International Journal of Research Studies in Science, Engineering and Technology
Volume 1, Issue 8, November 2014, PP 23-29
ISSN 2349-4751 (Print) & ISSN 2349-476X (Online)

Node Clone Detection in Wireless Sensor Networks

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Abstract: *Wireless sensor networks are harmed to the node clone, and different distributed protocols have been proposed to detect this attack. However, they require too strong assumptions to be practical for randomly deployed sensor networks. Here, we propose two new node clone detection protocols with different tradeoffs on network conditions and performance. The first one is based on a DHT concept which abbreviated as distributed hash table, by which a fully decentralized, key-based caching and checking system is constructed to catch cloned nodes effectively. The protocol performance on efficient storage consumption and high security level is theoretically deducted through a probability model, and the resulting equations, with necessary modification for real application, are supported by the simulations. But the DHT-based protocol incurs similar communication cost as previous techniques, it may be considered a little high for some scenarios. To overcome communication cost problem our second approach RDE/DDE distributed detection protocol, named randomly directed exploration, presents good communication performance for dense sensor networks, by a probabilistic directed forwarding technique along with random initial direction and border determination. The simulation results uphold the protocol design and show its efficiency on communication overhead and satisfactory detection probability*

1. INTRODUCTION

A **wireless sensor network (WSN)** consists of spatially distributed autonomous sensors to *monitor* physical or environmental conditions, such as temperature, pressure, sound, etc. and to cooperatively pass their data through the network to a main location. The more modern networks are bi-directional, also enabling *control* of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on.

The WSN is built of "nodes" – from a few to several hundreds or even thousands, where each node is connected to one (or sometimes several) sensors. Each such sensor network node has typically several parts: a radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting. A sensor node might vary in size from that of a shoebox down to the size of a grain of dust, although functioning "motes" of genuine microscopic dimensions have yet to be created. The cost of sensor nodes is similarly variable, ranging from a few to hundreds of dollars, depending on the complexity of the individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network. The propagation technique between the hops of the network can be routing or flooding.

The main characteristics of a WSN include:

- Power consumption constrains for nodes using batteries or energy harvesting
- Ability to cope with node failures
- Mobility of nodes
- Communication failures
- Heterogeneity of nodes
- Scalability to large scale of deployment
- Ability to withstand harsh environmental conditions
- Ease of use

2. LITERATURE SURVEY

Distributed detection of node replication attacks in sensor networks, B. Parno, A. Perrig, and V. Gligor

The low-cost, off-the-shelf hardware components in unshielded sensor-network nodes leave them vulnerable to compromise. With little effort, an adversary may capture nodes, analyze and replicate them, and surreptitiously insert these replicas at strategic locations within the network. Such attacks may have severe consequences; they may allow the adversary to corrupt network data or even disconnect significant parts of the network. Previous node replication detection schemes depend primarily on centralized mechanisms with single points of failure, or on neighborhood voting protocols that fail to detect distributed replications. To address these fundamental limitations, we propose two new algorithms based on emergent properties (Gligor (2004)), i.e., properties that arise only through the collective action of multiple nodes. Randomized multicast distributes node location information to randomly-selected witnesses, exploiting the birthday paradox to detect replicated nodes, while line-selected multicast uses the topology of the network to detect replication. Both algorithms provide globally-aware, distributed node-replica detection, and line-selected multicast displays particularly strong performance characteristics. We show that emergent algorithms represent a promising new approach to sensor network security; moreover, our results naturally extend to other classes of networks in which nodes can be captured, replicated and re-inserted by an adversary.

Looking up data in P2P systems: H. Balakrishnan, M. F. Kaashoek, D. Karger, R. Morris, and I. Stoica,The main challenge in P2P computing is to design and implement a robust and scalable distributed system composed of inexpensive, individually unreliable computers in unrelated administrative domains. The participants in a typical P2P system might include computers at homes, schools, and businesses, and can grow to several million concurrent participants.

Location-based compromise tolerant security mechanisms for wireless sensor networks: Y. Zhang,W. Liu,W. Lou, andY. Fang, Node compromise is a serious threat to wireless sensor networks deployed in unattended and hostile environments. To mitigate the impact of compromised nodes, we propose a suite of location-based compromise-tolerant security mechanisms. Based on a new cryptographic concept called pairing, we propose the notion of location-based keys (LBKs) by binding private keys of individual nodes to both their IDs and geographic locations. We then develop an LBK-based neighborhood authentication scheme to localize the impact of compromised nodes to their vicinity. We also present efficient approaches to establish a shared key between any two network nodes. In contrast to previous key establishment solutions, our approaches feature nearly perfect resilience to node compromise, low communication and computation overhead, low memory requirements, and high network scalability. Moreover, we demonstrate the efficacy of LBKs in counteracting several notorious attacks against sensor networks such as the Sybil attack, the identity replication attack, and wormhole and sinkhole attacks. Finally, we propose a location-based threshold-endorsement scheme, called LTE, to thwart the infamous bogus data injection attack, in which adversaries inject lots of bogus data into the network. The utility of LTE in achieving remarkable energy savings is validated by detailed performance evaluation.

3. IMPLEMENTATION

Techniques and protocol Used

1. Distributed hash table(DHT)
2. Randomly directed exploration

Distributed hash table (DHT)

Distributed hash table (DHT), by which a fully decentralized, key-based caching and checking system is constructed to catch cloned nodes. The protocol's performance on memory consumption and a critical security metric are theoretically deducted through a probability model, and the resulting equations, with necessary adjustment for real application, are supported by the simulations. In accordance with our analysis, the comprehensive simulation results show that the DHT-based protocol can detect node clone with high security level and holds strong resistance against adversary's attacks

Randomly directed exploration

This is intended to provide highly efficient communication performance with adequate detection probability for dense sensor networks. In the protocol, initially nodes send claiming messages containing a neighbor-list along with a maximum hop limit to randomly selected neighbors; then, the subsequent message transmission is regulated by a probabilistic directed technique to approximately maintain a line property through the network as well as to incur sufficient randomness for better performance on communication and resilience against adversary. In addition, border determination mechanism is employed to further reduce communication payload. During forwarding, intermediate nodes explore claiming messages for node clone detection. By design, this protocol consumes almost minimal memory, and the simulations show that it outperforms all other detection protocols in terms of communication cost, while the detection probability is satisfactory

Modules

- Setting up Network Model
- Initialization Process
- Claiming Neighbor's information
- Processing Claiming Message
- Sink Module
- Performance Analysis

Modules Description

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

Initialization Process

To activate all nodes starting a new round of node clone detection, the initiator uses a broadcast authentication scheme to release an action message including a monotonously increasing nonce, a random round seed, and an action time. The nonce is intended to prevent adversaries from launching a DoS attack by repeating broadcasting action messages.

Claiming neighbor's information

Upon receiving an action message, a node verifies if the message nonce is greater than last nonce and if the message signature is valid. If both pass, the node updates the nonce and stores the seed. At the designated action time, the node operates as an observer that generates a claiming message for each neighbor (examinee) and transmits the message through the overlay network with respect to the claiming probability. Nodes can start transmitting claiming messages at the same time, but then huge traffic may cause serious interference and degrade the network capacity. To relieve this problem, we may specify a sending period, during which nodes randomly pick up a transmission time for every claiming message.

Processing claiming messages

A claiming message will be forwarded to its destination node via several Chord intermediate nodes. Only those nodes in the overlay network layer (i.e., the source node, Chord intermediate nodes, and the destination node) need to process a message, whereas other nodes along the path simply route the message to temporary targets. Algorithm 1 for handling a message is the kernel of our DHT-based detection protocol. If the algorithm returns NIL, then the message has arrived at its destination. Otherwise, the message will be subsequently forwarded to the next node with the ID that is returned.

Sink Module

The sink is the point of contact for users of the sensor network. Each time the sink receives a question from a user, it first translates the question into multiple queries and then disseminates the queries to the corresponding mobile relay, which process the queries based on their data and return the query results to the sink. The sink unifies the query results from multiple storage nodes into the final answer and sends it back to the user.

Performance Analysis

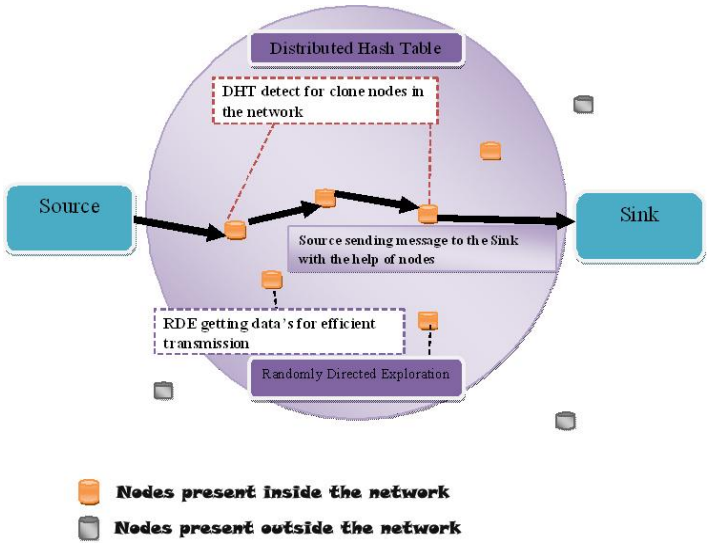
For the DHT-based detection protocol, we use the following specific measurements to evaluate its performance:

• Average number of transmitted messages, representing the protocol's communication cost;

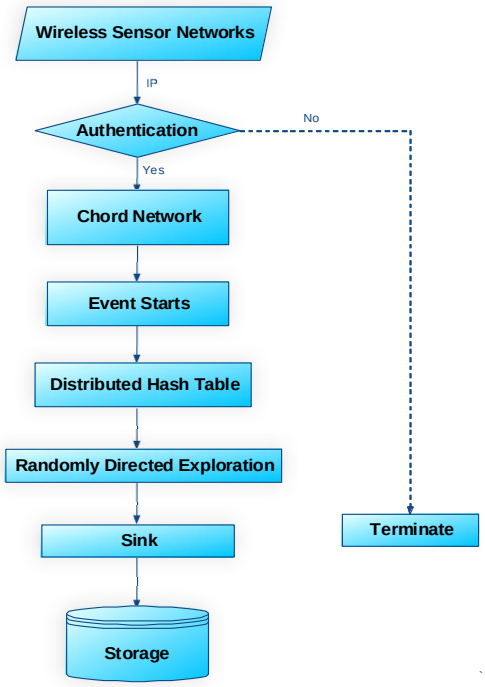
• Average size of node cache tables, standing for the protocol's storage consumption;

• Average number of witnesses, serving as the protocol's security level because the detection protocol is deterministic and symmetric.

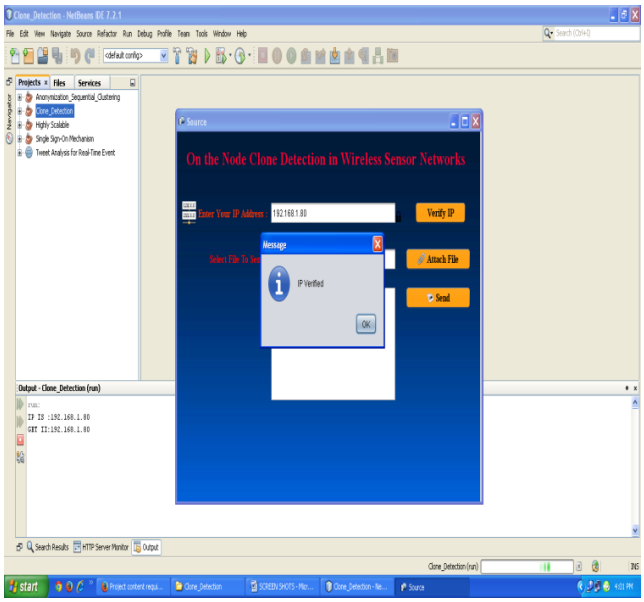
4. SYSTEM ARCHITECTURE

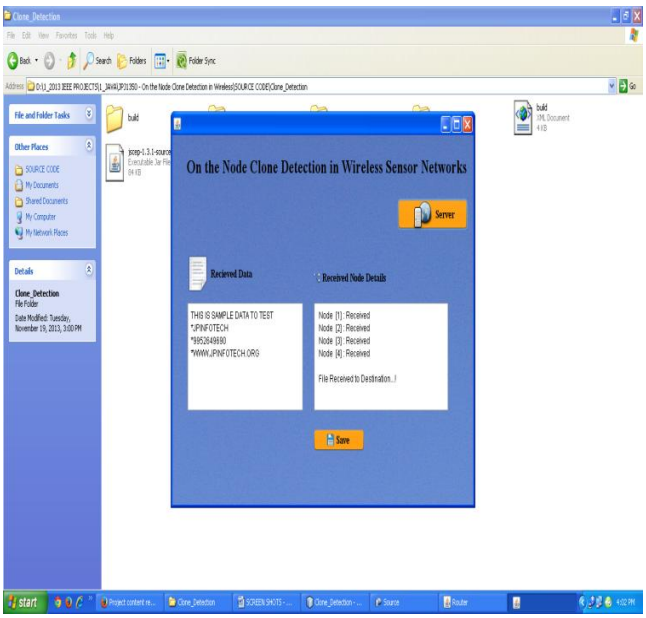


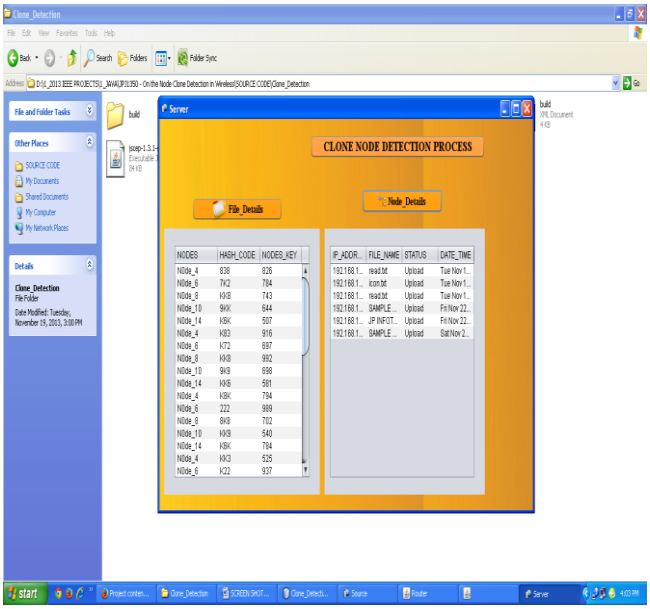
Data Flow Diagram

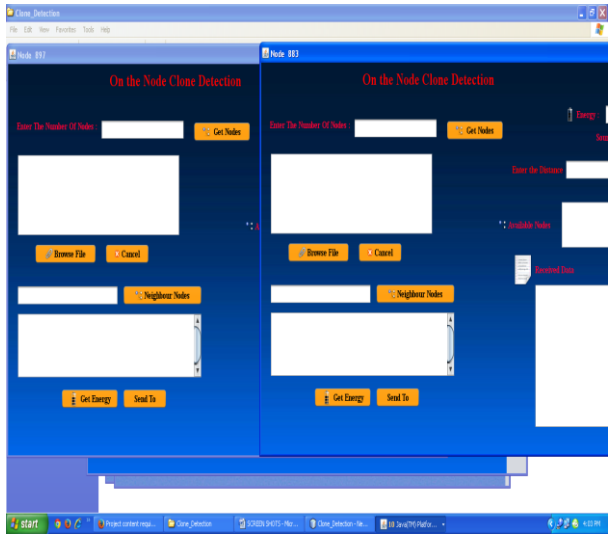


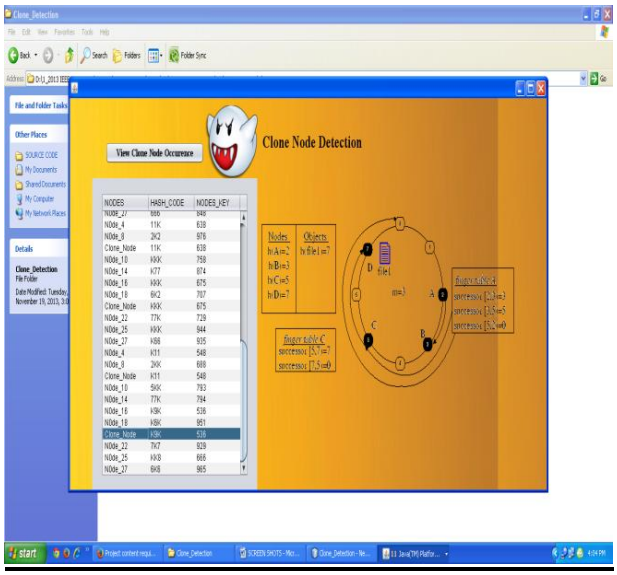
5. SCREEN SHOTS











6. CONCLUSION

Sensor nodes lack tamper-resistant hardware and are subject to the node clone attack. In this paper, we present two distributed detection protocols: One is based on a distributed hash table, which forms a Chord overlay network and provides the key-based routing, caching, and checking facilities for clone detection, and the other uses probabilistic directed technique to achieve efficient communication overhead for satisfactory detection probability. While the DHT-based protocol provides high security level for all kinds of sensor networks by one deterministic witness and additional memory-efficient, probabilistic witnesses, the randomly directed exploration presents outstanding communication performance and minimal storage consumption for dense sensor networks.

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