Defending Against Black Hole Attacks on AODV Routing

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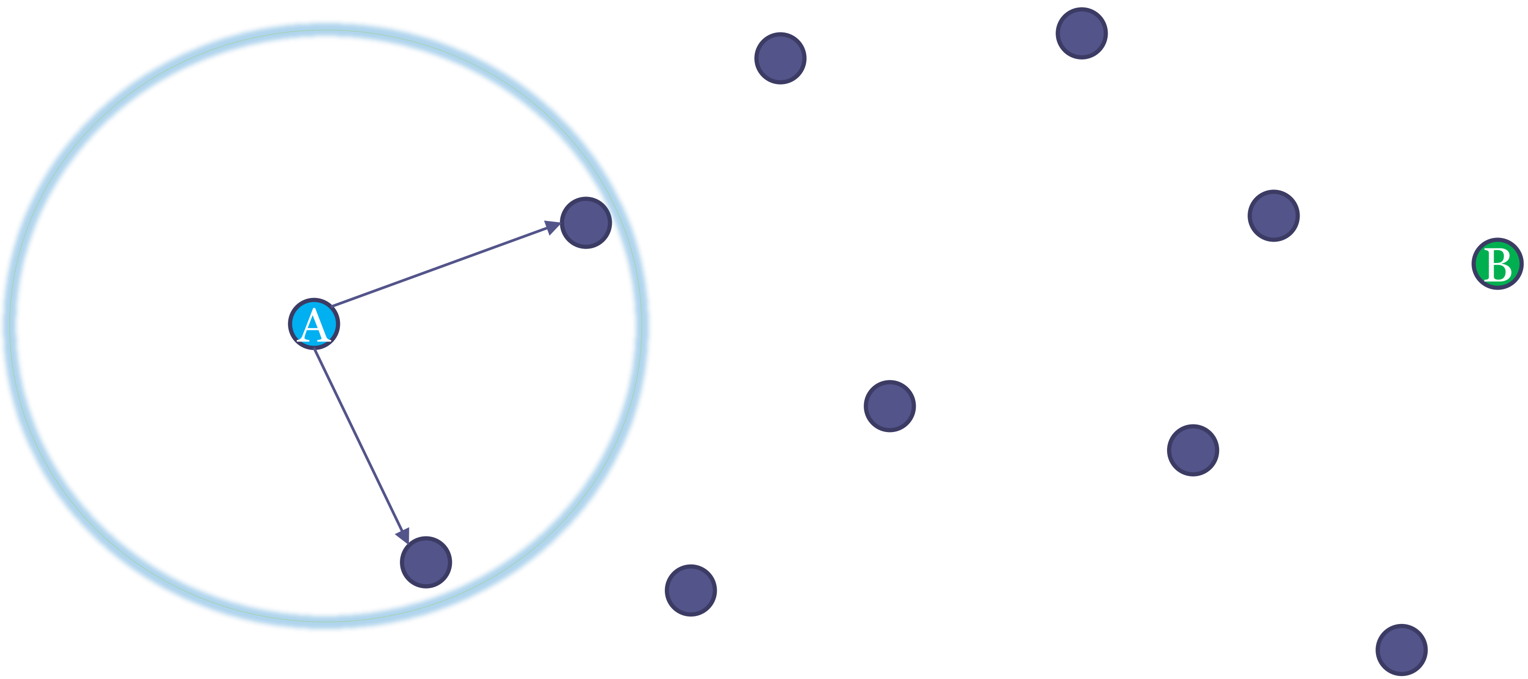
What is AODV Routing?

- Ad-hoc On Demand Distance Vector Routing (AODV)
- This is the routing protocol used in ZigBee, a popular standard for wireless mesh networks.
- A mesh network is a topology in which each node relays data for the network.

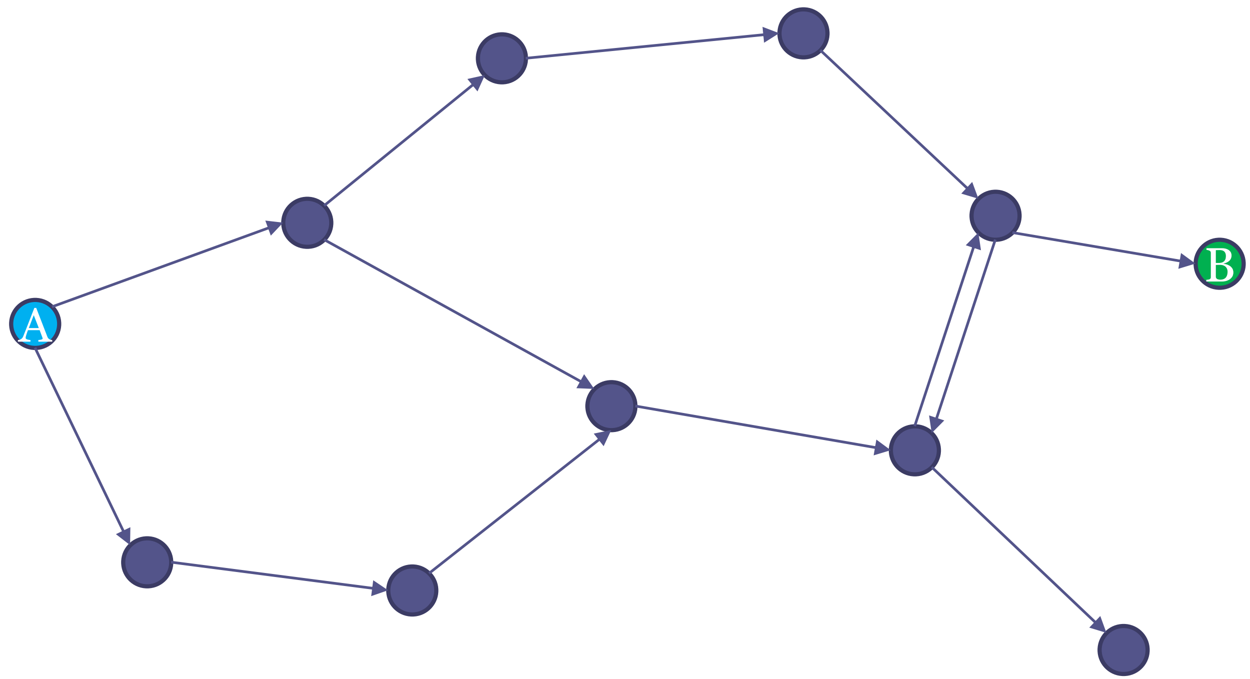
How does AODV work?

- Original sender broadcasts Route Request (RREQ).



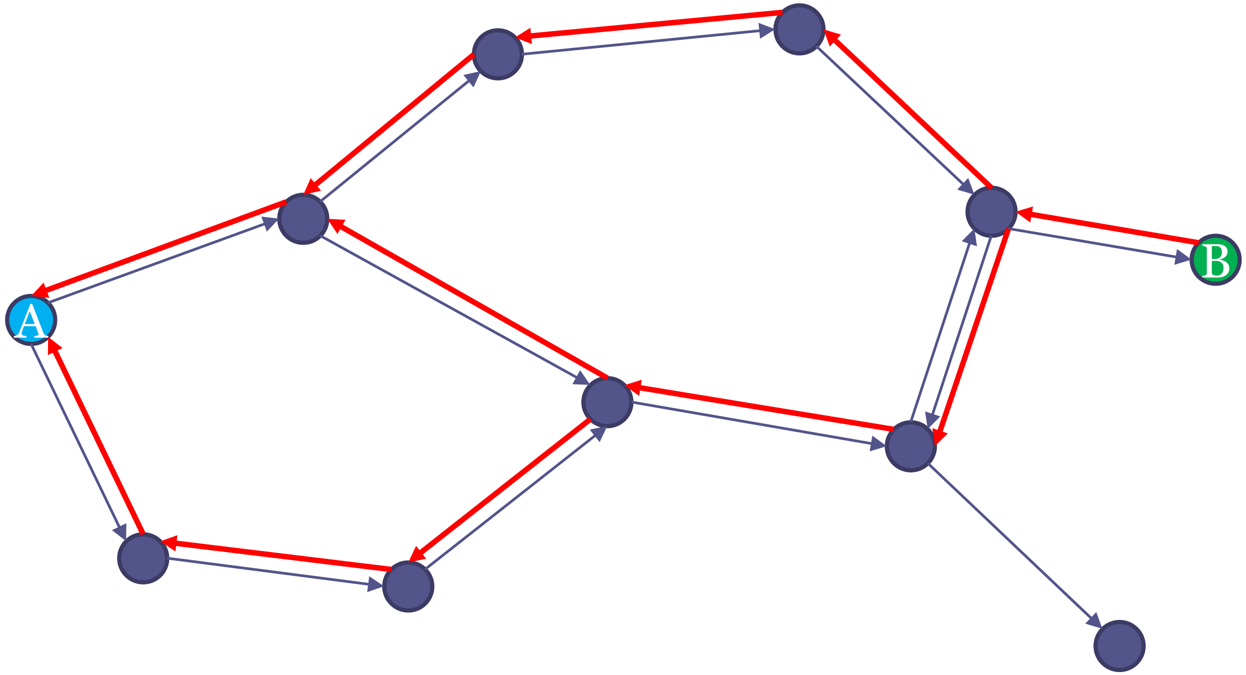
How does AODV work?

- Intermediate nodes propagate RREQ.



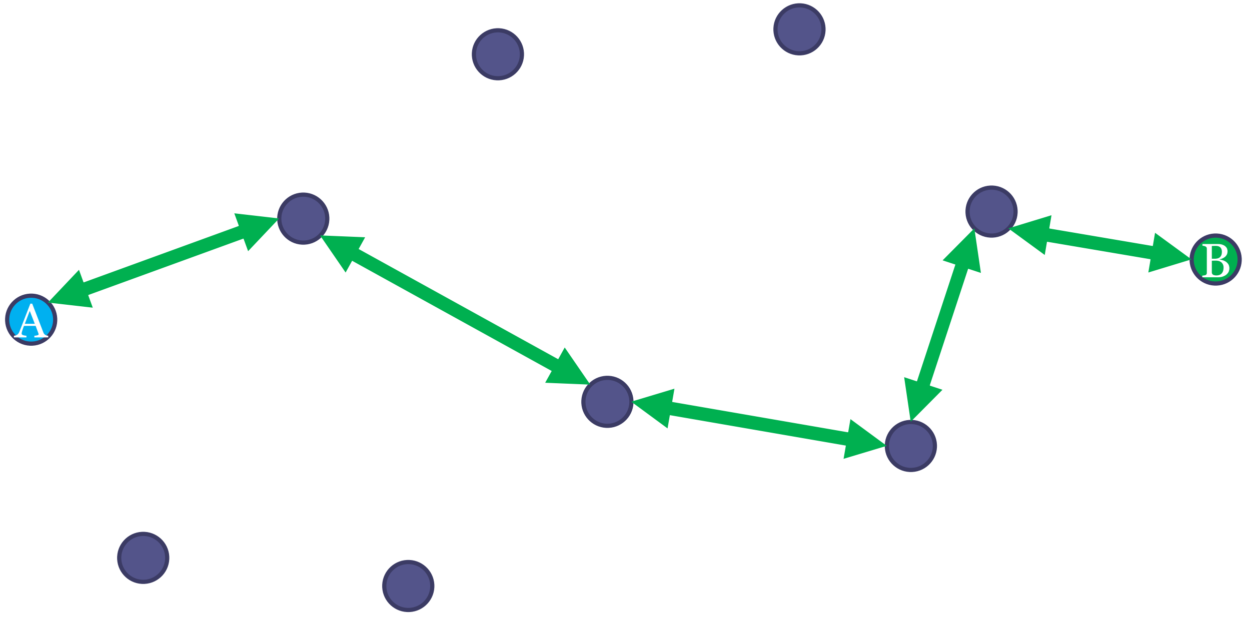
How does AODV work?

- Destination node sends Request Reply (RREP) back to sender for each RREQ.



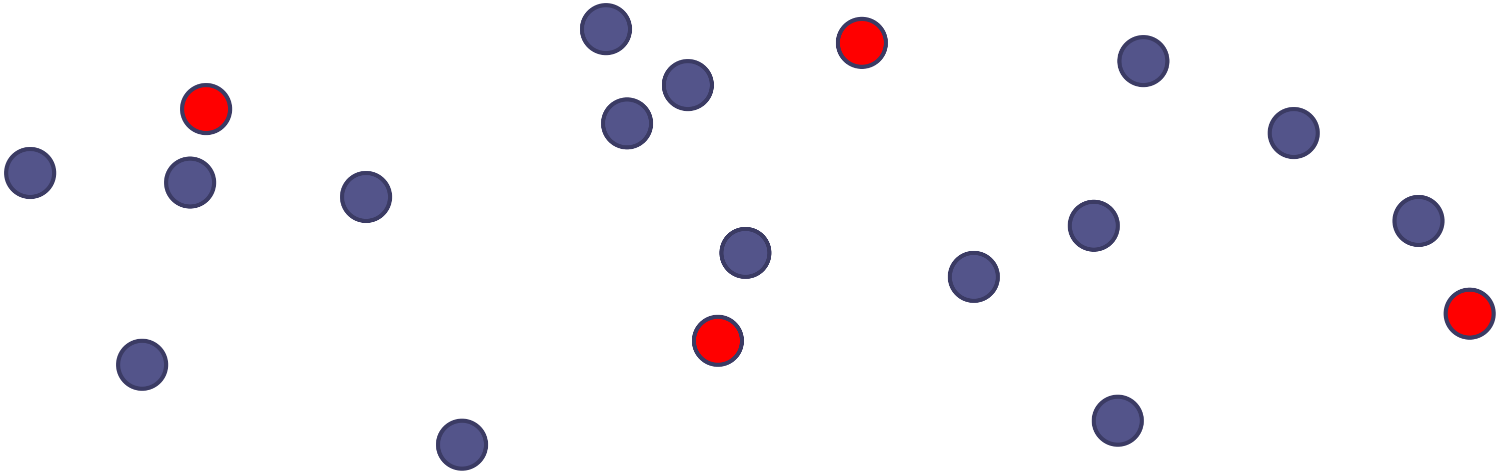
How does AODV work?

- Sender uses lowest hop-count route to communicate with destination.



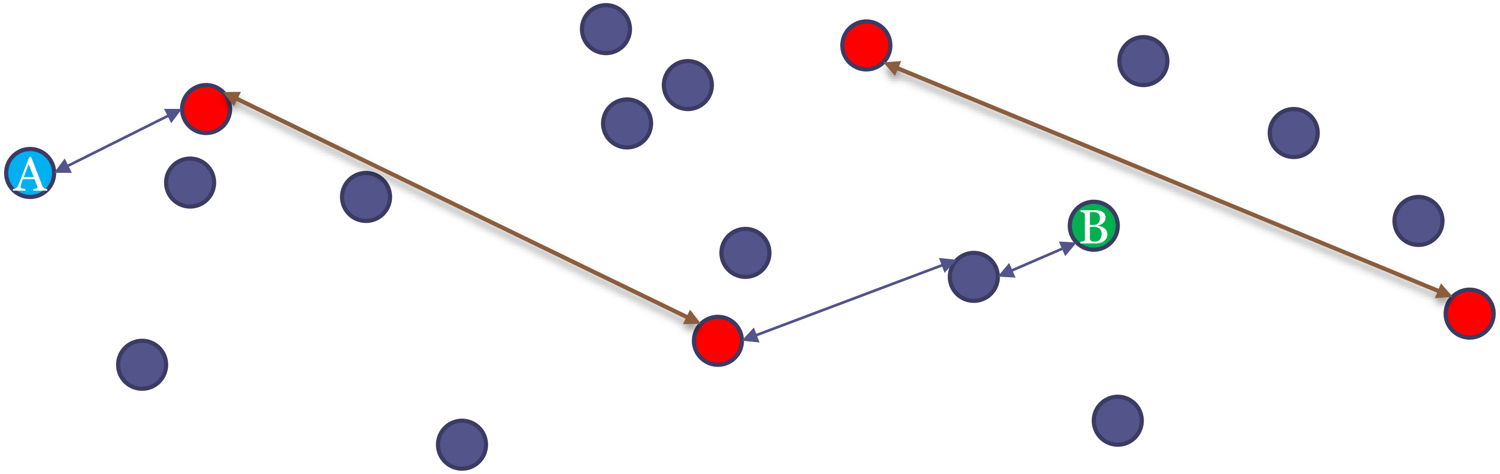
Wormhole Attack (Initial Conditions)

- Two or more nodes are deployed or captured by an adversary. *Capture is unnecessary*.



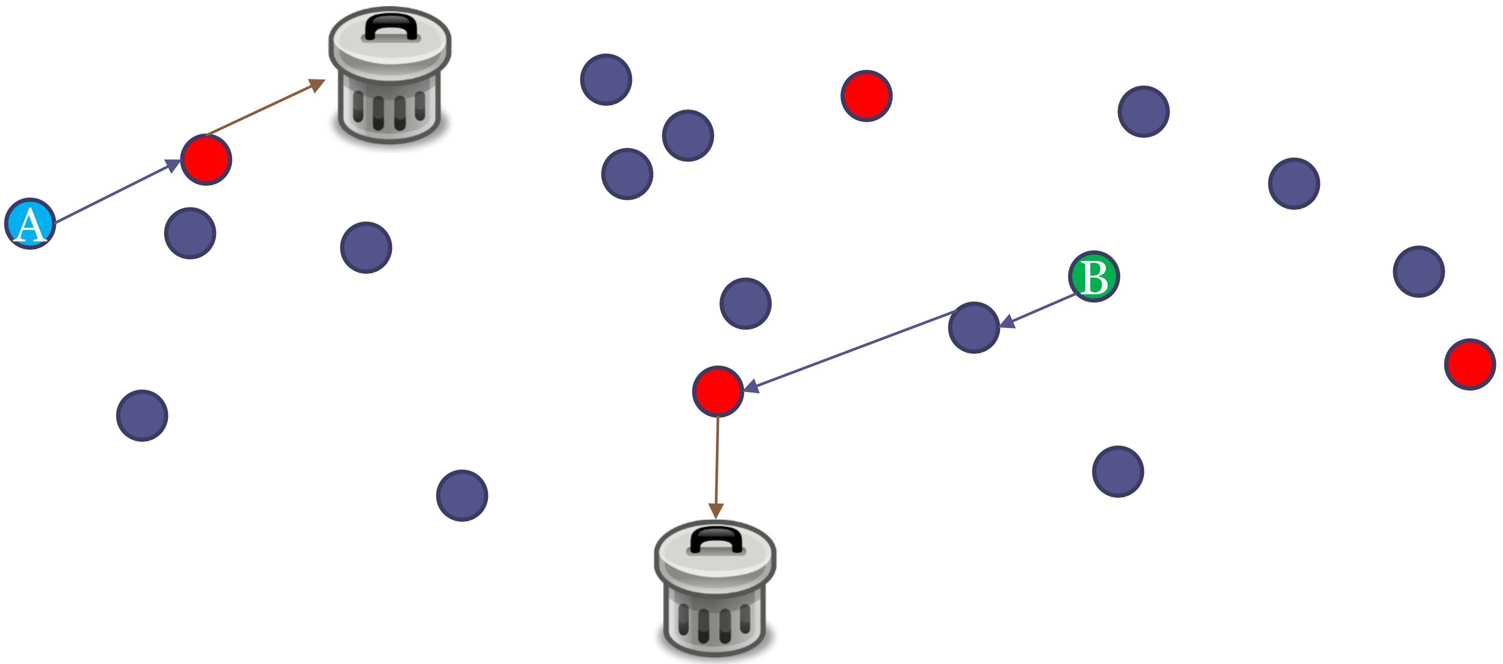
Wormhole Attack (Getting Selected)

- Each pair of enemy nodes creates a tunnel using long-range directional antennas (to offer the shortest path for many routes).



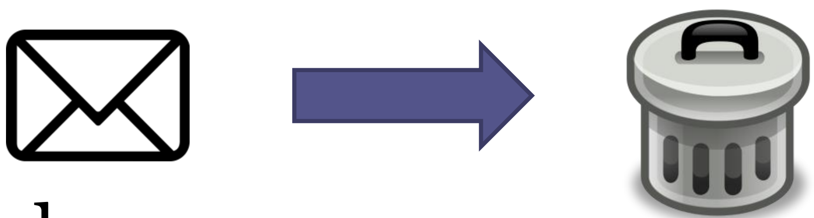
Black Hole Attack (Exploitation)

- The enemy nodes drop all packets rather than forwarding them.

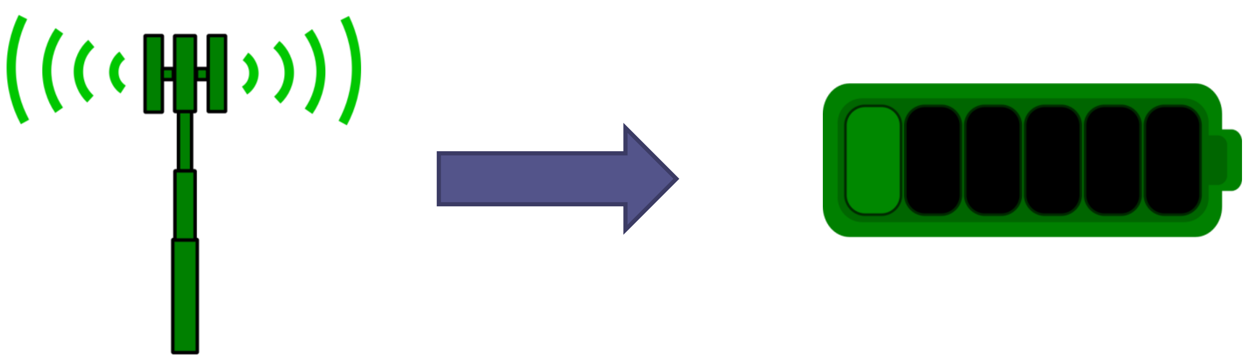


Attack Model (Results)

- Data loss
  - Packets never reach their destination.



- Energy loss
  - Nodes waste energy on radio communication.



Related Work

- Authentication based solutions:
  - Examples: Adriane, ARAN
  - Add encryption to message passing.
  - Allows for very secure communication.
  - Increases computational overhead on participating nodes.
  - Some methods also require centralized authentication.

Related Work

- Statistical intrusion detection systems:
  - Monitor normal packet loss due to network congestion.
  - Differentiates between normal loss and malicious packet dropping.
  - Requires consistent, heavy traffic which might not be present in a lightweight ad hoc network.

Related Work

- Intrusion detection systems via network monitoring devices:
  - Strategically placed devices observe network traffic to identify abnormal behavior.
  - Nodes identified as abnormal are communicated to legitimate nodes and avoided.
  - This can work well for static networks where security is extremely important.
  - Not suited for truly dynamic ad hoc networks.

Defensive Goals

- Primary Objective
  - Detect whether or not packets reach their destination. Pick a new route if too many packets are being dropped.
- Secondary Objective
  - Minimize message complexity in order to reduce network transmissions.

Our Approach

- Routes in AODV must be periodically refreshed.
- Source knows the number of data packets sent, and Destination knows the number received.
  - Exchange # of packets sent/received when refreshing routes.
- AODV floods the network when establishing routes.
  - A polling of the neighbors can be used to detect deception by enemy nodes. Once detected, pick a new route.

Advantages

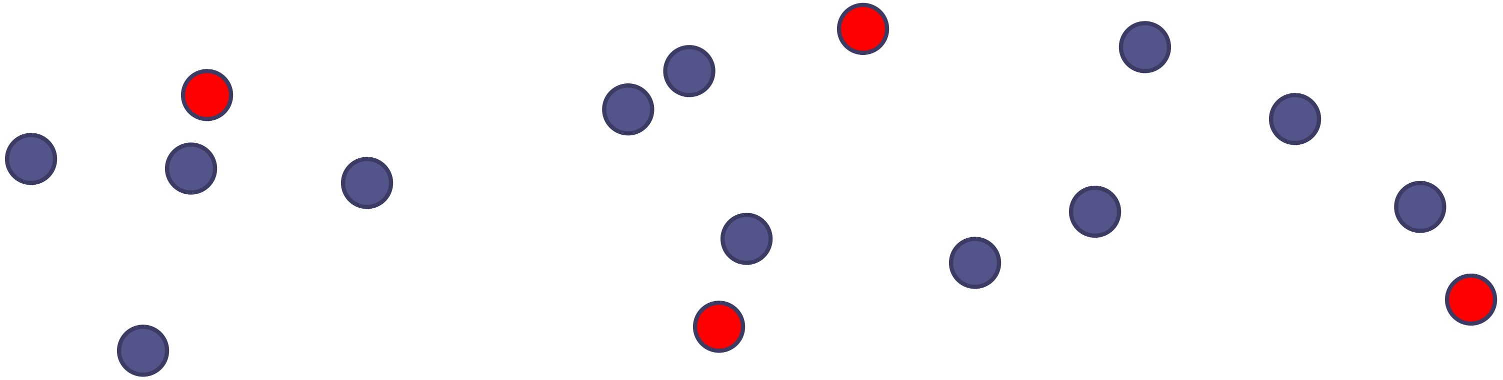
- Minimal changes to AODV.
  - Two new integer data fields.

- Zero encryption required.
  - Not computationally intensive.

- Does not increase message complexity.
  - Better battery life.

Evaluation

- We need to compare our solution to other techniques for preventing or countering black hole attacks.
- Suggested approach: Build a network simulation and test various attack scenarios.



Network Simulation

- Network is represented as a graph.
  - Edges connect nodes in communication range.
- Random nodes are chosen to form routes using AODV.
  - Dummy messages are sent one or both ways to simulate data transactions.
- Attackers attempt to execute black hole attacks per various scenarios.
- Simulation ends after a fixed period of time or fixed number of messages.

Attack Scenarios

- No black holes occur.
  - This would help test how proposed solutions affect normal network operation.
- A single black hole is formed.
  - This would show how proposed solutions work under ideal conditions.
- Multiple black holes are formed.
  - This would test what happens when the enemy has greater capabilities and can further disrupt the network.

Evaluation Metric

- Two main concerns:
  - Number of lost messages (L)
  - Message complexity of proposed solution (M)
- Minimizing L increases availability.
- Minimizing M decreases power usage.
- The end user can prioritize either one if we view this as a multi-objective problem.
  - This means the user can decide the relative weight of both metrics.

Sources

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Sources

- Images from openclipart.org
  - Including the adorable trash cans.