CONTENTS

APPROVAL ii

SELF DECLARATION AGAINST PLAGIARISM iii

ABSTRACT iv

ABSTRAK v

DEDICATION vi

ACKNOWLEDGMENTS vii

PREFACE viii

LIST OF NOTATIONS xvi

1 INTRODUCTION 1

1.1 Background . . . 1
1.2 Problem Identification and Objective . . . 2
1.3 Related Research and Contribution . . . 2
1.4 Scope of Works . . . 3
1.5 Hypothesis . . . 4
1.6 Research Methodology . . . 4
1.7 Writing Systematic . . . 4

2 LITERATURE STUDY 6

2.1 Wireless Sensor Network . . . 6
2.2 Queueing Network Model . . . 7
2.2.1 Single Service Centers . . . 7
2.2.2 Multiple Service Centers . . . 8
2.3 Computational Offloading . . . 8
2.4 Fog Computing . . . 12
2.5 K-means Clustering Algorithm . . . 14
2.6 Calinski-Harabasz Index . . . 16
2.7 ITU-T Recommendation G.114 . . . 16

3 RESEARCH METHODOLOGY **17**
3.1 Description of Proposed Method . . . 17
3.2 Clustering System Design . . . 19
3.3 Offloading System Design . . . 20
3.3.1 Layer Mapping Function . . . 22
3.4 Mathematical Model . . . 23
3.4.1 Network Model . . . 23
3.4.2 Service Delay . . . 24
3.4.3 Propagation and Transmission Delays . . . 25
3.4.4 Processing Delay of IoT Node . . . 25
3.4.5 Average Queue Length . . . 26
3.4.6 Utilization . . . 26
3.4.7 Traffic Queuing Model . . . 26
3.5 Validation . . . 29
3.5.1 Basic Assumption . . . 29
3.5.2 Requests Intergeneration Time . . . 29
3.5.3 Simulation Settings and Input Parameter . . . 29
3.5.4 Simulation Scenario . . . 32

4 PRESENTATION, ANALYSIS AND INTERPRETATION OF DATA **35**
4.1 Threshold Value Consideration . . . 36
4.2 End-to-end Delay Evaluation . . . 36
4.2.1 Controller Queue Average Waiting Time . . . 36
4.2.2 Fog Nodes Queue Average Waiting Time . . . 38
4.2.3 Fog Layer Average End-to-end Delay . . . 41
4.2.4 Offloaded Queue Average Waiting Time & Cloud End-to-end Delay . . . 42
4.2.5 Average Service Time . . . 43
4.2.6 Average End-to-end Delay . . . 44
4.3 Request Evaluation . . . 47
4.3.1 Requests Success Ratio . . . 47
4.3.2 Offloaded Requests . . . 49
4.4 Utilization Evaluation . . . 52
4.5 Summary of Findings . . . 54

5 CONCLUSION AND RECOMMENDATION **55**
5.1 Conclusions . . . 55
5.2 Future Works and Recommendation . . . 55

BIBLIOGRAPHY **57**

Appendices **59**

A MISCELLANEOUS **61**

A.1 Raw Table Results 61

A.2 Threshold Test 61