Contents

List of Figures
List of Tables
List of Algorithm
List of Abbreviations

Chapter 1. Introduction
1.1 MANETs and its vulnerabilities 1
1.2 Packet dropping attack: its remedies & mitigation 4
1.3 Motivation 7
1.4 Objective 9
1.5 Thesis outline 11

Chapter 2. Literature Review and General Discussion
2.1 Introduction to MANETs 14
2.1.1 Characteristics 14
2.1.2 Routing in MANETs 16
2.1.3 Routing Protocols 18
2.1.4 Mobility Model 20
2.1.4.1 Random Model 21
2.1.4.1.1 Random Waypoint Model 22
2.1.4.2 Levy Walk Model 23
2.1.4.3 Model with Temporal Dependency 24
2.1.4.3.1 Gauss Markov Mobility Model 25
2.1.4.4 Model with Spatial Dependency 25
2.1.4.4.1 Reference Point Group Model 25
2.1.4.5 Model with Geographic Restriction 26
2.1.4.5.1 Pathway Mobility Model 26
2.1.5 Security Issues 27
2.1.5.1 Introduction 27
2.1.5.2 Types of Attack in MANETs 28
2.1.5.3 Security Goals 32
2.1.5.4 Vulnerabilities in Existing Protocol 32
2.1.5.5 Security Mechanism 34
2.1.5.6 Secure Routing Protocol 35
   2.1.5.6.1 SAODV 37
   2.1.5.6.2 TAODV 38
   2.1.5.6.3 OCEAN 41
2.2 Packet Dropping Attack in MANETs 43
   2.2.1 Types of Packet Dropping Attack 44
      2.2.1.1 Selective Packet Dropping Attack 44
      2.2.1.2 Malicious Packet Dropping Attack 45
   2.2.2 Mitigation of Impact of Packet Dropping Attack in MANETs
      2.2.2.1 Selfish Node Mitigation 46
      2.2.2.2 Malicious Node Mitigation 47
2.3 PDA Detection Methodology 48
   2.3.1 Categories of PDA Detection Methodology 49
   2.3.2 Existing Detection Methodologies 53
   2.3.3 Desirable Properties of Detection Methodology 55
2.4 Game Theoretic Approach 56
   2.4.1 Introduction 56
   2.4.2 Game Theoretic Approach to PDA Detection in MANETs 58
      2.4.3 Equilibrium Concept 59
      2.4.4 Nash Equilibrium 59
2.5 Summary 60

Chapter 3. Centralized PDA Detection
3.1 Introduction 61
3.2 The Architecture 62
   3.2.1 Assumption 62
3.2.2 System Model
3.2.3 Proposed Methodology
3.2.4 Performance Parameters

3.3 Performance Evaluation

3.3.1 Centralized PDA Detection vs. AODV (RWP)

3.3.1.1 Detection Rate
- Effect of Percentage of Malicious Node
- Effect of Node Mobility
- Effect of Pause Time

3.3.1.2 False Positive Rate
- Effect of Percentage of Malicious Node
- Effect of Node Mobility
- Effect of Pause Time

3.3.1.3 Throughput Analysis
- Effect of Percentage of Malicious Node
- Effect of Node Mobility
- Effect of Pause Time

3.3.1.4 Packet Delivery Ratio Analysis
- Effect of Percentage of Malicious Node
- Effect of Node Mobility
- Effect of Pause Time

3.3.1.5 Normalized Routing Load Analysis
- Effect of Percentage of Malicious Node
- Effect of Node Mobility
- Effect of Pause Time

3.3.1.6 End-to-end Delay Analysis
- Effect of Percentage of Malicious Node
- Effect of Node Mobility
- Effect of Pause Time

3.3.1.7 Round Trip Time Analysis
- Effect of Percentage of Malicious Node
- Effect of Node Mobility
3.3.2 Centralized PDA Detection vs. AODV (LWM) 83

3.3.2.1 Detection Rate 84
Effect of Percentage of Malicious Node
Effect of Node Mobility
Effect of Pause Time

3.3.2.2 False Positive Rate 86
Effect of Percentage of Malicious Node
Effect of Node Mobility
Effect of Pause Time

3.3.2.3 Throughput Analysis 88
Effect of Percentage of Malicious Node
Effect of Node Mobility
Effect of Pause Time

3.3.2.4 Packet Delivery Ratio Analysis 90
Effect of Percentage of Malicious Node
Effect of Node Mobility
Effect of Pause Time

3.3.2.5 Normalized Routing Load Analysis 92
Effect of Percentage of Malicious Node
Effect of Node Mobility
Effect of Pause Time

3.3.2.6 End-to-end Delay Analysis 94
Effect of Percentage of Malicious Node
Effect of Node Mobility
Effect of Pause Time

3.3.2.7 Round Trip Time Analysis 96
Effect of Percentage of Malicious Node
Effect of Node Mobility
Effect of Pause Time

3.4 Discussion 98
Chapter 4. Distributed PDA Detection

4.1 Introduction 101
4.2 The Architecture of NAODV 101
  4.2.1 Assumption 101
  4.2.2 System Model 103
  4.2.3 Algorithm of the Proposed System (NAODV) 105
  4.2.4 Performance Parameters 110
4.3 Multi Agent System for Proposed Methodology 110
  4.3.1 Introduction 110
  4.3.2 Multi Agent Architecture 111
  4.3.3 Collaboration-Multi Agent System 112
4.4 Performance Evaluation of the Detection Mechanism 113
  4.4.1 NAODV using Random Way Point Model 113
    4.4.1.1 Detection Rate (NAODV, SAODV, TAODV) 114
      Effect of Percentage of Malicious Node
      Effect of Node Mobility
      Effect of Pause Time
    4.4.1.2 False Positive Rate (NAODV, SAODV, TAODV) 115
      Effect of Percentage of Malicious Node
      Effect of Node Mobility
      Effect of Pause Time
    4.4.1.3 Throughput Analysis (NAODV, SAODV, TAODV) 117
      Effect of Percentage of Malicious Node
      Effect of Node Mobility
      Effect of Pause Time
    4.4.1.4 Packet Delivery Ratio Analysis (NAODV, SAODV, TAODV) 118
      Effect of Percentage of Malicious Node
      Effect of Node Mobility
      Effect of Pause Time
    4.4.1.5 Normalized Routing Load Analysis 120
Effect of Percentage of Malicious Node
Effect of Node Mobility
Effect of Pause Time

4.4.1.6 End-to-end Delay Analysis 122

Effect of Percentage of Malicious Node
Effect of Node Mobility
Effect of Pause Time

4.4.1.7 Round Trip Time Analysis 124

Effect of Percentage of Malicious Node
Effect of Node Mobility
Effect of Pause Time

4.4.2 NAODV using Levy Walk Model 126

4.4.2.1 Detection Rate (NAODV, SAODV, TAODV) 126

Effect of Percentage of Malicious Node
Effect of Node Mobility
Effect of Pause Time

4.4.2.2 False Positive Rate (NAODV, SAODV, TAODV) 128

Effect of Percentage of Malicious Node
Effect of Node Mobility
Effect of Pause Time

4.4.2.3 Throughput Analysis 130

Effect of Percentage of Malicious Node
Effect of Node Mobility
Effect of Pause Time

4.4.2.4 Packet Delivery Ratio Analysis 131

Effect of Percentage of Malicious Node
Effect of Node Mobility
Chapter 5. Game Theoretic Approach

5.1 Introduction 141
5.2 Game Model 143
5.3 The Proposed Framework 144
5.4 Design of Utility Function 145
5.5 Coalition Stability 146
5.6 Definition of Pareto Order 146
5.7 Coalition Rule 146
5.8 Stability Condition 147
5.9 Simulation and Results 148
5.10 Discussion 152

Chapter 6. Conclusion and Future Work

6.1 Conclusion 153
6.1.1 Centralized PDA Detection 153
6.1.2 Distributed PDA Detection 154
6.1.3 Game Theoretic Approach

6.2 Future Research Direction

Appendix-A  Network Simulator 2
  A.1 Introduction
  A.2 NS 2 for Wireless Network
  A.3 Running A New Routing Protocol

Appendix-B  Decision tree algorithm – ID5R
  B.1 Introduction
    B.1.1 Introduction to ID5R
    B.1.2 Algorithm of ID5R

Appendix-C  Protocol structure for SAODV and TAODV

Bibliography

Publication