





ثبكة المعلومات الجامعية





جامعة عين شمس

التوثيق الالكتروني والميكروفيلم



نقسم بللله العظيم أن المادة التي تم توثيقها وتسجيلها علي هذه الأفلام قد اعدت دون آية تغيرات



يجب أن

تحفظ هذه الأفلام بعيداً عن الغبار

في درجة حرارة من 15-20 مئوية ورطوبة نسبية من 20-40 %

To be kept away from dust in dry cool place of 15-25c and relative humidity 20-40 %



ثبكة المعلومات الجامعية









Mathematics Department

ON TEMPORAL LOGIC

A THESIS
SUBMITTED FOR THE DEGREE OF Ph.D. IN SCIENCE
(Computer Science)

Presented By

Hany Bakheet Lateef Bakheet

Department of Mathematics Faculty of Education Ain Shams University

Supervised By

Dr. Mahmoud Khairat Ahmed Khairat

Department of Mathematics
Faculty of Science
Ain Shams University

Dr. Sameh Sami Daoud

Department of Mathematics Faculty of Science Ain Shams-University

M. A. Alel El Na by

Dr. Mokhtar Ahmed Abd El-Naby

Department of Mathematics
Faculty of Education
Ain Shams University

Submitted to
Department of Mathematics
Faculty of Science
Ain Shams University

Cairo

2002



Abstract

The aim of the proposed study is to arrive a new concept in Temporal Logic of Actions (TLA) which is one of the important branches in artificial intelligence. It is designed for the specification and verification of reactive systems in terms of their actions. The research in that way is a new contribution; which will help in investigating the aims and properties of programming in its general form.

Acknowledgments

I would like to thank my supervisors Dr. Mahmoud Khairat Ahmed Khairat, Dr. Sameh Sami Daoud and Dr. Mokhtar Ahmed Abd El-Naby for their helpful, guidance and patience in supervising me throughout my period of study for this thesis, and for teaching me the value of Temporal Logic and Temporal Logic of Actions.

Numerous people have contributed their advice. In particular, I would like to thank Dr. Stephan Merz from the Institut für Informatik, TU München, Germany, and my special thanks go to prof. Dr. Fred Kröger (from the Institut für Informatik, TU München, Germany) for suggesting the subject of this research during my stay in Germany and also for their help in starting the first steps of this work.

Finally, I would like to express my heartfelt gratitude to my parents and my family for their unending support during the past years.

CONTENTS

Introduction	1
CHAPTER 1 : Short Survey	5
1. Some Program Logic	5
1.1. Modal Logic	5
1.2. Tense Logic	 7
1.3. Dynamic Logic	7
2. Concepts of Classical Logics and Temporal Logics	10
2.1. Concepts and notions of Classical Logic	10
2.2. Concepts and notions of Temporal Logic	15
2.3. Kinds of Temporal Logic	20
3. Concept and Notation of Temporal Logic of Actions	21
3.1. Logic Versus Programming	21
3.2. The Logic of Actions	23
3.2.1. Values, Variables, and States	23
3.2.2. State Functions and Predicates	24
3.2.3. Actions	25
3.2.4. Predicates as Actions	26
3.2.5. Validity and Provability	26
3.2.6. Rigid Variables and Quantifiers	26
3.2.7. The Enabled Predicate	28
3.3. Simple Temporal Logic	28
3.3.1. Temporal Formulas	29
3.3.2. Some Useful Temporal Formulas	30
3.3.2.1. Eventually	3 0
3.3.2.2. Infinitely Often and Eventually Always	3 0
3.3.2.3. Leads To	31
3.3.3. Validity and Provability	31
3.4. The Raw Logic	32
3.4.1. Actions as Temporal Formulae	32
3.5. Temporal Logic of Actions (TLA)	33

CHAPTER 2: Some suggested Languages for Propositional Ten	moral
Logic of Actions	39
1. The \mathcal{L}_1 version from \mathcal{L}_{TA}	20
2. The \mathcal{L}_2 version from TLA	39
3. The \mathcal{L}_{2n} version from TLA	40
4. The \mathcal{L}_3 version	43
5. The \mathcal{L}_{3a} version	45
6. The \mathcal{L}_4 version	46
	46
7. The £ _{4a} version Some Theorems	47
Some Theorems	47
CHAPTER 3: The Soundness of the Suggested System for the	
Propositional Temporal Logic of Actions (PTLA)	61
	~~
- A Language Legal of PTLA	61
- The Formal System Σ_{PTLA}	67
- Soundness Theorem for ∑ _{PTLA}	68
- Deduction Theorem of PTLA - Some deriving Formulas	72
Some deriving Pormulas	73
CHAPTER 4: The Completeness of the Suggested System for	r tha
Propositional Temporal Logic of Actions (PTLA)	79
- Completeness of \sum_{PTLA}	79
- Satisfiability theorem of Σ_{PTLA}	90
- Completeness theorem of Σ_{PTLA}	92
 Notes about the Formal System and Some Principles The Principle of Linearity 	92
- The Principle of Induction	92
	93
CHAPTER 5: Unified Propositional Temporal Logic of Actio	ns
(UPTLA)	95
- A Language of UPTLA	o -
- The Formal System ∑ _{UPTLA}	95 103
Soundness Theorem for \(\sum_{\text{UPTLA}} \)	103

- Deduction Theorem of UPTLA	107
- Some deriving Formulas	108
- Completeness of ∑ _{UPTLA}	110
- Satisfiability theorem of \sum_{UPTLA}	121
- Completeness theorem of $\Sigma_{ ext{UPTLA}}$	122
- Conclusion	122
- List of symbols	125
- References	. 127