OBAFEMI AWOLOWO UNIVERSITY

DEVELOPMENT OF AN AGENT-BASED APPROACH TO NODES' MISBEHAVIOUR IN MOBILE AD-HOC NETWORKS

BY

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CERTIFICATION

The undersigned hereby certify that this is an original research carried out by BRIGHT Samera Uga with registration number TP11/12/H/1683 in the Department of Computer Science and Engineering, faculty of Technology, Obafemi Awolowo University under my supervision.

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DEDICATION

This thesis is dedicated to the Holy spirit the third person of the trinity through whom I had access to the father, the Almighty God, for His divine wisdom, speed and guidance. He is a friend, a mentor indeed my all in all. Howbeit when He the Spirit of truth shall come He will guide you into all truth, for He shall not speak of himself, but whatsoever He shall hear, that shall he speak, and He will show you things to come. He shall glorify me, for He shall receive of mine and shall show it unto you… (John 16: 13-15)

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I wish to acknowledge God the Father, God the Son and God the Holy Spirit, the only one God of the liberation commission by whose Grace and Mercy I am whom I am today. Verily, Verily I say unto you, He that believes on me the works that I do he shall do also and greater works than these shall he do, because I go unto my father (John 14:12). Indeed you have given me the grace this do this great work. Thank you Lord.

My profound gratitude also goes to my supervisor Prof. G. A. Aderounmu who was always there to make sure I do the right thing and do it well, for his motivation, for his expertise and vast knowledge contributed to this work. I also wish to appreciate my co-supervisor Dr E .A. Olajubu for his contributions and support. Thank you sir.

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My special thanks go to my friends who made my stay in Ife worthwhile like Taiwo Adelowo, Rebecca, Charles Mabude, Princewill Akpojotor, Oluwatosin Hassan, Tobi Ayelara and Simeon Yange.

My roommates E210 Lizzy Umunakwe, Oluwatofunmi, Wunmi, Mummy Shayo indeed we lived together like on family, I am going to miss all of you.

My dear family is not left out in this, my appreciation goes to my immediate family: My beloved husband, my treasure Apst Bright Francis Ekpo for his love and support, thank you so, so much my love, my children: Joseph for his encouragement and sweet words when I am

depressed, I bless God for your life, Patrick for being a mother to prospect when I am a way, Prospect for allowing me to leave home for Ife even when he needs me the most, my pio pio I'll soon be fully available to you.

My extended family: My beloved mothers Mrs. Magaret and Awa Okpabi, for your labor in prayer and for being a mother to my children when I am away. Others have one mother but my blessing is double so I have two. Mummy's thank you so much without you this dream would not have come through. My beloved sisters, Mrs. Monica Uko, Mrs. Franca Kaza, Mrs. Queen Akumbu, Loveth, and Winifred Okpabi (baby of the house) for your encouragement and prayer, I am proud to be associated with this family. I appreciate you Prof. Oga Ajene, for your support and fatherly advice, Prof Uko John Otor also for your support and encouragement. Dr E. Ukonu, you are not left out, I appreciate you for your support. Thank you so much.

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Last but not the least, my Appreciation goes to my late Father Hon Ogo Okpabi who planted this seed of success in me. You waited patiently to see this come through but death took you away, however I've not relented I have pursued your heart desire and here I present this work to you. I hope you can hear me. Thanks so much. I've been searching and I'm yet to see a father like you. I miss you so much. Thank you Daddy.

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ABSTRACT

Benign Nodes in Mobile Ad-Hoc Networks (MANETs) exhibit some forms of Misbehaviour due to their open nature and limited resources such as battery power and central processing unit. Existing Misbehaviour detection mechanisms developed to address this are faced with challenges of overhead and latency due to their complexity and failure to isolate and block misbehaving nodes. Hence this study formulated, simulated and evaluated a mobile agent acknowledgment (MAACK) scheme with the aim of reducing routing overhead and latency.

The scheme is made up of two reactive Mobile Agent packets which were developed using object oriented algorithm and deployed to report misbehaving nodes to the source and destination by registering the internet protocol (IP) address of misbehaving nodes in their header. To achieve this, intermediate forwarder nodes were programmed to exhibit Misbehaviour by dropping packets at a range of 10% to 40% of the total nodes in the network then the mobile agent packets were instantiated as soon as there is drop. Simulation of MAACK was carried out in Network Simulator-3 (NS-3) and results Benchmarked with an existing scheme called the Enhanced Adaptive Acknowledgment (EAACK) using packet delivery ratio (PDR), routing overhead (RO) and latency as performance metrics in two scenarios. Scenario one isolates all misbehaving nodes by invalidating all routes through them while scenario two drops all packets from misbehaving nodes to deny them access to resources on the network.

The simulation result shows that MAACK performs better than EAACK by 60.14% in routing overhead, 28.9% in packet delivery ratio for scenario one. Scenario two shows that MAACK performs 8.13% less at intervals of 0% to 30% malicious nodes and 14.44% better at

30% to 40% malicious nodes respectively. Latency was also reduced by average of 45.6% for 100 flows and 99% above 100 flows.

In conclusion, this model could be adapted by Ad-Hoc network protocol developers in that it guarantees high packet delivery ratio low latency and routing overhead.

CHAPTER ONE

INTRODUCTION

1.1 Background

A Mobile Ad-Hoc Network (MANET) is a set of mobile nodes (hosts) linked together temporarily, which communicate with each other via wireless links either directly or relying on other nodes as router for a particular purpose such as rescue missions, teleconferencing etc. (Neelavathy and Sridharan, 2011). According to Al-Roubaiey *et al*.(2010) and Nan *et al*.(2011), the word Ad-Hoc is a Latin word meaning 'for this Purpose' as the name implies, ad-hoc networks are set up for a particular purpose after which each participating nodes can move out. It is therefore self- organized in such a way that a collection of mobile nodes without the help of any fixed infrastructure and central management is formed automatically. Each node is equipped with a wireless receiver and transmitter that communicate with other nodes in the vicinity of its radio communication range. It is also dynamic in nature and nodes constantly move in and out of their network vicinity. In MANET cooperative participation among all the nodes is required for decision-making, key distribution, routing, and forwarding of packets, due to its decentralized nature.

MANETs can be classified into two types according to Khatawkar *et al*.(2011) as: closed and open. In a closed MANET, all mobile nodes cooperate with each other toward a common goal, such as emergency search/rescue or military and law enforcement operations while in an open MANET, different mobile nodes with different goals share their resources in order to ensure global connectivity. In general, characteristics of MANETs can be summarized as:

i. Unreliability of wireless links between nodes. Because of the limited energy supply for the wireless nodes and the mobility of the nodes, the wireless links between mobile nodes in the ad-hoc network are not consistent for the communication participants.

ii. Constantly changing topology. Due to the continuous motion of nodes, the topology of the mobile ad-hoc network changes constantly: the nodes can continuously move into and out of the radio range of the other nodes in the ad-hoc network, and the routing information will be changing all the time because of the movement of the nodes.

iii. Lack of incorporation of security features in statically configured wireless routing protocol not meant for ad-hoc environments.

iv. Dependency on decentralized and distributed paradigm in MANETs allows an adversary to exploit new types of attacks that are designed to destroy the cooperative algorithms used in ad-hoc networks.

Due to the features listed above, mobile ad-hoc networks are more prone to suffer from malicious behaviours and attacks than the traditional wired networks. These attacks can be classified as passive attacks and active attacks (Nan *et al*., 2010). For passive attacks, packets containing secret information might be eavesdropped, which violates confidentiality. Examples include eavesdropping, traffic analysis and monitoring. Active attacks, includes injecting packets to invalid destinations in the network, deleting packets, modifying the contents of packets, and impersonating other nodes, integrity, authentication, and non-repudiation. Examples include jamming, spoofing, modification, replaying and Denial of Service (DoS).

Misbehaviour in MANETs can be classified as being selfish or malicious. An individual mobile node which may attempt to benefit from other nodes, but refuses to share its own resources is called selfish or malicious nodes, and their behaviour is termed selfishness or misbehaviour. A selfish or malicious node may agree on forwarding control packets while dropping all or part of the data packets it received to conserve its energy. To alleviate the effects of such selfish nodes in MANETs, many researchers brought proactive security approaches like cryptography and authentication to improve the security level of MANETs. However, all of these do not detect

malicious attacks early and therefore attackers have plenty of time to inflict the network. To address this challenge, Intrusion Detection System (IDS) were incorporated into MANETs, which can act as a second layer of defense and a complement to the existing prevention techniques. However, Nan *et al*.(2010) reports that due to the pervasive communication nature and open network media in MANETs like infrastructure less network and self-configuring capabilities, traditional IDSs are no longer suitable for MANETs, because the compromised nodes are originally the benign users of the ad-hoc network therefore they can easily pass the authentication and get protection from the security mechanisms. As a result, the adversaries can make use of them to gain normal access to the services that should only be available to the authorized users in the network, and they can use the legal identity provided by the compromised nodes to conceal their malicious behaviours**.**

Misbehaving nodes exhibits one or more of following characteristics: Packet dropping, Battery drained, Buffer over Flow, Bandwidth consumption, Stale packets, Delay of packets, Link break, Message tampering (forged packets), Fake or wrong routing,