

**THE EFFECT OF EAVESDROPPING AND WORMHOLE ATTACKS
ON MOBILE AD HOC NETWORK**

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By

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ABSTRACT

Security has become the main concern to grant protected communication between mobile nodes in an unfriendly environment. Wireless Ad Hoc network might be unprotected against attacks by malicious nodes. This project evaluates the impact of some adversary attacks on mobile Ad Hoc network system (MANET's) which have been tested using QualNet simulator. Moreover, it investigates the active and passive attack on mobile Ad Hoc network. At the same time, it measures the performance of MANET with and without these attacks. The simulation is done on data link layer and network layer of mobile nodes in wireless Ad Hoc network. The results of this evaluation are very important to estimate the deployment of the Mobile Ad Hoc nodes for security. Moreover, this study has been analyzed the performance of MANET and perform "what-if" analyses to optimize them.

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Nadher Mohammed A. Al-Safwani

DEDICATION

I would like to dedicate this thesis to my father and mother,
wife, brothers, and sisters who lovely encouraged
and support me through all my study
The motivation for all I do.

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LIST OF ABBREVIATIONS

AODV	Ad Hoc on demand Distance Vector
CBR	Constant Bit Rate
DoS	Denial of Service
FTP	File Transfer Protocol
ICMP	Internet Control Message Protocol
IETF	Internet Engineering Task Force
IP	Internet Protocol
MAC	Medium Access control
MANET	Mobile Ad Hoc Network
NS	Network Simulation
SNT	Scalable Network Technologies
SYN	Synchronize
TCP	Transmission Control Protocol
UDP	User Data Protocol
WLAN	Wide Local Area Network

CHAPTER ONE

INTRODUCTION

1.1 Background

The wireless arena has been growing exponentially in past few decades. We have seen a great advances in network infrastructures as growing availability of wireless applications and the emergence of universal wireless devices like laptops ,PDA ,and cell phone (Papaleo, 2007). Nowadays, mobile users can rely on cellular phone to check emails and browse the internet. For example ,travelers with laptop can use the internet anytime and anywhere (Basagni, Conti, & Giordano, 2004). In the next generation of wireless communication systems, there will be a need for the fast deployment of independent mobile users. Important examples include establishing survivable, efficient, dynamic communication for emergency operations, disaster recovery, and military networks. Such network scenarios cannot rely on centralized and organized connectivity.

There are currently two kinds of mobile wireless networks. The first type is known as infrastructured networks with fixed and wired gateways. Typical applications of this type of “one-hop” wireless network include wireless local area networks (WLANs). The second type of mobile wireless network is infrastructureless mobile network commonly known as the Ad Hoc network or wireless Ad Hoc network (Jin & Jin, 2008).

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REFERENCES

- Anguswamy, R., Thiagarajan, M., & H.Dagli, C. (2008). Systems Methodology and Framework for problem definition in Mobile ad hoc networks.
- Anjum, F., & Mouchtaris, P. (2007). security for Wireless Ad Hoc security
- Basagni, S., Conti, M., & Giordano, S. (2004). Mobile Ad Hoc Networking.
- Bianchi, A., & Pizzutilo, S. (2008). A Tool for Modeling and Simulating Mobile Ad-hoc Networks.
- Bye, R., Schmidt, s., Luther, k., & Albayrak, s. (2008). Application-Level simulation for network security
- Caballero, E. J. (2006). Vulnerabilities of Intrusion Detection Systems in Mobile Ad-hoc Networks - The routing problem.
- Caro, G. A. D. (2003). Analysis of simulation environments for mobile ad hoc networks.
- Carrillo, L., Marzo, J. L., VILÀ, P., & VILÀ, P. (2004). MAntS-Hoc: A Multi-agent Ant-based System for Routing in Mobile Ad Hoc Networks.
- Çayırıcı, E., & Rong, C. (2009). Security in Wireless Ad Hoc and Sensor Networks.
- CCapkun, S., Hubaux, J. P., & Buttya'n, L. (2006). Mobility Helps Peer-to-Peer Security.
- Chan, H., & Perrig, A. (2003). Security and Privacy in Sensor Networks.
- Choi, S., Kim, D.-y., Lee, D.-h., & Jung, J.-i. (2008). WAP:Wormhole Attack Prevention Algorithm in Mobile Ad Hoc Networks.
- Demetrios, Z.-Y. (2001). A Glance at Quality of Services in Mobile Ad-Hoc Networks.
- djenouri, D., khelladi, L., & Badache, N. (2005). A Survey of Security Issues in Mobile Ad Hoc and Sensor Networks.

- Erciyes, K., Dagdeviren, O., & Cokuslu, D. (2006). Modeling and Simulation of Wireless sensor and Mobile Ad Hoc Networks
- Garrido, P. P., Malumbres, M. P., & Calafate, C. T. (2007). EVALUATION OF 802.11E MODELS UNDER NS-2 AND OPNET MODELER SIMULATION TOOLS IN MANET NETWORKS
- Garrido, P. P., Malumbres, M. P., & Calafate, C. T. (2008). ns-2 vs. OPNET: a comparative study of the IEEE 802.11e technology on MANET environments.
- Ghaffari, A. (2006). Vulnerability and Security of Mobile Ad hoc Networks.
- Hogie, L. (2007). Mobile Ad Hoc Networks: Modelling, Simulation and Broadcast-based Applications.
- Hu, Y., Perrig, A., & Johnson, D. B. (2002). Ariadne: A Secure OnDemand Routing Protocol for Ad Hoc Networks.
- Jin, C., & Jin, S.-W. (2008). Invulnerability Assessment for Mobile Ad Hoc Networks.
- Johston, D., & Walker, J. (2004). Overview of IEEE 802.16 security.
- Kargl, F., & Schoch, E. (2007). Simulation of MANETs: A Qualitative Comparison between JiST/SWANS and ns-2.
- Karlof, C., & Wagner, D. (2003). Secure Routing in Wireless Sensor Networks: Attacks and Countermeasures.
- Kurkowski, S., Camp, T., & Colagrosso, M. (2005). MANET Simulation Studies: The Incredibles.
- Lin, X.-H., Kwok, Y.-K., & Lau, V. K. N. (2003). Power Control for IEEE 802.11 Ad Hoc Networks: Issues and A New Algorithm.
- Liu, J., Fu, F., Xiao, J., & Lu, Y. (2007). Secure Routing for Mobile Ad Hoc Networks.

- Michiardi, P., & Molva, R. (2002). Simulation-based Analysis of Security Exposures in Mobile Ad Hoc Networks.
- Mishra, A. (2008). Security and Quality of service in Ad hoc wireless Networks.
- Mishra, A., Nadkarni, K., Patcha, A., & Tech, V. (2004). Intrusion Detection in Wireless Ad Hoc Networks.
- Ning, P., & Sun, K. (2003). How to Misuse AODV: A Case Study of Insider Attacks against Mobile Ad-Hoc Routing Protocols.
- Otrok, H., Paquet, J., Debbabi, M., & Bhattacharya, P. (2007). Testing Intrusion Detection Systems in MANET: A Comprehensive Study.
- Papaleo, G. (2007). Wireless Network Intrusion Detection System: implementation and architectural issues.
- Ravi, S., Raghunathan, A., & Chakradhar, S. (2003). Embedding Security in Wireless Embedded Systems.
- Sabir, A., Murphy, S., & Yang, Y. (2006). Generic Threats to Routing Protocols.
- Sarkar, S. K., Basavaraju, T. G., & Puttamadappa, C. (2008). ad hoc mobile wireless networks : principles, protocols, and applications.
- Schoch, E., Feiri, M., & Frank Kargl, M. W. (2008). Simulation of Ad Hoc Networks: ns-2 compared to JiST/SWANS.
- Schoch, E., Feiri, M., Kargl, F., & Weber, M. (2008). Simulation of Ad Hoc Networks: ns-2 compared to JiST/SWANS.
- Sharma, S., & Gupta, R. (2009). Simulation Study of Blackhole Attack in the Mobile Ad Hoc Networks.

- Stajano, F., & Anderson, R. (2004). The Resurrecting Duckling: Security Issues for Ad-hoc Wireless Networks.
- Thales. (2007). Implementing Mobile Ad Hoc Networking (MANET) over Legacy Tactical Radio Links.
- Turban, E. a. A., J.E (1998). decision support systems and intelligent systems. Scalable Network Technologies (SNT) . QualNet. <http://www.qualnet.com/>.
- Vinayakray, P. (2002). Security within Ad hoc Networks.
- Wang, H., Wang, Y., & Han, J. (2009). A Security Architecture for Tactical Mobile Ad hoc Networks.
- Wu, B., Chen, J., Wu, J., & Cardei, M. (2006). A Survey on Attacks and Countermeasures in Mobile Ad Hoc Networks.
- YianHuang, & Lee, W. (2003). A Cooperative Intrusion Detection System for Ad Hoc Networks.
- Yu, S., Zhang, Y., Song, C., & Chen, K. (2005). A security architecture for Mobile Ad Hoc Networks.
- Yun, J., Sohn, K., & Yoon, H. (2007). Dynamic Simulation on Network Security Simulator using SSFNET.
- Zhang, Y., Huang, Y.-a., & Lee, W. (2005). An Extensible Environment for Evaluating Secure MANET.
- Zhou, L., & Haas, Z. J. (1999). Securing Ad Hoc Networks. Cornell University Ithaca, NY 14853.