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A Novel Approach of Distributed Trust Model for Secure Transmission in WSN

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Abstract:
For wireless sensor networks (WSNs), many factors, such as mutual interference of wireless links, battlefield applications and nodes exposed to the environment without good physical protection, result in the sensor nodes being more vulnerable to be attacked and compromised. In order to address this network security problem, an efficient distributed trust model is proposed. First, according to the number of packets received by sensor nodes, direct trust and recommendation trust are selectively calculated. Then, communication trust, energy trust and data trust are considered during the calculation of direct trust. Furthermore, trust reliability and familiarity are defined to improve the accuracy of recommendation trust. The trust analysis is performed here based on the honesty, reliability and the effective parameters. The proposed EDTM can evaluate trustworthiness of sensor nodes more precisely and prevent the security breaches more significantly. The experimental results represents that proposed model outperforms other similar models, e.g., NBBTE trust model.

INTRODUCTION:

WSNS are emerging technologies that have been widely used in many applications such as emergency response, healthcare monitoring, battlefield surveillance, habitat monitoring, traffic management, smart power grid, etc. However, the wireless and resource-constraint nature of a sensor network makes it an ideal medium for malicious attackers to intrude the system. Thus, providing security is extremely important for the safe application of WSNs. Various security mechanisms, e.g., cryptography, authentication, confidentiality, and message integrity, have been proposed to avoid security threats such as Eavesdropping, message replay, and fabrication of messages. However, these approaches still suffer from many security vulnerabilities, such as node capture attacks and denial-of-service (DoS) attacks. The traditional security mechanisms can resist external attacks, but cannot solve internal attacks effectively which are caused by the captured nodes. To establish secure communications, we need to ensure that all communicating nodes are trusted. This highlights the fact that it is critical to establish a trust model allowing a sensor node to infer the trustworthiness of another node.

ASSUMPTIONS AND NETWORK MODEL:

Scenario:

In this paper, we consider a scenario in whichall the sensor nodes are randomly deployed without mobility. As shown in Fig.1, there are three kinds of nodes in the network: subject nodes, recommender and object nodes. If a sensor node A wants to obtain the trust value of another sensor node B, the evaluating sensor node A is named as subject node and the evaluated node B is the object node. This paper is a multi-hop network which means that the sensor nodes can only directly communication with the neighbor nodes within their communication range.

The packets exchanged between any two non-neighbor nodes are forwarded by other nodes. The forwarding node not only can just “pass” the packets from source nodes to destination nodes but also can process the information based on their own judgments. Generally, the trust value is calculated based on a subject’s observation on the object and recommendations from a third party. The third party which provides recommendations is a recommender.

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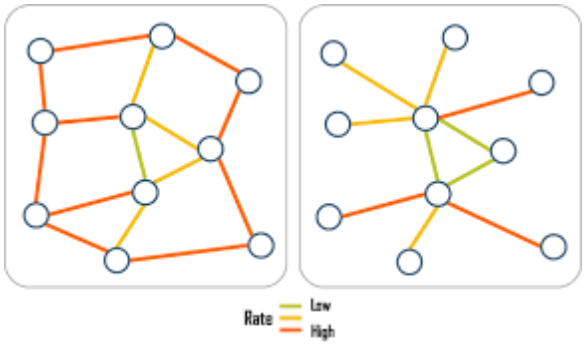

Figure: The network structure

Node capability:

It assumes that sensor nodes havethe same capability of computing, communicating and storing. Their communication ability is limited by specific wireless techniques. Only when two nodes moveinto each other's communication range could they detect each other and start communication. A homogeneous WSN is considered, that is all the sensor nodes have the same initial energy level and communication range. Additionally, in order to secure data transmission over the wireless network, each node is assigned a unique ID and a pair of public/private keys for encrypting and decrypting data, as well as with a public key certificate issued by some trustable Public Key Infrastructure (PKI). Each node keeps a list of neighbor nodes which stores their IDs and their communication information.

Attack model:

There exist many malicious attacks inWSNs, such as DoS attack, node replication, Sybil attack, wormhole attack, attacks on Information, etc. Moreover, it should be noticed that similar to most security schemes, a trust model is also vulnerable to many malicious attacks, such as bad/good-mouthing attack and on-off attack. In a bad-mouthing attack, malicious nodes intentionally give dishonest recommendation to neighbor nodes. For example, they maliciously provide lower recommendation for normal ones during trust evaluation. Thus, recommendations under bad-mouthing attack cannot reflect the real opinions of the recommender. On the contrary, the sensor nodes conducting good mouthing attack intentionally provide higher trust value for malicious nodes.

In an on-off attack, malicious nodes can behave good or bad alternatively. When the trust values of malicious nodes are significantly reduced, they can act well for a period to improve their trust values.

ADVANTAGES OF PROPOSED SYSTEM:

- It can prevent security breaches more effectively
- Provide more security
- Trusted key exchange
- Increase the packet delivery ratio

DISADVANTAGES OF EXISTING SYSTEM:

- There may occur DoS attacks
- Cannot solve the internal attacks
- Trust assessment only provide for neighbor nodes
- Do not solve the trust dynamic problem

PROPOSED SYSTEM:

- In this project, we propose an efficient distributed trust model (EDTM). The proposed EDTM can evaluate the trust relationships between sensor nodes more precisely and can prevent security breaches more effectively.
- This project is a multi-hop network which means that the sensor nodes can only directly communication with the neighbor nodes within their communication range.
- The packets exchanged between any two non-neighbor nodes are forwarded by other nodes.
- The forwarding node not only can just "pass" the packets from source nodes to destination nodes but also can process the information based on their own judgments.

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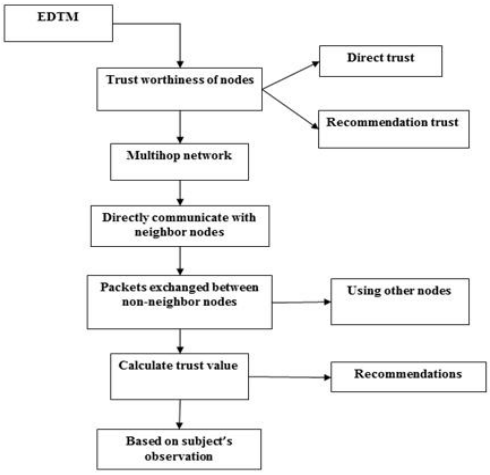
- Generally, the trust value is calculated based on a subject's observation on the object and recommendations from a third party.

BLOCK DIAGRAM



OVERVIEW OF EDTM:

To efficiently compute the trust values on sensor nodes,we first need a clear understanding of the trust definition and the various trust properties that are adopted in a trust model.

Definition and properties of Trust:

Trust:

There are several definitions given to trust in the literature. Trust is always defined by reliability, utility, availability, risk, quality of services and other concepts. Here, trust is defined as a belief level that one sensor node puts on another node for a specific action according to previous observation of behaviors. That is, the trust value is used to reflect whether a sensor node is willing and able to act normally in WSNs. In this paper, a trust value ranges from 0 to 1. A value of 1 means completely trustworthy and 0 means the opposite.

Direct Trust:

Direct trust is a kind of trust calculated based on the direct communication behaviors. It reflects the trust relationship between two neighbor nodes.

Recommendation Trust:

As mentioned above, since the recommendations from third parties are not always reliable, we need an efficient mechanism to filter the recommendation information. The filtered reliable recommendations are calculated as the recommendation trust.

Indirect Trust:

When a subject node cannot directly observe an object nodes' communication behaviors, indirect trust can be established. The indirect trust value is gained based on the recommendations from other nodes. Based on [11] and [12], we can conclude that there arethree main properties of trust: asymmetry, transitivity and composability. Asymmetry implies that if node Atrusts node B, it does not necessarily mean that node B trusts node A. Transitivity means the trust value can be passed along a path of trusted nodes. If node A trusts node B and node B trusts node C, it can be inferred that node A trusts node C at a certain level. The transitivitymeans the trust value can bepassed along a path of trusted nodes.

If node A trusts node B and node B trusts node C, it can be inferred that node A trusts node C at a certain level. The transitivity is a very important property in trust calculation between two non-neighbor nodes. Composability implies that trust values received from multiple available paths can be composed together to obtain an integrated valueis a very important property in trust calculation between two non-neighbor nodes. Composability implies that trust values received from multiple available paths can be composed together to obtain an integrated value.

The Structure of EDTM:

In this section, we describe the overall architecture ofEDTM. When we say node B is trustworthy or untrustworthy for node A, there is a trust model between node A and node B. As shown in Fig.2, EDTM consists of two main components: one-hop trust model and multi-hop trust model which includes the following six components: direct trust module, recommendation trust module, indirect trust module,

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integrated trust module, trust propagation module and trust update module. When a subject node wants to obtain the trust value of an object, it first checks its recorded list of neighbor nodes. If the ID of the object node is in the list of neighbor nodes, the one-hop trust model is triggered. Otherwise, the multi-hop trust model is started. In the one-hop trust model, if the trust is calculated based on node B's direct experiences with node A completely, this model is called direct trust model. Otherwise, the recommendation trust module is built. In the multi-hop trust model, once the subject node A receives recommendations from other nodes about the object node B, indirect trust model can be established. In current trust models, the direct trust and recommendation are always used to evaluate the trustworthiness of sensor nodes.

The direct trust is directly calculated based on the communication behaviors between two neighbor nodes. However, due to malicious attacks, using only direct trust to evaluate sensor nodes is not accurate. Thus, the recommendation from other sensor nodes is needed to improve the trust evaluation. In addition, if the number of communication packets between two neighbor nodes is too small, it is difficult to decide whether an object node is good or bad based on only few interactions.

Therefore, in the one-hop trust model, we define a threshold of communication packets .If the communication packets between the subject and object nodes are higher than the threshold Thnum, only the direct trust is calculated. Otherwise, the recommendations from the recommenders are needed for the object's trust evaluation. In the multi-hop trust model, the subject node first needs to select a set of recommenders. Then, the indirect trust is calculated based on recommendations and trust propagation. Next, we describe the detail calculation of direct, recommendation, and indirect trust.

TRUST CALCULATION IN EDTM

The calculation of Direct Trust

Unlike prior work, we compose our direct trust by considering communication trust, energy trust and data trust. The sensor nodes in WSNs usually collaborate and communicate with neighbor nodes to perform their tasks. Therefore, the communication behaviors are always checked to evaluate whether the sensor node is normal or not.

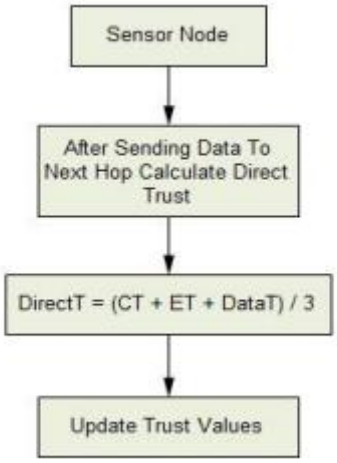

Fig: Direct Trust

Calculation of the Communication Trust:

The information on a sensor node's prior behavior is one of the most important aspects of the communication trust. However, communication channels between two sensor nodes are unstable and noisy, thus monitoring sensor node's behaviors in WSNs based on previous communication behaviors involves considerable uncertainty.

$$T_{com} = \frac{2b + u}{2} \quad (1)$$

where $b = \frac{s}{s+f+1}$, $u = \frac{1}{s+f+1}$.

Calculation of the Energy Trust:

Energy is an important metric in WSNs since sensor nodes are extremely dependent on the amount of energy they have. Malicious nodes always consume abnormal energy to launch malicious attacks. For example, malicious nodes which conduct DoS attack consume much more energy than normal nodes while selfish nodes consume less energy.

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Therefore, we use energy as a QoStrust metric to measure if a sensor node is selfish or maliciously exhaust additional energy.

$$T_{ene} = \begin{cases} 1 - p_{ene}, if E_{res} \geq \theta \\ 0, else \end{cases} \quad (2)$$

Calculation of the Data Trust:

The trust of the data affects the trust of the network nodes that created and manipulated the data, and vice-versa, we introducethe evaluation of data trust in this section. The data packets have spatial correlation, that is, the packets sent among neighbor nodes are always similar in the samearea. The data value of these packets in general followssome certain distribution, such as a normal distribution.

$$T_{data}=2(0.5 - \int_{\mu}^{v_d} f(x)dx) = 2\int_{v_d}^{\infty} f(x)dx \quad (3)$$

Calculation of the Recommendation Trust:

The recommendation trust is a special type of directtrust. When there are no direct communication behaviors between subject and object nodes, the recommendations from recommender are always taken into account for trust calculation. However, in most existing related works, the true and false recommendations are not distinguished. How to detect and get rid of false recommendations is important since it has great impact on the trust calculation.

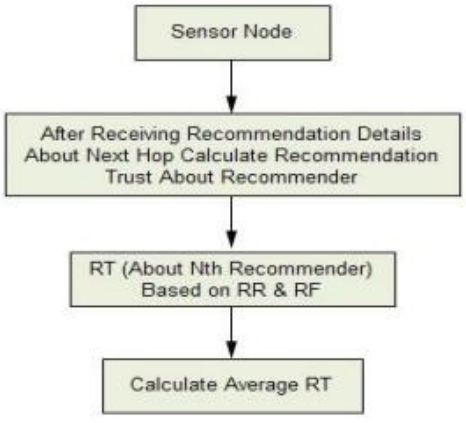

Fig: Recommendation Trust

Calculation of the Indirect Trust:

WSNs are multi-hop networks, when there are no direct communications between subject and object nodes, indirect trust can be established since trust is transitive. In this paper, the calculation of indirect trust includes two steps: 1) the first step is to find multi-hop recommenders between subject and object nodes, and 2) the second step is the trust propagation which aims at computing the direct trust. The path from the subject node to the object node established by the recommenders is named as Trust Chain.

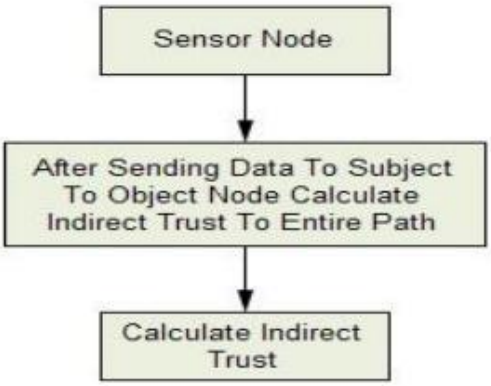

Fig: Indirect Trust

Update of Trust value:

Due to the dynamic behavior of WSNs such as leavingor joining the network, the trust values of sensor nodes should be updated periodically. First, the trust value should not be updated too often. Because frequently updating the trust value will waste a lot of energy, and the trust evaluation will be easily affected by the network traffic conditions (e.g., congestion and delay). In addition, the update cycle time cannot be too long. A node's historical trust values should be taken into account to measure its current trustworthiness. If the cycle time is too long, it cannot efficiently reflect the current behaviors of the object node. To solve these issues, we use a sliding time window concept to update the trust value.

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SIMULATION RESULTS AND ANALYSIS:

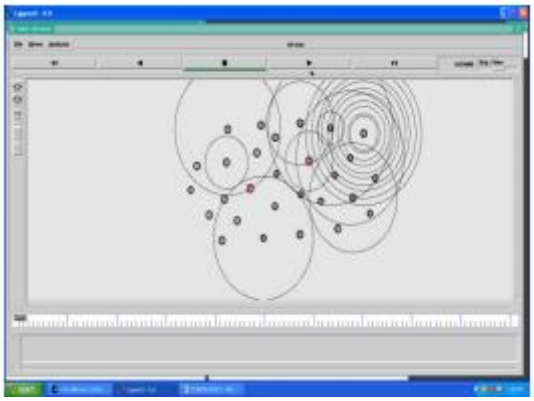

Fig: Network Topology

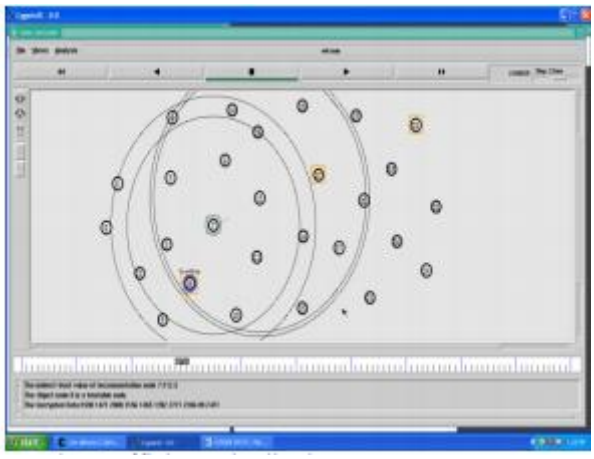

Fig: Efficient Distribution Trust Management

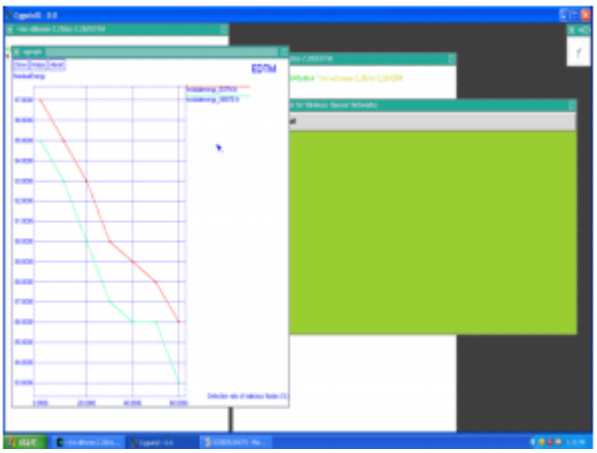

Fig: Residual Energy

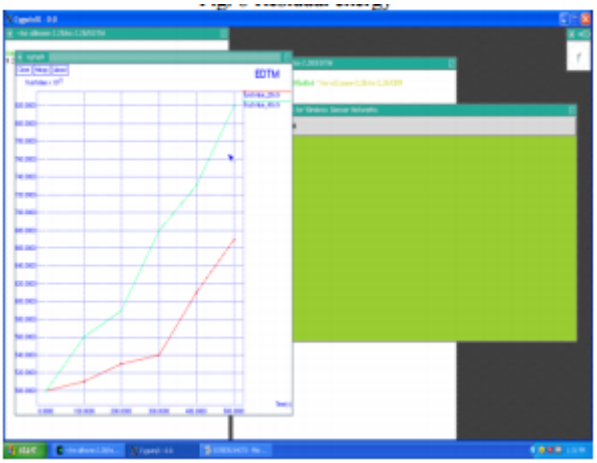

Fig: Direct Trust Value

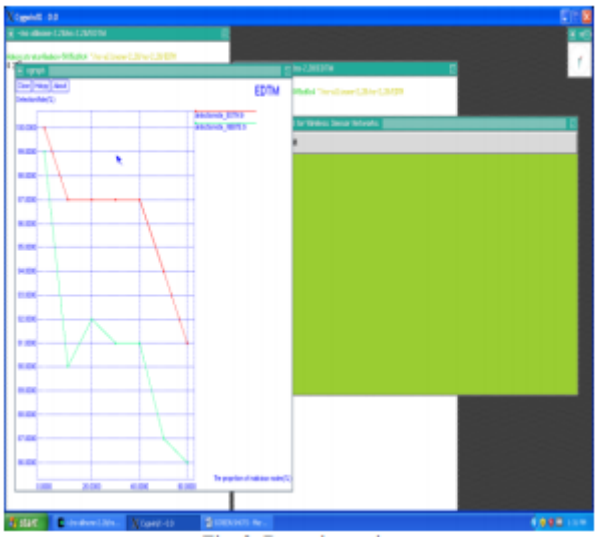

Fig: Detection Ratio

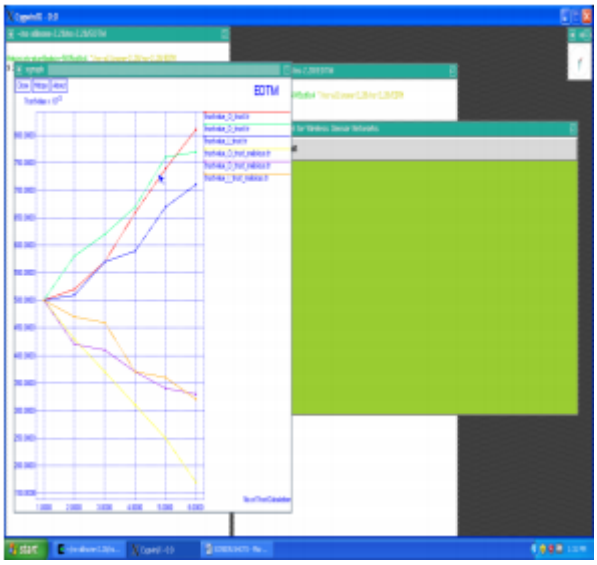

Fig: Direct and indirect Trust Value

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CONCLUSIONS:

The trust model has become important for malicious nodes detection in WSNs. It can assist in many applications such as secure routing, secure data aggregation, and trusted key exchange. Due to the wireless features of WSNs, it needs a distributed trust model without any central node, where neighbor nodes can monitor each other. In addition, an efficient trust model is required to handle trust related information in a secure and reliable way. In this paper, a distributed and efficient trust model named EDTM is proposed. During the EDTM, the calculation of direct trust, recommendation trust and indirect trust are discussed. Furthermore, the trust propagation and update are studied. Simulation results show that EDTM is an efficient and attack-resistant trust model. However, how to select the proper value of the weight and the defined threshold is still challenge problem, which we plan to address in our future research endeavors.

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