An Attack-Resistant Trust Management Scheme For Securing Vehicular Ad Hoc Networks

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Abstract- *Vehicular ad hoc networks (VANETs) have the potential to transform the way people travel through the creation of a safe interoperable wireless communications network that includes cars, buses, traffic signals, cell phones, and other devices. However, VANETs are vulnerable to security threats due to increasing reliance on communication, computing, and control technologies. The unique security and privacy challenges posed by VANETs include integrity (data trust), confidentiality, nonrepudiation, access control, real-time operational constraints/demands, availability, and privacy protection. The trustworthiness of VANETs could be improved by addressing holistically both data trust, which is defined as the assessment of whether or not and to what extent the reported traffic data are trustworthy, and node trust, which is defined as how trustworthy the nodes in VANETs are In this paper, an attack-resistant trust management scheme (ART) is proposed for VANETs that is able to detect and cope with malicious attacks and also evaluate the trustworthiness of both data and mobile nodes in VANETs*

Keywords- energy optimization, wireless energy transfer, routing protocol, node lifetime, communication overheads.

I. INTRODUCTION

In recent year the growing needs for increased safety and efficiency of road transportation system have promoted automobile manufacturers to integrate wireless communications and networking into vehicles. The wirelessly networked vehicles naturally form Vehicular Ad-hoc Networks (VANETs), in which vehicles cooperate to relay various data messages through multi-hop paths, without the need of centralized administration. VANETs have the potential to transform the way people travel through the creation of a safe, interoperable wireless communications network. In VANETs, various nodes, such as vehicles and Roadside Units (RSUs), are generally equipped with sensing, processing, and wireless communication capabilities. Both Vehicle-to Vehicle (V2V) and Vehicle-to-Infrastructure(V2I) communications enable safety applications that provide warnings regarding road accidents, traffic conditions (e.g., congestion, emergency braking, icy road) and other relevant transportation events. However, VANETs are vulnerable to threats due to increasing reliance on communication, computing and control technologies.

a) Developing a protocol to optimize energy. LEACH,PEGASIS, Low energy adhoc sensors. Delay aware routing protocol, TDMA protocols
b) Devising a hardware solution to optimize energy. (Design level optimization)(MIMO)
c) Dedicated sensors to optimize task on each sensor. (Load balancing)
d) Clustering approach to resolve energy consumption in the network. (EECS),HEED
e) Introducing cloud to optimize the operation and storage in sensors.
f) Optimization achieved through altering the data packet parameter (packet size optimization)
g) Optimization achieved through varying sensor parameters. (Target coverage)
h) Energy optimization using nature inspired algorithms. (ANT, swarm)
i) Hybrid algorithms. (hybrid)
j) Energy reduction using miscellaneous methods. (Relay data mules).
k) Wireless Energy Transfer(WET)

The rest of the paper is organized to cover the following 11 point in the literature survey and methodology (comparison of work) consequently. Finally a conclusion based on the following work will be given at the conclusion section.

II. LITERATURE SURVEY

Developing a protocol to optimize energy

This method has been identified to build a routing protocol that ensures energy efficiency through optimization some of the case studies are made on the following protocols and the discussions are discussed as follows:

a) DSRC
b) MANET
c) CALM
d) MBWA
e) WiMAX

a) DSRC: Dedicated Short Range Communication

It is the frequency band that is used as a DSRC delivers safety and non safety messages in entire network by using its safety and non safety channels. Non safety applications are related to comfort of the passengers and to improve the traffic system. Parking availability and toll collection services are examples of these applications. Security is an important issue especially in this kind of network where one altered message can creates problem for the users in many ways. Attackers create problem directly and indirectly by launching different kind of attacks.

b) MANET: Mobile Ad Hoc Networks

The key difference of VANET and MANET is the special mobility pattern and rapidly changeable topology. It is not effectively applied the existing routing protocols of MANETs into VANETs. In this investigation, we mainly survey new routing results in VANET. We introduce unicast protocol, multicast protocol, geocast protocol, mobicast protocol, and broadcast protocol. It is observed that carry-and-forward is the new and key consideration for designing all routing protoc ols in VANETs. With the consideration of multi-hop forwarding and carry-and-forward techniques, min-delay and delay-bounded routing protocols for VANETs are discussed in VANETs. Besides, the temporary network fragmentation problem and the broadcast stor m problem are further considered for de-signing routing protocols in VANETs. The temporary network fragmentation problem caused by rapidly changeable topology influence on the performance of data transmissions.

c) CALM:

Recent advancement in wireless communication technologies and automobiles have enabled the evolution of Intelligent Transport System (ITS) which addresses various vehicular traffic issues like traffic congestion, information dissemination, accident etc.

d) MBWA:

SOFTWARE SPECIFICATION:

- OS : Linux (VMware)
- Simulator : NS2
- Language : TCL / TK
- Graph : GNUPLOT
- Protocol Design : CC

Dedicated to NS2 Simulation Test Bed:

e)

NS-2 is n event driven packet level network simulator developed as a part of the VINT project (Virtual Internet Test bed).Version 1 of NS was developed in 1995 and with version 2 in 1996. The Ns-2 with C++/OTCL integration feature. Version 2 included a scripting language called Object oriented Tcl (OTcl). It is an open source software package available for both Windows 32 and Linux platforms. NS-2 has many and expanding uses included.

Simulation Tool

MBWA, are used to support safety critical applications and non-safety infotainment or entertainment based applications. Safety applications such as collision avoidance, pre-crash sensing or lane changing are aimed to minimize road accidents by using traffic monitoring and management applications.

e) WiMAX: Worldwide Interoperability for Microwave Access

WiMAX can provide at-home or mobile Internet access across whole cities or countries. In many cases, this has resulted in competition in markets which typically only had access through an existing incumbent DSL (or similar) operator.

Additionally, given the relatively low costs associated with the deployment of a WiMAX network (in comparison with 3G, HSDPA, xDSL, HFC or FTTx), it is now economically viable to provide last-mile broadband Internet access in remote locations.

HARDWARE SPECIFICATION

- Processor Type : Pentium IV
- Processor Speed : 2.7GHz
- RAM : 1GB

NS2 are often growing to include new protocols. LANs need to be updated for new wired/wireless support. ns are an object oriented simulator, written in C++, with an OTcl interpreter as a front-end. The simulator supports a class

hierarchy in C++ and a similar class hierarchy within the OTcl interpreter (also called the interpreted hierarchy). The two hierarchies are closely related to each other; from the user's perspective, there is a one-to-one correspondence between classes in the interpreted.

NS2uses two languages because simulator has two different kinds of things it needs to do. On one hand, detailed simulations of protocols require a systems programming language which can efficiently manipulate bytes, packet headers, and implement algorithms that run over large data sets. For these tasks run-time speed is important and turn-around time (run simulation, find bug, fix bug, recompile, re-run) is less important.

HEED: Hybrid energy efficient distributed [10]

This protocol is a clustering protocol. It makes use of the residual energy as main parameter and the network topology features that are considered as secondary. The primary assumption is that all the nodes are homogenous i.e. with same amount of energy initially.

S. No	Design level	Optimization
1	Architecture-level	In the Architecture-level optimization we have connecting which enables data transmission to distant clients existing various locations of the network. This connection is nothing but overlapping a sensor network with slices of the IP network.
2	Component-level	The component level design optimization is achieved through COTS sensor nodes deliver optimization prospects at this level through tunable parameters whose standards can be focused to meet erratic application necessities such as sensing, power. Storage and so on. This level focuses on sensing unit, processing unit, transceiver unit, storage unit, actuator unit, location finding unit and the power unit. All of these components are considered for the optimization.
3	Data Link-level	In the Data link-level the design optimization is provided by majorly in the presence of the QoS parameters. Some major techniques that are identified are, channel access plan, message size, duty cycle, and receiver power off, dying nodes, self-organization and failure recovery. The approaches that are followed are: 1. Load Balancing and Throughput Optimizations 2. Power/Energy Optimizations
4	Network-level	Immediately after the data link layer we have shift our focus onto network layer. This layer deals with the transfer of packets from source to destination and in WSN it has to sense the data from the environment in which it is deployed and transfer the data. Here the implementation of energy efficient routing protocol is critical to save the node energy spent on routing. Preferably, data distribution and routing protocols should mark energy efficiency, toughness, and scalability. The approaches that are followed here are: 1. Query Dissemination Optimizations 2. Real-Time Constrained Optimizations 3. Network Topology Optimizations 4. Resource Adaptive Optimizations
5	Operating System-level	In a sensor node the operating system (OS) offers optimization trials because the operations of the sensor nodes lies between the single and general applications that run on multiple platforms. It is the job of the OS in the sensor node to manage I/o, Processor, memory, hardware, power and so on. Hence the approaches that are discussed here are: 1. Event-Driven Optimizations 2. Dynamic Power Management 3. Fault-Tolerance

In the paper the influence of heterogeneity in terms of node energy is studied. That is there will be sensors that have slightly higher energy those other nodes to form the heterogeneity. The lifetime of sensor nodes in the networks is inadequate; we have to re-energize the sensor network by adding more nodes.

Introducing cloud to optimize the operation and storage in sensors

The other possible method that is applicable for energy optimization is integrating sensor networks with the

cloud [11]. Design and Optimization of Traffic Balance Broker for Cloud–Based Telehealth Platform speaks about the following idea. In this architecture the cloud broker manages the requests from the server and also the memory allocation

Optimization achieved through altering the data packet parameter

Optimization achieved through altering the data packet parameter (packet size optimization) is explained well in the paper "Energy Efficiency based Packet Size Optimization in Wireless Sensor Networks [12]". In the WSN, noticing events, processing the sensed data and communicating with neighbor nodes are the important functions. The energy constraint has led to the consideration of the QoS parameters to improve the above said functions and this paper presents consumption characteristics and channelization to handle the parameters instead of the traditional Forward Error Correction mechanism.

Optimization achieved through varying sensor parameters

Target coverage mechanism has also been a method of energy optimization that is discussed in the paper "Energy - Efficient Target Coverage in Wireless Sensor Networks [13]", to increase the network lifetime, the sensor nodes are divided into a number of sets, so as to each set covers all the targets. These sensor sets are triggered consecutively, so that only one set is active at a time. The sensors from the active set are either in the active state or in the deep state based on the requirement. The transition from active mode to sleep mode will increase the network longevity.

Energy optimization using nature inspired algorithms

Optimization of Energy Consumption in Wireless Sensor Networks based on Nature-Inspired Algorithms [14], proposes a new way to optimize energy using Modified Particle Swarm Optimization (MPSO) and Ant Colony Optimization (ACO) algorithms. These are the

Nature-inspired algorithms that change the way the stereotyped algorithms are build and come examples for these are Particle Swarm Optimization (PSO), Bee Colony Optimization (BCO) and Ant Colony Optimization (ACO) have been introduced. Here an advanced algorithm has been proposed to the existing algorithms to increase the efficiency.

Hybrid algorithms

Minimizing the Energy Consumption in Wireless Sensor Networks [15] is a work that considers the following points to reduce the energy consumption: mobile base stations, data mules, and mobile relays. Here the Mobile Base Station gathers the data and to stabilize the transmission load, multiple hop transmission is required. The base station calculates the data from the visited nodes and the battery life gets exhausted very quickly.

Energy reduction using miscellaneous methods

The improvised form of the mobile stations which collects the data from the sensor nodes and send it to the BS are called the Data Mules. They perform like the polling officers that poll the station frequently to check if some data is available. Henceforth they also form a path which can sense them obility of the data and hence optimize on the same. Similarly Data relays are alos a form of replacement on mobile stations.

Wireless energy transfer

The paper "Throughput Optimization for Massive MIMO Systems Powered by Wireless Energy Transfer", proposes a promising way of energy optimization, Wireless Energy Transfer (WET). Far-field wireless energy transfer (WET) serves the power-limited devices in wireless networks [1]. WET refers to the use of radiative electromagnetic (EM) wave produced from a power transmitter to transport energy to a power receiver. The EM frequency decline rapidly over spaces, to understand WET in exercise, the EM energy needs to be focused into a thin ray to attain effectual broadcast of power, also mentioned to as energy beamforming.

Genetic algorithms

Usage of genetic algorithms has also been in practice to serve the purpose of energy optimization in WSN. One such genetic algorithm inspired energy optimization protocol is GAEEP [16]. The jest of paper is grouping sensor nodes to form clusters in order to achieve the network scalability and to exploit the network lifetime.

Metrics tabulation based on the above discussed work to justify the clustering approach is written below:

S. No	Domain in focus	Parameters	Complexity	Research weight age	Merits	Demerits
I	Developing a protocol to optimize energy.	• Packet Throughput • Delay • Energy	Moderate	High	Efficient way to conserve energy and reduce overheads	Energy localization is not given preference
II	Devising a hardware solution to optimize energy	Hardware parameters	High	Low	Effective approach that gives a new hardware and it can be used to specific purpose	Not cost efficient as it requires new infrastructure
III	Dedicated sensors to optimize task on each sensor	• Load • Energy Dissipation • Delay	Moderate	Moderate	Effective load balancing method	Not effective in identify energy drop-offs
IV	Clustering approach to resolve energy consumption in the network	• Load • Energy Dissipation • Delay • Throughput	Moderate	High	Energy localization with energy drop offs are identified	Needs improvement in scheduling and prioritizing packet transaction
V	Introducing cloud to optimize the operation and storage in sensors	• Memory • Energy • Throughput	High	High	Energy optimization is effective due to usage of cloud	Does not solve the energy problem but only subsides the issue
VI	Optimization achieved through altering the data packet parameter	• Packet size • Packet delivery ratio • Energy • Delay	Low	High	Effective way to optimize energy by altering packets	Stereotyped and over exploited method.
VII	Optimization achieved through varying sensor parameters.	• Energy Dissipation • Load • Throughput	Low	Moderate	Efficient solution to precise problem	No scalability to higher range of networks
VIII	Energy optimization using nature inspired algorithms.	• Energy Dissipation • Load • Throughput • Delay	High	Moderate	Energy localized and optimized	Complex methods and cost ineffective
IX	Hybrid algorithms.	• Energy Dissipation • Load • Throughput • Delay	High	Moderate	Parameterized energy saving done	Complex methods and cost ineffective
X	Energy reduction using miscellaneous methods.	• Energy Dissipation • Load • Throughput Delay	Moderate	Low	Multiple parameters considered to reduce energy consumption	No energy localization is done
XI	WET	• Energy Dissipation • Load • Throughput • Delay	High	Low	New approach to transmit energy	No energy localization is done
		• Energy Dissipation			Multiple parameters	

XII	Genetic Algorithms	• Load • Throughput • Delay	High	Low	considered to reduce energy consumption	Complex methods and cost ineffective

Derivational model on pure clustering and comparison study

The method that is pervasively used to find the solution for energy optimization in the WSN is clustering. The approach of clustering in the implementing a routing protocol is a proven method to overcome the problem of node lifetime and hence a critical routing protocol with an adequate algorithm to serve the purpose. The option that can be chosen in this regards is the hierarchal routing [18]. The following term are clustering taxonomy [20] which will be used in the rest of the paper:

Node

1. Ordinary node: It is node that does not participate in the clustering activities and it would just sniff around the network to analyses the incoming and outgoing packets.
2. Gateway: This node is responsible from transmission of packets from source to destination.
3. Cluster Head: The node that will be elected in the cluster to be a head to initiate the process of communication and monitor the cluster.

UNIT TESTING

Unit testing involves the design of test cases that validate that the internal program logic is functioning properly, and that program inputs produce valid outputs. All decision branches and internal code flow should be validated. It is the testing of individual software units of the application .it is done after the completion of an individual unit before integration. This is a structural testing, that relies on knowledge of its construction and is invasive. Unit tests perform basic tests at component level and test a specific business process, application, and/or system configuration. Unit tests ensure that each unique path of a business process performs accurately to the documented specifications and contains clearly defined inputs and expected results.

FUNCTIONAL TESTING

Functional tests provide systematic demonstrations that functions tested are available as specified by the business and technical requirements, system documentation, and user manuals.

Functional testing is centered on the following items:

Valid Input : identified classes of valid input must be accepted.
Invalid Input : identified classes of invalid input must be rejected.
Functions : identified functions must be exercised.
Output : identified classes of application outputs.
Systems/Procedures : interfacing systems or procedures must be invoked.

Organization and preparation of functional tests is focused on requirements, key functions, or special test cases. In addition, systematic coverage pertaining to identify Business process flows; data fields, predefined processes, and successive processes must be considered for testing. Before functional testing is complete, additional tests are identified and the effective value of current tests is determined.

SYSTEM TESTING

System testing ensures that the entire integrated software system meets requirement. It tests a configuration to ensure known and predictable results. An example of system testing is the configuration oriented system integration test. System testing is based on process descriptions and flows, emphasizing pre-driven process links and integration points.

WHITE BOX TESTING

White Box Testing is a testing in which in which the software tester has knowledge of the inner workings, structure and language of the software, or at least its purpose. It is purpose. It is used to test areas that cannot be reached from a black box level.

BLACK BOX TESTING

Black Box Testing is testing the software without any knowledge of the inner workings, structure or language of the module being tested. Black box tests, as most other kinds of tests, must be written from a definitive source document, such as specification or requirements document, such as specification or requirements document.

Test objectives

- All field entries must work properly.
- Pages must be activated from the identified link.
- The entry screen, messages and responses must not be delayed.

INTEGRATION TESTING

Software integration testing is the incremental integration testing of two or more integrated software components on a single platform to produce failures caused by interface defects. The task of the integration test is to check that components or software applications, e.g. components in a software system or – one step up – software applications at the company level – interact without error.

ACCEPTANCE TESTING

User Acceptance Testing is a critical phase of any project and requires significant participation by the end user. It also ensures that the system meets the functional requirements.

TEST RESULTS

All the test cases mentioned above passed successfully. No defects encountered.

PERFORMANCE EVALUATION

Finally we analyze the performance between Existing and proposed methods

- Delay
- Packet delivery ratio
- Throughput.
- Energy Consumption.

Delay

It is defined as the average time taken by the packet to reach the server node from the client node.

Delivery Ratio

Packet Delivery Ratio is defined as the average of the ratio of the number of data packets received by each receiver over the number of data packets sent by the source.

Throughput

Throughput is the number of useful bits per unit of time forwarded by the network from a certain source address to a certain destination, excluding protocol overhead, and excluding retransmitted data packets.

Energy Consumption

Energy consumption is nothing but overall energy consumed for transmission. CE denotes the consumed energy for all nodes. Final energy is taken after sending and receiving of each node. Final energy is also called remaining energy. The energy model defined in a node has an initial value that is the level of energy the node has at the beginning of the simulation. This energy is termed as initial Energy. In simulation, the variable "energy" represents the energy level in a node at any specified time. The energy consumption level of a node at any time of the simulation can be determined by finding the difference between the current energy value and initial Energy value. If an energy level of a node reaches zero, it cannot receive or transmit anymore packets.

$$CE = \left(\sum_{i}^{n} \text{Initial\_Energy} - \text{Final\_Energy [i]} \right)^{n}$$

Capabilities of CH

1. Agility: It refers to the movement of clusters and here the classification is made as:
   a. Mobile clustering: Here the CH moves around the cluster and hence the cluster structure has to be preserved.
   b. Stationery clustering: Here the CH is fixed and moves only in the limitedarea.
2. Functionality: It describes about the functions that are performed on a cluster and theyare:
   a. Transmission of data by theCH
   b. Aggregation of data by theCH
   c. Management of data by theCH
   d. Maintaining structure of data by theCH
3. Consistency in energy: It is about the energy distribution in the cluster. There are 2 classification whichare:
   a. Homogenous energy cluster where the energy distribution is equal in the cluster and election of CH israndom.
   b. Heterogeneous energy cluster where the energy distribution is unequal in the cluster and hence CH election ispredetermined.

Clustering activities that are scheduled from initial to final phase of the network are

1. Construction cluster: This is about how the clusters are formed in the network and there are also schemes related to this. Theyare:
    a. Distributed Cluster formation: A cluster is formed in the network which is a result of all the nodes and their equal participation.
    b. Centralized Cluster formation: Here the clusters are formed by the CHalone.
    c. Hybrid Cluster formation: It is a combination of the above said methods.
2. Cluster head selection: The selection of the cluster head can be done is these two possible ways:
    a. Prior assigned: CH is elected out of various parameters of cluster
    b. Random: CH election is done in random.
3. Clustering mechanism : The formation of the cluster is can be done as:
    a. Active: Where the nodes and sensors are in sync.
    b. Passive: It contradicts active.
    c. Hybrid: It is a mix if both methods.
4. Objectives: The main objective of clustering is to attain:
    a. Robust connectivity in the cluster and the network.
    b. Improving nodes lifetime.
    c. Making the network more fault tolerant.

Clustering algorithm characteristics

a) Convergence Rate: Here the algorithms are classified based on the convergence time i.e., more the number of nodes converge to the time at the same time more constant is the rate and for variable it is contradictory to the above statement.
b) Distribution estimation: Here the classification is made on the coverage of nodes in the cluster, based on which it is either termed as probabilistic od iterative.

In clustering we have numerous techniques. It can be broadly classified into inter cluster routing and intra cluster routing based on the location of the configuration of the cluster. Since we focus on the energy optimization within the cluster, the routing scheme that is opted is intra clustering. In the intra-cluster routing the regions are divided into the intensity based region and the non- intensity based region. In the intensity region the network is identified to consume more energy due to high data rate and transactions. The energy optimization should be applied in this section itself. The routing strategy opted here is multi-hop routing and this saves the energy as the data which has to be sent is not sent to the destination directly but sent to the nearest node and then the packet is routed to the actual destination. In the intensity based region the TDMA approach is followed and in the Non intensity region the CSMA/CA is followed. Now the concern is about the cluster head selection and to do this the approaches followed are LEACH and LEACH-C, In LEACH-C the cluster head and cluster flushes the information to the sink of the network and the sink is responsible for the scheduling and synchronization of the data. The process of cluster head selection happens when the remaining energy in the node is capable to complete the entire cycle.
The classification of the hierarchical clustering done on the WSN is described in 4 categories:

a) Chain based routing
b) Tree based routing
c) Grid based routing
d) Area based routing

Chain based hierarchical routing:

The algorithms that are identified are:

Classification of clustering

S. No	Category and name	Description	Advantages	Disadvantages
1	Hierarchical- Chain Based	The data transmission happens when there is a chain constructed and the data is finally delivered by the leader node. The node with the highest residual energy will be elected as the cluster head and transmission follows the path: node to cluster head to base station. There will be only mode that communicates to the base station	The simplicity in the topology helps to configure the node faster and the energy is conserved as there is no communication overhead. It provides the small transmit distances to cover and hence easily reconfigurable.	Due to chain management there is huge delay is packet routing and since the network information is just maintained by the leader node thee structure becomes less robust

2	Hierarchical-tree based	In this structure a tree like structure is created to build the topology and the parent node is responsible for data dissemination and aggregation. The parent node communicates the leaf node and the network is likewise created.	The simplicity in the topology helps to configure the node faster and t energy is conserved as there is no communication overhead.	Due to chain management there is huge delay is packet routing and since the network information is just maintained by the leader node thee structure becomes less robust. The energy consumption is also uneven due to construction of trees.
3	Hierarchal-gridbased	In this structure a grid like structure is created to build the topology and the location aware routing is followed by the node for data dissemination and aggregation. The parent node communicates the leaf node and the network is likewise created.	The topology is simple and hence data delivery is made efficient.	The main issue is with the load balancing and overload. Since the networks are formed by grids and the location aware sensors always transfer the data to the nearest node the energy managementis uneven.
4	Hierarchical- area based	This structure is the most efficient one. It creates the area based on the load of the network and hence there is no uneven energy distribution. Once such areas are created the dFata collection from the nodes start from one end. The nodes that are ON will transmit the data and the nodes at the sink start collection of data. Thereby load balancing is done.	The advantages are that the topology formed are very simple and the there is even energy distribution of load throughout the network. The energy consumption is also less as the network collects that data from the nodes that are ON. The key feature is the load balancing done on the network.	The disadvantages are high capital investment cost. The topology is simple yet robust to implement and hence costly to implement. This structure is also less scalable due to the specific region identification requires more information.

If we consider the hierarchical routing for the clustering approach in WSN the following parameter play a vital role to select an appropriate algorithm. They are:

a) Energy efficiency
b) Data delivery
c) Algorithm complexity
d) Implementation cost

The comparison of the above said protocols are done based on the following parameters and are tabulated as follows:

S. No	Protocol	Energy efficiency	Data delivery	Algorithm complexity	Implementation cost
1	Chain Based	Low	Slow	Simple	High
2	Tree based	Low	Medium	Simple	High
3	Grid Based	Medium	Medium	Moderate	High
4	Area Based	High	Fast	Moderate	Moderate

III. CONCLUSIONS

In this paper, an attack-resistant trust management scheme named ART is proposed to evaluate the trustworthiness of both traffic data and vehicle nodes for VANETs. In the ART scheme, the trustworthiness of data and nodes are modeled and evaluated as two separate metrics, namely data trust and node trust, respectively. In particular, data trust is used to assess whether or not and to what extent the reported traffic data are trustworthy. On the other hand, node trust indicates how trustworthy the nodes in VANETs are. To validate the proposed trust management scheme, extensive experiments have been conducted, and experimental have been conducted, and experimental results show that the proposed ART scheme accurately evaluates the trustworthiness of data as well as nodes in VANETs, and it can also cope with various malicious attacks

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