UNIVERSITAS
GADJAH MADA
Verifikasi Integritas Firmware ESP32 Secara Terdesentralisasi Berbasis Smart Contract DChain
Brian Ilham Hermatristan, Triyogatama Wahyu Widodo, M.Kom
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

TABLE OF CONTENTS

PAGE OF CONSENT UNDERGRADUATE THESIS III
DECLARATION OF NON-PLAGIARISM IV
PREFACE V
TABLE OF CONTENTS VI
LIST OF FIGURES IX
LIST OF TABLES X
INTISARI XI
ABSTRACT XII
CHAPTER I 1
1.1 Background 1
1.2 Problem Statement 3
1.3 Scope of the Problem 4
1.4 Research Objectives 5
1.5 Research Benefits 6
A. Academic Benefits 6
B. Practical Benefits 6
1.6 Writing Systematics 6
CHAPTER II LITERATURE REVIEW 8
CHAPTER III 13
3.1 Research Stages 13
3.2 System Analysis and Architecture Design 15
3.2.2 Three-Tier Architecture Design 16
3.2.3 Data Flow and Communication Protocol 17
3.2.4 Component-Level Design Flowcharts 18
3.3 Theoretical Background 20
3.3.1 Firmware Integrity and the Single Point of Failure Problem 20
3.3.2 ESP32 Security Primitives and Cryptographic Hashing 21
3.3.3 Blockchain, Smart Contracts, and EVM-Compatible Networks 21
3.3.4 The Gateway Model and Verification Latency 22
3.4 Testing and Data Collection Methodology 23
3.4.1 Integrity Testing (Effectiveness) 23
3.4.2 Performance Testing (Latency) 23

UNIVERSITAS
GADJAH MADA
Verifikasi Integritas Firmware ESP32 Secara Terdesentralisasi Berbasis Smart Contract DChain
Brian Ilham Hermatristan, Triyogatama Wahyu Widodo, M.Kom
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

3.4.3 Smart Contract Unit Testing 24
3.4.4 Fail-Safe Mechanism Validation 25
3.4.5 End-to-End Mainnet Validation 25
CHAPTER IV IMPLEMENTATION 27
4.1 Tools, Materials, and Implementation Procedures 27
4.1.1 Hardware and Software 27
4.1.2 Implementation Procedure Overview 28
4.2 Smart Contract Implementation 29
4.2.1 Contract Development and Compilation 29
4.2.2 Unit Testing 32
4.2.3 Deployment to dChain Mainnet 33
4.3 Gateway Server Implementation 35
4.3.1 Server Architecture and REST API 35
4.3.2 Blockchain Integration via Web3.js 37
4.3.3 On-Chain Verification Logging 38
4.4 ESP32 Firmware Implementation 39
4.4.1 WiFi Connectivity 39
4.4.2 Firmware Hash Calculation 40
4.4.3 HTTP Communication with Gateway 40
4.4.4 Boot Decision and Fail-Safe Mechanism 41
CHAPTER V RESULTS AND DISCUSSION 44
5.1 Smart Contract Testing Results 44
5.2 Functional Verification Testing 45
5.2.1 Positive Test Results (Genuine Firmware) 45
0xa40f250435e4a94205013bbc6dc3436823bc86054533e8eb6c4bc8752b264845 45
5.2.2 Negative Test Results (Tampered Firmware) 46
5.3 Fail-Safe Mechanism Validation 47
5.4 Verification Latency Analysis 48
5.4.1 Ideal Network Condition 48
5.4.2 Degraded Network Condition 49
5.4.3 Comparative Analysis 50
5.4.4 Comparative Analysis to Centralized Architecture 52
5.5 End-to-End System Validation on dChain Mainnet 52
5.6 SPOF Elimination Analysis 55
CHAPTER VI 57
CONCLUSION 57
6.1 Conclusion 57

UNIVERSITAS
GADJAH MADA
Verifikasi Integritas Firmware ESP32 Secara Terdesentralisasi Berbasis Smart Contract DChain
Brian Ilham Hermatristan, Triyogatama Wahyu Widodo, M.Kom
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

6.2 Suggestions 58
6.3 Limitations 59
REFERENCE 62