Experimental Evaluation of Security Flaws and their Prevention using Trust and IDS over Wireless Ad hoc Network

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Abstract— in the last few decades, we have seen the large number of wireless communications technologies. Wireless technologies are widely used today across the globe to support the communications needs of very huge numbers of end users. Rapid and automatic establishment of wireless networks and services in the absence of a fixed infrastructure is one of the big challenge of communication. Wireless Ad-hoc networks form a relatively new and very different field of research. Wireless Ad-hoc networks are decentralized, self-organizing networks capable of forming a communication network without any fixed infrastructure. Wireless Ad-hoc networks have various advantages over traditional communication networks. The benefits and commercial potentials of the ad hoc architecture have attracted considerable attention in different application domains. In the wireless ad hoc networks allows a group of communication nodes to set up a network among themselves, without the support of a central controller. In wireless ad hoc network, nodes in most traditional networks use their resources only for data communications, while the infrastructure runs centralized algorithms in determining optimal network behavior. In contrast, ad hoc and sensor network node resources must support network formation and management activities, in addition to data communication. Security and QoS in ad hoc wireless networks have recently become very important and actively researched topics because of a growing demand to support live streaming audio and video in civilian as well as military applications. The wireless links between nodes are highly susceptible to link attacks, which include passive eavesdropping, active interfering, leaking secret information, data tampering, impersonation, message replay, message distortion, and denial of service. In this paper, we provide a comprehensive overview on different types security flaws and their possible prevention schemes over Wireless Ad hoc Networks.

Key words: QoS, AODV, MANETs

I. INTRODUCTION

Wireless networks have rapidly become an essential part of our life. Evidence of this is the widespread usage of such networks in several areas. In addition, the widespread availability of miniature wireless devices such as PDAs, cellular phones, Pocket PCs, and small fixtures on buildings, sensors are one step towards making possible the vision of wireless a reality. Technology under development for wireless ad hoc networks is enabling our march toward this end goal; however the security concerns in wireless networking remains a serious impediment to widespread adoption. Therefore, security of such wireless ad hoc networks is an important area that needs to be addressed if such networks are to be widely used. There are two ways of doing this. One way is for the researchers Security in wireless networks differs markedly from security for their wireline counterparts due to the very nature of the physical medium. To achieve the goal of security and privacy in future mobile communication networks, further research and technology development will be required. The complexity of the problem is greatly compounded when the nodes of the network have to accommodate rapid and unpredictable motion, dynamically altering the connectivity of the network itself [1]. Mobile Ad hoc wireless networks are self-creating, self-organizing, and self-administering. They come into being solely by interactions among their constituent wireless nodes, and it is only such interactions that are used to provide the necessary administration functions supporting such networks.

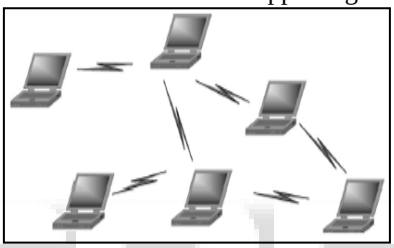

Fig. 1: Mobile Ad hoc Networks

A. *Security Issues and Challenges*

Security is an essential service for wired and wireless network communications. Any network that has to be protected might have weaknesses or vulnerabilities, some or all of which may be targeted by an attacker [2]. Hence, one approach to designing security mechanisms for any network is to look at the threats that the network faces and the attacks possible given the vulnerabilities. The designed security mechanisms should then ensure that the system is secure in the light of these threats, attacks, and vulnerabilities. *Threat* is the means through which the ability or intent of an agent to adversely affect an automated system, facility or operation can be manifested. All methods or things used to exploit a weakness in a network, operation, or facility constitute threat agents. *Vulnerability* is any hardware, firmware, or software flaw that leaves an information system open for potential exploitation. The exploitation can be of various types, such as gaining unauthorized access to information or disrupting critical processing. An *attack* is an attempt to bypass the security controls on a computer. The attack may alter, release, or deny data. The success of an attack depends on the vulnerability of the system and the effectiveness of existing countermeasures. Attacks can be divided into two main categories:

1) Passive Attacks

The attacker just snoops the network without disrupting the network operation. These attacks compromise the confidentiality of the data and tell which nodes are working in promiscuous mode.

– Eavesdropping: It is reading or snooping of messages by an unintended receiver. In MANET, the nodes share a

wireless medium so nodes can easily overhear communication of the nodes within its transmission range. This attack can be prevented by using encryption.
- Selfishness: A selfish node in order to save its battery life and resources does not participate in routing either by dropping the packets or not forwarding them.

2) Active Attacks

Attacks in which attacker disrupts the normal operation of the network by fabricating messages, dropping or modifying packets, replaying packets or tunneling them to other part of the network. Basically the content of passing message is modified. These can be internal attacks and external attacks [4].
- External attacks: In external attack the attacker wants to cause congestion in the network this can be done by the propagation of fake routing information. The attacker disturbs the nodes to avail services.
- Internal attacks: In internal attacks the attacker wants to gain the access to network & wants to participate in network activities. Attacker does this by some malicious impersonation to get the access to the network as a new node or by directly through a present node and using it as a basis to conduct the attack [5].

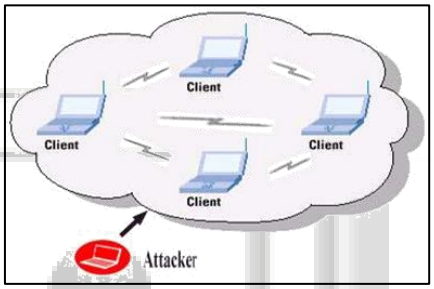

Fig. 2: Example of External attack

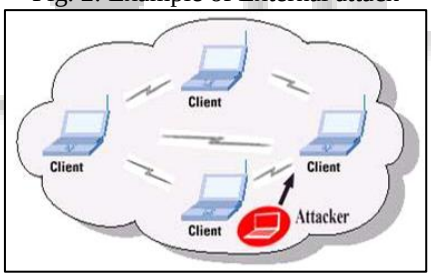

Fig. 3: Example of Internal attack

B. Security Mechanisms

A variety of security mechanisms have been invented to counter malicious attacks. The conventional approaches such as authentication, access control, encryption, and digital signature provide a first line of defense. As a second line of defense, intrusion detection systems and cooperation enforcement mechanisms implemented in MANET can also help to defend against attacks or enforce cooperation, reducing selfish node behavior [6].

1) Preventive Mechanism

The conventional authentication and encryption schemes are based on cryptography, which includes asymmetric and symmetric cryptography. Cryptographic primitives such as hash functions (message digests) can be used to enhance data integrity in transmission as well. Threshold cryptography can be used to hide data by dividing it into a number of shares. Digital signatures can be used to achieve data integrity and authentication services as well. It is also necessary to consider the physical safety of mobile devices, since the hosts are normally small devices, which are physically vulnerable. For example, a device could easily be stolen, lost, or damaged. In the battlefield they are at risk of being hijacked. The protection of the sensitive data on a physical device can be enforced by some security modules, such as tokens or a smart card that is accessible through PIN, passphrases, or biometrics. Although all of these cryptographic primitives combined can prevent most attacks in theory, in reality, due to the design, implementation, or selection of protocols and physical device restrictions, there are still a number of malicious attacks bypassing prevention mechanisms.

2) Reactive Mechanism

An intrusion detection system is a second line of defense. There are widely used to detect misuse and anomalies. A misuse detection system attempts to define improper behavior based on the patterns of well-known attacks, but it lacks the ability to detect any attacks that were not considered during the creation of the patterns; Anomaly detection attempts to define normal or expected behavior statistically. It collects data from legitimate user behavior over a period of time, and then statistical tests are applied to determine anomalous behavior with a high level of confidence. In practice, both approaches can be combined to be more effective against attacks. Some intrusion detection systems for MANET have been proposed in recent research papers.

II. LITERATURE REVIEW

MANET is very much popular due to the fact that these networks are dynamic, infrastructure less and scalable. Despite the fact of popularity of MANET, these networks are very much exposed to attacks. Wireless links also makes the MANET more susceptible to attacks which make it easier for the attacker to go inside the network and get access to the ongoing communication.

In [1], Dahill, et al. proposed ARAN, a routing protocol for ad hoc networks that uses authentication the use of a trusted certificate server. In ARAN end-to-end authentication is achieved by the source by having it verify that the intended destination was reached. In this process, the source trusts the destination to choose the return path. In this the source begins route instantiation by broadcasting a Route Discovery Packet (RDP) that is digitally signed by the source. Following this, every intermediate node verifies the integrity of the packet received by verifying the signature. The first intermediate node appends its own the signature encapsulated over the signed packet that it is received from the source. All subsequent intermediate nodes remove the signature of their predecessors, verify it and then append their signature to the packet. One primitive solution to vanish the RREP forging is to disable the ability to reply in a message of an intermediate node, so all reply messages should be sent out only by the destination node. This method avoid intermediate node to reply which avoid in certain case the Black Hole and implements the secure protocol. This increase the routing delay in large networks and a malicious node can take advantage by replying message instead of destination node. So for this one or more routes are used by the intermediate nodes which replay the RREQ messages to confirm the routes from intermediate nodes and destination nodes for sending out the data packets. In case if it does not exist, the reply messages is discarded from intermediate node and alarm

messages are sent to the network. This method avoids the Black Hole problem thus preventing the network from malicious node. This will result in great delay especially in large networks and in addition the attacker can fabricate a reply message on behalf of the destination node.

In [2], VinhHoa LA et al. presents a survey of VANETs attacks and their solutions Risks caused by security attacks are one of the major security issues for the VANETs that are constraining the deployment of the vehicular ad hoc networks. The authors presented an upto- date collection of attacks damaging VANETs, sampled the practical scenarios and also discussed the existing solutions to deal with attacks, and characterized each attack to have a thorough look over it. The authors conclude intruder detection as the better mechanism and intend to construct an intrusion detector for VANETs to alert the attacks in the case performing.

In [3], BhimsinghBohara et al. discuss the effect of gray hole attack and their counter measuring solution over mobile adhoc network. The Grayhole attack is an active kind of attack on adhoc networks where the attacking node first forwards packets and then later on drops the packets resulting in Denial of Service (DoS). The author use Intrusion Detection scheme to report violation of policy and the nodes whose packets are dropped again try to establish new paths using Route Requests messages. The Gray hole attack is in a way bit similar to Black hole attack. A black hole attack where drops all the packets, on the other hand the gray hole attacking node drops packet with certain probability. The authors analyzed the effects of gray hole in an AODV network. From simulation results with varying speed and 30 nodes for normal AODV as well as after the inclusion of gray hole in AODV.

In [4], OnkarV.Chandure et al. describe the basic idea related with the implementation of AODV protocol and evaluates the impact of gray hole attack on adhoc network. A Gray hole is a node that selectively drops and forwards data packets after advertises itself as having the shortest path to the destination node in response to a route request message. The authors analyse the impact of gray hole attack on adhoc network for different performance metrices like packet delivery ratio and end to end delay. Simulation of AODV as well as gray hole attack is carried out by using ns-2 simulator.

In [5], Chetan S. Dhamande et al. presented a brief study on different for the minimizing the impact of gray hole attack using AODV routing protocol.. Gray hole attack ultimately decrease the performance of the network & also corrupt the data Proposed solution is mainly focus on the miminize the impact of gray hole attack in MANET & also improve the security as well as the performance of the network. A gray hole may exhibit its malicious behavior in different ways. It may drop packets coming from or destined to certain specific node(s) in the network while forwarding all the packets for other nodes. Another type of gray hole node may behave maliciously for Some time duration by dropping packets but may switch to normal behaviour later.

In [6], TarunVarshney et al. investigate more existing mechanisms to prevent blackhole attack and propose a slight modification to AODV, called Watchdog –AODV (WAODV) that detects blackhole attack and also attempt to reduce further rise in normalized routing overhead.This mechanism firstly detects a blackhole node and provide a new route to source node. This mechanism greatly increases reliability of detection and isolation of multiple malicious blackhole nodes during route discovery process and discovers a short and secure route towards destination without introducing additional control packets.

In [7], Homgei Deng, Wei Li, and Dharma P. Agarwal proposed a method to surmount the blackhole problem. The scheme assumes that every node that sends a RREP adds also the extra information of the next hop which allows the source to identify the replier's honesty. Therefore, when a source of a RREQ receives a RREP from an intermediate node the source sends an extra request called Further-Request to the next node (information that is known from the RREP that is already received) and examine if the replier has actually a path to the destination. Due to the great overhead that the mechanism introduces the authors suggest its usage only in cases whenever the network finds a suspected node. The authors have not made any simulations of the mechanism's usage thus, factors such as detection time, false positive and false negative are not provided.

In [8], Chang Wu Yu et al. proposed a distributed and cooperative procedure to detect black hole node. In this each node detect local anomalies. It collects information to construct an estimation table which is maintained by each node containing information regarding nodes within power range. This scheme is initiated by the initial detection node which first broadcast and then it notifies all one-hop neighbors of the possible suspicious node. They cooperatively decide that the node is suspicious node. Immediately after the conformation of black hole, the global reaction is activated to establish proper notification system to send warning to whole network. The simulation result show the higher black hole detection rate and achieves better packet delivery. When the network is busier it achieves less overhead.

In [9] Satoshi Kurosawa et al. use an anomaly detection scheme. It uses dynamic training method in which the training data is updated at regular time intervals. Multidimensional feature vector is defined to express state of the network at each node. Each dimension is counted on every time slot.Itusesdestination sequence number to detect attack. The feature vector include Number of sent out RREQ messages, number of received RREP messages, the average of difference of destination sequence number in each time slot between sequence number of RREP message and the one held in thelist. They calculate mean vector by calculating some mathematical calculation. They compare distance between the mean vector and input data sample. If distance is greater than some threshold value then there is an attack. The updated data set to be used for next detection. Repeating this for time interval T anomaly detection is performed.

III. PROPOSED METHODOLOGY

Security is an essential service for wired and wireless network communications. The success of mobile ad hoc networks (MANET) strongly depends on people's confidence in its security. The wireless adhoc networks need more security because it is more vulnerable to attacks by design. In this our objective is to Implement Two passive attacks namely Blackhole and Grayhole attack over MANETs. Simulate Black-hole and Grayhole attack under AODV routing protocol over varying network scenarios using network

simulator such as ns2 – version Comparison of the extent of damage caused to the network under these two passive attacks and prevent these attacks using modified watchdog and IDS schemes implemented over ns2 simulator.

IV. RESULTS AND DISCUSS

As per earlier discussion, simulation is performed using ns-2 simulator to analyze and evaluate the effect of Passive attack on AODV routing protocol under for different pause time scenarios. Here, this performance is evaluated based on different performance metrics like throughput, average end-to-end delay and packet delivery ratio. A detail simulation study is presented below.

A. Packet Delivery Ratio

Packet Delivery ratio is defined as the ratio of packets that are successfully delivered to a destination compared to the number of packets that have been sent out by the sender.

Packet Delivery Ratio = ∑ Number of packets received / ∑ Number of packets sent

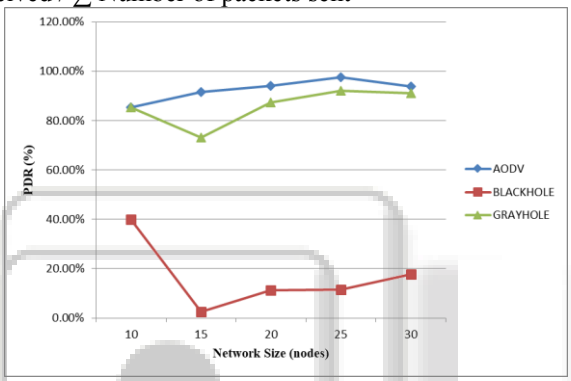

Fig. 4: PDR OF AODV under Multiple Black Hole and Gray Hole Attacker Nodes.

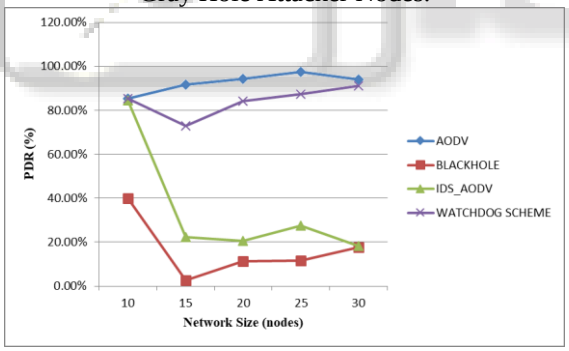

Fig. 5: PDR OF AODV under Multiple Black Hole Nodes and its Counter Measuring Techniques IDS AODV And Watchdog AODV

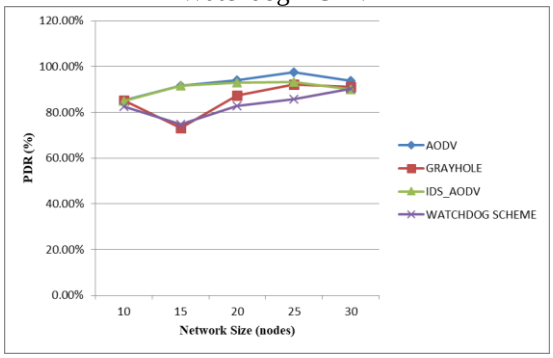

Fig. 6: PDR of AODV under Multiple Grayhole Nodes and Its Counter Measuring Techniques Ids AODV and Watchdog AODV.

B. Throughput

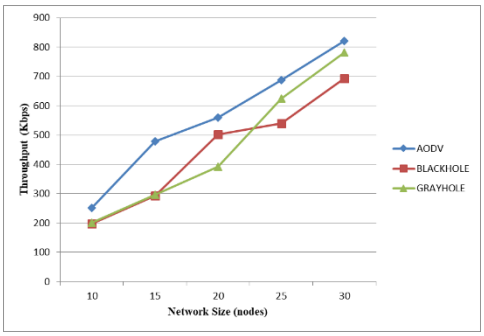

Fig. 7: Throughput of AODV under Multiple Black Hole and Gray Hole Attacker Nodes.

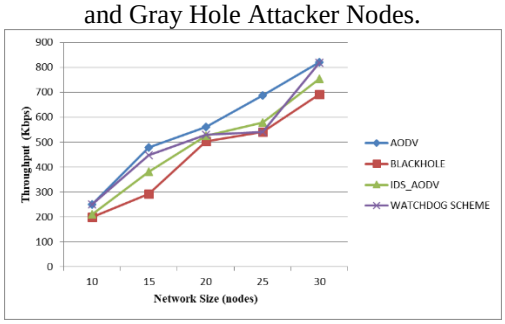

Fig. 8: Throughput of AODV under Multiple Black Hole Nodes and its Counter Measuring Techniques IDS AODV and Watchdog AODV.

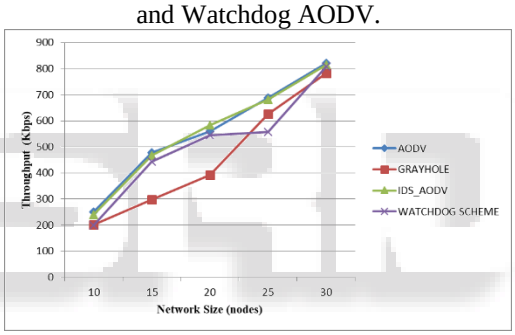

Fig. 9: Throughput of AODV under Multiple Gray Hole Nodes and its Counter Measuring Techniques IDS AODV and Watchdog AODV..

C. Average Delay

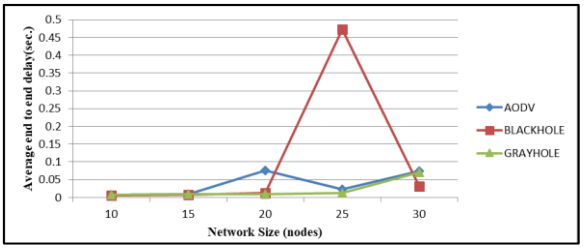

Fig. 10: Average Delay of AODV under Multiple Black Hole and Gray Hole Attacker Nodes.

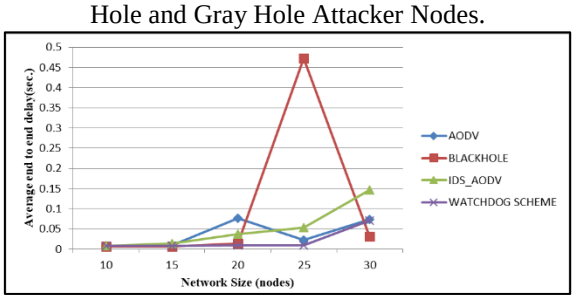

Fig. 11: Average Delay of AODV under Multiple Black Hole Nodes and its Counter Measuring Techniques IDS AODV and Watchdog AODV.

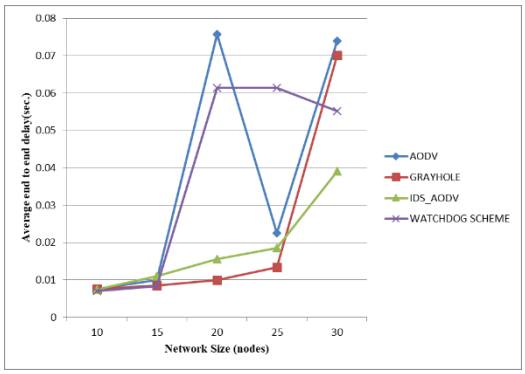

Fig. 12: Average Delay of AODV under Multiple Gray Hole Nodes and its Counter Measuring Techniques IDS AODV and Watchdog AODV.

V. CONCLUSION AND FUTURE WORK

In this thesis, we evaluate the effect of the black hole and gray hole attack in the Ad hoc networks. Having simulated the black hole and gray hole attack, we saw that the performance of AODV is heavily affected for blackhole and gray hole attacks over Wireless ad-hoc environment. The security schemes such as WATCHDOG AODV govern trust among communicating entities are collectively known as trust management. Here we evaluate the effect of multiple black hole and gray hole attacker nodes on the performance of entire network and compared two possible trust management and cryptography based solution that tries to eliminate the black hole and gray hole by monitoring scheme to isolate malicious node from the network. , we can conclude that Watchdog IDS trust management solution for preventing black hole attack is much better than other proposed IDS AODV solution and IDS-AODV solution for gray hole attacker nodes is much better than other WATCHDOG AODV scheme. We have seen a great development in the field of wireless networks (infrastructure based) and in the field of Mobile ad hoc network (infrastructure less network). The succinct discussion in this paper shows that, In spite the large efforts of the MANET research community and the ample progress made during the last years, a lot of technical issues remain unanswered. From an economical point of view, mobile ad-hoc networks open up new business opportunities for telecom operators and service providers. To this end, appropriate business scenarios, applications and economical models need to be identified, together with technological advances, making a transition of ad-hoc networks to the commercial world viable.

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