Deconstructing Source Location Privacy-aware Routing Protocols

Arshad Jhumka and Matthew Bradbury

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Outline

- Introduction
- Related Work
- Models Used
- Example Techniques
- Source Location Privacy Components
- Case Studies

What is a Wireless Sensor Network?

A wireless sensor network (WSN) is a collection of computing devices called nodes, they have:

- a short range wireless radio
- an array of sensors such as light, heat and humidity
- a simple low powered CPU
- a battery with limited power supply

Applications include:

- Tracking
- **Monitoring**

What is Context Privacy?

- Privacy threats can be classified as either content-based or **context-based**
- Content-based threats have been widely addressed (using cryptography) (Perrig et al. [6])
- Context-based threats are varied
- We focus on protecting the location context of broadcasting nodes

The Problem of Source Location Privacy (SLP)

Given:

- A WSN that detects valuable assets
- A node broadcasting information about an asset

Found:

- An attacker can find the source node
  by backtracking the messages sent through the network.
- So by deploying a network to monitor a valuable
  asset, a way has been provided for it to be captured.

The Problem:

- Panda-Hunter Game
- Difficult

Related Work

- Attacker Models (Benenson et al. [1])
- Phantom Routing (Kamat et al. [3])
- Fake Sources: TFS/PFS (Bradbury et al. [2])
- Combination: Tree-based (Long et al. [4])
- Global Attacker: (Mehta et al. [5])

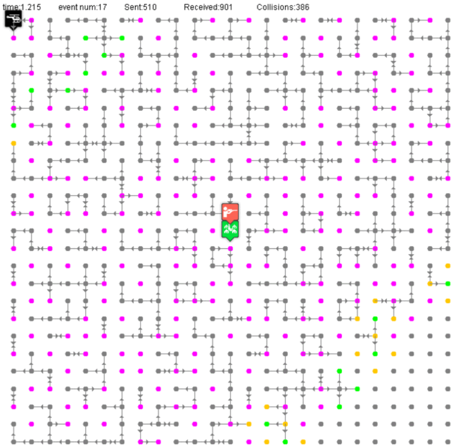
Privacy Model

- Aim of an SLP protocol: prevent the attacker from capturing an asset through information the WSN leaks.
- A stationary asset cannot be protected as an attacker can perform an exhaustive search.
- Mobile assets will only stay in detection range of a WSN node for a certain amount of time.
- The SLP problem can only be considered when it is time-bounded.
- This captures the maximum amount of time an asset will stay near a certain node.
- The *safety period* is how long the asset will be protected for.
- Other work has defined the safety period as unbounded and attempted to increase it.
- We assume a bounded safety period.

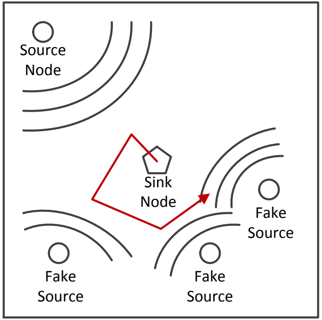
Attacker Model

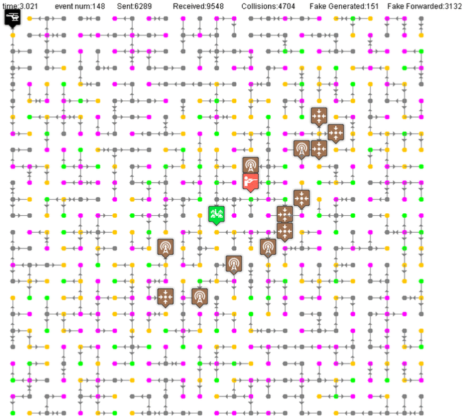
- Attacker's aim is to reach the source within the safety period
- Assume a distributed eavesdropper present in the network
- Attacker range is limited to not cover the entire network
- Attacker is mobile
- Attacker follows first new packet it receives

Example: Protectionless Flooding

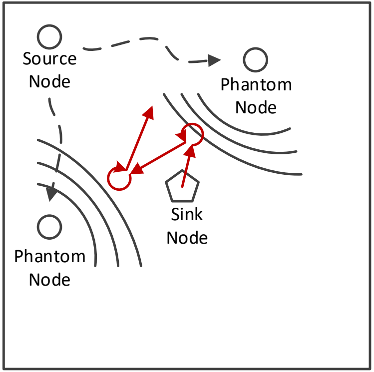


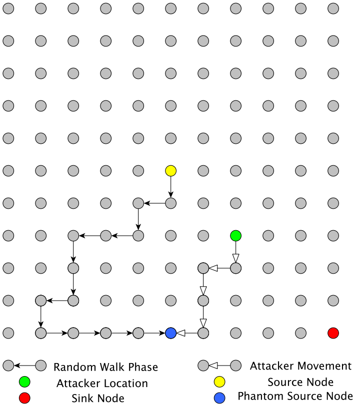
Example: Dynamic Fake Sources





Example: Phantom Routing





Deconstruction

We argue that routing-based SLP techniques can be separated into two categories:

- Spatial
  - Lure the attacker to some other part of the network instead of the source-detecting node.
  - Requires spatial redundancy in the network.
- Temporal
  - Delay the attacker on its path to the source, so the safety period expires.
  - Requires delay-tolerant application.

Some algorithms will use a combination of these strategies to delay the attacker.

Component 1: Selection of Decoys

- Decoys need to be selected so there is little or no correlation between them and the source
- Decoy selection should not indirectly leak the source's location

- Spatial Selection
  - Attacker is made to travel a longer route (other than shortest path)
  - Decoys typically change slowly and subsequent decoys are close to one another
- Temporal Selection
  - Attacker is made to miss messages, causing it to be delayed
  - Decoys typically change frequently

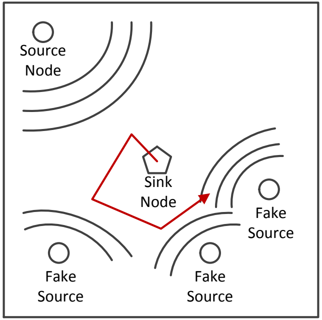
Component 2: Use and Routing of Control Messages

- Spatial Selection
  - Aim to select decoys close to one another to lure the attacker along a path
  - Decoys need to be chosen in a space away from the source
  - Control messages need to select these decoys
  - Allows different protocols for convergecast routing and control message routing
- Temporal Selection
  - Aim to select decoys so that an attacker misses messages and is delayed
  - Decoys can be spread out over an area
  - The control messages typically form part of the convergecast route

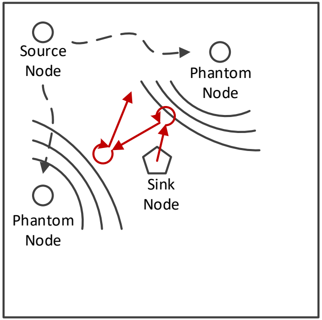
Component 3: Use and Routing of Decoy Messages

- Spatial
  - Decoy nodes are luring the attacker, so want the attacker to receive these messages
  - Flooding is a good protocol, as it should lure the attacker from anywhere in the network
- Temporal
  - Decoy messages typically not required
  - As SLP is provided by the attacker missing hearing messages

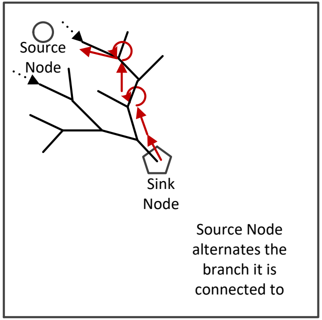
Case Studies



(a) Dynamic Fake Sources: An example of spatial selection of decoys [2].



(b) Phantom routing: An example of temporal selection of decoys [3].



(c) Tree routing: An example of temporal delay by alternating which branch the source node attaches to.

What does this mean?

Routing-based SLP techniques need to:

- Provide spacial redundancy in which to allocate decoy nodes
- Delay messages in a suitable way

- Not all applications will be able to provide spacial redundancy
- Not all applications will be able to tolerate delays
- This categorisation helps identify requirements of algorithms that the network deployer needs to provide

Some Exclusions

- Not all SLP techniques can be categorised using these components
- We are focusing on protocols at the routing layer protecting against a local attacker

The following types of protocols are examples that will not decompose this way:

- MAC based protocols
- Data mule approaches
- Global privacy techniques

Summary

- Routing-based SLP techniques are either spatial, temporal or a combination
- Identified three key components
  - Decoy Selection
  - Routing of control messages
  - Routing of decoy messages
- Given three examples to demonstrate these points

Future Work:

- We will formalise the components
- Develop correctness proofs for the composition to yield SLP-aware protocols

Questions

Any questions?

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[1] Zinaida Benenson, Peter M. Cholewinski, and Felix C. Freiling. *Wireless Sensors Networks Security*, chapter Vulnerabilities and Attacks in Wireless Sensor Networks, pages 22–43. IOS Press, 2008.

[2] M. Bradbury, M. Leeke, and A. Jhumka. A dynamic fake source algorithm for source location privacy in wireless sensor networks. In *14th IEEE International Conference on Trust, Security and Privacy in Computing and Communications (TrustCom)*, pages 531–538, August 2015. doi: 10.1109/Trustcom.2015.416.

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[6] Adrian Perrig, John Stankovic, and David Wagner. Security in wireless sensor networks. *Commun. ACM*, 47(6):53–57, June 2004. ISSN 0001-0782. doi: 10.1145/990680.990707.