

CONTENTS

ENDORSEMENT LETTER

STATEMENT OF ORIGINALITY

ABSTRACT	iv
-----------------	-----------

THANK YOU NOTE	v
-----------------------	----------

Preface	vi
----------------	-----------

Contents	vii
-----------------	------------

List of Figures	x
------------------------	----------

List of Tables	xii
-----------------------	------------

LIST OF ABBREVIATIONS	xiii
------------------------------	-------------

I INTRODUCTION	1
-----------------------	----------

1.1 Background	1
1.2 Formulation of Problem	2
1.3 Purpose of Research	2
1.4 Scope of Problem	2
1.5 Research Method	3
1.6 Thesis Organization	3

II BASIC CONCEPT	4
-------------------------	----------

2.1 Internet of Things (IoT)	4
2.2 Bluetooth	4
2.2.1 Bluetooth Protocol Stacks	5
2.2.1.1 The Baseband Layer	5
2.2.1.2 The Link Controller and Link Manager	6
2.2.1.3 The HCI Interface	7
2.2.1.4 The L2CAP Layer	7
2.2.1.5 The Service Discovery Protocol	7
2.2.1.6 The RFCOMM Layer	8

2.3	Bluetooth Low Energy (BLE)	8
2.3.1	BLE Protocol Stack	9
2.3.1.1	Host Protocol	9
2.3.1.2	Controller Protocol	10
2.3.1.3	Security System of BLE	11
2.4	Authentication Security System	13
2.4.1	Token-Based Authentication	13
2.4.2	Token-Based Authentication on Bluetooth Low Energy	14
2.5	Packet Sniffing	15
2.5.1	Bluetooth Packet Sniffing	16
III TOKEN AUTHENTICATION MECHANISM FOR BLUETOOTH LOW ENERGY (BLE) NETWORKS		17
3.1	Design System	17
3.1.1	Temperature Sensor System Design	18
3.1.2	Token Authentication Mechanism for BLE based Temperature Sensor System Design	19
3.1.3	Token Authentication Testing with Packet Sniffing	20
3.2	Tools Specification	21
3.2.1	Hardware	21
3.2.2	Software	25
3.3	Implementation of The System	28
3.3.1	Testing Scenario	29
3.3.2	Temperature Sensor Configuration	30
3.3.3	Ubertooth ONE Configuration	31
3.3.4	Application Interface	33
3.4	Calibration Data Aggregation	35
3.4.1	Throughput	35
3.4.2	Delay	35
3.4.3	Jitter	36
IV EVALUATION		37
4.1	Capturing Process	37
4.2	Connectivity Analysis	40
4.3	Throughput, Delay, and Jitter Analysis	43
4.4	Authentication Analysis	44
4.5	Device Capabilities Analysis	51
4.5.1	Room Temperature	51

4.5.2	Body Temperature	54
4.5.3	Extreme Temperature	56
V	CONCLUSION	60
5.1	Conclusions	60
5.2	Suggestions	60
	Bibliography	62
	APPENDIX	1
A	TABLE RESULTS OF EXPERIMENT	1
B	CODING	3
C	IMAGE RESULTS OF EXPERIMENT	1