

CONTENTS

APPROVAL	ii
SELF DECLARATION AGAINST PLAGIARISM	iii
ABSTRACT	iv
ABSTRAK	v
DEDICATION	vi
ACKNOWLEDGMENTS	vii
PREFACE	viii
CONTENTS	ix
LIST OF TABLES	xi
LIST OF FIGURES	xii
LIST OF TERMS	xiii
LIST OF NOTATIONS	xiv
1 INTRODUCTION	1
1.1 Rationale	1
1.2 Theoretical Framework	2
1.3 Conceptual Framework/Paradigm	3
1.3.1 Key Variables Related to the Problem	3
1.3.2 Schematic Diagrams of the Framework	4
1.3.3 Discussion of the Paradigm	5
1.4 Statement of the Problem	5
1.5 Objective and Hypotheses	6
1.6 Assumption	7
1.7 Scope and Delimitation	7
1.8 Significance of the Study	8
2 REVIEW OF LITERATURE AND STUDIES	9
2.1 Related Literatures	9
2.2 Related Studies	11
2.2.1 LoRaWAN	11

2.2.2	Differential Privacy	12
2.2.3	Replay and RF Jamming Attacks	12
2.2.4	Timestamp Validation Mechanisms	13
3	RESEARCH METHODOLOGY	14
3.1	Research Design	14
3.1.1	System/Product/Method Implementation	14
3.1.2	Experiment Scenario	19
3.1.3	Interpretation of Measurements	23
3.1.4	Validity and Reliability	23
3.2	Tools for Data Analysis	24
4	PRESENTATION, ANALYSIS AND INTERPRETATION OF DATA	25
4.1	Presentation of Data	25
4.2	Analysis of the Data	27
4.2.1	Security Analysis	27
4.2.2	Time Analysis	29
4.2.3	Correlation	30
4.2.4	Differences of Measures	30
4.2.5	Interpretation of Data	30
4.3	Summary of Findings	31
5	CONCLUSION AND RECOMMENDATIONS	32
5.1	Conclusions	32
5.2	Recommendations	32
	BIBLIOGRAPHY	34
	Appendices	35
A	MISCELLANEOUS	37
A.1	Equation #examples	37
A.2	Figure #examples	37
A.3	Table #examples	38
B	Curriculum Vitae # Example	44

LIST OF TABLES

4.1 Execution Time Comparison with Payload Size	26
A.1 Example of Tables	38
A.2 Iris flower data set #Example of longtable	39

LIST OF FIGURES

1.1	LoRaWAN Framework: Interaction between End Devices, Gateways, and the Network Server.	4
2.1	Key Derivation from ECDH Shared Secret	10
2.2	LoRaWAN Join Procedure: The process of Over-the-Air Activation (OTAA) in normal operation.	11
2.3	Differential Privacy	12
2.4	Jamming and Replay attack on OTAA Join-Request.	12
3.1	Attack scenario depicting selective RF jamming and replay attacks in the LoRaWAN join procedure.	16
3.2	Truncated Laplace Time Perturbation (TDP) model applied to timestamps in the LoRaWAN join procedure.	18
3.3	Experiment Simulation System Architecture and Technology Stack.	21
3.4	LoRaWAN Join Procedure Process Flow on Simulation Experiment.	22
3.5	Experiment Simulation Join-Request Attack on Chirpstack Environment.	23
4.1	Threshold Impact on Join Request Validation Success.	27
4.2	Log Evidence Before Implementing Time Validation	28
4.3	Log Evidence of Invalid Join Request After Validation on Replay Attack.	29
4.4	Log Evidence of Legitimate Join Requests Being Accepted After Validation	29
4.5	Execution Time Comparison	29
A.1	Picture of mary elizabeth winstead	38
A.2	Example of block diagram.	38