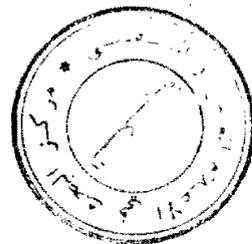


**DISTRIBUTED ALGORITHMS FOR
ELECTION IN UNIDIRECTIONAL AND
COMPLETE NETWORKS**

Yehuda Afek

November 1985
CSD-850036

IST 2012



UNIVERSITY OF CALIFORNIA

Los Angeles

Distributed Algorithms for Election in
Unidirectional and Complete Networks

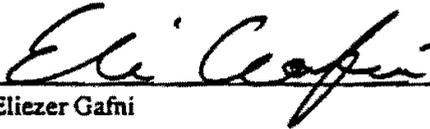
A dissertation submitted in partial satisfaction of the
requirements for the degree Doctor of Philosophy
in Computer Science

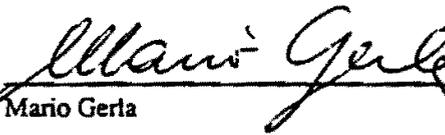
by

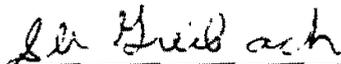
Yehuda Afek

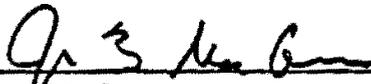
1985

The dissertation of Yehuda Afek is approved.


Eliezer Gafni


Mario Gerta


Sheila A. Greibach


James MacQueen


Bruce Rothschild


Leonard Kleinrock, Committee chair

University of California, Los Angeles

1985

Table of Contents

page

1.	INTRODUCTION	1
1.1.	Data Communication Networks	2
1.2.	Distributed Algorithms	3
1.3.	Election and Traversal	5
1.3.1.	The Election Problem	5
1.3.2.	The Traversal Problem	5
1.4.	Models	6
1.5.	Performance Measures	10
1.6.	Previous Work	11
1.6.1.	Election in Ring Networks	12
1.6.2.	Election in General Networks	14
1.6.3.	Election in Complete Networks	17
1.6.4.	Election in Unidirectional Networks	17
1.7.	Dissertation Overview	18
2.	ALGORITHMS FOR ELECTION IN COMPLETE NETWORKS	22
2.1.	Introduction	23
2.2.	The Synchronous Algorithm	23
2.2.1.	Description of the Algorithm	24
2.2.2.	Time and Message Complexities	25
2.3.	Asynchronizing the synchronous algorithm	27
2.3.1.	Description of the algorithm	28
2.3.2.	Time and Message Complexities	30
2.4.	Algorithms for Election in Asynchronous Complete Networks	36
2.4.1.	Algorithm A	37
2.4.2.	Algorithm B	41
2.4.3.	Algorithm C	44
2.5.	Conclusions	48
3.	LOWER BOUNDS FOR ELECTION IN COMPLETE NETWORKS	50
3.1.	Introduction	50
3.2.	Lower Bounds	51
3.2.1.	Definitions and Assumptions	51
3.2.2.	A Lower Bound on Message Complexity	53
3.2.3.	A Lower Bound on Time Complexity	55
3.3.	Conclusions	57
4.	TRAVERSAL OF UNIDIRECTIONAL NETWORKS	59
4.1.	Introduction	59
4.2.	Traversal-1: a simple traversal algorithm	62
4.3.	Traversal-2: Simulating Directed Depth First Traversal	65
4.3.1.	Bidirectional directed depth first traversal	66
4.3.2.	Unidirectional depth first traversal, using a spanning in- directed tree	71
4.3.3.	On the fly in-tree construction	73
4.4.	Traversal-3: an algorithm for a network of finite automata	78
4.4.1.	Reducing the communication complexity of Traversal-2 to	

$O(n \cdot E + n^2 \cdot \log n)$ bits	79
4.4.2. A finite automata implementation of Traversal-2	82
4.5. Lower Bounds	83
4.6. Applications	84
4.6.1. Producing a spanning out-tree	85
4.6.2. Applications of the traversal algorithm	86
4.6.2.1. Broadcast with Echo	87
4.6.2.2. Messages sending	88
4.6.2.3. Emulating bi-directional distributed algorithms	89
5. ELECTION IN UNIDIRECTIONAL NETWORKS	90
5.1. Introduction	90
5.2. A Unidirectional Election Algorithm	93
5.2.1. Definitions and Outline	93
5.2.2. Selection of a Cluster-Outgoing Link	96
5.2.2.1. Distributed Depth First Traversal of Unidirectional Networks	96
5.2.2.2. Selecting a cluster outgoing link	98
5.2.3. Cycle Detection	99
5.2.4. Cycle Contraction and Cluster Synchronization	100
5.2.4.1. Merging the in-trees	101
5.2.4.2. Acknowledging the broadcast	101
5.2.5. Termination	102
5.3. Complexity of the Election Algorithm	102
5.3.1. Cluster Synchronization Cost	103
5.3.2. Cycle Detection Cost	103
5.3.3. The Cost of Cluster Outgoing Link Selection	104
5.3.3.1. Cluster-Head Election	105
5.4. The Traversal Algorithm as a Special Case of the Election Algorithm	107
5.4.1. Deriving Traversal-2 from the election algorithm	107
5.4.2. Deriving Traversal-3 from the election algorithm	110
5.5. Concluding Remarks	111
References	113