

Computer Simulation Using Excel without Programming

Evon M. O. Abu-Taieh

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Boca Raton, Florida
USA • 2008

ISBN-10: 1-58112-394-9
ISBN-13: 978-1-58112-394-4

Computer Simulation Using Excel without Programming

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Submitted in Partial fulfillment of the Requirements for the
Degree of Doctor of Philosophy in Computer Information Systems
College of Banking and Financial Sciences
The Arab Academy for Banking and Financial Science

To Mother & Father
To my Teachers, Family and Friends

ACKNOWLEDGMENTS

I am particularly indebted to my supervisor Dr. Asim El-Sheik. I am deeply grateful to his support, advice and encouragement. Furthermore, I am deeply grateful to the appointed committee: Dr. Ahmad Mashhour, Dr. Raed Abu-Zitar, and Abid Thyab Al-Ajeeli.

Also, deeply grateful for my teachers of Dr. Jalal El-Outom, Dr. Walid Slamah, Dr. Ala'a Abu-Samaha, Dr Munib Qutishat, and Dr. Sattar Jabbar Aboud.

I am also grateful for Dr. Jeihan Abu-Tayeh for her penmanship and editing style.

I would like to thank DR. Fawaz Abu-Tayeh, Dr. Alia Abu-Tayeh, Eng. Akef Abu-Tayeh and Sultaneh Abu-Tayeh for their financial support throughout my study, also for the technical advice and constant encouragement.

I would like to extend my deep gratitude to H.E. Minister of Transport Saoud Nsairat and H.E. Secretary General Eng. Alaa Batayneh, not discounting the role of my colleagues at the Ministry of Transport Eng. Osama Al-Karadsheh, Murad Al-Haroun, Ahamad Masud, Firas Shawar, and Anas Abd Al-Rahman.

Last, not least, my friend Eng. Maha El-Maheid, and my family for their encouragement and moral support.

ABSTRACT

Defining Simulation in its broadest aspect as embodying a certain model to represent the behavior of a system, whether that may be an economic or an engineering one, with which conducting experiments is attainable. Such a technique enables the management, when studying models currently used, to take appropriate measures and make fitting decisions that would further complement today's growth sustainability efforts, apart from cost decrease, as well as service delivery assurance. As such, the Computer Simulation technique contributed in cost decline; depicting the "cause & effect", pinpointing task-oriented needs or service delivery assurance, exploring possible alternatives, identifying problems, as well as, proposing streamlined measurable deliverable solutions, providing the platform for change strategy introduction, introducing potential prudent investment opportunities, and finally providing safety net when conducting training courses. Yet, Simulation Development process is hindered due to many reasons. Like a rose, Computer Simulation technique, does not exist without thorns; of which the length, as well as, the communication during the development life cycle. While Computer Simulation technique proves to be highly specialized, nevertheless, it is task-oriented. Moreover, it reflects real life problems; hence, it addresses numerous scenarios with handful of variables. Not only is it costly, as well as, liable for human judgment, but also, the results are complicated and can be misinterpreted.

Within this context, the researcher attempts to employ a method, using spreadsheets as simulation environment while simplifying the program code, and thus surmounting the aforementioned problems. The idea of this method is defined as follows; one procedure is defined for *beginning* any activity, one procedure is defined for *ending* any activity, and one procedure is defined for any activity *process*. This is attainable by using each entity as a parameter being passed from one procedure to another utilizing the Object Oriented programming language Visual Basic. Consequently, a computer simulation system, *E3P-Sim*, is realized.

E3P-Sim is programmed based on: Three-Phase Discrete event, Activity Cycle Diagram (ACD), Object Oriented Language, and Microsoft Excel. *E3P-Sim* is a general-purpose package, and not a task-oriented package. *E3P-Sim* accepts the model, built using interactive ACD on Excel spreadsheet. As such, *E3P-Sim* is built using Three-Phase, to bypass the deadlock problems, Object Oriented Language during simulation package programming, in order to simplify the code and relieve the modeler from such chore. Intentionally, this package uses Microsoft Excel as a reporting tool, since Excel is a popular reporting and analysis tool.

CONTENTS

CHAPTER 1	16
INTRODUCTION	16
INTRODUCTION	17
THESIS OBJECTIVE & CONTRIBUTION.....	18
OUTLINE OF THESIS	19
CHAPTER 2	23
BACKGROUND OF SIMULATION	23
INTRODUCTION	24
SIMULATION DEFINITIONS	25
FORMS OF MODELS.....	26
WHY SIMULATE?.....	27
MODELING APPROACHES.....	32
GENERAL CONSIDERATIONS	33
SIMULATION MODELING APPROACHES.....	33
<i>Process Interaction approach</i>	33
<i>Transaction-Flow Approach</i>	34
<i>Event Scheduling approach</i>	35
<i>Activity Scanning approach</i>	36
<i>Three-Phase approach</i>	37
<i>Comparison between simulation approaches</i>	38
MODELING NOTATIONS	40
<i>Activity Cycle Diagrams (ACD)</i>	40
<i>The Four-Phase Method (FPM)</i>	42
Extended Activity Cycle Diagrams (X-ACDs)	43
Hierarchy Activity Cycle Diagrams (H-ACDs)	44
PETRI NETS.....	50
<i>Definition of Petri Nets</i>	51
<i>Overview of Classical Petri Nets</i>	53
<i>Classification of Petri Nets</i>	55
SAMPLING METHODS OR INPUT MODELING.....	55
<i>Sampling Methods or Input Modeling</i>	56
<i>Monte Carlo Simulation</i>	60
Application.....	60
<i>Neural Network and Simulation</i>	61
WEB BASED SIMULATION & OBJECT ORIENTED SIMULATION.....	63
WEB BASED SIMULATION.....	63
<i>Simulation and Animation Basic Approaches</i>	64
Remote Simulation and Animation Approach	64
Local Simulation and Animation approach.....	65
Remote Simulation and Local Visualization Approach	65
<i>Environment and Languages for web based simulation</i>	66
Why Java has potential with web based simulation	69
OBJECT ORIENTED SIMULATION.....	70
<i>Principles of Modeling</i>	71
<i>The Aims of a Model</i>	71
SUMMARY	72
CHAPTER 3	73
METHODOLOGY	73
INTRODUCTION	74

RESEARCH DESIGN	74
INSTRUMENTS	76
SAMPLING METHODS AND PROCEDURES	78
ANALYTICAL METHODS	78
CHAPTER 4.....	83
SIMULATION PACKAGES REVIEW	83
INTRODUCTION	84
SURVEY REVIEW	84
APPLICATIONS	87
<i>Analytica</i>	87
<i>AnyLogic 5.0</i>	89
<i>Arena</i>	90
<i>AutoMod</i>	91
<i>AweSim</i>	92
<i>Berkeley Madonna™</i>	94
<i>BuildSim</i>	96
<i>Crystal Ball Standard Edition & Professional Edition</i>	97
<i>DecisionPro</i>	98
<i>DecisionScript</i>	98
<i>Design II simulation Package</i>	99
<i>Dymola</i>	100
<i>Ecosim Pro</i>	102
<i>eM-Plant</i>	103
<i>Enterprise Dynamics</i>	103
<i>ExpertFit</i>	105
<i>Extend</i>	105
<i>Factory Explorer</i>	107
<i>FirstSTEP Designer</i>	109
<i>Flexsim</i>	111
<i>GAUSS</i>	113
<i>GoldSim</i>	114
<i>GPSS World for Windows</i>	115
<i>MAST</i>	115
<i>MICROSAINT</i>	117
<i>MyStartegy</i>	118
<i>ModelMaker</i>	119
<i>NAG SMP Library</i>	121
<i>NAG C Library</i>	122
<i>Optsim (Artifex)</i>	122
<i>PASION Simulation System</i>	124
<i>MJC²</i>	124
<i>SLIM</i>	125
<i>Process Industry Manufacturing Scheduling System (PIMSS)</i>	127
<i>ProModel-ProcessModel</i>	128
<i>Proplanner Manufacturing Process Management Software</i>	129
<i>ProVision</i>	130
<i>PowerSim</i>	131
<i>QX3D</i>	132
<i>Resource Manager</i>	132
<i>SAAM II</i>	133
<i>SansGUI Modeling and Simulation Environment</i>	135
<i>SAS Software</i>	135
<i>ShowFlow</i>	136
<i>SIGMA</i>	137

<i>SimCreator</i>	138
<i>SimCAD Pro</i>	139
<i>SIMPROCESS</i>	140
<i>SIMUL8</i>	140
<i>STELLA / itthink</i>	141
<i>STARDIS</i>	142
<i>Supply Chain Builder</i>	143
<i>VisSim</i>	145
<i>Visual Simulation Environment</i>	146
<i>WebGPSS (micro-GPSS)</i>	148
<i>Witness</i>	149
FINDINGS.....	150
<i>Comparing to E3P-Sim</i>	152
CHAPTER 5	155
COMPUTER SIMULATION WITH ENHANCED THREE PHASES MODELLING USING ACTIVITY CYCLE DIGRAM: E3P-SIM	155
<i>E3P-Sim</i>	156
Tools bar.....	156
ENTITY.....	157
ACTIVITY CYCLE DIAGRAM.....	159
<i>Queue</i>	159
<i>Activity</i>	161
<i>Split Activity</i>	162
<i>Line/connector</i>	162
DATA TO KEEP TRACK OF FOR SCHEDULING.....	163
ASSUMPTIONS.....	164
SAVING AND DOCUMENTING THE RESULTS.....	165
<i>Port Example</i>	167
Creating the model.....	167
<i>Results & documentation</i>	168
<i>Supermarket</i>	170
Creating the model.....	170
<i>Restaurant</i>	171
Creating the model.....	172
<i>Clinic Example</i>	172
Creating the model.....	173
<i>Pub example</i>	173
Creating the model.....	174
<i>Call Center Example</i>	174
Creating the model.....	175
<i>Airport Passenger</i>	175
Creating the model.....	176
MANUAL RUN AND TRACING.....	177
CASE STUDY ANALYSIS.....	186
System Generated Data.....	187
Results Comparison.....	190
CODE SIMPLIFICATION DESCRIPTION.....	193
<i>Code Description</i>	195
<i>Advantages and Limitations of E3P-Sim</i>	198
Advantages.....	199
Limitations.....	201
CHAPTER 6	202
SUMMARY, CONCLUSIONS AND FUTURE RESEARCH	202
SUMMARY.....	203

CONCLUSION	204
FUTURE RESEARCH	207
REFERENCES	208
APPENDIX A.....	211
THE ORIGINAL CODE	211
APPENDIX B.....	247
TRANSPARENT FORMS	247
APPENDIX C.....	252
FORMS CODE.....	252
APPENDIX D.....	272
SAMPLE RUNS.....	272
APPENDIX E.....	314
MANUAL RUNS.....	314

Figures

Figure 1: A process-Interaction Executive [Pidd, 1998].	34
Figure 2: An Event-Scheduling Executive [Pidd, 1998]	36
Figure 3: An Activity-Scanning Executive [Pidd, 1998].	37
Figure 4: A Three-Phase Executive [Pidd, 1998].	38
Figure 5: Symbols for Activity Cycle Diagrams [Pidd, 1998]	40
Figure 6: Generic Activity Cycle Diagram.	41
Figure 7: Life Cycles of each Entity in PUB Example.	41
Figure 8: Life Cycles of each Entity in PUB Example Completed Using ACD.	42
Figure 9: The X-ACD Symbol Set (Adapted from Pooley and Hughes 1991) [Odhabi, et al 1997].	43
Figure 10: The H-ACD Symbol Set (Adapted from Kienbaum and Paul 1994a)	46
Figure 11: An Illustration of the Four-Phase Method [Odhabi, et al 1998]	50
Figure 12: Modeling Elements of Classical Petri Nets [Sawhney et al., 1999].	53
Figure 13: Enhanced Petri Nets Modeling Symbols [Sawhney et al., 1999].	54
Figure 14: A Taxonomy for Input Models [Leemis, 2000, 15]	59
Figure 15: Remote S&A Data Transfer [Lorenz et al., 1997]	65
Figure 16: Client-Site Simulation with Loaded Applets [Lorenz et al., 1997].	65
Figure 17: Remote Simulation and Local Visualization [Lorenz et al., 1997].	66
Figure 18: Graphical Modeling Using Silk-Based JavaBeans [Healy and Kilgore, 1997].	68
Figure 19: The proposed simulation life cycle [El Sheikh, Abu-Taieh, Eldabi, 2005]	76
Figure 20: Analytica Overview [Lumina Web].	88
Figure 21: Analytica Model Development Windowd [Lumina Web].	88
Figure 22: Analytica Output Analysis [Lumina Web].	88
Figure 23: Development Window [AnyLogic Web].	89
Figure 24: Running Example [AnyLogic Web].	90
Figure 25: Development Window [ArenaSimulation Web].	91
Figure 26: Some Examples in 3D [AutoMod Web].	92
Figure 27: The AweSim Executive [O'Reilly, 2002].	92
Figure 28: Multi Model Window [O'Reilly, 2002].	93
Figure 29: Multi Report Window [O'Reilly, 2002].	93
Figure 30: Phase Plane (X-Y) Plots [BerkeleyMadonna Web].	94
Figure 31: Controlling the Model [BerkeleyMadonna Web].	95
Figure 32: Oscilloscope Plots [BerkeleyMadonna Web].	95
Figure 33: Oscilloscope plot vs. Time [BerkeleyMadonna Web].	95
Figure 34: Runs Comparison [BerkeleyMadonna Web].	95
Figure 35: BuildSim Data Analysis [BuildSim Web].	96
Figure 36: Crystal Ball Tool Bar [Goldman, 2002].	97
Figure 37: Sample Output Analysis [Goldman, 2002].	98
Figure 38: EDoctor Decsion Script Example [vanguardsw Web].	99
Figure 39: Refinery Example [WinSim Web].	100
Figure 40: Robotic Arm [DynaSim Web].	101
Figure 41: Development Environment [DynaSim Web].	101
Figure 42: European Space Agency ESA space [EcoSimPro Web].	102
Figure 43: Ecosim Pro Development Environment [EcoSimPro Web].	102
Figure 44: eM-plant at Work [TecnoMatix Web].	103

Figure 45: Manufacturing Example in 3D [EnterpriseDynamics Web].	104
Figure 46: Airport Example in 3D [EnterpriseDynamics Web].	104
Figure 47: Baggage Sorter in 3 D [EnterpriseDynamics Web].	104
Figure 48: Discrete Event System [ImaginThatInc Web].	106
Figure 49: Continuous System [ImaginThatInc Web].	107
Figure 50: Activ X Excel Embded in Extend [Krahl, 2003].	107
Figure 51: A Diagram of the Relationships between System Components [WWK Web].	108
Figure 52: Major System Inputs and Outputs [WWK Web].	108
Figure 53: Symbols used in FirstSTEP [Interfacing Web].	109
Figure 54: Development environment in FirstSTEP [Interfacing Web].	110
Figure 55: Running example of FirstSTEP [Interfacing Web].	110
Figure 56: 3 D Example of Loading Trucks [Flexsim Web].	111
Figure 57: Port Example in 3D [Flexsim Web].	112
Figure 58: Development Environment [GoldSim Web].	114
Figure 59: GoldSim Hierarchical [GoldSim Web].	115
Figure 60: The Interface Window for Development Environment [CMSRES Web].	116
Figure 61: MICROSAINTE Environment [maad Web].	117
Figure 62: MICROSAINTE animation in Bank Example [maad Web].	118
Figure 63: MICROSAINTE Analysis [maad Web].	118
Figure 64: A Running Animated Model [MyStartegy Web].	119
Figure 65: ModelMaker Analysis Tools [ModelKinetix Web].	120
Figure 66: Development Environment [ModelKinetix Web].	120
Figure 67: The Demo at Work in NAG SMP Library [NAG Web].	121
Figure 68: NAG C in Excel [NAG Web].	122
Figure 69: Optsim (Artifex) Example Running [RSoftDesign Web].	123
Figure 70: Example of PASION while running [raczynski Web].	124
Figure 71: Slim At Work [MJC Web].	126
Figure 72: Machine Usage Scheduling [MJC Web].	127
Figure 73: Development Interface [ProModel Web].	128
Figure 74: ProModel Analysis [ProModel Web].	129
Figure 75: ProModel Animation [ProModel Web].	129
Figure 76: Typical Continuous Process Using Continuous Process Notations [PowerSim Web].	131
Figure 77: Building a Robotic Arm Based on a Stick Figure Using QX3D [QX3D Web].	132
Figure 78: Analysis [SAAM II Web].	133
Figure 79: Development Environment [SAAM II Web].	134
Figure 80: Overview of the Software [ProtoDesign Web].	135
Figure 81: Dynamic Data Exchange with Excel [ShowFlow Web].	136
Figure 82: Animated Factory Using Show Flow [ShowFlow Web].	137
Figure 83: Parcel Sorting System Using show flow [ShowFlow Web].	137
Figure 84: Off the Road Example [SimCreator Web].	138
Figure 85: Development Environment [CreateASoft Web].	139
Figure 86: Help Desk Example [SimProcess Web].	140
Figure 87: Network Example [SimProcess Web].	140
Figure 88: Development Environment [SIMUL8 Web].	141
Figure 89: STELLA Example in Web Based Demo [GoldSim Web].	142
Figure 90: Snap Shot of STARDIS at Work [STARDIS Web].	143
Figure 91: Running Demo Example [Siprelle, et al., 2003].	144

Figure 92: Sample Report [Siprelle, et al., 2003].	144
Figure 93: VisSim Model Building Environment with Example [VisSim Web].	146
Figure 94: Manufacturing Example [OrcaComputer Web].	147
Figure 95: Washington DC Metro System [OrcaComputer Web].	147
Figure 96: Gulf WAR Simulated Example [Balci et al, 1998].	147
Figure 97: Overall view [Lanner Web].	149
Figure 98: Excel Usage in Simulation Packages.	150
Figure 99: Simulation Types.	151
Figure 100: Object Oriented Languages Use.	152
Figure 101: Simulation Approaches.	153
Figure 102: 3D vs. 2D Animation.	153
Figure 103: <i>E3P-Sim</i> Toolbar.	156
Figure 106: The que shapes.	159
Figure 108: Different types of activity.	161
Figure 111: The split activity.	162
Figure 112: Connector.	163
Figure 113: Port Exmpl Model ACD.	167
Figure 114: Graph of the Queues length vs Run Time.	168
Figure 115: Live Graph Of The Ques.	169
Figure 116: Supermarket Model ACD.	170
Figure 117: Retsurant Example.	171
Figure 118: Clinic Example ACD.	173
Figure 119: Pub Example ACD.	174
Figure 120: Call Center ACD.	175
Figure 121: Passenger Going Through Airport.	176
Figure 122: Queues snap shots	187
Figure 123: Item Statistics Spreadsheet As It Appears In The <i>E3P-Sim</i> .	189
Figure 124: Arrival rates – Jobs generated as the simulation progresses	191
Figure 125: Compare two Bs Arrive & Call [Pidd, 1998].	193
Figure 126: Compare two Bs EndServe & EndTalk [Pidd, 1998].	193
Figure 127: Compare two conditional procedures [Pidd, 1998].	194
Figure 128: Procedure B1 Job Generator [Abu-Taieh, 2004].	194
Figure 129: Procedure B2 or End service [Abu-Taieh, 2004].	195
Figure 130: Procedure C or Begin service.	195
Figure 131: <i>E3P-Sim</i> Structure.	200

Tables

Table 1: X-ACD & H-ACD symbols Comparison.....	49
Table 2: Comparison Between Web Featursand Simulation [Kuljis and Paul , 2000].....	70
Table 3: Table of Simulation Sesources Based on the Work of [Rizzoli, 2003].....	86
Table 4 : Review of the Simulation Packages	151
Table 5: Buttons Descriptions.....	157
Table 6: Items Attribuites for the Port Example.....	168
Table 7: Items Attribuites for the Supermarket Example.	170
Table 8: Restaurant Items.	172
Table 9: Clinic Items.....	173
Table 10 : Pub Example Items.....	174
Table 11: Call Center Sample ITEMS.....	175
Table 12: Items of Airport Example.....	177
Table 13: Intial Conditions	177
Table 14: Running Cycle 1	178
Table 15: Running Cycle 2	178
Table 16: Running Cycle 3	178
Table 17: Running Cycle 4	178
Table 18: Running Cycle 5	179
Table 19: Running Cycle6	179
Table 20: Running Cycle 7	179
Table 21: Running Cycle 8	179
Table 22: Running Cycle 9	180
Table 23: Running Cycle 10	180
Table 24: Running Cycle 11	180
Table 25: Running Cycle 12	181
Table 26: Running Cycle 13	181
Table 27: Running Cycle 14	181
Table 28: Running Cycle 15	181
Table 29: Running Cycle 16	182
Table 30: Running Cycle 17	182
Table 31: Running Cycle 18	182
Table 32: Running Cycle 19	182
Table 33: Running Cycle 20	183
Table 34: Running Cycle 21	183
Table 35: Running Cycle 22	183
Table 36: Running Cycle 23	183
Table 37: Running Cycle 24	183
Table 38: Running Cycle 25	184
Table 39: Running Cycle 26	184
Table 40: Running Cycle 27	184
Table 41: Items activity Statistics	185
Table 42: E3P-Sim queues snap shots	186
Table 43: <i>Items/Activities</i> statistics	187
Table 44: Continuum of <i>Items/Activities</i> statistics.....	188
Table 45: Jobs arrivals in three different runs	190

Table 46: Arrival frequency	190
Table 47: Statistical comparisons	192
Table 48: Data Storage structure in sheet 5.	198

Chapter 1

INTRODUCTION

Introduction

The Computer Simulation technique proved to be of an immense importance in today's growth sustainability; enabling the management to take appropriate measures and make fitting decisions, when studying models currently used, in order with the aim of enhancing performance competence, through avoiding extra cost resulted from repetitive experimentation, conducting different scenarios while controlling time, comprehending the "cause & effect", pinpointing task-oriented needs or service delivery assurance, exploring possible alternatives, identifying problems, as well as, proposing streamlined measurable deliverable solutions, providing the platform for change strategy introduction, introducing potential prudent investment opportunities, and finally providing safety net when conducting training courses. Yet, Computer Simulation technique is task-oriented, although it is highly specialized. Moreover, since it reflects real life problems, hence, it addresses numerous scenarios with handful of variables. Not only is it costly, as well as, liable for human judgment, involving lengthy channels of communication, and requiring special training, thus not user friendly, but also, the results are complicated and can be misinterpreted.

Throughout this thesis, the researcher addresses these issues through employing a state of the art method that involves using spreadsheets as simulation environment while simplifying the program code, thus realizing a computer simulation system that is based on Three-Phase Discrete Event, Activity Cycle Diagram (ACD), Object Oriented Language, and Microsoft Excel will be made. It is a general-purpose system, and not a task-oriented one, as others that have been investigated throughout this research, as such, it is built using Three-Phase, to bypass the deadlock problems, Object Oriented Language during simulation system programming, in order to simplify the code and relieve the end-user from this chore. Intentionally, this system uses Microsoft Excel as a reporting tool, since Excel is a popular reporting and analysis tool, bearing in mind that using excel in simulation is not new, in fact 15 out of the examined 56 system, have used Microsoft Excel as a reporting tool. In conclusion, it is worth mentioning that the efforts to attain this system were based on a published research paper.

Thesis Objective & Contribution

The objective of this research is to develop a general purpose computer simulation system, named *E3P-Sim* that needs no programming interventions from the user, through using Three-Phase Discrete event, Activity Cycle Diagrams (ACD), Object Oriented Language, and Microsoft Excel. As such, the contribution of this work is illustrated through combining the four elements concomitantly, without undermining the fact that each element was used either combined with another or alone, in one way or another, yet none of the investigated 56 systems used all four as stated in chapter 4 of this research. In general, the system would serve as a model that doesn't require programming intervention, thus reducing model building time, in the same token; it allows the modeler to experiment with different scenarios and input models easily, as well as, efficiently. Equally the *E3P-Sim* offers self-explanatory and reliable results that can be manipulated using the Microsoft Excel tools.

The researcher chose to try out the efficiency, validity and liability of this system, using the "Convenience Sample" (Mason and Gunst and Huss, 1989, p15) through examining this package against well known published simulation problems that amounted to approximately ten published problems, comprising different service delivery institutions that include; PUB, Port, Supermarket, clinic, restaurant, call center, and airport.

James Henriksen stated in a panel discussion during the winter simulation conference 2003 that "software vendor's primary goal should be to maximize the following expression [Henriksen, 2003]:

$$\frac{\text{Functionality X Ease-of-Use}}{\text{Cost X Complexity}}$$

The system used Three-Phase simulation approach for the sake of ridding the system from deadlock dilemma from which other simulation approaches may suffer as seen in chapter 2; therefore, such approach will increase the functionality described by Henriksen. On another note, the *Factory Explorer* is very close to *E3P-Sim* yet *Factory Explorer* uses Event Based simulation approach. In the Event Based simulation approach "there are only two phases then all events are mixed then the method is not parsimony, which means it is very hard to enhance" [Pidd,1998] as explained in chapter 2.

The Activity Cycle Diagrams (ACD) is known for some qualities that made it compelling to use. First, ACD is very simple with only two symbols for the modeler to remember, which makes ACD very easy to use. Second, ACD is parsimonious as described by [Pidd, 1998]. Third, ACD is very “useful for understanding and communication” [Elsheikh, 1987]. Fourth, ACD has two extra desirable aspects “comprehension, communication and generality (Doukiis, 1985)” [Elsheikh, 1987]. Because of those qualities and their affect on Henriksen’s function the ACD was used.

The use of Visual Basic, which is object oriented language, simple and easy to use language and not propriety, will decrease the complexity factor mentioned by Henriksen and will decrease the cost. Also Visual Basic accentuates the "mean stream" idea mention by [Booch et al, 1999]. Also the use of object oriented language will eliminate Brittle, long, hard to maintain code [Booch et al, 1999]. The aim of using Visual Basic is to Aid in simplifying the code of the Three-Phase simulation approach as suggested in the research by [Abu-Taieh, 2004].

The decision to use Microsoft Excel was made based on many reasons. First, the use of Excel is not new 15 packages out of 56 packages studied for this purpose use Excel as reporting tool. Many suggested such idea like [Leathrum et al., 2000], [Amico, 2000], [Seila, 2001], [Evans, 2000], [Diab, 1997], and [Hill, 2002] to name a few. [Hill, 2002] recited 5 good reasons to use Excel: "run statistical analysis, conduct mathematical modeling, import and export data, and a means to store and manage data". In addition, Excel is well known package and familiar to users. Within this context, the closest to *E3P-Sim* is *Crystal Ball* simulation system in the sense of making use of Microsoft Excel and Visual Basic, yet *Crystal Ball* is based on Monte Carlo which "can be loosely described as statistical simulation methods" [CSEP Web, 1995].

The use of the aforementioned not only does it increase the two nominator factors of Henriksen's expression, but also reduces the two denominator factors simultaneously, which will only maximize Henriksen's expression, thus stirring the motivation throughout this research.

Outline of Thesis

First, a comprehensive explanatory platform of simulation background is stated in chapter 2. As this chapter comprises of five sections, it reviews simulation definitions, forms of models,

the need for simulation, simulation approaches and modeling notations. Simulation definition is essential, in order to set research boundaries. Moreover, the chapter discusses forms of models: scale model of the real system, or discrete and continuous models. Subsequently, the chapter states a documentation of several reasons by different authors pertaining to the question of “*why simulate?*”, Followed by a thorough discussion of Modeling Approaches in respect to general considerations. Considering that simulation modeling approaches are discussed with special emphasis on the discrete-events types only: process-interaction, event scheduling, and activity scanning, yet, a slight comparison is made between the different approaches. Furthermore, the chapter discusses the different modeling notations Activity Cycle Diagram (ACD) with different versions of the ACD: Extended Activity Cycle Diagrams (X-ACD) and Hierarchy Activity Cycle Diagrams (H-ACD). Furthermore, the chapter discusses sampling methods (input modeling).

On another note, the second section of chapter 2 embarks on further discussing Petri Nets. Although it conducts concurrent discrete events dynamic systems simulation which is outside the scope of this thesis, nonetheless, various simulation packages that are discussed in chapter 4, namely *Optsim (Artifex)*, use Petri Nets. Therefore, it is imperative to discuss Petri Nets, particularly that the idea of Petri Nets was developed to answer the question of concurrency, which naturally arises constantly when discussing simulation. The Petri Nets will be discussed by interpreting the formal definition of Petri Nets, describing the classical Petri Nets and the different classification of Petri Nets. Furthermore, the third section of this chapter will be directed to identify and categorize the sampling methods available in the simulation and statistical world, as many simulation packages, discussed in chapter 4, pride themselves about the number of sampling function available to the user. Moreover, the fourth section of chapter 2 tackles three interrelated topics: *sampling methods* and their taxonomy, *Monte Carlo simulation* that represents part of the sampling methods taxonomy, which is particularly important since 4 simulation packages use it; namely: *Crystal Ball*, *BuildSim*, *Decision Script* and *Decision Pro* (see chapter 4). *Neural Network*, which is the third topic discussed, particularly since many simulation packages use the idea of neural network as fitter functions. Finally, the fifth section of chapter 2 entails providing the idea of object oriented simulation, while being compared to algorithmic perspective. Discussing object oriented perspective entails reviewing the web based technology, as such, this section tackles three topics: first, web based simulation, which illustrates all three different types of simulation and modeling, second, the different

programming languages and environments, through which simulation can be done with object oriented perspective, third, the principles and aims of modeling from an object oriented perspective is introduced.

Second, chapter 3 demonstrates the methodology, which has been followed by the researcher in an attempt to employ a state of the art method that involves using spreadsheets as simulation environment while simplifying the program code, thus realizing a computer simulation system that is based on Three-Phase Discrete Event, Activity Cycle Diagram (ACD), Object Oriented Language, and Microsoft Excel will be made. As such, the contribution of this work is illustrated through combining the four elements concomitantly, without undermining the fact that each element was used either combined with another or alone, in one way or another, yet none of the investigated 56 systems used all four as stated in chapter 4 of this research. In general, the system would serve as a model that doesn't require programming intervention, thus reducing model building time, in the same token; it allows the modeler to experiment with different scenarios and input models easily, as well as, efficiently. Equally the *E3P-Sim* offers self-explanatory and reliable results that can be manipulated using the Microsoft Excel tools. Furthermore, the researcher chose to try out the efficiency, validity and liability of this system, using the "Convenience Sample" (Mason and Gunst and Huss, 1989, p15) through examining this package against well known published simulation problems that amounted to approximately seven published problems, comprising different service delivery institutions that include; PUB, Port, Supermarket, clinic, restaurant, call center, and airport.

Third, the result of studying 56 commercial and non-commercial simulation packages is given in chapter 4. The packages are thoroughly studied either by conducting experiments using them, or studying what was available about them over the internet. This chapter provides the researcher with the two faces of one coin theory and its implementation, likewise, this chapter sheds the light on the fact that *E3P-Sim* is not like any other package in the market place and the only one that uses Three-Phase approach, ACD, Microsoft Excel, and Visual Basic.

In conclusion, chapter 5 introduces the proposed system, which is named *E3P-Sim*; moreover, the chapter explains how the system works from both technical and user points of view. In addition, the chapter lists a number of examples, which illustrate how the system

provides solution to various prominent problems in the simulation arena. Furthermore, the code and the philosophy behind it are thoroughly discussed, as well as the advantages and limitations of the system.

Finally, chapter 6 summarizes the research that has been carried out, in order to achieve this thesis. In addition, the chapter states the conclusion, through which the product of this research has been realized and named *E3P-Sim*, highlighting the fact that *E3P-Sim* has been thoroughly tested through its examination against well known published simulation problems that amounted to approximately ten published problems, comprising different service delivery institutions. Moreover, the chapter suggests, as well as thoroughly investigates future research prospects.

Chapter 2

BACKGROUND OF SIMULATION

Introduction

The aim of this chapter is to serve as a comprehensive explanatory platform of simulation. It is imperative to define simulation, in order to set boundaries for the research. As such, the chapter comprises of five main sections: an overview of simulation modeling approaches, modeling notations, Petri Nets, sampling methods or input methods, and WEB Based simulation and Object Oriented simulation.

The chapter starts with a review of simulation definitions, forms of models, the need for simulation, simulation approaches and modeling notations. Next, the chapter discusses forms of models: scale model of the real system, or discrete and continuous models. Furthermore, the question “*why simulate?*” is addressed, through discussing a number of reasons by different authors in this section. Modeling approaches are discussed next with general considerations. Simulation modeling approaches are analyzed, emphasizing especially on the discrete types; namely: process-interaction, event scheduling, and activity scanning, with a minuscule comparison between the different approaches. Moreover, the chapter discusses the different modeling notations Activity Cycle Diagram (ACD) with different versions of the ACD: Extended Activity Cycle Diagrams (X-ACD) and Hierarchy Activity Cycle Diagrams (H-ACD).

Bearing in mind that Petri Nets handles concurrent discrete events dynamic systems simulation, which is outside the scope of this thesis, nonetheless, various simulation packages that are discussed in chapter 4, namely Optsim (Artifex), have used Petri Nets. Therefore, it has been reasoned to be imperative to further discuss Petri Nets in the second section of this chapter. Particularly that the idea of Petri Nets was developed to answer the question of concurrency, which naturally arises constantly when discussing simulation. The Petri Nets will be discussed by interpreting the formal definition of Petri Nets, describing the classical Petri Nets and the different classifications of Petri Nets. However, the section does not include the parallel discrete-event simulation languages (PDES); although some papers, such as [Low et al., 1999] are available for concerned to read.

Given the significance to identify with all or most of the sampling methods that exist, in order to evaluate simulation packages, particularly with regards to the taxonomy of the input

method, therefore, the third section of this chapter aims to identify and categorize the sampling methods available in the simulation and statistical world, as many simulation packages, discussed in chapter 4, pride themselves about the number of sampling function available to the user. It is worth noting, however, that the taxonomy will enable the prospective user to know if the input method suitable for Time-independent Models or Stochastic Processes. For example, if a simulation package claims that it uses Markov Chain in Time-independent Univariate Discrete Models; then evaluator of the simulation package will have to reconsider the package viability.

Furthermore, the fourth section tackles three interrelated topics: sampling method and their taxonomy is the first. Second, Monte Carlo simulation, which represents part of the sampling methods taxonomy, noting that Monte Carlo is particularly important, since four simulation packages have used it (see chapter 4); namely: *Crystal Ball*, *BuildSim*, and *Decision Script* and *Pro*. And finally, Neural network, which is regarded as a sampling method, since many simulation packages use the idea of neural network as fitter functions.

Finally, the fifth section of this chapter reviews web based simulation, along with all three different types of simulation and modeling. In addition to the different programming languages and environments, through which simulation can be done using object oriented perspective. Then, the idea of object oriented simulation is discussed in comparison to algorithms perspective. As such, modeling principles and aims, from an object oriented perspective, is introduced as a reminder to the reader. Considering that WEB Based simulation and Object Oriented is to give an overview of the object oriented simulation perspective, consequently discussing object oriented perspective entails discussing the web based technology, particularly, since the effect of object oriented is visibly seen on the web based technology.

Simulation Definitions

In their book, Paul & Balmer have quoted Pidd defining simulation as

Analyst builds a model of the system of interest, writes computer program which embody the model and uses a computer to initiate the system's behavior when subject to a Variety of operating policies. Thus the most desirable policy may be selected [Paul & Balmer, 1998].