

Contents

Certificate	v
Acknowledgements	vii
Abstract	ix
List of Figures	xix
List of Tables	xxv
Abbreviations	xxvii
1 Introduction	1
1.1 Motivation	1
1.2 Objectives of the Thesis	3
1.3 Queueing Systems	3
1.4 Applications of Queueing Based Service Systems	5
1.4.1 Flexible Assembly Systems	6
1.4.2 Fault-tolerant Machining Systems	6
1.4.3 Production Systems	6
1.4.4 Communication Systems	6
1.4.5 Computer System	6
1.4.6 Traffic System	7
1.5 Characteristics of Queueing Systems	7
1.5.1 The Population of Prospective Customers	7
1.5.2 Input or Arrival Pattern	7
1.5.3 System Capacity	8
1.5.4 Service Discipline	8
1.5.5 Service Mechanism	8
1.5.6 State of the System	9
1.6 Some Important Random Processes	9
1.6.1 Stochastic Process	10
1.6.2 Stationary Process	10

1.6.3	Markov Process	10
1.6.4	Markov Chain	11
1.6.4.1	Discrete-Time Markov Chain	11
1.6.4.2	Continuous-Time Markov Chain	11
1.6.5	Bernoulli Process	11
1.6.6	Binomial Process	12
1.6.7	Counting Process	12
1.6.8	Poisson Process	12
1.6.9	Renewal Process	12
1.6.10	Birth and Death Process	13
1.6.11	Quasi-Birth and Death Process	13
1.6.12	Chapman-Kolmogorov Theorem	14
1.6.13	Chapman-Kolmogorov Equations	14
1.7	Finite and Infinite Queueing Systems	14
1.7.1	Finite Capacity Queueing System	15
1.7.1.1	Single Server Finite Capacity Queueing Model . .	15
1.7.1.2	Multiple Server Finite Capacity Queueing Model .	16
1.7.2	Finite Population Queueing System	17
1.8	Performance Measures	19
1.8.1	Customer-Oriented	19
1.8.2	System-Oriented	20
1.9	Solution Techniques	22
1.9.1	Transient Solution	22
1.9.1.1	Laplace Transformation	22
1.9.1.2	Runge-Kutta Method	22
1.9.2	Steady-State Solution	23
1.9.2.1	Successive Over-Relaxation Method	23
1.9.2.2	Gauss Elimination Method	24
1.9.2.3	Matrix Inverse Method	25
1.9.2.4	Newton's Method	25
1.10	Optimization Techniques	26
1.10.1	Quasi-Newton Method	27
1.10.2	Direct-Search Method	28
1.10.3	Particle Swarm Optimization	28
1.10.4	Cuckoo Search Algorithm	30
1.10.5	Bat Algorithm	32
1.11	Some Basic Terminologies	34
1.11.1	Customers Behavior	35

1.11.2 Server's Behavior	35
1.11.2.1 Unreliable Server	35
1.11.2.2 Server's Vacation	36
1.12 Literature Review	38
1.12.1 Development of Queueing Theory	38
1.12.2 Customer Impatient	39
1.12.3 Feedback	41
1.12.4 Vacation Policies	42
1 Optimal Analysis of the Service Systems	45
2 Multi-Server Service System with Impatient and Bernoulli Scheduled Modified Vacation	47
2.1 Introduction	47
2.2 Problem Formulation and Notations	50
2.2.1 Matrix Representation	53
2.2.2 Matrix Analytic Solution Algorithm	56
2.3 System Performance Measures	57
2.4 Cost Analysis	62
2.5 Special Cases	63
2.6 Particle Swarm Optimization	64
2.7 Numerical Results	64
2.8 Conclusion and Future Prospective	74
3 Service System with Emergency Vacation	77
3.1 Introduction	77
3.2 Model Description	80
3.3 Matrix Analytic Solutions	82
3.4 System Performance Measures	84
3.5 Cost Function	85
3.6 Optimal Analysis	85
3.6.1 Bat Algorithm	86
3.6.2 Particle Swarm Optimization	86
3.6.3 Quasi-Newton Method	86
3.7 Numerical Results	86
3.8 Conclusion and Future Prospective	92
4 Operating Strategies in Markovian Environment	97
4.1 Introduction	97

4.2	Model Description	101
4.3	System Performance Measures	104
4.4	Cost Analysis	105
4.5	Optimal Analysis	106
4.5.1	Cuckoo Search Algorithm	107
4.5.2	Particle Swarm Optimization	107
4.5.3	Quasi-Newton Method	107
4.5.4	Direct-Search Method	107
4.6	Numerical Results	108
4.7	Conclusion and Future Scope	120
II	Sensitivity Analysis of the Service Systems	123
5	Vacation Queueing Model with <i>F</i>-Policy and Vacation Interruption	125
5.1	Introduction	125
5.2	Model Description	128
5.2.1	Notations	130
5.2.2	Matrix Analytic Solutions	131
5.2.3	Steady-State Probabilities	133
5.3	System Performance Measures	134
5.4	Cost Analysis	136
5.5	Particle Swarm Optimization	137
5.6	Sensitivity Analysis	138
5.7	Numerical Results	139
5.7.1	Numerical Simulation	139
5.7.2	Sensitivity Results	144
5.7.3	Optimal Analysis	146
5.8	Conclusion and Future Scope	148
III	Transient Analysis of the Machining Systems	151
6	Single Server Queueing Model with Feedback	153
6.1	Introduction	153
6.2	Model Description	156
6.3	The Transient Solution	156
6.4	Measure of Effectiveness	159
6.5	Numerical Results	160
6.6	Conclusion and Future Scope	164

7 Reliability and Vacation: The Critical Issue	165
7.1 Introduction	165
7.2 Machine Repair Problem (MRP)	167
7.3 MRP with N-Policy	171
7.4 MRP with Bernoulli Vacation Policy (BV)	174
7.5 MRP with Multiple Vacation Policy (MV)	178
7.6 MRP with Single Vacation Policy (SV)	181
7.7 MRP with Multiple Working Vacation Policy (MWV)	184
7.8 MRP with Single Working Vacation Policy (SWV)	188
7.9 MRP with Vacation Interruption Policy (VI)	191
7.10 Discussion	195
8 Unreliable Service and Vacation Interruption	199
8.1 Introduction	199
8.2 Machine Repair Problem (MRP)	201
8.3 Working Vacation and Vacation Interruption	204
8.4 MRP with WV, VI and Unreliable Service	208
8.5 Special Cases	212
8.6 Cost Analysis	213
8.6.1 Steady-State Analysis	213
8.6.2 Cost Function	214
8.6.3 Particle Swarm Optimization	215
8.7 Numerical Results and Discussion	215
8.8 Conclusion	221
9 Closure	227
9.1 Conclusions	227
9.2 Specific Contributions	228
9.3 Future Scope	229
Bibliography	231
List of Publications	259
Conferences / Workshops Attended	261
Brief Biography of the Candidate	262
Brief Biography of the Supervisor	263