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Intrusion Detection in Mobile Ad-Hoc Networks using Bayesian Game Methodology

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Abstract: The dynamic and distributed nature of MANETs make them vulnerable to various types of attacks like black hole attack, traffic distortion, IP spoofing, DoS attack etc. Malicious nodes can launch attacks against other normal nodes and deteriorate the overall performance of the entire network [1–3]. Unlike in wired networks, there are no fixed checkpoints like router and switches in MANETs, where the Intrusion Detection System (IDS) can be deployed .However, due to limited wireless communication range and node mobility, nodes in MANET must cooperate with each other to provide networking services among themselves. Therefore, each node in a MANET acts both as a host and a router. Present Intrusion Detection Systems (IDSs) for MANETs require continuous monitoring which leads to rapid depletion of a node's battery life. To avoid this issue we propose a system to prevent intrusion in MANET using Bayesian model based MAC Identification from multiple nodes in network. Using such system we can provide lightweight burden to nodes hence improving energy efficiency. Simulated results shows improvement in estimated delay and average bits transfer parameters

***Keywords**: Mobile Ad hoc Network; IDS; Routing protocols; Bayesian, MAC*

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I. INTRODUCTION

Mobile Ad-hoc Networks (MANETs) are a collection of heterogeneous, infrastructure less, self-organizing and battery powered mobile nodes with different resources availability and computational capabilities. The dynamic and distributed nature of MANETs makes them suitable for deployment in extreme and volatile environmental conditions. They have found applications in diverse domains such as military operations, environmental monitoring, rescue operations etc. Each node in a MANET is equipped with a wireless transmitter and receiver, which enables it to communicate with other nodes within its wireless transmission range.

Therefore, nodes in MANETs must cooperate in many aspects including intrusion detection for their well being [6–8]. IDSs have been deployed with great degree of success across diverse domains like wireless Ad-hoc networks [5,9], MANETs [10–12], wireless sensor networks [13], cyber-physical system [14], cloud computing [15], large scale complex critical infrastructures [16] etc.

In this paper, we focus on IDS for MANETs. Due to absence of any centralized monitoring entity in MANETs, each node runs its own IDS and usually operates in a promiscuous mode. However, owing to limited battery life, it is not feasible to keep the IDS running continuously on MANET nodes. Most of the current MANET IDS schemes do not take into account the nature of the environment they are operating in and therefore they end up monitoring all nodes with equal probability, irrespective of whether or not the node being monitored has a history profile of being malicious. This results in a poor monitoring strategy wherein the node operating the IDS ends up wasting most of its energy monitoring the normal nodes. Another issue with many MANET IDS schemes [17–19] is that they generate heavy intrusion detection related traffic. Unlike the wired networks, MANETs have limited bandwidth and therefore, a large amount of intrusion detection related traffic can cause severe congestion in the network and limit the flow of normal traffic. In addition, heavy intrusion detection traffic also leads to more energy consumption among MANET nodes for processing them. Designing a MANET IDS scheme that is energy efficient and generates a low IDS traffic, while at the same time maintaining a high accuracy and detection rate is an active area of research.

II. RELATED WORK:

In this section, we provide a brief background study on different types of MANET IDS based on their detection mechanism and modes of operation. We then discuss about various intrusion detection issues in MANETs and analyze the related works which have been categorized into non-game theory based and game theory based. Finally, the drawbacks associated with the related works have been listed out which provides us with the motivation for our work to address them.

Shakshuki et al. [18] proposed an IDS named Enhanced Adaptive Acknowledgment (EAACK) for MANETs. Their scheme requires all acknowledgment packets to be digitally signed by its sender and verified by its receiver. They used DSA and RSA as digital signatures and showed that their scheme is able to detect wide range of attacks. However, the drawback of their scheme is the requirement to digitally sign all the acknowledgments which increases computational overhead.

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Marti et al. [32] proposed an IDS scheme for MANET which consists of two different modules, viz. the Watchdog and the Pathrater. In this scheme, the Watchdog acts as an IDS for the MANET and detects malicious node behaviors in the network by promiscuously listening to its next hop's transmission. If the Watchdog notices that its immediate next node fails to forward the packet within a given period of time then it increments the node's failure counter. If the failure counter of the monitored node exceeds a threshold value then the Watchdog reports the node as misbehaving. The Pathrater is then employed to inform the routing protocol to avoid the reported nodes for further data transmission. The drawback of this scheme is that it requires continuous monitoring by the Watchdog for detecting intrusions.

Lui et al. [17] proposed a TWOACK MANET IDS scheme which requires every data packets transmitted over three consecutive nodes along the source to the destination path to be acknowledged. Every node along the route has to send back an acknowledgment packet to the node that is two hop counts away from it in the route. The arrival of TWOACK packet at first node X (in the three consecutive nodes along the route) indicates a successful transmission of packet from node X to node Z via the intermediate node Y. However, if this TWOACK packet is not received within a given predefined time interval, both nodes Y and Z are reported as malicious. The drawback of this scheme is that it introduces a routing overhead due to frequent TWOACK packet generation.

Misra et al. [33] proposed a distributed self-learning, energyaware and low complexity protocol for intrusion detection in wireless sensor network. Their protocol uses the stochastic Learning Automata (LA) on packet sampling mechanism to obtain an energy efficient IDS. They showed that their approach was successful in detecting and removing malicious packets from the WSN. The drawback of this scheme is that the LA needs multiple rounds of learning before it becomes efficient.

Haddadi and Sarram [34] proposed a hybrid IDS model for Wireless Local Area Network (WLAN) that uses both misuse and anomaly based IDS sub-modules to detect intrusion. The drawback of this approach is that the response times of the misuse based and anomaly based IDSs are different. It also introduces significant computational overhead due to processing of the same data traffic by two different IDSs. A light weight, energy efficient and non-cryptographic intrusion detection solution against the gray hole attack in MANET is proposed in Reference [35] by Mohanapriya and Krishnamurthi.

Summary

In summary, we found that most of the non-game theory based IDS schemes proposed in the literature are computationally expensive and require continuous monitoring, thereby leading to more power consumption for operating the IDS. The game theory based IDSs proposed in the literature addresses this issue to some extent. However, most of the previous works on game theory based MANET IDS assumes a complete information game where both players (attacker and defender) have complete information about the game. But such an assumption is usually not valid in a real network, where each node only has a partial information about the network because all network parameters are not known a priori. We also found that most of the games are static in nature where the strategies and utilities of players are fixed and repeated over a period of time. This approach fails in a dynamic environment where players adopt different strategies at various stages of the game. We also found that most of IDSs proposed in literature for MANETs are specific to certain classes of attacks like blackhole attack, wormhole attack etc. [32,40]. All these drawbacks in the related works provide us with the motivation to propose a new MANET IDS scheme based on incomplete information game to address them.

III. PROPOSED SYSTEM

The proposed system can be described as following modular explanation.

Setting up Network Model

Our first module is setting up the network model. We consider a large-scale, homogeneous sensor network consisting of resource-constrained sensor nodes. Analogous to previous distributed detection approaches; we assume that an identity-based public-key cryptography facility is available in the sensor network. Prior to deployment, each legitimate node is allocated a unique ID and a corresponding private key by a trusted third party. The public key of a node is its ID, which is the essence of an identity-based cryptosystem. Consequently, no node can lie to others about its identity. Moreover, anyone is able to verify messages signed by a node using the identity-based key. The source nodes in our problem formulation serve as storage points which cache the data gathered by other nodes and periodically transmit to the sink, in response to user queries. Such network architecture is consistent with the design of storage centric sensor networks

Falsifying the local value:

A compromised node C can falsify its own sensor reading with the goal of influencing the aggregate value. We assume that if a node is compromised, all the information it holds will be compromised. We conservatively consider that all malicious nodes can collude or can be under the control of a single attacker. We use a Byzantine fault model, where the adversary can inject any message through the compromised nodes. Compromised nodes may behave in arbitrarily malicious ways, which means that the sub-aggregate of a compromised node can be arbitrarily generated. However, we assume that the attacker does not launch DoS attacks, e.g., the multi-hop flooding attacks with the goal of making the whole system unavailable.

Computing Sum Despite Attacks:

In this module, we develop an attack-resilient protocol which enables BS to compute the aggregate despite the presence of the attack. We observe that, in general, BS can verify the final synopsis if it receives one valid MAC for each '1' bit in the synopsis. In fact, to verify a particular '1' bit, say bit i , BS does not need to receive authentication messages from all of the nodes which contribute to bit i . As an example, more than half of the nodes are likely to contribute to the leftmost bit of the synopsis, while to verify this bit, BS needs to receive a MAC only from one of these nodes.

Snapshots

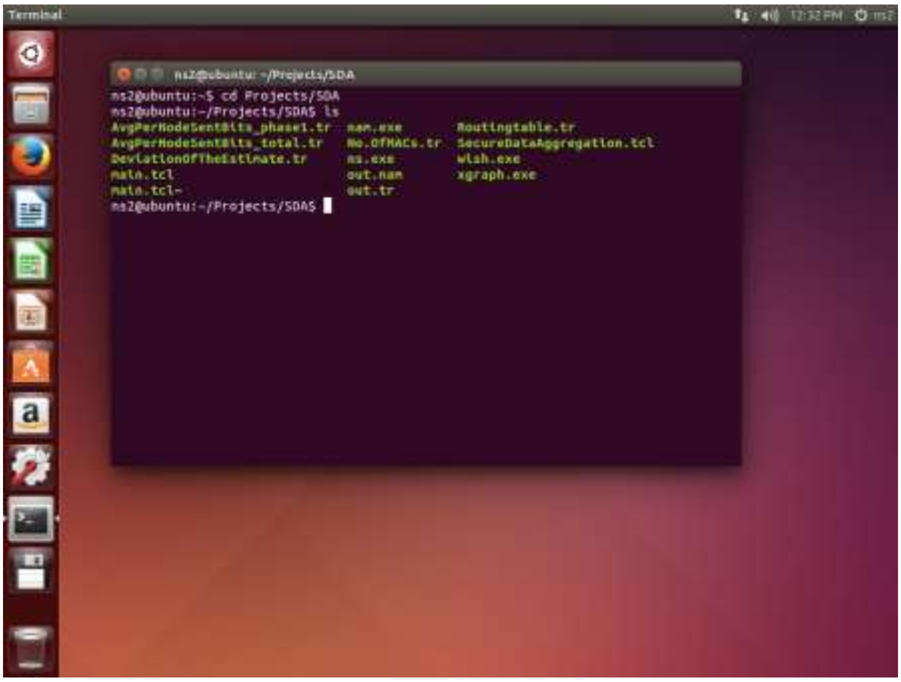

Fig: Ns2 Command Prompt

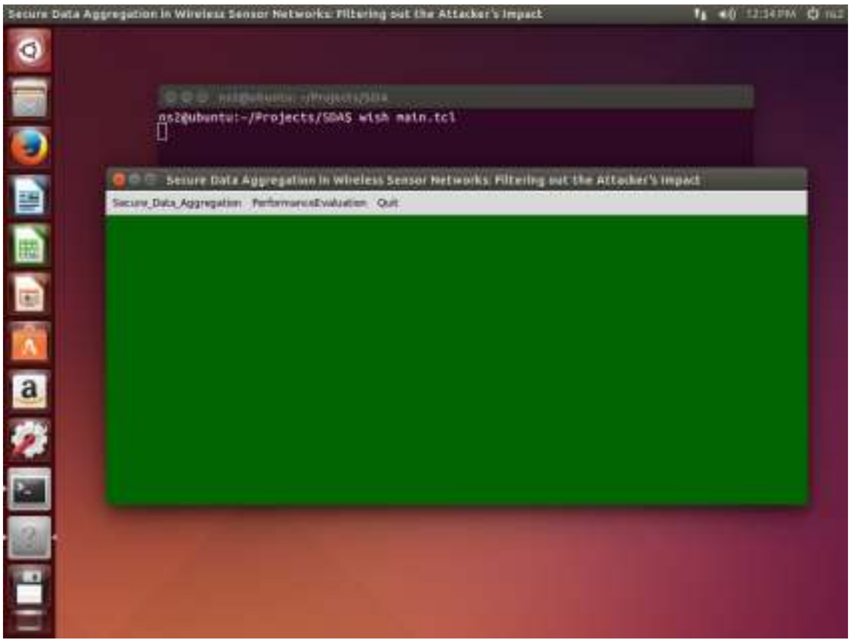

Fig: Front UI Form

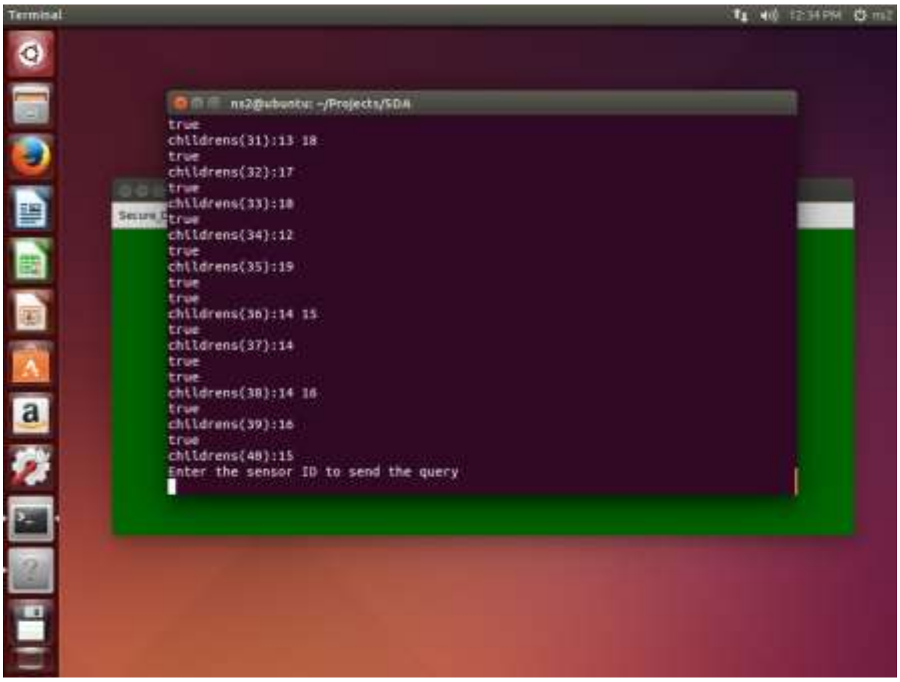

Fig: Sender Selection

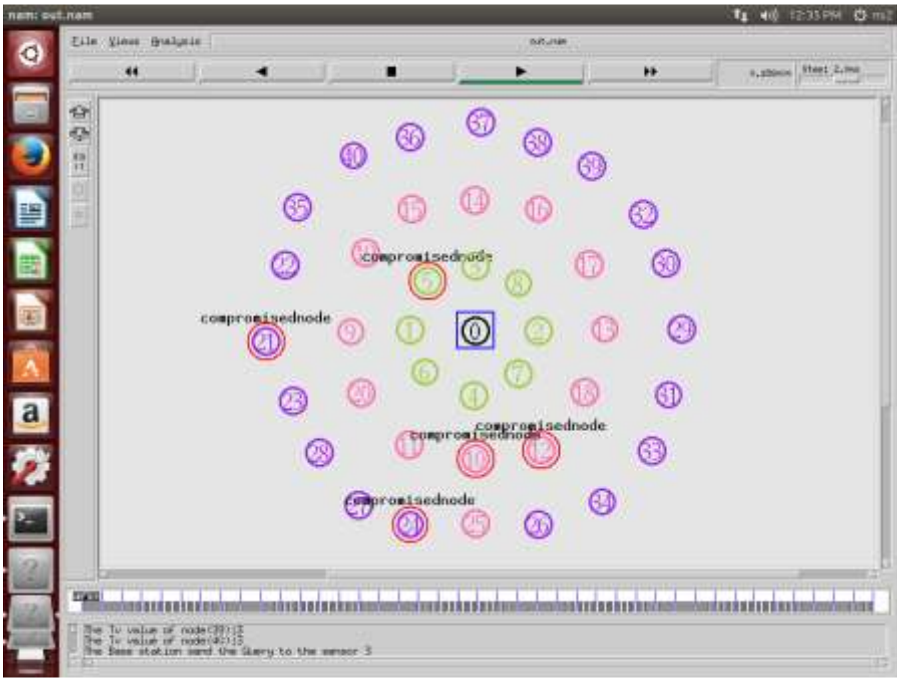

Fig: Ring Based MANET with clustering

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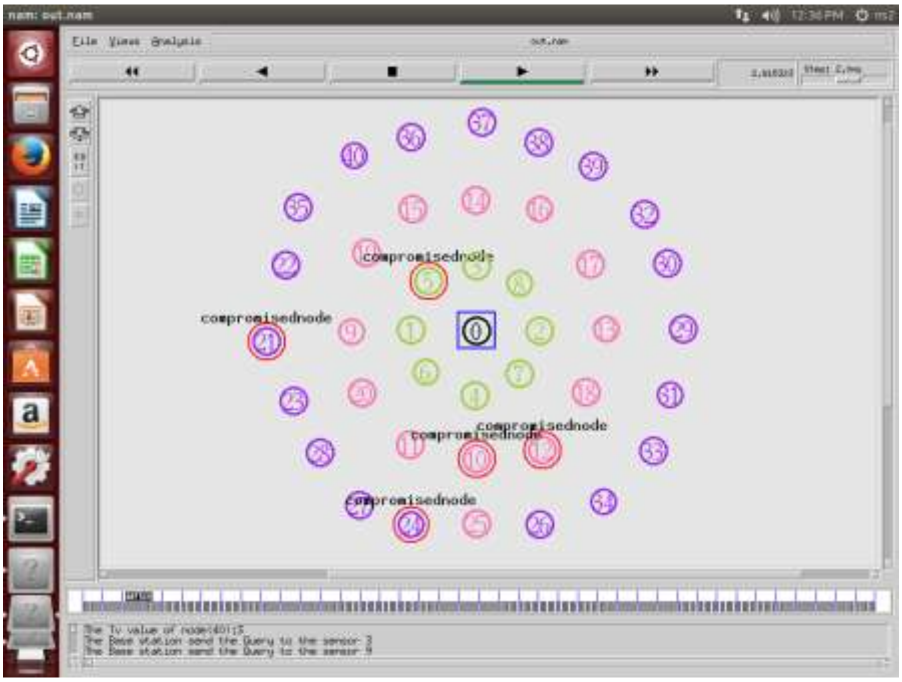

Fig: Initiating Data Transfer

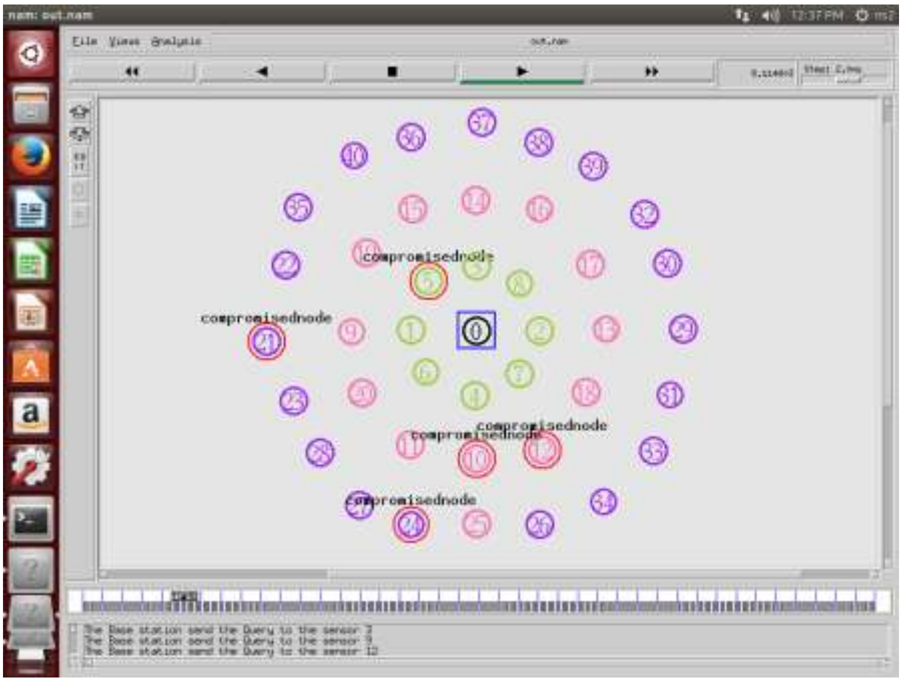

Fig: Data Transmission

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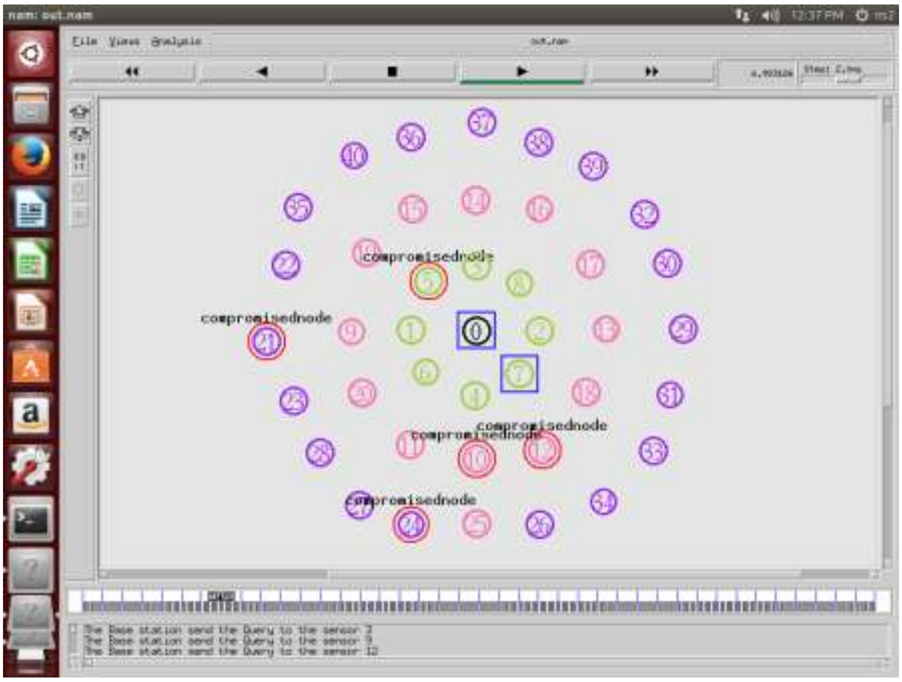

Fig: Sending Data from one cluster to another

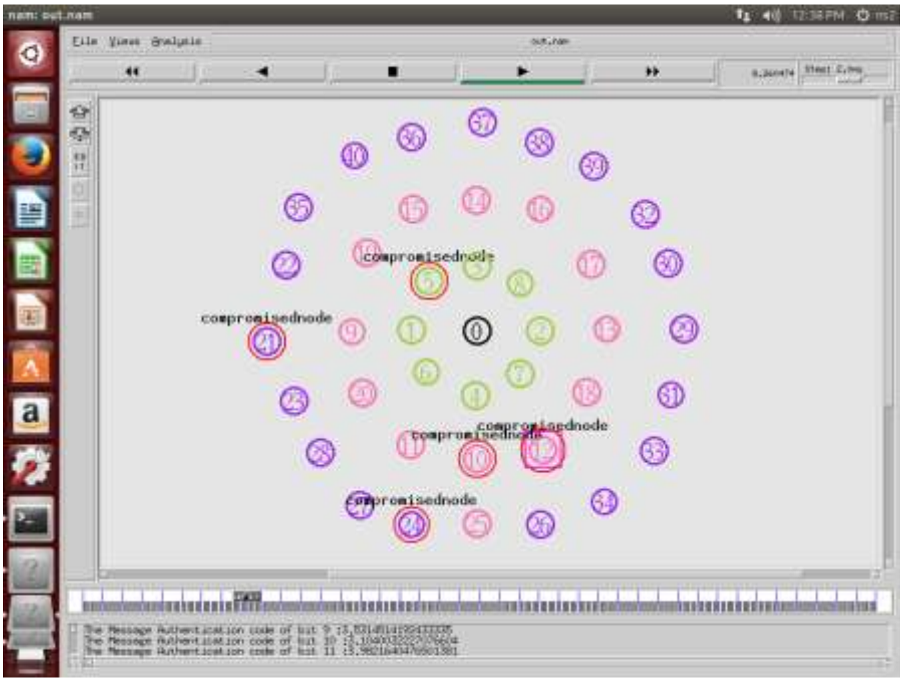

Fig: MAC Authentication for Checking Compromised Node

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IV. RESULT ANALYSIS

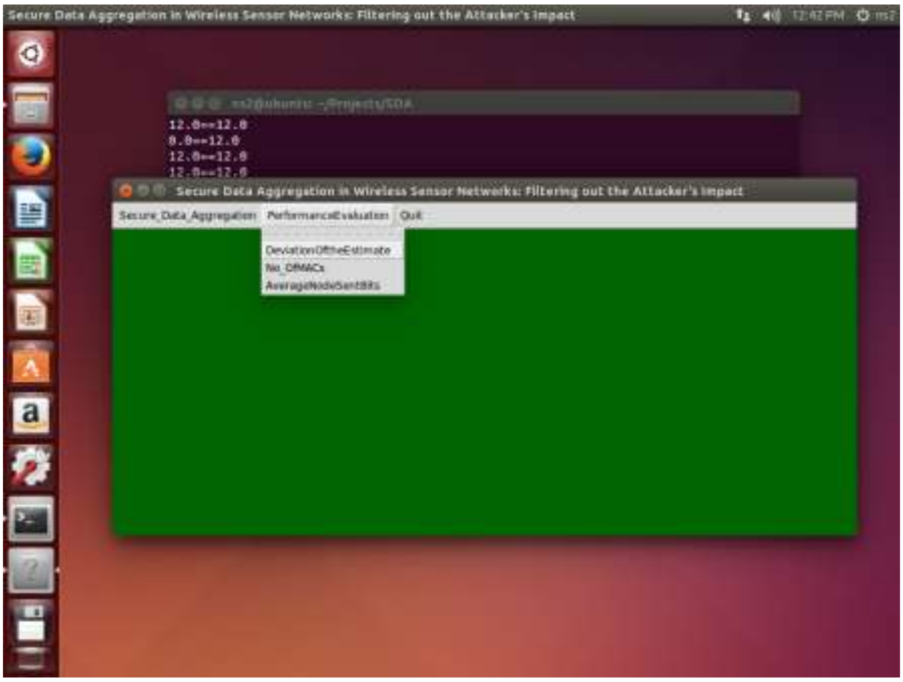

Fig 7.1: Menu Form for Graph Selection

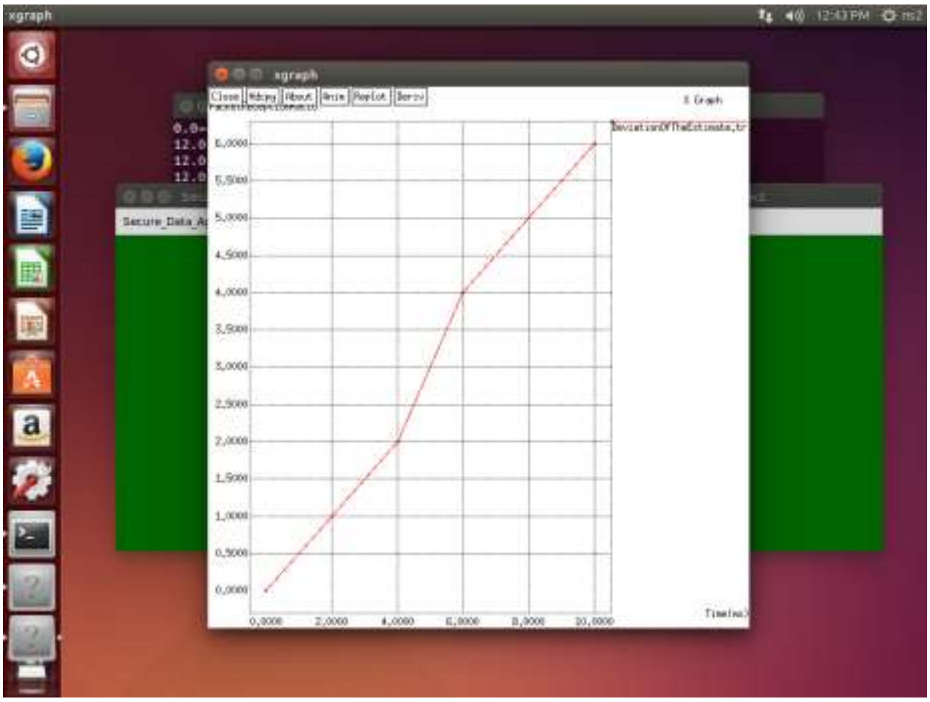

Fig 7.2: Deviation of Estimate Delivery

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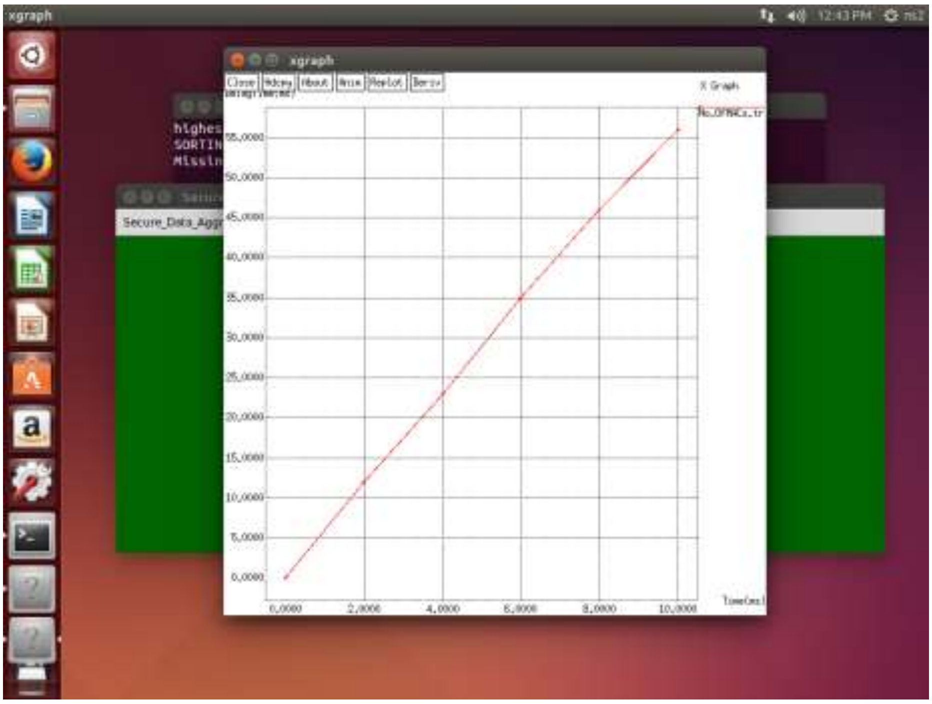

Fig 7.3: Number of MAC Delivery

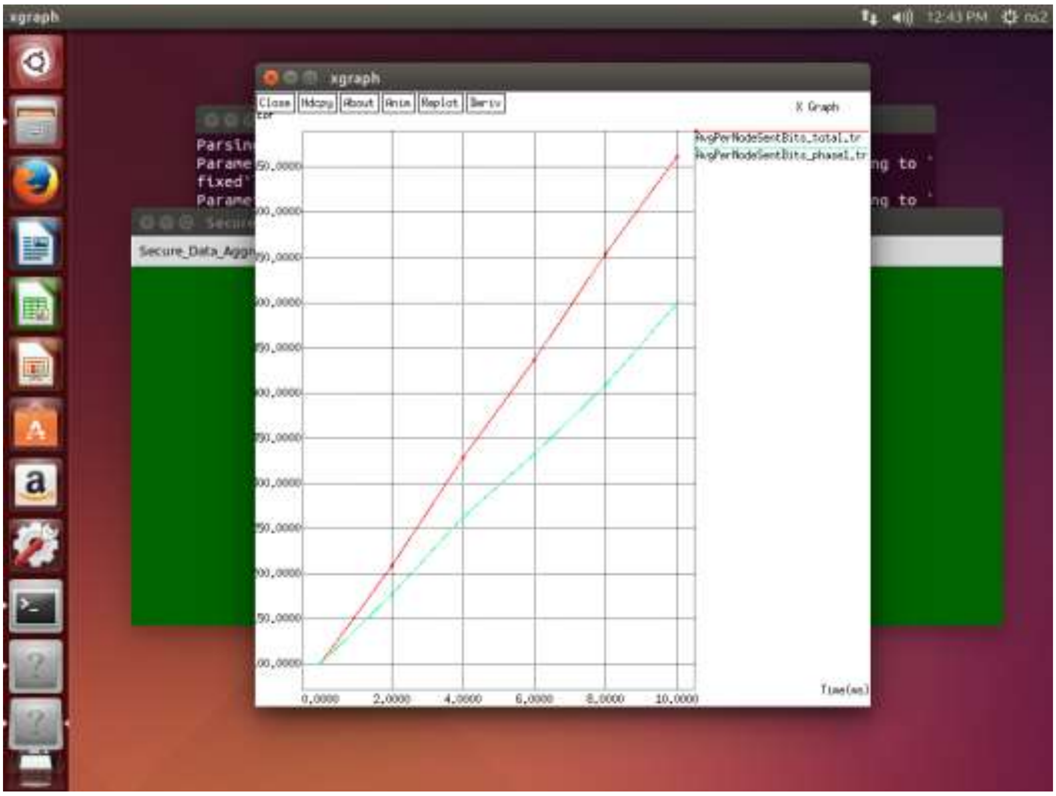

Fig 7.4: Average Node Sent Bits

V. CONCLUSION

We discussed the security issues of in-network aggregation algorithms to compute aggregates such as predicate Count and Sum. In particular, we showed the falsified sub-aggregate attack launched by a few compromised nodes can inject arbitrary amount of error in the base station's estimate of the aggregate. We presented an attack-resilient computation algorithm which would guarantee the successful computation of the aggregate even in the presence of the attack.

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