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  
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  46  
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 62
3.2.3 Proposed Methodology 64
3.2.4 Performance Parameters 67
3.3 Performance Evaluation 68

3.3.1 Centralized PDA Detection vs. AODV (RWP) 68

3.3.1.1 Detection Rate 69
  Effect of Percentage of Malicious Node
  Effect of Node Mobility
  Effect of Pause Time

3.3.1.2 False Positive Rate 71
  Effect of Percentage of Malicious Node
  Effect of Node Mobility
  Effect of Pause Time

3.3.1.3 Throughput Analysis 73
  Effect of Percentage of Malicious Node
  Effect of Node Mobility
  Effect of Pause Time

3.3.1.4 Packet Delivery Ratio Analysis 75
  Effect of Percentage of Malicious Node
  Effect of Node Mobility
  Effect of Pause Time

3.3.1.5 Normalized Routing Load Analysis 77
  Effect of Percentage of Malicious Node
  Effect of Node Mobility
  Effect of Pause Time

3.3.1.6 End-to-end Delay Analysis 79
  Effect of Percentage of Malicious Node
  Effect of Node Mobility
  Effect of Pause Time

3.3.1.7 Round Trip Time Analysis 81
  Effect of Percentage of Malicious Node
Effect of Node Mobility
Effect of Pause Time

3.3.2 Centralized PDA Detection vs. AODV (LWM)  
3.3.2.1 Detection Rate  
Effect of Percentage of Malicious Node  
Effect of Node Mobility  
Effect of Pause Time  
3.3.2.2 False Positive Rate  
Effect of Percentage of Malicious Node  
Effect of Node Mobility  
Effect of Pause Time  
3.3.2.3 Throughput Analysis  
Effect of Percentage of Malicious Node  
Effect of Node Mobility  
Effect of Pause Time  
3.3.2.4 Packet Delivery Ratio Analysis  
Effect of Percentage of Malicious Node  
Effect of Node Mobility  
Effect of Pause Time  
3.3.2.5 Normalized Routing Load Analysis  
Effect of Percentage of Malicious Node  
Effect of Node Mobility  
Effect of Pause Time  
3.3.2.6 End-to-end Delay Analysis  
Effect of Percentage of Malicious Node  
Effect of Node Mobility  
Effect of Pause Time  
3.3.2.7 Round Trip Time Analysis  
Effect of Percentage of Malicious Node  
Effect of Node Mobility  
Effect of Pause Time
Chapter 4. Distributed PDA Detection

4.1 Introduction

4.2 The Architecture of NAODV

4.2.1 Assumption

4.2.2 System Model

4.2.3 Algorithm of the Proposed System (NAODV)

4.2.4 Performance Parameters

4.3 Multi Agent System for Proposed Methodology

4.3.1 Introduction

4.3.2 Multi Agent Architecture

4.3.3 Collaboration-Multi Agent System

4.4 Performance Evaluation of the Detection Mechanism

4.4.1 NAODV using Random Way Point Model

4.4.1.1 Detection Rate (NAODV, SAODV, TAODV)

Effect of Percentage of Malicious Node

Effect of Node Mobility

Effect of Pause Time

4.4.1.2 False Positive Rate (NAODV, SAODV, TAODV)

Effect of Percentage of Malicious Node

Effect of Node Mobility

Effect of Pause Time

4.4.1.3 Throughput Analysis (NAODV, SAODV, TAODV)

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)

Effect of Percentage of Malicious Node

Effect of Node Mobility

Effect of Pause Time
4.4.1.5 Normalized Routing Load Analysis (NAODV, SAODV, TAODV) Effect of Percentage of Malicious Node Effect of Node Mobility Effect of Pause Time

4.4.1.6 End-to-end Delay Analysis (NAODV, SAODV, TAODV) Effect of Percentage of Malicious Node Effect of Node Mobility Effect of Pause Time

4.4.1.7 Round Trip Time Analysis (NAODV, SAODV, TAODV) Effect of Percentage of Malicious Node Effect of Node Mobility Effect of Pause Time

4.4.2 NAODV using Levy Walk Model

4.4.2.1 Detection Rate (NAODV, SAODV, TAODV) Effect of Percentage of Malicious Node Effect of Node Mobility Effect of Pause Time

4.4.2.2 False Positive Rate (NAODV, SAODV, TAODV) Effect of Percentage of Malicious Node Effect of Node Mobility Effect of Pause Time

4.4.2.3 Throughput Analysis (NAODV, SAODV, TAODV) Effect of Percentage of Malicious Node Effect of Node Mobility Effect of Pause Time

4.4.2.4 Packet Delivery Ratio Analysis (NAODV, SAODV, TAODV) Effect of Percentage of Malicious Node
Effect of Node Mobility
Effect of Pause Time

4.4.2.5 Normalized Routing Load Analysis
(NAODV, SAODV, TAODV)
Effect of Percentage of Malicious Node
Effect of Node Mobility
Effect of Pause Time

4.4.2.6 End-to-end Delay Analysis
(NAODV, SAODV, TAODV)
Effect of Percentage of Malicious Node
Effect of Node Mobility
Effect of Pause Time

4.4.2.7 Round Trip Time Analysis
(NAODV, SAODV, TAODV)
Effect of Percentage of Malicious Node
Effect of Node Mobility
Effect of Pause Time

4.5 Discussion

Chapter 5. Game Theoretic Approach

5.1 Introduction
5.2 Game Model
5.3 The Proposed Framework
5.4 Design of Utility Function
5.5 Coalition Stability
5.6 Definition of Pareto Order
5.7 Coalition Rule
5.8 Stability Condition
5.9 Simulation and Results
5.10 Discussion

Chapter 6. Conclusion and Future Work

6.1 Conclusion
6.1.1 Centralized PDA Detection
6.1.2  Distributed PDA Detection 154
6.1.3  Game Theoretic Approach 154
6.2  Future Research Direction 155

Appendix-A  Network Simulator 2 156
  A.1  Introduction 156
  A.2  NS 2 for Wireless Network 158
  A.3  Running A New Routing Protocol 160

Appendix-B  Decision tree algorithm – ID5R 163
  B.1  Introduction 163
    B.1.1  Introduction to ID5R 163
    B.1.2  Algorithm of ID5R 164

Appendix-C  Protocol structure for SAODV and TAODV 166

Bibliography 171
Publication 195