# DETERMINING EFFICIENT SCHEDULING APPROACH OF DOCTORS FOR OPERATING ROOMS: AN ANALYSIS ON AL-SHAHID GHAZI AL-HARIRI HOSPITAL IN BAGHDAD

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**DETERMINING EFFICIENT SCHEDULING APPROACH OF DOCTORS FOR OPERATING ROOMS: AN ANALYSIS ON AL-SHAHID GHAZI AL-HARIRI HOSPITAL IN BAGHDAD**

By

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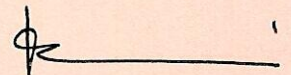Operating Rooms : An Analysis on Al- Shahid Ghazi Al- Hariri
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# ABSTRACT

Government hospitals in Iraq have long been suffering from overcrowded patients, and shortages of doctors and nurses. Unstable environment with occurrences of random war-related incidents has put further burden on hospitals' limited resources particularly the surgical department. Large number of pre-scheduled elective surgeries has occasionally been interrupted by the incoming war-related incidents patients. This in turn has put tremendous pressure on the hospital management to maximize utilization of its operating rooms' resources including surgeons and nurses, whilst simultaneously minimizing idle time. Al-Shahid Ghazi Al-Hariri hospital in Baghdad is presently experiencing these issues. Therefore, this study has been undertaken with the aims to identify efficient scheduling approach for elective surgeries for operating rooms in Al-Shahid Ghazi Al-Hariri hospital while considering interruptions from non-elective surgery (incoming patients from war-related incidents). Specifically, this study intends to develop a Mixed Integer Linear Programming (MILP) model to maximize the utilizations of operating rooms, availability of surgeons as well as to minimize potential idle time. A meta-heuristic approach in the form of a Tabu Search is then employed to generate an acceptable solution and utilizing time more efficiently. Real data was collected from the hospital in the form of interviews, observations and secondary reports. The initial MILP computational results show that the proposed model has successfully produced optimal solutions by improving the utilization of operating rooms. Notwithstanding, the difficulty to produce results in reasonable time for larger problem instances has led to the application of a more efficient meta-heuristic approach. The Tabu Search results indicated better performance of the model with good quality solutions in fewer computation times. The finding is important as it determines the feasibility of the proposed model and its potential benefit to all relevant stakeholders.

**Keywords:** operating room scheduling, tabu Search, mixed integer linear programming, elective surgery, non-elective surgery

# ABSTRAK

Hospital kerajaan di Iraq telah lama menghadapi masalah kebanjiran pesakit, dan kekurangan doktor dan jururawat. Persekitaran yang tidak stabil dengan insiden berkaitan perang yang sering berlaku telah menambahkan beban terhadap sumber hospital yang terhad terutamanya di bahagian pembedahan. Sejumlah besar pesakit yang telah dijadualkan untuk menjalani pembedahan elektif kerap diganggu dengan kemasukan pesakit daripada insiden berkaitan peperangan. Keadaan ini telah memberi tekanan yang hebat kepada pengurusan hospital untuk memaksimakan penggunaan sumber bilik pembedahan termasuk pakar bedah dan jururawat, pada masa yang sama meminimumkan masa melahu. Hopital Al-Shahid Ghazi Al-Hariri di Baghdad sedang berhadapan dengan masalah tersebut. Oleh yang demikian, kajian ini dijalankan untuk mengenal pasti pendekatan penjadualan yang cekap untuk pembedahan elektif bagi bilik pembedahan di Hospital Al-Shahid Ghazi Al-Hariri, pada masa yang sama mempertimbangkan gangguan daripada pembedahan bukan elektif (kemasukan pesakit daripada insiden berkaitan peperangan). Secara khususnya, kajian ini bertujuan menghasilkan sebuah model Pengaturcaraan Integer Linear campuran (MILP) bagi memaksimumkan penggunaan bilik pembedahan, kebolehsediaan pakar bedah dan meminumumkan potensi masa melahu. Pendekatan meta-heuristik dalam bentuk Pencarian Tabu digunakan untuk menghasilkan penyelesaian yang boleh diterima dan penggunaan masa yang lebih cekap. Data sebenar telah dikumpul daripada hospital melalui temu bual, pemerhatian dan laporan sekunder. Hasil pengiraan awal MILP menunjukkan bahawa model yang dicadangkan berjaya menghasilkan penyelesaian optimum dengan peningkatan penggunaan bilik pembedahan. Walau bagaimapun, kesukaran untuk menghasilkan keputusan dalam masa yang berpatutan bagi masalah yang lebih besar telah membawa kepada aplikasi pendekatan meta-heuristik yang lebih cekap. Hasil Pencarian Tabu menunjukkan prestasi model yang mempunyai kualiti penyelesaian yang baik dengan berkurangnya masa pengiraan. Hasil kajian ini penting kerana dapat menentukan kebolehlaksanaan model yang dicadangkan dan potensi faedahnya kepada semua pemegang taruh yang berkaitan.


**Kata kunci:** jadual bilik pembedahan, pencarian tabu, pengaturcaraan integer linear campuran, pembedahan elektif, pembedahan bukan elektif

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# ACKNOWLEDGEMENT

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| | |
|---|---|
| EMR | Electronic Medical Record |
| SPT | Shortest Processing Time |
| LBBD | Logic-Based Benders' Decomposition |
| LPT | Longest Processing Time |
| PTD | Priority type duration |
| EDD | Earliest Due Date |
| FCFS | First Come First Served |
| CR | Critical Ratio |
| S/RO | Slack Per Remaining Operation |
| STR | Slack Time Rule |
| LWR | Lower Work Remaining |
| LCFS | Last Come First Served |
| WINQ | Work In Next Queue |
| COVERT | Cost Cover Time |
| MILP | Mixed Integer Liner Programming |
| ILP | Integer Linear Programming |
| DP | Dynamic Programming |
| LP | Liner Programming |
| OR | Operating Room |
| AC | Ant Colony |
| TS | Tabu Search |
| GA | Genetic Algorithm |
| MMBJS | Multi-Mode Blocking Job Shop |
| DESM | Discrete Event Simulation Model |
| OLAS | Over-Lapping Appointment Scheduling |
| FJSSP | Flexible Job Shop Scheduling Problem |
| GDP | Generalized Disjunctive Programming |
| SOMO | Self-Organizing Map -based Optimization |
| DSS | Decision Support System |
| Q-ECTS | Quasi-Experimental Controlled Time-Series |
| STS | Simulation-based Tabu Search |
| IPETS | Integer Programming Enhanced Tabu Search |
| BPETS | Binary Programming Enhanced Tabu Search |
| GP | Goal programming |
| PACU | Post Anesthesia Care Unit |
| ICU | Intensive Care Unit |
| FMOP | Fuzzy Multi-Objective Optimizing |
| MSS | Master Surgical Schedules |
| DEMO | Design and Engineering Methodology for Organization |
| DS | Duration of Surgery |
| SCs | Surgeon assigned to surgery |
| S | Set of surgeries |

| | |
|---|---|
| C | Set of surgeons |
| R | Set of rooms |
| D | Set of days |
| T | Set of periods |
| ns | Number of elective surgeries |
| nc | Number of surgeons |
| nr | Number of rooms |
| nd | Number of days |
| nt | Number of periods |

# CHAPTER ONE

# INTRODUCTION

## 1.1    Health Sector in Iraq Overview

The healthcare expenditure in Iraq has been rising because of the growing number of diseases, epidemics and accidents. The Iraqi healthcare system uses a hospital-oriented model for capital investment and thereby exhibits limited efficiency. The Ministry of Health is the main provider of therapeutic and preventive healthcare. The private sector provides curative services only to a limited section of the population primarily, those who can pay for the services it provides (Ministry of Iraqi health & world Health Organization, 2009). According to Ministry of Iraqi Health (2014) in the National Health Policy Report 2014-2023, the Iraqi health sector suffers from multiple short comings, in spite of a large number of employees (about 237,901). There is a substantial shortage of specialised medical staff since a majority of the staff members are not qualified and hold administrative or support jobs.

The Iraqi healthcare sector faces a shortage of staff with advanced skills and critical specialties like Anaesthetics, Radiology, Oncology, Forensic Medicine and cardiology. There is a lack of highly qualified nurses. The population growth rate in Iraq is 3.4%, which further intensifies the problem. The morbidity and mortality map is also changing rapidly through increased heart diseases, tumours and psychological disorders. Furthermore, the national crisis, threatened security and disasters put severe pressure on the healthcare system. 'Duplication of work' whereby public-sector healthcare employees work in more than one place, is also a problem. This in turn leads to reduced

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# APPENDICES

# APPENDIX 1

## RANDOM DATA GENERATED RESULTS

This Result Has been Registered on:12/15/2017    5:42:07 PM

\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#

Day #1

\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#

\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#\#

Room (1) MAXz is: 0.439

Room (2) MAXz is: 0.58

Room (3) MAXz is: 0.804

Room (2) MAXz is: 0.913

Room (3) MAXz is: 0.925

Room (1) MAXz is: 0.98

Room (2) MAXz is: 0.638

Room (2) MAXz is: 0.385

Room (3) MAXz is: 0.438

Room (1) MAXz is: 0.433

Room (2) MAXz is: 0.669

Room (2) MAXz is: 0.538

Room (3) MAXz is: 0.488

Room (1) MAXz is: 0.415

Room (2) MAXz is: 0.998

Room (2) MAXz is: 0.585

Room (3) MAXz is: 0.496

Room (1) MAXz is: 0.679

Room (1) MAXz is: 0.573

Room (2) MAXz is: 0.988

Room (3) MAXz is: 0.48

Room (3) MAXz is: 0.92

Room (1) MAXz is: 0.677

Room (2) MAXz is: 0.717

Room (1) MAXz is: 0.92

Room (1) MAXz is: 0.923

Room (2) MAXz is: 0.46

Room (3) MAXz is: 0.271

Room (1) MAXz is: 0.888

Room (1) MAXz is: 0.904

Room (2) MAXz is: 0.454

Room (3) MAXz is: 0.448

Room (1) MAXz is: 0.713

Room (2) MAXz is: 0.61

1

Room (3) MAXz is: 0.535

Room (2) MAXz is: 0.908

Room (1) MAXz is: 0.85

Room (2) MAXz is: 0.669

Room (1) MAXz is: 0.319

Room (2) MAXz is: 0.919

Room (2) MAXz is: 0.604

Room (3) MAXz is: 0.6

Room (3) MAXz is: 0.869

Room (3) MAXz is: 0.925

Room (1) MAXz is: 0.58

Room (1) MAXz is: 0.573

Room (3) MAXz is: 0.731

Room (2) MAXz is: 0.604

Room (3) MAXz is: 0.623

Room (3) MAXz is: 0.825

Room (1) MAXz is: 0.63

Room (3) MAXz is: 0.902

Room (2) MAXz is: 0.64

Room (3) MAXz is: 0.785

Room (2) MAXz is: 0.52

Room (1) MAXz is: 0.788

Room (1) MAXz is: 0.725

Room (2) MAXz is: 0.71

Room (3) MAXz is: 0.727

The Average of MAXz for day (1) is: 0.738

Room (1) MAXz is: 0.723

The Execution Time is: (453) sec

##############################################################

Day #2

##################################################

##################################################

Room (1) MAXz is: 0.933

Room (2) MAXz is: 0.981

Room (2) MAXz is: 0.938

Room (1) MAXz is: 0.429

Room (3) MAXz is: 1.238

Room (2) MAXz is: 0.785

Room (1) MAXz is: 0.85

Room (2) MAXz is: 0.308

Room (2) MAXz is: 0.156

Room (3) MAXz is: 0.902

Room (3) MAXz is: 0.731

Room (3) MAXz is: 0.815

Room (1) MAXz is: 0.71

Room (1) MAXz is: 0.444

Room (3) MAXz is: 0.108

Room (2) MAXz is: 0.156

Room (1) MAXz is: 0.604

Room (3) MAXz is: 0.152

Room (3) MAXz is: 0.952

Room (1) MAXz is: 0.623

Room (1) MAXz is: 0.85

Room (2) MAXz is: 0.219

Room (3) MAXz is: 0.438

Room (1) MAXz is: 0.358

Room (2) MAXz is: 0.546

Room (2) MAXz is: 0.67

Room (3) MAXz is: 0.44

Room (1) MAXz is: 0.954

Room (2) MAXz is: 0.252

Room (1) MAXz is: 0.27

Room (2) MAXz is: 0.638

Room (3) MAXz is: 0.988

Room (1) MAXz is: 0.877

Room (2) MAXz is: 0.929

Room (3) MAXz is: 0.794

Room (1) MAXz is: 0.579

Room (3) MAXz is: 0.769

Room (1) MAXz is: 0.502

Room (2) MAXz is: 0.585

Room (2) MAXz is: 0.915

Room (2) MAXz is: 0.89

Room (3) MAXz is: 0.815

Room (3) MAXz is: 0.679

Room (1) MAXz is: 0.998

Room (2) MAXz is: 0.781

Room (3) MAXz is: 0.52

Room (1) MAXz is: 0.067

Room (2) MAXz is: 0.681

Room (2) MAXz is: 0.463

Room (3) MAXz is: 0.179

Room (1) MAXz is: 0.729

Room (3) MAXz is: 0.915

Room (1) MAXz is: 0.631

Room (2) MAXz is: 0.308

Room (3) MAXz is: 0.983

Room (1) MAXz is: 0.77

Room (2) MAXz is: 0.141

Room (3) MAXz is: 0.356

Room (1) MAXz is: 0.544

Room (1) MAXz is: 0.733

Room (1) MAXz is: 0.598

Room (3) MAXz is: 0.629

Room (1) MAXz is: 0.856

Room (2) MAXz is: 0.652

Room (2) MAXz is: 0.525

Room (2) MAXz is: 0.6

Room (3) MAXz is: 0.81

Room (1) MAXz is: 0.69

Room (2) MAXz is: 0.352

Room (3) MAXz is: 0.606

Room (1) MAXz is: 0.717

Room (3) MAXz is: 0.72

Room (1) MAXz is: 0.979          Room (3) MAXz is: 0.54

Room (2) MAXz is: 0.881          Room (1) MAXz is: 0.615

Room (3) MAXz is: 0.673          Room (3) MAXz is: 0.281

Room (1) MAXz is: 0.229          The Average of MAXz for day (2) is: 0.752

Room (2) MAXz is: 0.452          The Execution Time is: (952) sec

###########################################################

Day #3

#################################################

#################################################

Room (1) MAXz is: 0.825          Room (2) MAXz is: 0.454

Room (2) MAXz is: 0.885          Room (3) MAXz is: 0.746

Room (3) MAXz is: 0.917          Room (1) MAXz is: 1.215

Room (1) MAXz is: 0.631          Room (2) MAXz is: 0.721

Room (2) MAXz is: 0.754          Room (2) MAXz is: 0.658

Room (3) MAXz is: 0.519          Room (2) MAXz is: 0.904

Room (3) MAXz is: 1.015          Room (3) MAXz is: 0.679

Room (1) MAXz is: 0.594          Room (3) MAXz is: 0.765

Room (2) MAXz is: 1.352          Room (1) MAXz is: 0.469

Room (1) MAXz is: 0.523          Room (1) MAXz is: 0.906

Room (1) MAXz is: 0.869          Room (2) MAXz is: 0.629

Room (3) MAXz is: 0.698          Room (3) MAXz is: 1.288

Room (1) MAXz is: 1.296          Room (1) MAXz is: 1.013

Room (2) MAXz is: 1.175          Room (2) MAXz is: 1.179

Room (3) MAXz is: 0.698          Room (3) MAXz is: 1.352

Room (3) MAXz is: 1.098          Room (1) MAXz is: 0.754

Room (1) MAXz is: 0.681          Room (2) MAXz is: 0.967

Room (2) MAXz is: 0.515          Room (1) MAXz is: 0.504

Room (1) MAXz is: 1.058

Room (2) MAXz is: 0.833

Room (2) MAXz is: 1.385

Room (3) MAXz is: 0.54

Room (3) MAXz is: 1.348

Room (1) MAXz is: 1.044

Room (3) MAXz is: 0.771

Room (1) MAXz is: 0.573

Room (1) MAXz is: 0.904

Room (2) MAXz is: 0.644

Room (2) MAXz is: 1.417

Room (3) MAXz is: 0.554

Room (3) MAXz is: 0.452

Room (3) MAXz is: 0.769

Room (1) MAXz is: 0.971

Room (3) MAXz is: 1.348

Room (1) MAXz is: 0.963

Room (2) MAXz is: 0.831

Room (1) MAXz is: 1.271

Room (2) MAXz is: 1.25

Room (3) MAXz is: 1.096

Room (3) MAXz is: 1.146

Room (1) MAXz is: 1.421

Room (2) MAXz is: 0.765

Room (2) MAXz is: 0.919

Room (3) MAXz is: 0.838

Room (1) MAXz is: 1.119

Room (2) MAXz is: 0.602

Room (2) MAXz is: 0.848

Room (3) MAXz is: 0.967

Room (3) MAXz is: 1.24

Room (1) MAXz is: 0.965

Room (2) MAXz is: 0.852

Room (2) MAXz is: 0.933

Room (1) MAXz is: 0.652

Room (3) MAXz is: 1.044

Room (1) MAXz is: 0.915

Room (2) MAXz is: 1.104

Room (1) MAXz is: 1.31

Room (2) MAXz is: 0.794

Room (2) MAXz is: 0.727

Room (3) MAXz is: 0.717

Room (3) MAXz is: 0.575

Room (3) MAXz is: 0.954

Room (1) MAXz is: 0.648

Room (1) MAXz is: 1.008

Room (2) MAXz is: 0.788

Room (2) MAXz is: 1.3

Room (3) MAXz is: 0.902

Room (3) MAXz is: 0.615

Room (1) MAXz is: 1.108

Room (2) MAXz is: 1.171

Room (3) MAXz is: 1.038

Room (1) MAXz is: 1.206

Room (2) MAXz is: 0.585

Room (3) MAXz is: 1.231

Room (1) MAXz is: 0.627

Room (2) MAXz is: 1.381

Room (3) MAXz is: 0.49

Room (1) MAXz is: 0.485

Room (3) MAXz is: 1.217

Room (1) MAXz is: 0.804

Room (1) MAXz is: 0.888

Room (2) MAXz is: 0.544

The Average of MAXz for day (3) is: 0.797

The Execution Time is: (1172) sec

###########################################################

Day #4

#################################################

#################################################

Room (1) MAXz is: 0.44

Room (2) MAXz is: 0.498

Room (3) MAXz is: 0.373

Room (3) MAXz is: 1.04

Room (1) MAXz is: 0.856

Room (2) MAXz is: 0.885

Room (1) MAXz is: 0.542

Room (2) MAXz is: 0.792

Room (3) MAXz is: 1.071

Room (1) MAXz is: 1.077

Room (2) MAXz is: 0.723

Room (2) MAXz is: 1.227

Room (3) MAXz is: 1.071

Room (1) MAXz is: 0.413

Room (1) MAXz is: 0.958

Room (3) MAXz is: 1.038

Room (1) MAXz is: 0.34

Room (2) MAXz is: 0.754

Room (1) MAXz is: 0.725

Room (2) MAXz is: 0.6

Room (3) MAXz is: 1.308

Room (1) MAXz is: 1.127

Room (2) MAXz is: 1.021

Room (1) MAXz is: 0.742

Room (2) MAXz is: 1.058

Room (3) MAXz is: 0.602

Room (3) MAXz is: 0.681

Room (1) MAXz is: 0.758

Room (2) MAXz is: 1.269

Room (3) MAXz is: 0.446

Room (1) MAXz is: 0.971

Room (3) MAXz is: 0.671

Room (3) MAXz is: 0.429

Room (3) MAXz is: 0.508

Room (1) MAXz is: 0.402

Room (1) MAXz is: 0.756

Room (2) MAXz is: 1.283

Room (3) MAXz is: 0.867

Room (1) MAXz is: 0.819

Room (2) MAXz is: 1.298

Room (3) MAXz is: 0.542

Room (3) MAXz is: 0.702

Room (1) MAXz is: 0.721

Room (3) MAXz is: 0.606

Room (1) MAXz is: 0.827

Room (2) MAXz is: 0.463

Room (3) MAXz is: 0.842

Room (1) MAXz is: 1.29

Room (2) MAXz is: 0.881

Room (2) MAXz is: 1.233

Room (3) MAXz is: 0.981

Room (1) MAXz is: 0.765

Room (3) MAXz is: 1.017

Room (1) MAXz is: 0.388

Room (1) MAXz is: 1.079

Room (2) MAXz is: 1.025

Room (3) MAXz is: 0.821

Room (3) MAXz is: 0.479

Room (1) MAXz is: 0.548

Room (2) MAXz is: 0.65

Room (3) MAXz is: 1.108

Room (1) MAXz is: 0.375

Room (2) MAXz is: 0.842

Room (1) MAXz is: 1.081

Room (2) MAXz is: 1.125

Room (3) MAXz is: 0.65

Room (1) MAXz is: 1.296

Room (2) MAXz is: 1.129

Room (3) MAXz is: 0.998

Room (3) MAXz is: 1.229

Room (1) MAXz is: 1.2

Room (2) MAXz is: 0.74

Room (3) MAXz is: 0.448

Room (1) MAXz is: 1.277

Room (2) MAXz is: 1.121

Room (2) MAXz is: 1.021

Room (3) MAXz is: 0.725

Room (3) MAXz is: 0.34

Room (3) MAXz is: 0.492

Room (3) MAXz is: 0.488

Room (1) MAXz is: 0.833

Room (3) MAXz is: 0.729

Room (1) MAXz is: 0.429

Room (2) MAXz is: 0.6

Room (3) MAXz is: 0.967

Room (1) MAXz is: 1.173

Room (2) MAXz is: 0.823

Room (2) MAXz is: 0.513

Room (3) MAXz is: 1.221

Room (1) MAXz is: 0.696

Room (2) MAXz is: 0.648

Room (1) MAXz is: 1.094

Room (2) MAXz is: 0.542

Room (2) MAXz is: 0.771

Room (3) MAXz is: 0.56

Room (3) MAXz is: 1.202

Room (1) MAXz is: 0.935

Room (2) MAXz is: 0.698

Room (2) MAXz is: 0.713

Room (3) MAXz is: 1.185

Room (1) MAXz is: 0.91

Room (2) MAXz is: 1.256

Room (1) MAXz is: 0.842

Room (3) MAXz is: 0.654

Room (1) MAXz is: 1.192

Room (2) MAXz is: 0.583

Room (2) MAXz is: 0.583

Room (2) MAXz is: 0.502

Room (3) MAXz is: 0.671

Room (3) MAXz is: 0.327

Room (3) MAXz is: 1.067

Room (1) MAXz is: 1.165

Room (2) MAXz is: 0.602

Room (2) MAXz is: 1.027

Room (3) MAXz is: 0.729

Room (1) MAXz is: 1.135

Room (2) MAXz is: 1.067

Room (3) MAXz is: 0.763

Room (3) MAXz is: 0.402

Room (3) MAXz is: 0.735

Room (1) MAXz is: 0.663

Room (2) MAXz is: 1.035

Room (3) MAXz is: 0.635

Room (1) MAXz is: 1.123

Room (2) MAXz is: 0.475

Room (3) MAXz is: 0.917

Room (1) MAXz is: 1.279

Room (2) MAXz is: 0.567

Room (2) MAXz is: 1.265

Room (3) MAXz is: 0.438

Room (3) MAXz is: 1.308

Room (1) MAXz is: 0.956

Room (2) MAXz is: 0.923

Room (3) MAXz is: 1.227

Room (1) MAXz is: 0.898

Room (2) MAXz is: 0.569

Room (1) MAXz is: 1.183

Room (2) MAXz is: 0.398

Room (2) MAXz is: 0.763

Room (2) MAXz is: 1.083

Room (3) MAXz is: 0.569

Room (3) MAXz is: 0.702

Room (3) MAXz is: 0.721

Room (1) MAXz is: 0.85

Room (3) MAXz is: 0.594

Room (1) MAXz is: 0.904

Room (2) MAXz is: 0.533

Room (2) MAXz is: 0.402

Room (2) MAXz is: 1.219

Room (3) MAXz is: 0.435

The Average of MAXz for day (4) is: 0.841

The Execution Time is: (2036) sec

###########################################################

Day #5

###################################################

###################################################

Room (1) MAXz is: 0.877

Room (2) MAXz is: 1.125

Room (3) MAXz is: 0.456

Room (3) MAXz is: 1.173

Room (1) MAXz is: 1.071

Room (2) MAXz is: 0.665

Room (2) MAXz is: 0.717

Room (3) MAXz is: 0.994

Room (1) MAXz is: 1.058

Room (2) MAXz is: 0.606

Room (3) MAXz is: 0.419

Room (3) MAXz is: 0.55

Room (1) MAXz is: 0.638

Room (2) MAXz is: 0.377

Room (2) MAXz is: 0.844

Room (3) MAXz is: 0.323

Room (1) MAXz is: 0.429

Room (3) MAXz is: 0.917

Room (1) MAXz is: 0.729

Room (2) MAXz is: 0.406

Room (2) MAXz is: 1.215

Room (3) MAXz is: 0.696

Room (1) MAXz is: 0.227

Room (1) MAXz is: 0.65

Room (3) MAXz is: 0.513

Room (1) MAXz is: 0.977

Room (2) MAXz is: 1.115

Room (3) MAXz is: 1.046

Room (1) MAXz is: 0.49

Room (1) MAXz is: 0.333

Room (2) MAXz is: 0.233

Room (3) MAXz is: 0.375

Room (1) MAXz is: 0.602

Room (2) MAXz is: 0.413

Room (2) MAXz is: 1.204

Room (3) MAXz is: 1.096

Room (1) MAXz is: 0.806

Room (3) MAXz is: 0.954

Room (1) MAXz is: 0.369

Room (2) MAXz is: 0.481

Room (1) MAXz is: 0.252

Room (1) MAXz is: 1.052

Room (2) MAXz is: 1.008

Room (3) MAXz is: 1.015

Room (1) MAXz is: 0.556

Room (2) MAXz is: 0.675

Room (3) MAXz is: 0.779

Room (1) MAXz is: 1.027

Room (2) MAXz is: 0.788

Room (3) MAXz is: 0.427

Room (3) MAXz is: 0.431

Room (1) MAXz is: 0.59

Room (2) MAXz is: 0.798

Room (3) MAXz is: 0.569

Room (1) MAXz is: 0.752

Room (2) MAXz is: 0.65

Room (3) MAXz is: 0.798

Room (1) MAXz is: 0.275

Room (2) MAXz is: 0.771

Room (1) MAXz is: 0.431

Room (3) MAXz is: 1.188

Room (1) MAXz is: 1.156

Room (2) MAXz is: 1.217

Room (3) MAXz is: 1.065

Room (1) MAXz is: 0.633

Room (2) MAXz is: 1.029

Room (1) MAXz is: 1.213

Room (2) MAXz is: 0.483

Room (3) MAXz is: 0.398

Room (3) MAXz is: 0.919

Room (1) MAXz is: 0.242

Room (2) MAXz is: 0.563

Room (1) MAXz is: 0.917

Room (2) MAXz is: 0.333

Room (2) MAXz is: 0.333

Room (2) MAXz is: 0.515

Room (3) MAXz is: 0.623

Room (3) MAXz is: 0.783

Room (1) MAXz is: 0.535

Room (2) MAXz is: 0.519

Room (1) MAXz is: 1.031

Room (2) MAXz is: 0.533

Room (2) MAXz is: 0.6

Room (3) MAXz is: 0.625

Room (3) MAXz is: 1.065

Room (1) MAXz is: 0.633

Room (2) MAXz is: 0.948

Room (1) MAXz is: 0.883

Room (2) MAXz is: 0.631

Room (3) MAXz is: 1.175

Room (1) MAXz is: 0.869          Room (2) MAXz is: 0.923

Room (2) MAXz is: 0.74           Room (3) MAXz is: 0.723

Room (3) MAXz is: 0.48           Room (1) MAXz is: 0.631

Room (3) MAXz is: 0.806          Room (3) MAXz is: 1.169

Room (1) MAXz is: 0.973          Room (1) MAXz is: 1.08

Room (2) MAXz is: 0.681          Room (2) MAXz is: 0.815

Room (3) MAXz is: 1.129          Room (2) MAXz is: 0.756

Room (1) MAXz is: 0.506          Room (3) MAXz is: 0.84

Room (2) MAXz is: 0.892          Room (1) MAXz is: 0.313

Room (1) MAXz is: 1.115          Room (1) MAXz is: 0.408

Room (2) MAXz is: 0.506          Room (2) MAXz is: 0.508

Room (2) MAXz is: 0.592          Room (3) MAXz is: 0.44

Room (3) MAXz is: 0.38           Room (3) MAXz is: 0.77

Room (3) MAXz is: 0.519          Room (1) MAXz is: 0.644

Room (3) MAXz is: 1.208          Room (2) MAXz is: 0.773

Room (1) MAXz is: 0.985          Room (3) MAXz is: 0.783

Room (2) MAXz is: 0.804          Room (1) MAXz is: 1.004

Room (1) MAXz is: 0.829          Room (2) MAXz is: 0.67

Room (2) MAXz is: 0.492          Room (2) MAXz is: 0.629

Room (2) MAXz is: 0.731          Room (3) MAXz is: 0.83

Room (3) MAXz is: 1.017          Room (3) MAXz is: 0.535

Room (1) MAXz is: 1.081          Room (1) MAXz is: 0.827

Room (2) MAXz is: 0.317          Room (2) MAXz is: 0.742

Room (2) MAXz is: 0.767          Room (3) MAXz is: 0.821

Room (3) MAXz is: 0.64           Room (1) MAXz is: 0.554

Room (3) MAXz is: 0.298          Room (2) MAXz is: 1.133

Room (1) MAXz is: 0.675          Room (3) MAXz is: 0.994

Room (1) MAXz is: 0.8

Room (2) MAXz is: 0.656

Room (3) MAXz is: 0.956

Room (1) MAXz is: 0.88

Room (1) MAXz is: 0.83

Room (2) MAXz is: 0.67

Room (1) MAXz is: 0.983

Room (2) MAXz is: 1.175

Room (3) MAXz is: 0.69

Room (3) MAXz is: 0.908

Room (1) MAXz is: 1.015

Room (2) MAXz is: 0.6

Room (2) MAXz is: 1.019

Room (3) MAXz is: 0.708

Room (1) MAXz is: 0.431

Room (3) MAXz is: 0.827

Room (1) MAXz is: 1.133

Room (2) MAXz is: 1.169

Room (3) MAXz is: 0.877

Room (1) MAXz is: 0.38

Room (1) MAXz is: 0.885

Room (2) MAXz is: 1.19

Room (3) MAXz is: 0.233

Room (3) MAXz is: 1.177

Room (1) MAXz is: 0.298

Room (1) MAXz is: 0.517

Room (1) MAXz is: 0.473

Room (2) MAXz is: 0.806

Room (1) MAXz is: 1.031

Room (2) MAXz is: 0.65

Room (2) MAXz is: 0.279

Room (3) MAXz is: 0.788

Room (3) MAXz is: 0.54

Room (1) MAXz is: 0.635

Room (2) MAXz is: 0.733

Room (3) MAXz is: 0.958

Room (1) MAXz is: 0.675

Room (2) MAXz is: 0.546

Room (1) MAXz is: 0.98

Room (2) MAXz is: 0.633

Room (3) MAXz is: 0.798

Room (1) MAXz is: 0.988

Room (2) MAXz is: 0.894

Room (3) MAXz is: 0.875

Room (1) MAXz is: 1.031

Room (2) MAXz is: 0.642

Room (2) MAXz is: 1.021

Room (3) MAXz is: 0.946

Room (1) MAXz is: 0.917

Room (2) MAXz is: 0.954

Room (3) MAXz is: 1.047

Room (3) MAXz is: 0.998

Room (1) MAXz is: 1.094

Room (1) MAXz is: 1.175

Room (2) MAXz is: 1.044

Room (3) MAXz is: 0.444

The Average of MAXz for day (5) is: 0.902

The Execution Time is: (1753) ms

############################################################

The elapset time for day (1) is: 453 sec

The elapset time for day (2) is: 952 sec

The elapset time for day (3) is: 1172 sec

The elapset time for day (4) is: 2036 sec

The elapset time for day (5) is: 1753 sec

The Total elapset time is: 6366 sec

# APPENDIX 2

## MILP RESULTS FOR ELECTIVE SURGERY

## WEEK NUMBER 1

Hussien Ali System (MILP)

####################################################

This Result Has been Registered on:12/28/2017    6:50:07 AM


Day #1

##########################

Room (1) MAXz is: 0.875

Room (2) MAXz is: 0.813

Room (3) MAXz is: 0.917

Room (3) MAXz is: 0.938

Room (1) MAXz is: 0.853

Room (2) MAXz is: 0.917

The Average of MAXz for day (1) is: 0.877

The Execution Time is: (160) sec

###############################

Day #2

################################

Room (1) MAXz is: 0.868

Room (2) MAXz is: 0.826

Room (3) MAXz is: 0.785

Room (2) MAXz is: 0.848

Room (3) MAXz is: 0.795

Room (1) MAXz is: 0.879

The Average of MAXz for day (2) is: 0.825

The Execution Time is: (359) sec

###################################

Day #3

#####################

Room (1) MAXz is: 0.758

Room (2) MAXz is: 0.65

Room (3) MAXz is: 0.695

Room (2) MAXz is: 0.8

Room (3) MAXz is: 0.706

Room (1) MAXz is: 0.738

The Average of MAXz for day (3) is: 0.723

The Execution Time is: (843) sec

#####################

Day #4

######################

Room (1) MAXz is: 0.658

Room (2) MAXz is: 0.658

Room (3) MAXz is: 0.606

Room (3) MAXz is: 0.658

Room (1) MAXz is: 0.648

Room (2) MAXz is: 0.627

The Average of MAXz for day (4) is: 0.639

The Execution Time is: (219) sec

######################

Day #5

######################

Room (1) MAXz is: 0.617

Room (2) MAXz is: 0.608

Room (3) MAXz is: 0.586

Room (3) MAXz is: 0.627

Room (1) MAXz is: 0.59

Room (2) MAXz is: 0.638

The Average of MAXz for day (5) is: 0.61

The Execution Time is: (452) sec

##########################

**WEEK NUMBER 2**

Hussien Ali System (MILP)

################################

This Result Has been Registered on:12/28/2017    6:54:07 AM

##############################################################################

#####

Day #1

##############################

Room (1) MAXz is: 0.917

Room (2) MAXz is: 0.896

Room (3) MAXz is: 0.905

Room (2) MAXz is: 0.938

Room (3) MAXz is: 0.979

Room (1) MAXz is: 1.063

The Average of MAXz for day (1) is: 0.925

The Execution Time is: (582) sec

##############################

Day #2

##########################

Room (1) MAXz is: 0.952

Room (2) MAXz is: 0.829

Room (3) MAXz is: 0.848

16

Room (2) MAXz is: 0.806

Room (3) MAXz is: 0.775

Room (1) MAXz is: 0.848

The Average of MAXz for day (2) is: 0.841

The Execution Time is: (145) sec

##############################

Day #3

##############################

Room (1) MAXz is: 0.758

Room (2) MAXz is: 0.779

Room (3) MAXz is: 0.748

Room (3) MAXz is: 0.717

Room (1) MAXz is: 0.768

Room (2) MAXz is: 0.696

The Average of MAXz for day (3) is: 0.753

The Execution Time is: (629) sec

##############################

Day #4

##############################

Room (1) MAXz is: 0.533

Room (2) MAXz is: 0.595

Room (3) MAXz is: 0.69

Room (1) MAXz is: 0.565

Room (2) MAXz is: 0.596

Room (3) MAXz is: 0.648

The Average of MAXz for day (4) is: 0.61

The Execution Time is: (254) sec

##############################

Day #5

##############################

Room (1) MAXz is: 0.558

Room (2) MAXz is: 0.6

Room (3) MAXz is: 0.516

Room (3) MAXz is: 0.506

Room (1) MAXz is: 0.558

Room (2) MAXz is: 0.579

The Average of MAXz for day (5) is: 0.548

The Execution Time is: (580) sec

#########################

**WEEK NUMBER 3**

Hussien Ali System (MILP)

#############################

This Result Has been Registered on:12/28/2017     6:59:07 AM

##################################################################################

Day #1

########################

Room (1) MAXz is: 0.906

Room (2) MAXz is: 0.938

Room (3) MAXz is: 0.948

Room (1) MAXz is: 1

Room (3) MAXz is: 0.917

Room (2) MAXz is: 0.927

The Average of MAXz for day (1) is: 0.938

The Execution Time is: (687) sec

######################

Day #2

#########################

Room (1) MAXz is: 0.838

Room (2) MAXz is: 0.91

Room (3) MAXz is: 0.817

Room (3) MAXz is: 0.838

Room (1) MAXz is: 0.858

Room (2) MAXz is: 0.796

The Average of MAXz for day (2) is: 0.841

The Execution Time is: (250) sec

#########################

Day #3

###########################

Room (1) MAXz is: 0.706

Room (2) MAXz is: 0.738

Room (3) MAXz is: 0.79

Room (1) MAXz is: 0.748

Room (2) MAXz is: 0.738

Room (3) MAXz is: 0.706

The Average of MAXz for day (3) is: 0.738

The Execution Time is: (875) sec

#############################

Day #4

#############################

Room (1) MAXz is: 0.7

Room (2) MAXz is: 0.648

Room (3) MAXz is: 0.596

Room (2) MAXz is: 0.616

Room (3) MAXz is: 0.648

Room (1) MAXz is: 0.658

The Average of MAXz for day (4) is: 0.643

The Execution Time is: (531) sec

##########################

Day #5

##########################

Room (1) MAXz is: 0.61

Room (2) MAXz is: 0.538

Room (3) MAXz is: 0.548

Room (2) MAXz is: 0.527

Room (3) MAXz is: 0.485

Room (1) MAXz is: 0.569

The Average of MAXz for day (5) is: 0.541

The Execution Time is: (141) sec

##########################

**WEEK NUMBER 4**

Hussien Ali System (MILP)

#########################

This Result Has been Registered on:12/28/2017   7:10:07 AM

################################################################################

Day #1

#########################

Room (1) MAXz is: 0.968

Room (2) MAXz is: 0.948

Room (3) MAXz is: 0.939

Room (1) MAXz is: 0.98

Room (2) MAXz is: 0.906

Room (3) MAXz is: 1.01

The Average of MAXz for day (1) is: 0.956

The Execution Time is: (515) sec

##########################

Day #2

###########################

Room (1) MAXz is: 0.775

Room (2) MAXz is: 0.865

Room (3) MAXz is: 0.848

Room (2) MAXz is: 0.838

Room (1) MAXz is: 0.89

Room (3) MAXz is: 0.826

The Average of MAXz for day (2) is: 0.84

The Execution Time is: (110) sec

#############################

Day #3

##########################

Room (1) MAXz is: 0.717

Room (2) MAXz is: 0.748

Room (3) MAXz is: 0.738

Room (1) MAXz is: 0.696

Room (2) MAXz is: 0.737

Room (3) MAXz is: 0.78

The Average of MAXz for day (3) is: 0.727

The Execution Time is: (265) sec

###################################

Day #4

###################################

Room (1) MAXz is: 0.595

Room (2) MAXz is: 0.617

Room (3) MAXz is: 0.596

Room (1) MAXz is: 0.606

Room (2) MAXz is: 0.7

Room (3) MAXz is: 0.648

The Average of MAXz for day (4) is: 0.625

The Execution Time is: (578) sec

###########################

Day #5

###########################

Room (1) MAXz is: 0.505

Room (2) MAXz is: 0.496

Room (3) MAXz is: 0.58

Room (1) MAXz is: 0.538

Room (2) MAXz is: 0.516

Room (3) MAXz is: 0.558

The Average of MAXz for day (5) is: 0.522

The Execution Time is: (204) sec

###########################

# APPENDIX 3

**MILP RESULTS FOR WAR RELATED INCIDENTS**

**Week number 1**

Hussien Ali System (MILP)

####################################################

This Result Has been Registered on:1/30/2018    4:22:07 PM

############################################################################

Day #1

###########################

Room (1) MAXz is: 0.987

Room (2) MAXz is: 0.983

Room (3) MAXz is: 1.01

Room (2) MAXz is: .985

Room (1) MAXz is: .983

Room (3) MAXz is: 1097

The Average of MAXz for day (1) is: 1.00

The Execution Time is: (160) sec

##############################

Day #2

##############################

Room (1) MAXz i: 0.958

Room (2) MAXz s: 0.906

Room (3) MAXzis: 0.95

Room (2) MAX is: 0.986

Room (3) MAz is: 0.875

Room (1) MAXz is: 1.05

The Average of MAXz for day (2) is: 0.95

The Execution Time is: (359) sec

##############################

Day #3

##############################

Room (1) MAXz is: 0.758

Room (2) MAXz is: 0.96

Room (3) MAXz is: 0.875

Room (2) MAXz is: 0.98

Room (3) MAXz is: 0.86

Room (1) MAXz is: 0.83

The Average of MAXz for day (3) is: 0.882

The Execution Time is: (843) sec

##############################

Day #4

##############################

Room (1) MAXz is: 0.758

Room (2) MAXz is: 0.758

Room (3) MAXz is: 0.706

Room (3) MAXz is: 0.68

Room (1) MAXz is: 0.748

Room (2) MAXz is: 0.827

The Average of MAXz for day (4) is: 0.75

The Execution Time is: (219) sec

##############################

Day #5

##############################

Room (1) MAXz is: 0.617

Room (2) MAXz is: 0.638

Room (3) MAXz is: 0.606

Room (3) MAXz is: 0.627

Room (1) MAXz is: 0.658

Room (2) MAXz is: 0.628

The Average of MAXz for day (5) is: 0.631

The Execution Time is: (452) sec

################################

**Week number 2**

Hussien Ali System (MILP)

###################################################

This Result Has been Registered on:1/30/2018    4:26:14 PM

#############################################################################

Day #1

#####################################################

Room (1) MAXz is: 1.065

Room (2) MAXz is: 1.023

Room (3) MAXz is: 1.027

Room (3) MAXz is: 1.15

Room (1) MAXz is: 1.153

Room (2) MAXz is: 1.07

The Average of MAXz for day (1) is: 1.067

The Execution Time is: (582) sec

#############################

Day #2

##############################

Room (1) MAXz is: 1.09

Room (2) MAXz is: 0.93

Room (3) MAXz is: 0.891

Room (2) MAXz is: 0.848

Room (3) MAXz is: 0.93

Room (1) MAXz is: 0.98

The Average of MAXz for day (2) is: 0.97

The Execution Time is: (145) sec

#############################

Day #3

#############################

Room (1) MAXz is: 0.87

Room (2) MAXz is: 0.90

Room (3) MAXz is: 0.86

Room (2) MAXz is: 0.812

Room (3) MAXz is: 0.826

Room (1) MAXz is: 0.832

The Average of MAXz for day (3) is: 0.86

The Execution Time is: (629) sec

#############################

Day #4

#############################

Room (1) MAXz is: 0.612

Room (2) MAXz is: 0.68

Room (3) MAXz is: 0.806

Room (3) MAXz is: 0.74

Room (1) MAXz is: 0.658

Room (2) MAXz is: 0.687

The Average of MAXz for day (4) is: 0.70

The Execution Time is: (254) sec

#############################

Day #5

#############################

Room (1) MAXz is: 0.651

Room (2) MAXz is: 0.69

Room (3) MAXz is: 0.576

Room (3) MAXz is: 0.592

Room (1) MAXz is: 0.628

Room (2) MAXz is: 0.668

The Average of MAXz for day (5) is: 0.63

The Execution Time is: (580) sec

##############################

**Week number 3**

Hussien Ali System (MILP)

############################

This Result Has been Registered on:1/30/2018    4:38:27 PM

######################################################################

Day #1

######################

Room (1) MAXz is: 1.05

Room (2) MAXz is: 1.081

Room (3) MAXz is: 1.09

Room (2) MAXz is: 1.06

Room (1) MAXz is: 1.15

Room (3) MAXz is: 1.057

The Average of MAXz for day (1) is: 1.08

The Execution Time is: (687) sec

############################

Day #2

############################

Room (1) MAXz is: 0.968

Room (2) MAXz is: 1.046

Room (3) MAXz is: 0.94

Room (2) MAXz is: 0.916

Room (3) MAXz is: 0.972

Room (1) MAXz is: 0.98

The Average of MAXz for day (2) is: 0.97

The Execution Time is: (250) sec

################################

Day #3

################################

Room (1) MAXz is: 0.82

Room (2) MAXz is: 0.846

Room (3) MAXz is: 0.905

Room (2) MAXz is: 0.85

Room (3) MAXz is: 0.82

Room (1) MAXz is: 0.863

The Average of MAXz for day (3) is: 0.852

The Execution Time is: (875) sec

##############################

Day #4

##############################

Room (1) MAXz is: 0.81

Room (2) MAXz is: 0.754

Room (3) MAXz is: 0.69

Room (3) MAXz is: 0.75

Room (1) MAXz is: 0.76

Room (2) MAXz is: 0.687

The Average of MAXz for day (4) is: 0.74

The Execution Time is: (531) sec

###############################

Day #5

###############################

Room (1) MAXz is: 0.701

Room (2) MAXz is: 0.618

Room (3) MAXz is: 0.626

Room (3) MAXz is: 0.547

Room (1) MAXz is: 0.658

Room (2) MAXz is: 0.60

The Average of MAXz for day (5) is: 0.621

The Execution Time is: (141) sec

###############################

**Week number 4**

Hussien Ali System (MILP)

####################################################

This Result Has been Registered on:1/30/2018    4:46:35 PM

##############################################################################

Day #1

###########################

Room (1) MAXz is: 1.08

Room (2) MAXz is: 1.091

Room (3) MAXz is: 1.13

Room (2) MAXz is: 1.05

Room (1) MAXz is: 1.15

Room (3) MAXz is: 1.15

The Average of MAXz for day (1) is: 1.08

The Execution Time is: (515) sec

##############################

Day #2

#############################

Room (1) MAXz is: 0.868

Room (2) MAXz is: 0.886

Room (3) MAXz is: 0.98

Room (2) MAXz is: 0.956

Room (3) MAXz is: 0.927

Room (1) MAXz is: 1.04

The Average of MAXz for day (2) is: 0.97

The Execution Time is: (110) sec

Day #3

###########################

Room (1) MAXz is: 0.83

Room (2) MAXz is: 0.86

Room (3) MAXz is: 0.855

Room (2) MAXz is: 0.83

Room (3) MAXz is: 0.69

Room (1) MAXz is: 0.813

The Average of MAXz for day (3) is: 0.84

The Execution Time is: (265) sec

#############################

Day #4

#############################

Room (1) MAXz is: 0.68

Room (2) MAXz is: 0.714

Room (3) MAXz is: 0.69

Room (3) MAXz is: 0.75

Room (1) MAXz is: 0.70

Room (2) MAXz is: 0.807

The Average of MAXz for day (4) is: 0.724

The Execution Time is: (578) sec

############################

Day #5

##############################

Room (1) MAXz is: 0.561

Room (2) MAXz is: 0.85

Room (3) MAXz is: 0.626

Room (3) MAXz is: 0.642

Room (1) MAXz is: 0.618

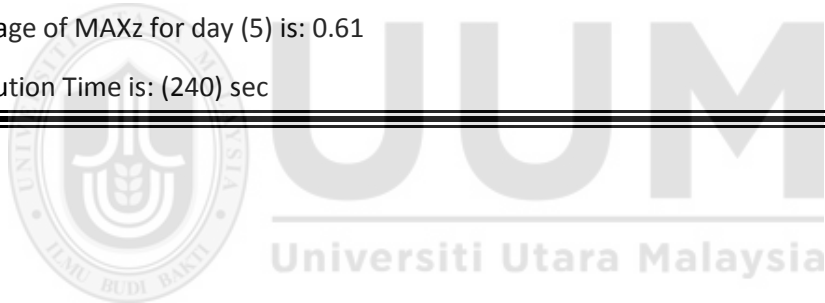Room (2) MAXz is: 0.59

The Average of MAXz for day (5) is: 0.61

The Execution Time is: (240) sec

# APPENDIX 4

**TABU SEARCH RESULTS FOR ELECTIVE SURGERY**

**Week number 1**

Hussien Ali System (TS)

####################################################

Room (1) MAXz is: 0.858

Room (2) MAXz is: 0.875

Room (3) MAXz is: 0.813

Next surgery will start at: 11:00:00, In Room: 1

Room (1) MAXz is: 0.81

Next surgery will start at: 10:30:00, In Room: 2

Room (2) MAXz is: 0.948

Next surgery will start at: 11:40:00, In Room: 0

Room (0) MAXz is: 0.906

Room (1) MAXz is: 0.952

Room (2) MAXz is: 0.858

Room (3) MAXz is: 0.806

Next surgery will start at: 11:40:00, In Room: 1

Room (1) MAXz is: 0.931

Next surgery will start at: 11:15:00, In Room: 2

Room (2) MAXz is: 0.733

Next surgery will start at: 12:25:00, In Room: 0

Room (0) MAXz is: 0.817

Room (1) MAXz is: 0.685

Room (2) MAXz is: 0.863

Room (3) MAXz is: 0.748

Next surgery will start at: 11:05:00, In Room: 0

Room (0) MAXz is: 0.675

Next surgery will start at: 12:30:00, In Room: 1

Room (1) MAXz is: 0.831

Next surgery will start at: 11:35:00, In Room: 2

Room (2) MAXz is: 0.758

Room (1) MAXz is: 0.596

Room (2) MAXz is: 0.658

Room (3) MAXz is: 0.606

Next surgery will start at: 11:10:00, In Room: 0

Room (0) MAXz is: 0.71

Next surgery will start at: 11:40:00, In Room: 1

Room (1) MAXz is: 0.69

Next surgery will start at: 11:15:00, In Room: 2

Room (2) MAXz is: 0.627

Room (1) MAXz is: 0.517

Room (2) MAXz is: 0.548

Room (3) MAXz is: 0.506

Next surgery will start at: 11:15:00, In Room: 2

Room (2) MAXz is: 0.558

Next surgery will start at: 11:20:00, In Room: 0

Room (0) MAXz is: 0.6

Next surgery will start at: 11:35:00, In Room: 1

Room (1) MAXz is: 0.538

The Average of MAXz for day (1) is: 0.88

The Execution Time is: (66) sec

The Best Solution is: (0.813)

The Average of MAXz for day (2) is: 0.83

The Execution Time is: (52) sec

The Best Solution is: (0.733)

The Average of MAXz for day (3) is: 0.72

The Execution Time is: (24) sec

The Best Solution is: (0.675)

The Average of MAXz for day (4) is: 0.648

The Execution Time is: (31) sec

The Best Solution is: (0.596)

The Average of MAXz for day (5) is: 0.61

The Execution Time is: (26) sec

The Best Solution is: (0.506)
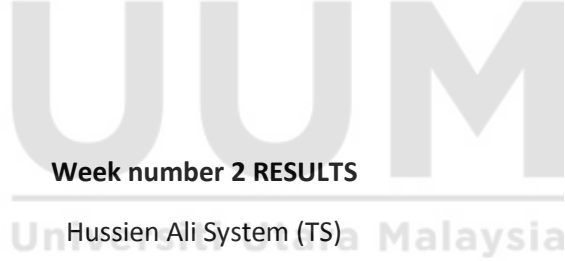
**Week number 2 RESULTS**

Hussien Ali System (TS)

####################################################

Room (1) MAXz is: 0.917

Room (2) MAXz is: 0.896

Room (3) MAXz is: 0.875

Next surgery will start at: 11:10:00, In Room: 1

Room (1) MAXz is: 0.938

Next surgery will start at: 11:00:00, In Room: 2

Room (2) MAXz is: 0.979

Next surgery will start at: 11:20:00, In Room: 0

Room (0) MAXz is: 1.063

Room (1) MAXz is: 0.952

Room (2) MAXz is: 0.879

Room (3) MAXz is: 0.848

Next surgery will start at: 11:50:00, In Room: 1

Room (1) MAXz is: 0.806

Next surgery will start at: 11:35:00, In Room: 2

Room (2) MAXz is: 0.775

Next surgery will start at: 12:25:00, In Room: 0

Room (0) MAXz is: 0.848

Room (1) MAXz is: 0.758

Room (2) MAXz is: 0.779

Room (3) MAXz is: 0.748

Next surgery will start at: 11:35:00, In Room: 2

Room (2) MAXz is: 0.717

Next surgery will start at: 11:40:00, In Room: 0

Room (0) MAXz is: 0.758

Next surgery will start at: 11:50:00, In Room: 1

Room (1) MAXz is: 0.696

Room (1) MAXz is: 0.533

Room (2) MAXz is: 0.585

Room (3) MAXz is: 0.69

Next surgery will start at: 10:40:00, In Room: 0

Room (0) MAXz is: 0.565

Next surgery will start at: 11:05:00, In Room: 1

Room (1) MAXz is: 0.596

Next surgery will start at: 11:55:00, In Room: 2

Room (2) MAXz is: 0.638

Room (1) MAXz is: 0.558

Room (2) MAXz is: 0.6

Room (3) MAXz is: 0.496

Next surgery will start at: 11:10:00, In Room: 2

Room (2) MAXz is: 0.506

Next surgery will start at: 11:40:00, In Room: 0

Room (0) MAXz is: 0.548

Next surgery will start at: 12:00:00, In Room: 1

Room (1) MAXz is: 0.579

The Average of MAXz for day (1) is: 0.932

The Execution Time is: (34) sec

The Best Solution is: (0.854)

The Average of MAXz for day (2) is: 0.841

The Execution Time is: (30) sec

The Best Solution is: (0.77)

The Average of MAXz for day (3) is: 0.747

The Execution Time is: (26) sec

The Best Solution is: (0.606)

The Average of MAXz for day (4) is: 0.61

The Execution Time is: (28) sec

The Best Solution is: (0.538)

The Average of MAXz for day (5) is: 0.548

The Execution Time is: (22) sec

The Best Solution is: (0.53)

Hussien Ali System (TS)

####################################################

Room (1) MAXz is: 0.906

Room (2) MAXz is: 0.938

Room (3) MAXz is: 0.948

Next surgery will start at: 11:15:00, In Room: 0

Room (0) MAXz is: 1

Next surgery will start at: 11:30:00, In Room: 1

Room (1) MAXz is: 0.917

Next surgery will start at: 14:50:00, In Room: 1

Room (1) MAXz is: 0.917

Room (1) MAXz is: 0.838

Room (2) MAXz is: 0.91

Room (3) MAXz is: 0.817

Next surgery will start at: 11:20:00, In Room: 2

Room (2) MAXz is: 0.838

Next surgery will start at: 11:30:00, In Room: 0

Room (0) MAXz is: 0.848

Next surgery will start at: 12:05:00, In Room: 1

Room (1) MAXz is: 0.796

Room (1) MAXz is: 0.706

Room (2) MAXz is: 0.738

Room (3) MAXz is: 0.79

Next surgery will start at: 11:15:00, In Room: 0

Room (0) MAXz is: 0.748

Next surgery will start at: 11:30:00, In Room: 1

Room (1) MAXz is: 0.738

Next surgery will start at: 11:55:00, In Room: 2

Room (2) MAXz is: 0.706

Room (1) MAXz is: 0.7

Room (2) MAXz is: 0.648

Room (3) MAXz is: 0.596

Next surgery will start at: 11:35:00, In Room: 1

Room (1) MAXz is: 0.606

Next surgery will start at: 11:10:00, In Room: 2

Room (2) MAXz is: 0.648

Next surgery will start at: 12:00:00, In Room: 0

Room (0) MAXz is: 0.658

Room (1) MAXz is: 0.61

Room (2) MAXz is: 0.538

Room (3) MAXz is: 0.548

Next surgery will start at: 11:30:00, In Room: 1

Room (1) MAXz is: 0.517

Next surgery will start at: 11:35:00, In Room: 2

Room (2) MAXz is: 0.465

Next surgery will start at: 12:05:00, In Room: 0
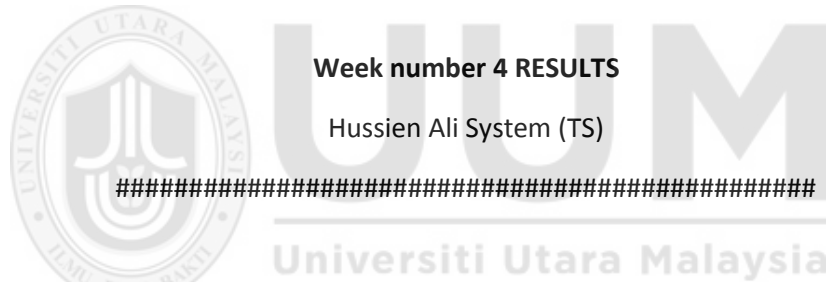
Room (0) MAXz is: 0.569

The Average of MAXz for day (1) is: 0.938

The Execution Time is: (44) sec

The Best Solution is: (0.906)

The Average of MAXz for day (2) is: 0.841

The Execution Time is: (30) sec

The Best Solution is: (0.796)

The Average of MAXz for day (3) is: 0.738

The Execution Time is: (22) sec

The Best Solution is: (0.706)

The Average of MAXz for day (4) is: 0.643

The Execution Time is: (34) sec

The Best Solution is: (0.596)

The Average of MAXz for day (5) is: 0.541

The Execution Time is: (42) sec

The Best Solution is: (0.517)

**Week number 4 RESULTS**

Hussien Ali System (TS)

####################################################

Room (1) MAXz is: 0.938

Room (2) MAXz is: 0.948

Room (3) MAXz is: 0.979

Next surgery will start at: 11:30:00, In Room: 0

Room (0) MAXz is: 0.938


Next surgery will start at: 11:35:00, In Room: 1

Room (1) MAXz is: 0.906

Next surgery will start at: 14:50:00, In Room: 1

Room (1) MAXz is: 1.01

Room (1) MAXz is: 0.775

Room (2) MAXz is: 0.765

Room (3) MAXz is: 0.848

Next surgery will start at: 10:55:00, In Room: 1

Room (1) MAXz is: 0.838

Next surgery will start at: 11:00:00, In Room: 0

Room (0) MAXz is: 0.89

Next surgery will start at: 14:25:00, In Room: 1

Room (1) MAXz is: 0.806

Room (1) MAXz is: 0.717

Room (2) MAXz is: 0.748

Room (3) MAXz is: 0.738

Next surgery will start at: 11:20:00, In Room: 0

Room (0) MAXz is: 0.696

Next surgery will start at: 11:35:00, In Room: 1

Room (1) MAXz is: 0.717

Next surgery will start at: 11:30:00, In Room: 2

Room (2) MAXz is: 0.748

Room (1) MAXz is: 0.585

Room (2) MAXz is: 0.617

Room (3) MAXz is: 0.596

Next surgery will start at: 11:05:00, In Room: 0

Room (0) MAXz is: 0.606

Next surgery will start at: 11:20:00, In Room: 1

Room (1) MAXz is: 0.7

Next surgery will start at: 11:10:00, In Room: 2

Room (2) MAXz is: 0.648

Room (1) MAXz is: 0.485

Room (2) MAXz is: 0.496

Room (3) MAXz is: 0.548

Next surgery will start at: 11:05:00, In Room: 0

Room (0) MAXz is: 0.538

Next surgery will start at: 11:10:00, In Room: 1

Room (1) MAXz is: 0.506

Next surgery will start at: 14:25:00, In Room: 1

Room (1) MAXz is: 0.558

The Average of MAXz for day (1) is: 0.957

The Execution Time is: (36) sec

The Best Solution is: (0.906)

The Average of MAXz for day (2) is: 0.84

The Execution Time is: (34) sec

The Best Solution is: (0.765)

The Average of MAXz for day (3) is: 0.727

The Execution Time is: (21) sec

The Best Solution is: (0.696)

The Average of MAXz for day (4) is: 0.625

The Execution Time is: (35) sec

The Best Solution is: (0.585)

The Average of MAXz for day (5) is: 0.522

The Execution Time is: (40) sec

The Best Solution is: (0.506)

# APPENDIX 5

**TABU SEARCH RESULTS FOR WAR-RELATED INCIDENTS**

**Week number 1**

Hussien Ali System (TS)

####################################################

Room (1) MAXz is: 1.006

Room (2) MAXz is: 0.934

Room (3) MAXz is: 1.054

Next surgery will start at: 10:30:00, In Room: 1

Room (1) MAXz is: 0.985

Next surgery will start at: 11:00:00, In Room: 0

Room (0) MAXz is: 0.983

Next surgery will start at: 13:35:00, In Room: 2

Room (1) MAXz is: 0.97

Room (1) MAXz is: 0.987

Room (2) MAXz is: 0.927

Room (3) MAXz is: 0.903

Next surgery will start at: 11:15:00, In Room: 1

Room (1) MAXz is: 0.848

Next surgery will start at: 11:05:00, In Room: 2

Room (2) MAXz is: 0.875

Next surgery will start at: 11:40:00, In Room: 0

Room (0) MAXz is: 0.939

Room (1) MAXz is: 0.872

Room (2) MAXz is: 0.8

Room (3) MAXz is: 0.764

Next surgery will start at: 11:10:00, In Room: 1

Room (1) MAXz is: 0.8

Next surgery will start at: 10:55:00, In Room: 2

Room (2) MAXz is: 0.706

Next surgery will start at: 11:40:00, In Room: 0

Room (0) MAXz is: 0.738

Room (1) MAXz is: 0.757

Room (2) MAXz is: 0.757

Room (3) MAXz is: 0.697

Next surgery will start at: 11:40:00, In Room: 1

Room (1) MAXz is: 0.638

Next surgery will start at: 11:15:00, In Room: 2

Room (2) MAXz is: 0.648

Next surgery will start at: 11:40:00, In Room: 0

Room (0) MAXz is: 0.627

Room (1) MAXz is: 0.694

Room (2) MAXz is: 0.63

Room (3) MAXz is: 0.582

Next surgery will start at: 11:15:00, In Room: 2

Room (2) MAXz is: 0.627

Next surgery will start at: 11:20:00, In Room: 0
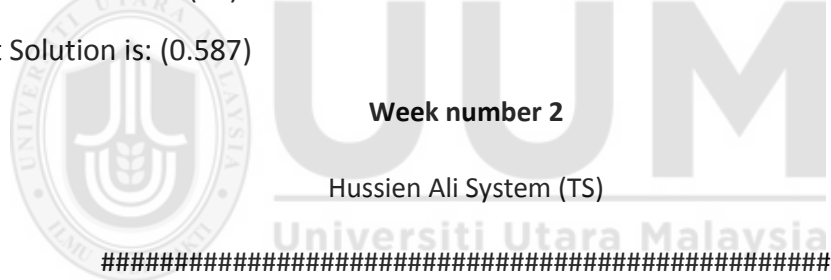
Room (0) MAXz is: 0.648

Next surgery will start at: 11:35:00, In Room: 1

Room (1) MAXz is: 0.58


The Average of MAXz for day (1) is: 1.00

The Execution Time is: (94) sec

The Best Solution is: (0.933)

The Average of MAXz for day (2) is: 0.947

The Execution Time is: (55) sec

The Best Solution is: (0.892)

The Average of MAXz for day (3) is: 0.877

The Execution Time is: (24) sec

The Best Solution is: (0.77)

The Average of MAXz for day (4) is: 0.748

The Execution Time is: (10) sec

The Best Solution is: (0.707)

The Average of MAXz for day (5) is: 0.632

The Execution Time is: (10) sec

The Best Solution is: (0.587)

**Week number 2**

Hussien Ali System (TS)

###################################################

Room (1) MAXz is: 1.09

Room (2) MAXz is: 1.04

Room (3) MAXz is: 0.99

Next surgery will start at: 11:10:00, In Room: 1

Room (1) MAXz is: 1.09

Next surgery will start at: 11:00:00, In Room: 2

Room (2) MAXz is: 1.06

Next surgery will start at: 11:20:00, In Room: 0

Room (0) MAXz is: 1.04

Room (1) MAXz is: 0.93

Room (2) MAXz is: 0.96

Room (3) MAXz is: 0.99

Next surgery will start at: 11:15:00, In Room: 1

Room (1) MAXz is: 0.948

Next surgery will start at: 11:00:00, In Room: 2

Room (2) MAXz is: 0.943

Next surgery will start at: 11:50:00, In Room: 0

Room (0) MAXz is: 0.976

Room (1) MAXz is: 0.872

Room (2) MAXz is: 0.83

Room (3) MAXz is: 0.81

Next surgery will start at: 11:05:00, In Room: 1

Room (1) MAXz is: 0.878

Next surgery will start at: 10:55:00, In Room: 2

Room (2) MAXz is: 0.888

Next surgery will start at: 11:25:00, In Room: 0

Room (0) MAXz is: 0.869

Room (1) MAXz is: 0.78

Room (2) MAXz is: 0.747

Room (3) MAXz is: 0.615

Next surgery will start at: 11:20:00, In Room: 1

Room (1) MAXz is: 0.658

Next surgery will start at: 11:05:00, In Room: 2

Room (2) MAXz is: 0.696

Next surgery will start at: 11:35:00, In Room: 0

Room (0) MAXz is: 0.738

Room (1) MAXz is: 0.623

Room (2) MAXz is: 0.632

Room (3) MAXz is: 0.621

Next surgery will start at: 11:20:00, In Room: 1

Room (1) MAXz is: 0.648

Next surgery will start at: 11:15:00, In Room: 2

Room (2) MAXz is: 0.67

Next surgery will start at: 11:25:00, In Room: 0

Room (0) MAXz is: 0.627

The Average of MAXz for day (1) is: 1.07

The Execution Time is: (109) sec

The Best Solution is: (1.04)

The Average of MAXz for day (2) is: 0.972

The Execution Time is: (93) sec

The Best Solution is: (0.833)

The Average of MAXz for day (3) is: 0.864

The Execution Time is: (92) sec

The Best Solution is: (0.811)

The Average of MAXz for day (4) is: 0.70

The Execution Time is: (35) sec

The Best Solution is: (0.697)

The Average of MAXz for day (5) is: 0.632

The Execution Time is: (17) sec

The Best Solution is: (0.597)

**Week number 3**

Hussien Ali System (TS)

####################################################

Room (1) MAXz is: 0.981

Room (2) MAXz is: 1.083

Room (3) MAXz is: 1.093

Next surgery will start at: 11:15:00, In Room: 0

Room (0) MAXz is: 1

Next surgery will start at: 11:30:00, In Room: 1

Room (1) MAXz is: 1.097

Next surgery will start at: 14:50:00, In Room: 1

Room (1) MAXz is: 1.087

Room (1) MAXz is: 0.898

Room (2) MAXz is: 0.97

Room (3) MAXz is: 0.977

Next surgery will start at: 11:20:00, In Room: 2

Room (2) MAXz is: 0.938

Next surgery will start at: 11:30:00, In Room: 0

Room (0) MAXz is: 0.98

Next surgery will start at: 12:05:00, In Room: 1

Room (1) MAXz is: 0.996

Room (1) MAXz is: 0.851

Room (2) MAXz is: 0.783

Room (3) MAXz is: 0.835

Next surgery will start at: 11:15:00, In Room: 0

Room (0) MAXz is: 0.848

Next surgery will start at: 11:30:00, In Room: 1

Room (1) MAXz is: 0.87

Next surgery will start at: 11:55:00, In Room: 2

Room (2) MAXz is: 0.866

Room (1) MAXz is: 0.73

Room (2) MAXz is: 0.78

Room (3) MAXz is: 0.726

Next surgery will start at: 11:35:00, In Room: 1

Room (1) MAXz is: 0.696

Next surgery will start at: 11:10:00, In Room: 2

Room (2) MAXz is: 0.68

Next surgery will start at: 12:00:00, In Room: 0

Room (0) MAXz is: 0.758

Room (1) MAXz is: 0.625

Room (2) MAXz is: 0.553

Room (3) MAXz is: 0.63

Next surgery will start at: 11:30:00, In Room: 1

Room (1) MAXz is: 0.617

Next surgery will start at: 11:35:00, In Room: 2

Room (2) MAXz is: 0.565

Next surgery will start at: 12:05:00, In Room: 0

Room (0) MAXz is: 0.59

The Average of MAXz for day (1) is: 1.075

The Execution Time is: (94) sec

The Best Solution is: (1.052)

The Average of MAXz for day (2) is: 0.971

The Execution Time is: (78) sec

The Best Solution is: (0.916)

The Average of MAXz for day (3) is: 0.85

The Execution Time is: (109) sec

The Best Solution is: (0.806)

The Average of MAXz for day (4) is: 0.738

The Execution Time is: (86) sec

The Best Solution is: (0.706)

The Average of MAXz for day (5) is: 0.619

The Execution Time is: (34) sec

The Best Solution is: (0.60)

**Week number 4**

Hussien Ali System (TS)

##################################################

Room (1) MAXz is: 1.13

Room (2) MAXz is: 1.093

Room (3) MAXz is: 1.054

Next surgery will start at: 11:30:00, In Room: 0

Room (0) MAXz is: 1.098

Next surgery will start at: 11:35:00, In Room: 1

Room (1) MAXz is: 1.06

Next surgery will start at: 14:50:00, In Room: 1

Room (1) MAXz is: 1.101

Room (1) MAXz is: 0.935

Room (2) MAXz is: 0.925

Room (3) MAXz is: 0.998

Next surgery will start at: 10:55:00, In Room: 1

Room (1) MAXz is: 0.98

Next surgery will start at: 11:00:00, In Room: 0

Room (0) MAXz is: 0.93

Next surgery will start at: 14:25:00, In Room: 1

Room (1) MAXz is: 0.906

Room (1) MAXz is: 0.862

Room (2) MAXz is: 0.893

Room (3) MAXz is: 0.783

Next surgery will start at: 11:20:00, In Room: 0

Room (0) MAXz is: 0.86

Next surgery will start at: 11:35:00, In Room: 1

Room (1) MAXz is: 0.717

Next surgery will start at: 11:30:00, In Room: 2

Room (2) MAXz is: 0.848

Room (1) MAXz is: 0.715

Room (2) MAXz is: 0.747

Room (3) MAXz is: 0.726

Next surgery will start at: 11:05:00, In Room: 0

Room (0) MAXz is: 0.706

Next surgery will start at: 11:20:00, In Room: 1

Room (1) MAXz is: 0.7

Next surgery will start at: 11:10:00, In Room: 2

Room (2) MAXz is: 0.748

Room (1) MAXz is: 0.60

Room (2) MAXz is: 0.611

Room (3) MAXz is: 0.63

Next surgery will start at: 11:05:00, In Room: 0

Room (0) MAXz is: 0.618

Next surgery will start at: 11:10:00, In Room: 1

Room (1) MAXz is: 0.61

Next surgery will start at: 14:25:00, In Room: 1

Room (1) MAXz is: 0.58

############################################################

The Average of MAXz for day (1) is: 1.099

The Execution Time is: (93) sec

The Best Solution is: (1.05)

The Average of MAXz for day (2) is: 0.965

The Execution Time is: (86) sec

The Best Solution is: (0.934)

The Average of MAXz for day (3) is: 0.838

The Execution Time is: (109) sec

The Best Solution is: (0.806)

The Average of MAXz for day (4) is: 0.723

The Execution Time is: (37) sec

The Best Solution is: (0.701)

The Average of MAXz for day (5) is: 0.612

The Execution Time is: (48) sec

The Best Solution is: (0.594)