

**AUTOMATED NURSE SCHEDULING USING
GENETIC ALGORITHM (GA)**

SHAHIRA NABILAH BT ZULKAFLI



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**AUTOMATED NURSE SCHEDULING USING
GENETIC ALGORITHM (GA)**

SHAHIRA NABILAH BT ZULKAFLI

**This report is submitted in partial fulfillment of the requirements for the Bachelor of
Computer Science (Artificial Intelligence)**


**FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY
UNIVERSITI TEKNIKAL MALAYSIA MELAKA
2011**

DECLARATION

I hereby declare that this project entitle

**AUTOMATED NURSE SCHEDULING USING
GENETIC ALGORITHM (GA)**

is written by me and is my own effort and that no part has been plagiarized without
citations.

STUDENT :  _____ Date: 08/07/2011
(SHAHIRA NABILAH BT ZULKAFLI)

SUPERVISOR :  _____ Date: 08/07/2011
(NUZULHA KHILWANI BT IBRAHIM)

DEDICATION

To my beloved mother, Zalina bt Yusoff and family for their love and support...

To my kind supervisor, Miss Nuzulha Khilwani for making it
worthwhile...

To all my lecturers and friends for their support...

ACKNOWLEDGEMENT

First of all, I would like to say Alhamdulillah, for giving me the strength and health to do this project work until it was done. I have taken efforts in this project. However, it would not have been possible without the kind support and help of many individuals and organizations. I would like to extend my sincere thanks to all of them.

The special thank goes to my helpful supervisor, Miss Nuzulha Khilwani for supervision and support that she gave. It is truly help the progression and smoothness of the project development. The co-operation is much indeed appreciated. Special thank also to her because proposed a well thesis idea to me, he has given me many useful suggestion and idea to finish the system. As my lecturer that teach GA subject, she give lots of idea how to implement GA in this project.

Not forgotten friends that in the same group that together works for Final Year Project, Amir Hamzah b Mat Saman, Chiam Cheah Bin, Yeap Jia Jun, Liyana Safraa bt Ahmad, Mohamad Fahmi b Nordin, Muhd Akmal Hakim b Tarmizi and Nor Hafizi. They were helpful that when we combined and discussed together, we had this task done.

Other than that I would like to thanks PSM (*Projek Sarjana Muda*) committee members on their kindness in organizing briefing, seminar and talk to student who took this subject. So that all this activity can help the student a lot for example can give an overview and idea to them begin doing the project.

Not forgotten thanking to my family for providing everything, such as money, to buy anything that are related to this project work and their advise, which is the most needed for this project. Internet, books, computers and all that as my source to complete this project.

ABSTRACT

Automatic Nurse Scheduling System is the system that develops by using Matlab Software to build a complete nurse scheduling working shift for a week. The schedule is design for government hospitals nurses that work for 24 hours shift system. The Technique that uses to develop this system is Genetic Algorithm (GA) which is this technique is one of the Artificial Intelligent techniques. Main objective of this project is to implement GA to solve Nurse Scheduling Problems (NSP). This report containing detail explanations about GA that being design and exploit to solve NSP. Early planning for completion of this project is explained to gain further understanding about the project topic especially NSP. NSP is difficult search problem with many constraints, consist of optimization problems with multi-objectives. Detailed algorithm of GA that used for this project explained.

ABSTRAK

Sistem Penjadualan Jururawat Automatik ialah sebuah sistem yang dibina menggunakan perisian Matlab untuk menghasilkan satu lengkap jadual kerja jururawat untuk satu minggu. Jadual ini direka untuk kerajaan hospital jururawat yang bekerja 24 jam shif system. Teknik yang digunakan untuk menghasilkan system ini ialah Algoritma Genetik (GA) dimana teknik ini adalah salah satu daripada Kepitaran Buatan teknik. Objektif utama projek ini adalah untuk mengaplikasikan GA untuk menyelesaikan Masalah Jadual Jururawat (NSP). Laporan ini mengandungi terperinci penerangan tentang GA yang telah di ubahsuai untuk menyelesaikan NSP. Perancangan awal untuk menyiapkan projek ini diterangkan untuk mendapatkan lebih fahaman tentang topic projek, terutamanya NSP. NSP ialah sukar carian permasalahan kerana mengandungi pelbagai kekangan (constraints) dengan pelbagai objektif. Algoritma terperinci tentang GA yang digunakan untuk projek ini diterangkan.

TABLE OF CONTENT

CHAPTER	SUBJECT	PAGE
	PROJECT TITLE	i
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENTS	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF TABLES	xi
	LIST OF FIGURE	xii
 CHAPTER I	 INTRODUCTION	
	1.1 Project Background	1
	1.2 Problem statement	2
	1.3 Objective	3
	1.4 Scope	3
	1.5 Project Significant	4
	1.6 Expected Output	4
	1.7 Conclusion	5

CHAPTER II	LITERATURE REVIEW AND PROJECT METHODOLOGY	
2.1	Introduction	6
2.2	Facts and Findings	7
2.2.1	Domain	7
2.2.2	Existing System	10
2.2.3	Technique	12
2.3	Project Methodology	13
2.4	Project Requirement	15
2.4.1	Software Requirement	16
2.4.2	Hardware Requirement	16
2.5	Project Schedule and Milestones	17
2.6	Conclusion	17
CHAPTER III	ANALYSIS	
3.1	Introduction	18
3.2	Problem Statement	19
3.2.1	Proposed System	19
3.3	Requirement Analysis	29
3.3.1	Data Requirement	29
3.3.2	Functional Requirement	30
3.3.3	Non-functional Requirement	31
3.4	Conclusion	32
CHAPTER IV	DESIGN	
4.1	Introduction	34
4.2	High Level Design	35
4.2.1	System Architecture	35
4.2.2	User Interface Design	36
4.2.3	Database Design	53
4.3	Detailed Design	54
4.3.1	Software Design	54
4.2.3	Physical Database Design	66

	4.4 Conclusion	66
CHAPTER V	IMPLEMENTATION	
	5.1 Introduction	67
	5.2 Software Development Environment Setup	67
	5.3 Software Configuration Management	68
	5.3.1 Configuration environment Setup	68
	5.3.2 Version Control Procedure	69
	5.4 Implementation Status	69
	5.5 Conclusion	70
CHAPTER VI	TESTING	
	6.1 Introduction	71
	6.2 Test Plan	72
	6.2.1 Test Organization	72
	6.2.2 Test Environment	73
	6.2.3 Test Schedule	73
	6.3 Test Strategy	74
	6.3.1 Classes of tests	74
	6.4 Test Implementation	76
	6.4.1 Test Description	76
	6.4.2 Test Data	77
	6.5 Test Result and Analysis	77
	6.6 Conclusion	82

CHAPTER VII	PROJECT CONCLUSION	
	7.1 Observation Weakness and Strengths	83
	7.1.1 Strengths	83
	7.1.2 Weakness	83
	7.2 Propositions for Improvement	84
	7.3 Contribution	85
	7.4 Conclusion	85
REFERENCES		86
BIBLIOGRAPHY		87
APPENDICES		89
	Appendix A : User Manual	
	Appendix B : Proposal	
	Appendix C : Questionnaire	
	Appendix D : Log Book	
	Appendix E : Gant Chart	
	Appendix F : Source Code	

LIST OF TABLES

TABLES	TITLE	PAGE
3.1	One Complete Schedule 17	20
3.2	Penalty Pattern 20	30
3.3	List of Nurse Name	30
4.1	Input Design	39
4.2	Penalty Pattern	42
4.3	Output, Complete schedule45	53
5.1	Implementation Status61	69
6.1	Test Plan65	77
6.2	Test Schedule	74
6.3	Result Graph	78
6.4	Result Summary	80
6.5	Average	88

LIST OF FIGURES

DIAGRAM	TITLE	PAGE
2.1	Spiral Model	14
3.1	Chromosome Candidate	25
3.3	New Chromosome	27
3.2	Crossover Process	27
3.4	Mutation	28
3.5	Switch 1	28
3.6	Switch 2	29
4.1	System Architecture	36
4.2	Complete user interface	36
4.3	Help Button	37
4.4	Instruction Window	37
4.5	Step 2,3, 4 and 5	38
4.6	Steps 6, 7, 8, 9, 10, 11, 12 and 13	39
4.7	Day Slot	41
4.8	Distribution shift cases.	42
4.9	Test case	43

4.10	Example Penalty Assignment	45
4.11	Example Penalty Assignment (Population)	45
4.12	Crossover Process	46
4.13	New Chromosome	46
4.14	Mutation Process	47
4.15	Generate button	48
4.16	Crossover button	49
4.17	Switch button	49
4.18	Statistic button	50
4.19	Plot button	50
4.20	Format Button	51
4.21	Save Button	52
4.21	Save Popup	52
5.1	System Environment	67
6.1	Population Vs iteration	81

CHAPTER I

INTRODUCTION

1.1 Project background

In the domain of healthcare, this is particularly challenging because of the presence of a range of different staff requirements on different days and shifts. In addition, unlike many other organizations, healthcare institutions work twenty-four hours a day for every single day of the year. Workers also have different hour of work. Most nurse scheduling problems are extremely difficult and complex. Tien and Kamiyama (1982), for example, say nurse scheduling is more complex than the traveling salesman problem. A general overview of various approaches for nurse scheduling can be found in Sitompul and Randhawa (1990), Cheang et al. (2003) and Burke et al. (2004). Early research (Warner and Prawda 1972; Miller et al. 1976; Trivedi and Warner 1976) concentrated on the development of mathematical programming models. The Nurse scheduling problem is the problem of determining a work schedule for nurses that is both reasonable (or fair) and efficient. Despite seeming trivial, this is a complex problem due to its many constraints and many possible combinations. It is a good example of the difficulties encountered in constraint programming.

1.2 Problem statements

Below is list of problem statement that arrive from NSP

1. Different nurse's working hour (a full time nurse would work 5 days or 4 nights, whereas typical part-time contracts are for 4 days or 3 nights, 3 days or 3 nights and 3 days or 2 nights).
2. A nurse doesn't do a late night shift followed by a day shift the next day.
3. A nurse doesn't work the day shift, night shift and late night shift on the same day.
4. The schedule needs to be renewing every month that contain different design for every week and need to publish a month earlier.
5. Nurse schedule are produce by the staff manually that cost more time and energy also lead to many errors such as redundancy. Eliminate hours spent scheduling and calling employees on the phone.
6. Working hour in hospitals are twenty-four hour per day and open seven days per week.
7. Conflict between nurse that sometimes have personnel problems in attending their shift (holidays, sick).

1.3 Objectives

Apply genetic algorithm in solving the problems.

1. Investigate nurse scheduling in Malaysia government hospitals.
2. To model the nurse scheduling using Genetic Algorithm.
3. Overcome hard constraints (if this constraint fails then the entire schedule is invalid) and soft constraints (it is desirable that these constraints are met but not meeting them doesn't make the schedule invalid).

4. To apply Genetic Algorithm for generating nurse rostering.

1.4 Scope

Scopes for this project are listed below. This scope will limit my project area.

1. Used for only government's hospital that operates twenty four hours daily that divided the nurse shift into three category, morning, afternoon and night.
2. The system will use matlab software and apply genetic algorithm.
3. The system prepared for nurse government hospitals in Malaysia only since private hospitals arrange their nurse differently.
4. Duty roster are divided into three shifts, morning, evening and night.
5. No adjustment can be done after duty roster generate.
6. The system will publish a month earlier so the employee can do self-schedule.

1.5 Project Significant

This system can help to overcome problems that always happen when the nurse schedule is arranged manually. Schedule that arrange manually usually have redundancy such as a nurse that already sing to day shift have the night shift. This system should benefit the employee the most. Nurse can do self-schedule based on the schedule that publishes a month earlier. They can apply for break and change the shift among themselves. Schedule that produce by this system will give the nurse time to rest which the system will be flexible with the shift. The head nurse that responsible for the schedule also can save time and efforts using this system. Plus, schedule that no redundancy and error can ease the nurse to work more efficiently, improve service/care coordination and decrease non-productive hours.

In addition, this project will lead to detail study about genetic algorithm method in solving scheduling problems.

1.6 Expected output

This project should successfully applied genetic algorithm to solve the nurse scheduling problem. The schedule should be flexible where there are no nurses that have both day and night shift. The system should arrange the most possible nurse schedule and displays all nurse names and their shift for a week.

1.7 Conclusions

From the previous explanation, this project can produce a system that can overcome problems that have been identified in nurse schedule arrangement. In the same time can gives detail study of genetic algorithm method in solving scheduling problem. The system can benefits the patient also where nurse can do their job professionally and give their patient the best efforts if they have a good working time.

CHAPTER II

LITERATURE REVIEW AND PROJECT METHODOLOGY

2.1 Introduction

In this chapter, I will explain more detail about my project domain and others existing system that familiar with my project but used different approach. The detail research about my project also will be explained in this chapter. Then I will state the requirement that I needed to complete the system. Plus, initial plan to start my project will be clearly pictured in this chapter. The initial plan includes milestone and methodology strategies. This plan will lead me for the whole semester to make sure I am right on schedule to complete the system.

2.2 Facts and findings

Some research must be made to search some facts and finding about the project to make me clearly understand about my project before I plan and decide my technique and methodology.

2.2.1 Domain

Scheduling problems involve solving for the optimal schedule under various objectives, different machine environments and characteristics of the jobs. Nurse scheduling problem also include in this domain. Nursing scheduling problem (NSP) had been discovering about twenty years ago. In the real world, to arrange the nurse scheduling we must considers shifts that split into morning, afternoon, and night, only one shift per nurse allowed per day and it will be no morning shift. NSP are build by considering to types of constraints, hard constraints and soft constraint.

2.1.1.1 Hard Constraints

Hard constraints represent the requirements that must be met in order to make the roster usable. If any one of the hard constraints is not meet in the project, the project is not working. The hard constraints that will be considered in my project are as following:

1. Cover needs to be fulfilled (i.e. no shifts must be left unassigned).
2. For each day a nurse may start only one shift.
3. Following a series of at least 2 consecutive night shifts a 48 hours rest is required.

4. During any period of 24 consecutive hours, at least 12 hours of rest is required. A night shift has to be followed by at least 14 hours rest. An exception is that once in a period of 21 days for 24 consecutive hours, the resting time may be reduced to 8 hours.
5. The number of consecutive night shifts is at most 2.
6. The number of consecutive shifts (workdays) is at most 5.
7. No Overlap between Assignments.

2.1.1.2 Soft Constraints

Soft constraints are designed to push the actual roster quality. Common soft constraints represent requests for free days, shift type preferences or requests for longer free time blocks between worked shifts. The soft constraints that will be considered in my project are as following:

Constraint	Weight	Penalty Function	Violation Measurement Factor
For the period of Friday 22:00 to Monday 0:00 a nurse should have either no shifts or at least 2 shifts ('Complete Weekend').	1000	Linear	Number of non-complete Weekends.
For any employees avoid stand-alone shifts. A stand alone shift is an isolated working day i.e. a shift on a day which is flanked by two days without shifts.	1000	Linear	Number of isolated shifts.
For employees with availability of 30-48 hours			Difference between length of series and acceptable

per week, the length of a series of <i>night</i> shifts should be within the range 2-3. It could be before another series.	1000	Quadratic	length range. e.g. if 1 night shift, factor = 1, if 2 or 3 night shifts, factor = 0, if 4 night shifts, factor = 1, if 5 factor = 2 etc.
For employees with availability of 0-30 hours per week, the length of a series of night shifts should be within the range 2-3. It could be before another series.	1000	Quadratic	Difference between length of series and acceptable length range
The rest after a series of day, early or late shift is a minimum of 2 days.	100	Linear	Factor is one if only one day of rest otherwise zero.
For employees with availability of 30-48 hours per week, within one week the number of shifts is within the range 4-5.	10	Quadratic	Difference between length of series and acceptable length range.
For employees with availability of 0-30 hours per week, within one week the number of shifts is within the range 2-3.	10	Quadratic	Difference between length of series and acceptable length range.
For employees with availability of 30-48 hours per week, the length of a series of shifts should be within the range of 4-6.	10	Quadratic	Difference between length of series and acceptable length range.
For employees with availability of 0-30 hours per week, the length of a	10	Quadratic	Difference between length of series and acceptable length range.

series of shifts should be within the range 2-3.			
For all employees the length of a series of early shifts should be within the range 2-3. It could be within another series.	10	Quadratic	Difference between length of series and acceptable length range.
For all employees the length of a series of late shifts should be within the range of 2-3. It could be within another series.	10	Quadratic	Difference between length of series and acceptable length range.
An <i>early</i> shift after a <i>day</i> shift should be avoided.	5	Linear	Number of early shifts after days shifts.
A <i>night</i> shift after an <i>early</i> shift should be avoided.	1	Linear	Number of night shifts after early shifts.

2.2.2 Existing system

Microcomputer-Based Decision Support System (DSS)

Mann and Watson define a DSS as follows: "A decision support system is an interactive system that provides the user with easy access to decision models and data in order to support semi-structured decision-making tasks." In 1991, Sitompul used a microcomputer-based DSS for nurse scheduling as a heuristic approach for generating nursing schedules for the Samaritan Hospital in Corvallis, Oregon. Sitompul's DSS model included five elements:

1. Pattern Generator: Generate a group of work and shift patterns.
2. Schedule Generator: Combine work and shift patterns to form working schedules.
3. Schedule Processor: Assign a schedule to each nurse.