

# Contents

## Preface — V

<b>1</b>	<b>Introduction to Cryptography — 1</b>
1.1	Cryptography — 1
1.1.1	Branches of Cryptology — 1
1.1.1.1	Introduction — 1
1.1.1.2	Cryptology — 1
1.1.1.3	Cryptography — 1
1.1.1.4	Encryption — 2
1.1.1.5	Decryption — 3
1.1.1.6	Cryptographic Key — 3
1.1.1.7	Cryptographic Protocol — 3
1.1.1.8	Cryptanalysis — 3
1.1.1.9	Cryptanalyst — 4
1.1.2	Cryptographic Design Principles — 4
1.1.2.1	Confusion — 4
1.1.2.2	Diffusion — 4
1.1.2.3	Avalanche Effect — 4
1.1.2.4	Random Oracle — 5
1.1.2.5	Kerckhoffs' Principle — 5
1.1.3	Symmetric Cryptography — 5
1.1.3.1	Secret Key — 5
1.1.3.2	Number of Keys — 5
1.1.4	Asymmetric Cryptography — 6
1.1.4.1	Key Pair for Asymmetric Cryptography — 6
1.1.4.2	Private Key — 6
1.1.4.3	Public Key — 6
1.1.4.4	Asymmetric Encryption — 7
1.1.4.5	Digital Signatures — 8
1.1.4.6	Combination of Encryption and Digital Signatures — 8
1.1.4.7	Man-in-the-Middle Attack — 8
1.1.4.8	Digital Certificate — 10
1.2	One-Way Hash Function — 11
1.2.1	Characteristics — 11
1.2.2	Hash Functions in Practice — 12
1.3	Block Cipher — 12
1.3.1	Construction — 12
1.3.2	Padding — 13
1.3.3	Block Ciphers in Practice — 13
1.3.3.1	Advanced Encryption Standard — 13

- 1.3.3.2 Lightweight Cipher PRESENT — 16
- 1.4 Block Cipher Modes of Operations — 18
  - 1.4.1 ECB Mode — 19
  - 1.4.2 CBC Mode — 19
- 1.5 Bit Stream Ciphers — 20
- 1.6 Message Authentication Codes — 21
  - 1.6.1 Authentication — 21
  - 1.6.2 MAC Generation Using a Symmetric Block Cipher — 23
  - 1.6.3 MAC Generation Using a Dedicated Hash Function — 23
  - 1.6.4 Security Aspects of MAC — 24
- 1.7 Digital Signatures — 25
  - 1.7.1 Digital Signatures with Appendix — 25
  - 1.7.2 Digital Signatures with Message Recovery — 26
  - 1.7.3 RSA Algorithm — 26
  - 1.7.4 Digital Signature Algorithm — 29
  - 1.7.5 Elliptic Curve Cryptography — 30
- References — 35
  
- 2 Threat Analysis and Risk Assessment — 37**
  - 2.1 Background — 37
    - 2.1.1 Software in Automotive — 37
    - 2.1.2 Threat Model — 38
    - 2.1.3 Threat Analysis — 38
  - 2.2 Threat Analysis and Risk Assessment in Automotive — 39
    - 2.2.1 Security Analysis Methodologies — 39
    - 2.2.2 HEAVENS Project Approach — 40
      - 2.2.2.1 Threat-Level Parameters — 41
      - 2.2.2.2 Impact-Level Parameters — 43
  - 2.3 Case Study: Advanced Driver Assistance System — 45
    - 2.3.1 System Background — 45
    - 2.3.2 Vehicular Architecture — 46
    - 2.3.3 Important Elements of the System — 46
    - 2.3.4 Threat Identification — 50
    - 2.3.5 Risk Assessment — 50
      - 2.3.5.1 Automated Parking via Bluetooth — 51
      - 2.3.5.2 Remote Access – Mobile Communications — 52
      - 2.3.5.3 Remote Access – Wi-Fi — 53
      - 2.3.5.4 Radar Spoofing — 54
      - 2.3.5.5 Reflashing ADAS ECU through Physical Access — 56
      - 2.3.5.6 Summary — 57
      - 2.3.5.7 Security Requirements — 58
    - References — 59

- 3 Machine Learning — 61**
  - 3.1 Machine Learning Categories — 61
  - 3.1.2 Supervised Machine Learning — 63
    - 3.1.2.1 Linear Regression — 64
    - 3.1.2.2 Logistic Regression — 64
    - 3.1.2.3 Support Vector Machines and Support Vector Regression — 65
    - 3.1.2.4 Decision Trees — 66
    - 3.1.2.5 Random Forests — 67
    - 3.1.2.6 Naïve Bayes — 67
    - 3.1.2.7 Artificial Neural Networks — 68
    - 3.1.2.8 Bootstrap Aggregating (Bagging) and Boosting — 70
    - 3.1.2.9 Stacked Aggregating — 71
  - 3.1.3 Unsupervised Machine Learning — 71
    - 3.1.3.1 Clustering Algorithms — 72
    - References — 84
  
- 4 Machine Learning for Anomaly Detection — 87**
  - 4.1 Intrusion Detection Systems — 87
    - 4.1.1 Overview and Categorization — 87
    - 4.1.2 Categorization and Properties of ML Techniques in Intrusion Detection Systems — 89
    - 4.1.3 Security Levels of Intrusion Detection Systems — 91
    - 4.1.4 ML-Based Anomaly Detection — 92
    - 4.1.5 Cyberattacks on ML-Based Intrusion Detection Systems — 99
      - 4.1.5.1 Use of GAN Technology for Targeted Circumvention of Protection Systems — 102
    - 4.1.6 Use of IDS for Automotive CAN — 105
      - 4.1.6.1 CAN Bus Architecture — 106
      - 4.1.6.2 CAN Bus Vulnerabilities and Possible Attacks — 115
      - 4.1.6.3 Security Solutions for CAN Bus — 121
      - References — 131
  
- 5 Distributed Ledger Technologies — 137**
  - 5.1 Introduction — 137
  - 5.2 Cryptocurrencies — 139
  - 5.3 Blockchain — 141
    - 5.3.1 Proof of Work — 147
    - 5.3.2 Bitcoin Vulnerabilities and Handling of Issues — 150
    - 5.3.3 Other Blockchain Cryptocurrencies — 153
  - 5.4 Tangle — 154
    - 5.4.1 IOTA Bundle — 160
  - 5.5 Hashgraph — 163

- 5.6 DLT Applications in Autonomous Driving — **180**
- 5.6.1 Financial Sector — **181**
- 5.6.2 Other Sectors — **181**
- 5.6.3 Tracking Supply Chains — **182**
- 5.6.4 Autonomous Driving Systems — **182**
- 5.6.5 Vehicle Lock/Unlock — **183**
- 5.6.6 Payments Related to Cars — **184**
- 5.6.7 Ridesharing of Autonomous Cars — **184**
- 5.6.8 Unadulterated Reading of Mileage — **185**
- 5.6.9 Motivating Ecologically Responsible Driving — **185**
- 5.6.10 Reservation of Parking Places — **186**
- 5.6.11 Avoiding Traffic Obstacles — **186**
- 5.6.12 Data Exchange for Digital Twin Synchronization — **186**
- 5.6.13 Registering and Management of Serial Numbers — **187**
- 5.6.14 Registries as the Digital Proof of Ownership — **187**
- 5.6.15 Software and Documents Release Management — **188**
- References — **188**
  
- 6 Self-Correcting and Authentication Algorithm for Automotive Applications — 190**
- 6.1 Self-Learning Algorithms — **190**
- 6.2 Related Work — **191**
- 6.3 Error Correction Codes — **193**
- 6.3.1 RS codes — **194**
- 6.3.2 Turbo Codes — **194**
- 6.3.3 Low Density Parity Check Codes — **195**
- 6.4 Two-Phase Self-Correcting Algorithm — **195**
- 6.4.1 Phase-I — **196**
- 6.4.2 Phase-II — **197**
- 6.5 Learning Property — **199**
- 6.6 Security Analysis — **200**
- 6.7 Simulation Results — **202**
- References — **206**