  2.3.1 Methods Used 28
    2.3.1.1 Temporal Database 28
    2.3.1.2 Case-Based Reasoning (CBR) 28
    2.3.1.3 Artificial Intelligence (AI) Based Models 31
  2.3.2 Materials Used 32
    2.3.2.1 Hardware Specification 32
    2.3.2.2 Software Specification 33
2.4 Technical Result
   2.4.1 Development of Interface 34
   2.4.2 Development of Database 38
   2.4.3 Function of Prioritize Emergency Case 40
   2.4.4 Function of Case-based Reasoning Technique 41
   2.4.5 Data Models 45

2.5 Testing Plan and Result 46
   2.5.1 Testing Plan 46
   2.5.2 Expected Result 47
   2.5.3 Actual Result 48
   2.5.4 Discussion 50

PART 3 CONCLUSION 51

3.1 Conclusion 51
3.2 Future Work 53

REFERENCES

APPENDIX
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table No.</th>
<th>Table Name</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.3.1</td>
<td>Comparisons Between the Existing Systems</td>
<td>8</td>
</tr>
<tr>
<td>2.2.1</td>
<td>EDSS Data Dictionary</td>
<td>26</td>
</tr>
<tr>
<td>2.2.1.1</td>
<td>EDSS Data for DOCTOR</td>
<td>26</td>
</tr>
<tr>
<td>2.2.1.2</td>
<td>EDSS Data for EMERGENCY</td>
<td>26</td>
</tr>
<tr>
<td>2.2.1.3</td>
<td>EDSS Data for PATIENT</td>
<td>27</td>
</tr>
<tr>
<td>2.2.1.4</td>
<td>EDSS Data for SCHEDULE</td>
<td>28</td>
</tr>
<tr>
<td>2.3.1</td>
<td>The Hardware Specification Table</td>
<td>33</td>
</tr>
<tr>
<td>2.3.2</td>
<td>The Software Specification Table</td>
<td>34</td>
</tr>
<tr>
<td>2.5.1</td>
<td>Draft for Acceptance Test in Pekan Hospital</td>
<td>47</td>
</tr>
</tbody>
</table>
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure No.</th>
<th>Figure Name</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.2.1</td>
<td>Waterfall Model</td>
<td>14</td>
</tr>
<tr>
<td>2.2.2</td>
<td>System Overview</td>
<td>17</td>
</tr>
<tr>
<td>2.2.3</td>
<td>Expert Decision Support System (EDSS) Context Diagram</td>
<td>18</td>
</tr>
<tr>
<td>2.2.4</td>
<td>Expert Decision Support System (EDSS) Flow Chart</td>
<td>19</td>
</tr>
<tr>
<td>2.2.5</td>
<td>Expert Decision Support System (EDSS) Use Case Diagram</td>
<td>20</td>
</tr>
<tr>
<td>2.2.6</td>
<td>EDSS Data Flow Diagram Level 0</td>
<td>22</td>
</tr>
<tr>
<td>2.2.7</td>
<td>EDSS Data Flow Diagram Level 1.0 (Process 13)</td>
<td>23</td>
</tr>
<tr>
<td>2.2.8</td>
<td>EDSS Data Flow Diagram Level 2.0 (Process 13.2)</td>
<td>24</td>
</tr>
<tr>
<td>2.2.9</td>
<td>EDSS Entity-Relation Diagram</td>
<td>25</td>
</tr>
<tr>
<td>2.3.1</td>
<td>Case’s Components – Relation between SP &amp; SL</td>
<td>30</td>
</tr>
<tr>
<td>2.3.2</td>
<td>Local Similarity Formula</td>
<td>31</td>
</tr>
<tr>
<td>2.3.3</td>
<td>Global Similarity Formula</td>
<td>32</td>
</tr>
<tr>
<td>2.4.1</td>
<td>Start Page for NetBeans IDE 7.4</td>
<td>36</td>
</tr>
<tr>
<td>2.4.2</td>
<td>Open Existing Project</td>
<td>37</td>
</tr>
<tr>
<td>2.4.3</td>
<td>Open Existing Project (cont.)</td>
<td>37</td>
</tr>
<tr>
<td>2.4.4</td>
<td>Main class for EDSS</td>
<td>38</td>
</tr>
<tr>
<td>2.4.5</td>
<td>Data source for EDSS</td>
<td>38</td>
</tr>
<tr>
<td>2.4.6</td>
<td>Add Jar File to Project Library</td>
<td>39</td>
</tr>
<tr>
<td>2.4.7</td>
<td>Add Jar File to Project Library (cont.)</td>
<td>40</td>
</tr>
<tr>
<td>2.4.8</td>
<td>Add JCBC driver to Project Library</td>
<td>40</td>
</tr>
<tr>
<td>2.4.9</td>
<td>Prioritize Emergency Case</td>
<td>41</td>
</tr>
<tr>
<td>2.4.10</td>
<td>Prioritize Emergency Case (cont.)</td>
<td>42</td>
</tr>
<tr>
<td>2.4.11</td>
<td>Case-Based Reasoning Technique</td>
<td>43</td>
</tr>
<tr>
<td>2.4.12</td>
<td>Case-Based Reasoning Technique (cont.)</td>
<td>44</td>
</tr>
<tr>
<td>2.4.13</td>
<td>Case-Based Reasoning Technique (cont.)</td>
<td>45</td>
</tr>
<tr>
<td>2.4.14</td>
<td>Data Model for ‘DOCTOR’ table</td>
<td>46</td>
</tr>
<tr>
<td>2.4.15</td>
<td>Data Model for ‘EMERGENCY’ table</td>
<td>46</td>
</tr>
<tr>
<td>2.4.16</td>
<td>Data Model for ‘PATIENT’ table</td>
<td>46</td>
</tr>
<tr>
<td>2.5.1</td>
<td>Actual Result</td>
<td>49</td>
</tr>
<tr>
<td>2.5.2</td>
<td>Actual Result (cont.)</td>
<td>50</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
<td></td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------------------------</td>
<td></td>
</tr>
<tr>
<td>AI</td>
<td>Artificial Intelligence</td>
<td></td>
</tr>
<tr>
<td>CBR</td>
<td>Case-Based Reasoning</td>
<td></td>
</tr>
<tr>
<td>CD</td>
<td>Compact Disc</td>
<td></td>
</tr>
<tr>
<td>DB</td>
<td>Database</td>
<td></td>
</tr>
<tr>
<td>DFD</td>
<td>Data Flow Diagram</td>
<td></td>
</tr>
<tr>
<td>EDSS</td>
<td>Expert Decision Support System</td>
<td></td>
</tr>
<tr>
<td>EMCR</td>
<td>Emergency Medical Communication Response</td>
<td></td>
</tr>
<tr>
<td>ICU</td>
<td>Intensive Care Unit</td>
<td></td>
</tr>
<tr>
<td>IDE</td>
<td>Integrated Development Environment</td>
<td></td>
</tr>
<tr>
<td>MS</td>
<td>Microsoft</td>
<td></td>
</tr>
<tr>
<td>SL</td>
<td>Solution</td>
<td></td>
</tr>
<tr>
<td>SP</td>
<td>Specification</td>
<td></td>
</tr>
</tbody>
</table>
Part 1

INTRODUCTION

This part is briefly discussed about the overview of the project. Basically, there are seven (7) sub sections for this technical report. The first section is the brief introduction, where briefly describe the project. The second section is the project review where discuss about the previous research and the relationship to the current project and further discuss about the system and its limitations in third section. Furthermore, the fourth section is the explanation of terminology and defines the scope of the project and its limitation of the study in fifth section. Lastly, the last section will briefly describe the whole technical report based on the sequences of each part of this technical report.

1.0 Introduction

Intelligence is the ability of think and understand instead of doing things by instinct or automatically. Artificial intelligence refers to the computer science principal that develops machine and software with human-like intelligence [1].

In artificial intelligence, an expert system is a computer system that can undergoes decision making process as a human expert with particular knowledge. Expert systems are designed to solve complex problems based on the reasoning regarding knowledge. Besides, it can speed the decision making process as all the knowledge being programmed, and the expert system will be able to give the output of decision based on knowledge.
In this project, “Expert Decision Support System” is to come out the fast decision as it will be implemented to an emergency department and it needed a quick decision once it needed decision making.

1.1 Project Purpose

This section is to clarify the purpose of this project with the three sub-sections: 1.1.1 Problem Statement, 1.1.2 Motivations and Objectives.

1.1.1 Problem Statement

In real world, emergency always happen and it always needed an immediate action to solve it as patient’s treatment duration is very crucial. In this case, there is always some reason to cause the duration of patient waiting for treatment longer; the common reason is human being. Undeniable, human always cause problem, and always have different type of personality, office conflicts and so on. During emergency, the time consume is very critical and huge when the information flow and standard procedure by nurse. The most crucial part is no unit being informed before a complete form is filled.

Besides, there is no expert system to decide which doctor has to handle which emergency case based on expertise and resource allocation. To further explain this point will be usually a doctor won’t be assigned to any cases, it will depends on which doctor is available; but, most of the time a doctor with different expertise will be assigned to a different emergency case to handle.

Lastly, based on understanding of research, there is no integration between units such as pharmacy has no interaction with registration and so on. All units have to wait to be informed by the nurse when it is needed during emergency. With this point, another part that will consume a lot of time where the unit itself cannot have any early preparation and have to wait until patient being deliver the unit only will start the procedure to give treatment to patient.
1.1.2 Motivations and Objectives

1.1.2.1 Motivations

Several motivations that are indirectly related to the project are defined as follows:

i. To be able to shorten the time taken for information flow between units.

ii. To be able to inform every unit to have well preparation with basic information filled even before the patient arrive hospital.

1.1.2.2 Objectives

Several objectives of the project are defined as follows:

i. To design and develop Expert Decision Support System (EDSS) that able to decide which expert doctor(s) will be assigned for each case based on the type of emergency.

ii. To prioritize which case should handle first based on stage of emergency and schedule of doctor availability.

iii. To implement the Case-Based Reasoning (CBR) technique for the selection of doctor at emergency department.
1.2 Review of Previous Research and Relationship to Current Project

In this sub section, we will briefly discuss about the entire process how this project came into concept and ideas. Besides, we will discuss the conclusion of each literature review and also the relationship to the current project.

1.2.1 Information Visualization to Support Management Decisions

In this literature review, it does not have any system and constructive evidence that can direct contribute how this entire system works. But, the main contribution of this literature is to discuss how importance of information visualization support the decision making process.

In short, this literature review strongly shows that three main functions of information visualization: (i) Communication, (ii) Knowledge Management, and (iii) decision support. A significant role of visualization is the Communication of information [4]. By visualization, information is able to transfer in the way of more understandable and easily accessible. Besides, in term of knowledge basis, visualization played an important role for knowledge management to be success or not. Due to different knowledge level and cultural background, different people might have different interpretation of information based on what they heard. With Visualization, it works as a catalyst and checkpoint to ensure the same information being transferred from ‘sender’ to ‘receiver’. Visualization can act as a ‘vehicle of thought’ to assists people in decision making support. The basic idea here is that visualization provides an information which is easily imagine and understandable to be transform into simple knowledge where it can further support in decision making.

Through this literature review, the proposed system is required a better understanding of information as emergency is not allowed any extra buffer time and also the information has to be always correct and concise. Just for an example to be more easily understand, a picture is captured and sent back to ICU system, the doctor can easily understand how is the condition of the patient and where is the part of body is
injured instead of only few verbal information that stated where is the roughly part injured and it is always some misinterpretation between both parties.

1.2.2 A Decision Support System for Supplier Selection Process

In the process of selecting a supplier in this technological innovations and changing customer demands has significantly showed that how important is the process of selecting a correct supplier. The concept of having a product at right cost, in the right quantity, with the right quality at the right time from the right source is crucially important to survive nowadays [2].

There is some important selection process being proposed in this literature, such as Date Envelopment Analysis (DEA) that allow to have a simultaneous analysis of multiple input and having multiple output, Cluster Analysis (CA) that is a basic method of statistics, Case-based Reasoning (CBR) system that solved problem by making use of previous similar situations, Artificial Intelligence (AI) that is based on computer-aided systems, and also Analytic Hierarchy Process (AHP) where can deal with imprecision in supplier choice [2].

Through this literature review, the proposed project is to determine the most suitable doctor to be assigned to which emergency case based on scheduling, priority, type of emergency, expertise of doctor and also the availability. With this similar literature study, the method used can be relate to this project and further using it as a guideline and reference to implement it into the system itself.
1.2.3 A Decision Support System for Surgery Sequencing at UZ Leuven’s Day-Care Department

In this literature review, there is a result obviously showed that there is only limited research effort towards decision support systems for organizational and managerial decision-making in hospitals [3]. This literature showed the effort of testing the applicability of a decision support system that to optimize the sequence of the surgeries in the day-care center.

In this system, patient is been categorized into few categories such as outpatient, inpatient, children, prioritized patients and so on. The aim of this study is to examine a case study how decision support systems can contribute to an improved outpatient surgical schedule [3].

Through this literature review, the proposed system is to check the scheduling the current availability of the doctor whether they are handling emergency case or ready or on-hold.
1.3 Explain the Current System and Its Limitation

The current system that using at Pekan Hospital is named “Emergency Medical Communication Response - EMCR” which is a system that integrates both front line (staff who handle patient direct) and backup line (staff who receive patient in each department) during emergency. It drafted a ‘Care Plan’ as a standard operating procedure during emergency case handling.

There is three (3) objective of this system: [5]
(i) **Safe Life** – To be able to transfer the first hand information (injuries) of patient and prepare the supposed care plan right after reach patient, before being send to hospital.
(ii) **Safe Time** – To be able to save up time during the process of awaiting for Medical Officer (MO), X-Ray Officer, Pharmacy Officer (JTMP) on call.
(iii)**Safe from Complaint** – To avoid any delay on giving treatment and body checking.

The current system is using a tool called “Government Integrated Radio Network - GRIN” and each department will have a walkie-talkie to standby. Besides, there is mobile phone and also home phone were used for communication purpose. Last but not least, there is an EMCR reference book to jot down and act as a reference when handling emergency case.

While there is some limitations that would like to point out:
(i) All these processes are still done manually by hand-written and hardcopy still have to pass through nurse from unit to unit.
(ii) Information transfer through verbally on phone. Every time, the doctor/staff on duty need to call and repeat again and again when communicate with different department.
(iii) There is no integration between each units, it solely depends on how the doctor/staff on duty communicate and controlling the process of information flow.
(iv) There is no visualization, just using verbalization.
### 1.3.1 Comparison Table

#### Table 1.3.1 Comparisons Between the Existing Systems.

<table>
<thead>
<tr>
<th>Features</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Information Visualization to Support Management Decisions</strong></td>
<td>It is focus mainly on communication, knowledge management, and decision support.</td>
<td>Visualization provides information which is easily understandable.</td>
<td>It took some time to receive the picture captured from evidence.</td>
</tr>
<tr>
<td><strong>A Decision Support System for Supplier Selection Process</strong></td>
<td>It is supplier selection process based on CA, CBR, AI, and AHP to decide which the best choice is.</td>
<td>This selection process can have a product at right cost, in the right quantity. (Similar with the proposed idea of this project)</td>
<td>It is a decision support system where cannot direct give result but suggestions.</td>
</tr>
<tr>
<td><strong>A Decision Support System for Surgery Sequencing at UZ Leuven's Day-Care Department</strong></td>
<td>It is focus mainly on optimization of decision support systems for organizational and managerial decision making in hospital.</td>
<td>Its visualization and algorithm performance on supporting decision support system in giving suggestion.</td>
<td>No online instrument and no linkage with electronic patient file.</td>
</tr>
<tr>
<td><strong>Emergency Medical Communication Response - EMCR</strong></td>
<td>It integrates both front line and backup line department during emergency.</td>
<td>GRIN - A tool to make the communication flow faster and easier between departments. Faster in information delivery.</td>
<td>The doctor and emergency department staff cannot visualize the information delivered through phone call.</td>
</tr>
</tbody>
</table>


1.4 Explanations of Terminology

1.4.1 Emergency Medical Communication Response (EMCR)

A system where integrate both parties between front line staff (people who have the first touch point with patient) and also secondary line staff (people who stand by at hospital and prepare to receive patient). EMCR drafted a ‘Care Plan’ to ensure the staff follow the standard of procedure when handling emergency case including emergency call reception, medical standby and reference cases. [5]

1.4.2 Expert Decision Support System for Doctor Selection

A system where able to decide the suitable doctor to handle emergency cases based on type of emergency, doctor availability, scheduling, expertise and other relevant cases.
1.5 Project Scope

The scopes of this project are:

i. System User
   a. The system is specially designed for emergency department, eg: doctor
   b. Not for user who did not involve in the decision making process of human
      resource management for emergency department, eg: patient.

ii. System Functionality
    a. The system provides a suggested decision to the on-duty doctor to decide
       who will be the best doctor available to handle each emergency case.

iii. System Data
    a. Doctor Schedule & Profile
    b. Emergency Case Type

iv. System Architecture and Platform
    a. The system will generate an output of suggested doctor to be assigned to
       handle the emergency case, and all the information will be sent and
       notified the doctor involved via mobile platform
1.6 Outline of Material

This project based technical report is divided into three (3) parts and each part is presented to discuss different aspects of the project. Below will be the outline of each part of this report:

i. Part 1 – Introduction

This part is to discuss the purpose of the project including the existing problem faced, the aim and objective of the project to solve the problem, and also the scopes. Besides, this section will discuss further about the existing system and its limitations.

ii. Part 2 – Report Body

This part will play an important role in this report where it will discuss the user requirement, design description, development plan and also testing plan.

iii. Part 3 – Conclusion

After all these research and execution of the project, it will be a summary of the entire project and also some suggestions and comments towards the project are presented in this part.
PART 2

REPORT BODY

This part is briefly discussed about the body of the project. Basically, there are five (5) sub sections for this technical report. The first section is the user requirement, where briefly describe the functionality of the project. The second section is the design description where discuss about the proposed design to solve the problem of the project and further discuss about the methods and materials used to develop the system in third section. Furthermore, the fourth section is the technical result. Lastly, the last section will briefly describe the testing plan and result where test whether the project meet requirements.

2.1 User Requirement

This sub-section is to briefly describe the user requirement after the client meeting at Pekan Hospital. The user requirement is a documents where act as a specification of requirements from the user's point of view. A client meeting has been scheduled to meet the client and asking some question to guide the user to come out with the idea of the system and the design description will be created based on the user needs.

Followed up by the client meeting, user as a paramedic staff who mainly involved in emergency department has pointed out that the current system used for communication, Emergency Medical Communication Response has its own limitation and wish to enhance it. Based on the discussion, we came out a decision to design a mobile platform
used for expert decision support system to decide or assign the most suitable doctor to handle each emergency case.

Developer needs to spend a lot of time to understand the procedure to handle emergency case and also some common terms used in emergency department. During the analysis of requirement period, developer needs to visit Pekan Hospital frequently to collect necessary data.

Besides that, user has pointed out that they hope the system can implement virtualization for the photo of patient's injury part and integration between departments can be more efficient. All the user requirement and sign-off form can referred to Appendix A.

2.2 Design Description

In this sub section, we will briefly discuss about the entire process how this project runs throughout the planning and maintenance process. Besides, we will discuss all the other relevant diagrams that can describe the project clearer.

2.2.1 Waterfall Model

According to (Benington, Herbert D., 1983), the waterfall model is a sequential design process often used in software development processes.[6] In Waterfall Model, each progress is seen as flowing steadily downwards (just like a waterfall) through the phases of Planning, Analysis, Design, Development, and Maintenance. The Waterfall Model is ensuring every process is well executed and confirmed before move to the next process, this is to ensure the quality of each process. Besides that, Waterfall Model is obviously reflects the entire process of this project where the project have to pass down from one process to another by approved by both supervisor and user. Due to the reason stated, this model has been used in creating the Expert Decision Support System. Figure 2.2.1 below illustrates the Waterfall Model for this Expert Decision Support System.
This Waterfall model consists of five (5) stages includes project planning, requirement analysis, system design, system development and maintenance.
2.2.1.1 Planning

Project Planning is the earliest stage of the project. All the essentials information that defines this project has to be carried out such as problem statements, objectives, scope of the project and so on. Few meetings and discussions have been carried out with the supervisor, Associate Prof. Dr. Noraziah Binti Ahmad on the motivations for the project.

A Gantt Chart planning from the beginning of the project until the end has been drafted accordingly after the project title has been agreed by the supervisor. The Gantt Chart of the project can be referred to Appendix B.

2.2.1.2 Analysis

Further analysis and research of the system requirements have been carried out. Comparison between proposed system design and current system has been carried out. Few client meetings have been carried with the paramedic staff in emergency department at Pekan Hospital. In this stage, we will be more understand the standard procedure of handling emergency and the common terms used to be implement in the project.

2.2.1.3 Design

During this phase, the prototypes of the system will be created based on the system design from user requirement analysis. The flowcharts and some relevant diagrams allow user to understand the whole picture of the system. The designs of the system have been displayed through storyboard.