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Randomly Directed Exploration
An Efficient Node Clone Detection Protocol in Wireless Sensor Networks

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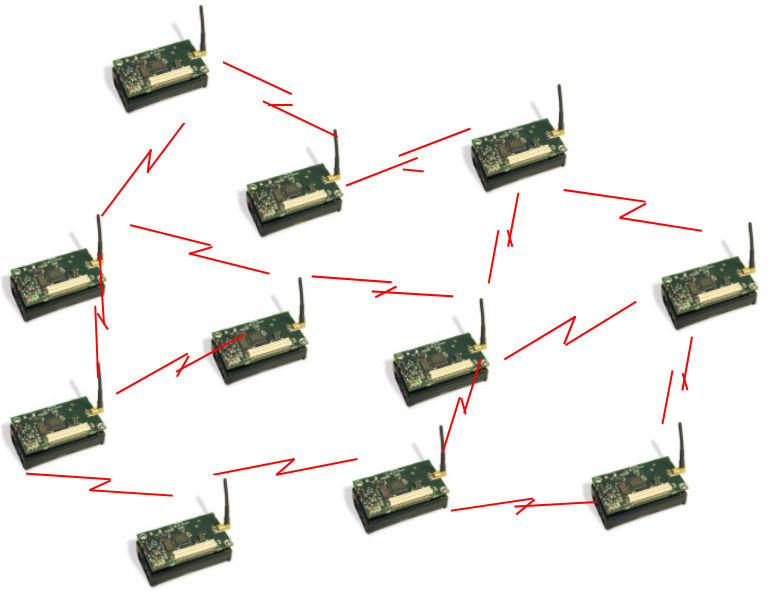
Overview

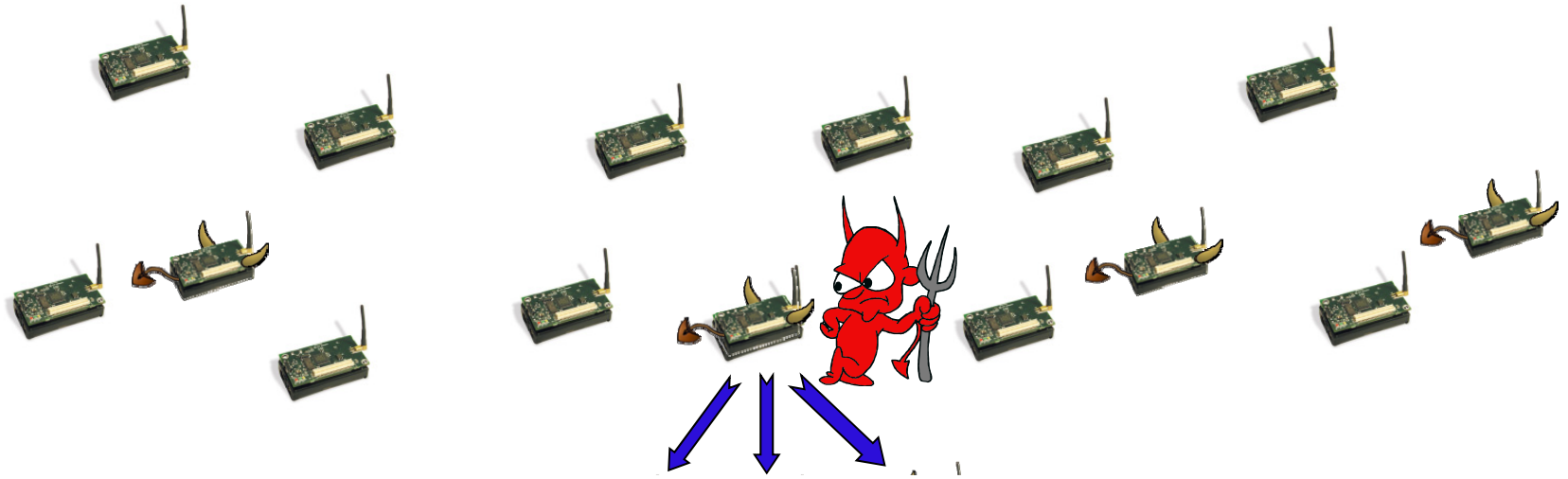
- Node Clone Attack and Previous Schemes
- Proposed Distributed Detection Protocol
- Simulations

Wireless Sensor Networks

- Ad-hoc
- A Large Number of Low-Cost Sensor Nodes
- Multi-Hop
- Infrastructureless



Node Clone Attack in WSNs

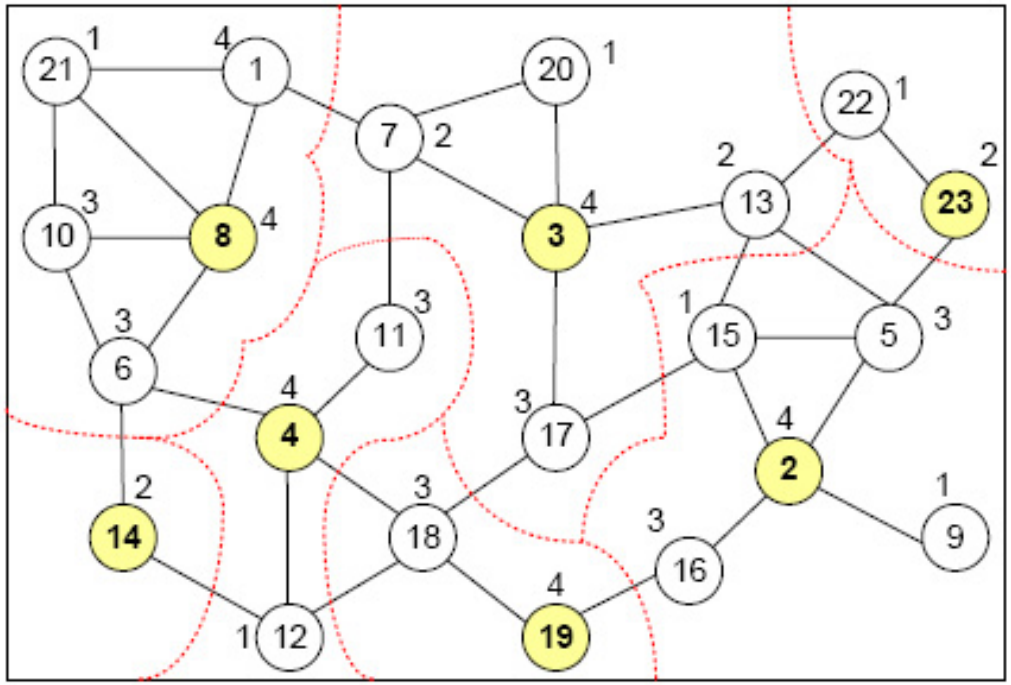


- Corrupt the collected information
- Spread abnormal behavior
- Exacerbate most of inside attacks

Centralized Approaches

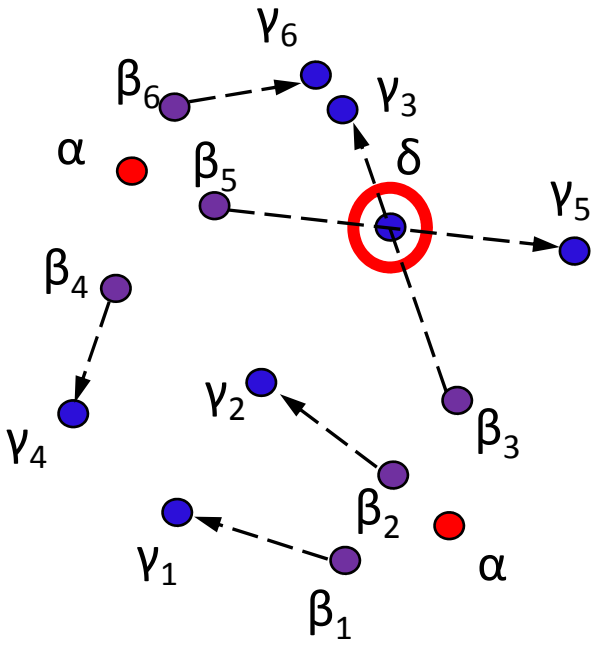
- Nodes report all neighbors to base station
- **SET**, [*Choi, Zhu,* and *Porta*, 2007]

Exclusive
Subset
Maximal
Independent
Set
Algorithm

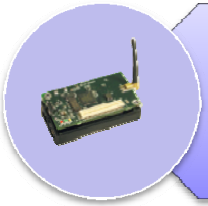


Distributed Approaches

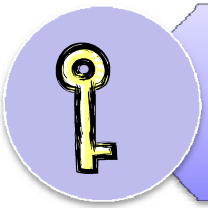
- Node-to-Network Broadcast
- *Parno, Perrig*, and *Gligor*, IEEE S&P 2005
  - Randomized Multicast
  - Line-selected Multicast
- GHT/DHT Based Schemes



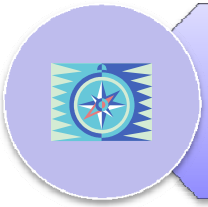
Network Model



Homogeneous Sensors Densely Deployed

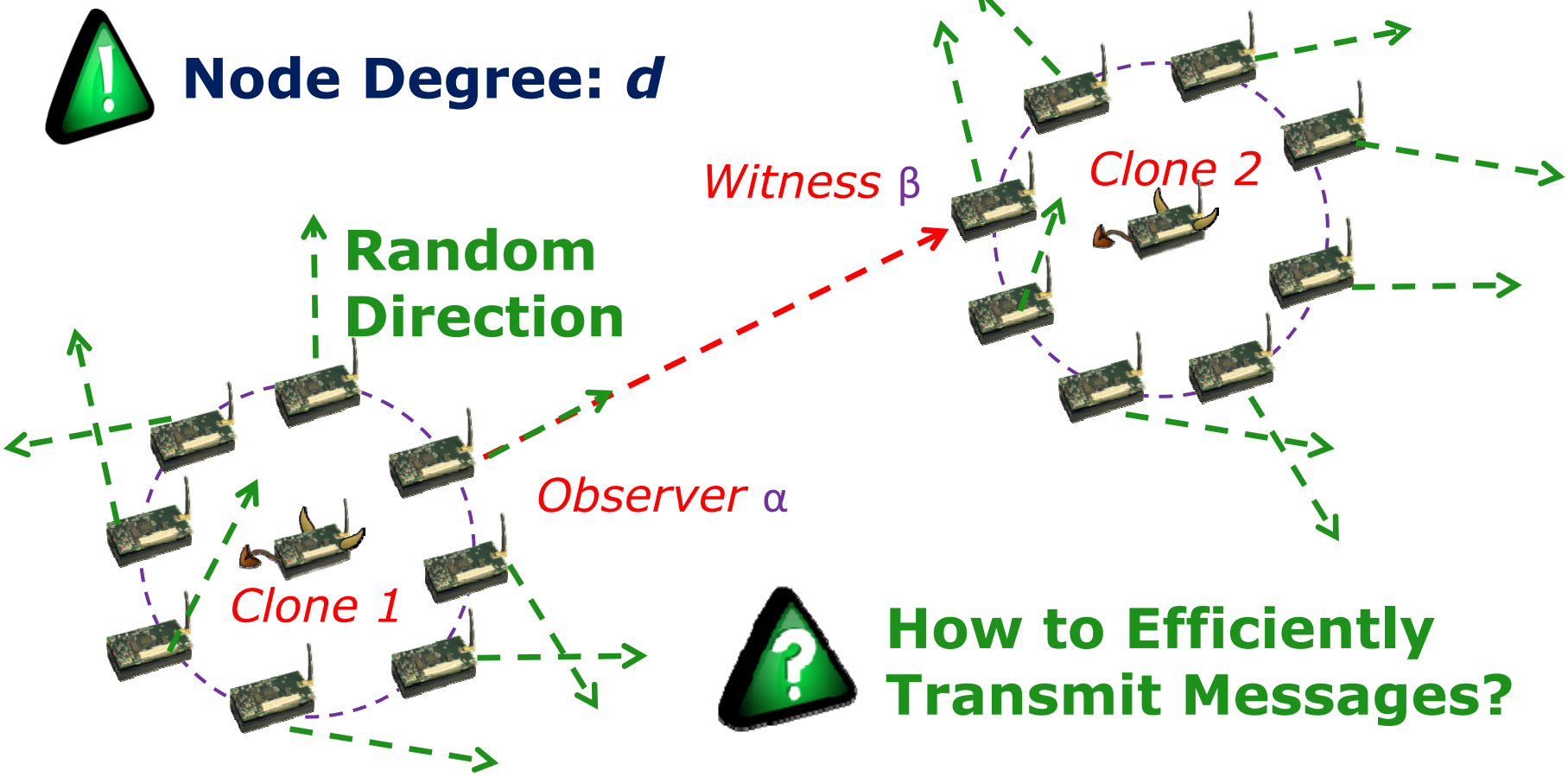


Identity-based Public-key Cryptography

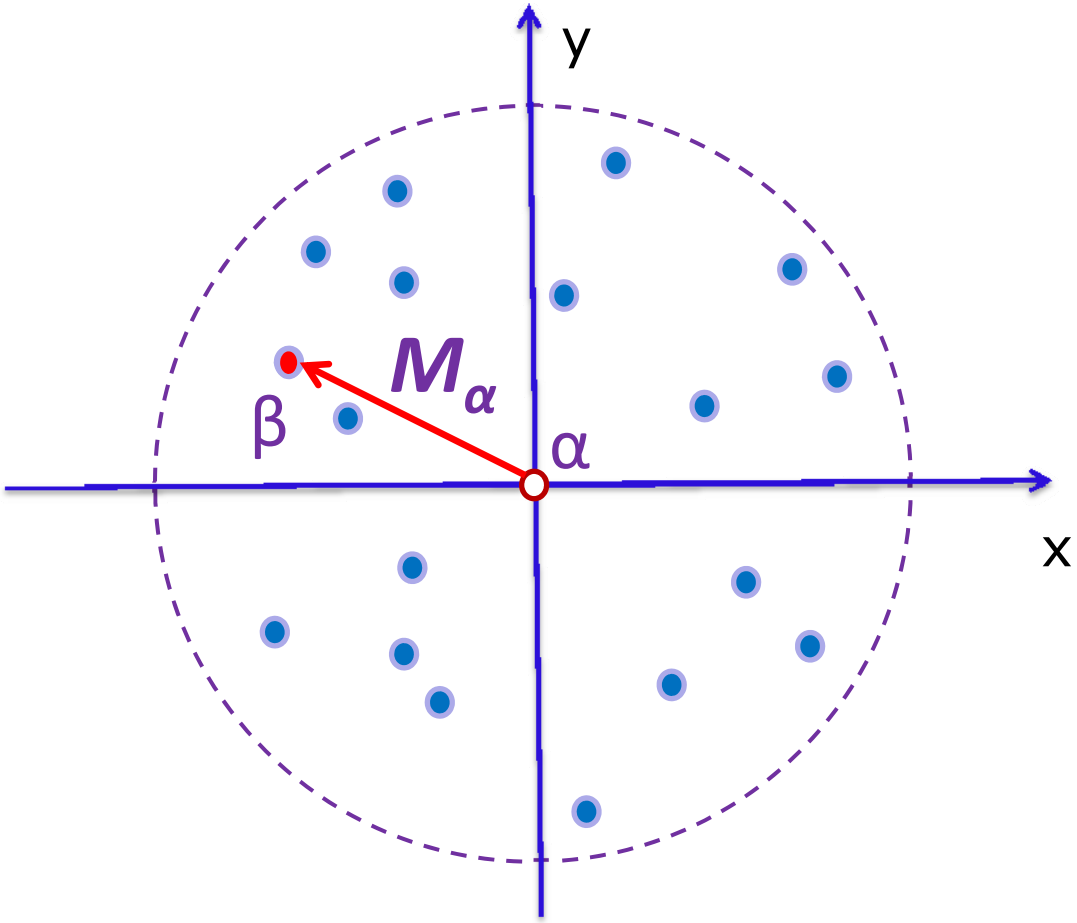


Secure Localization Mechanism

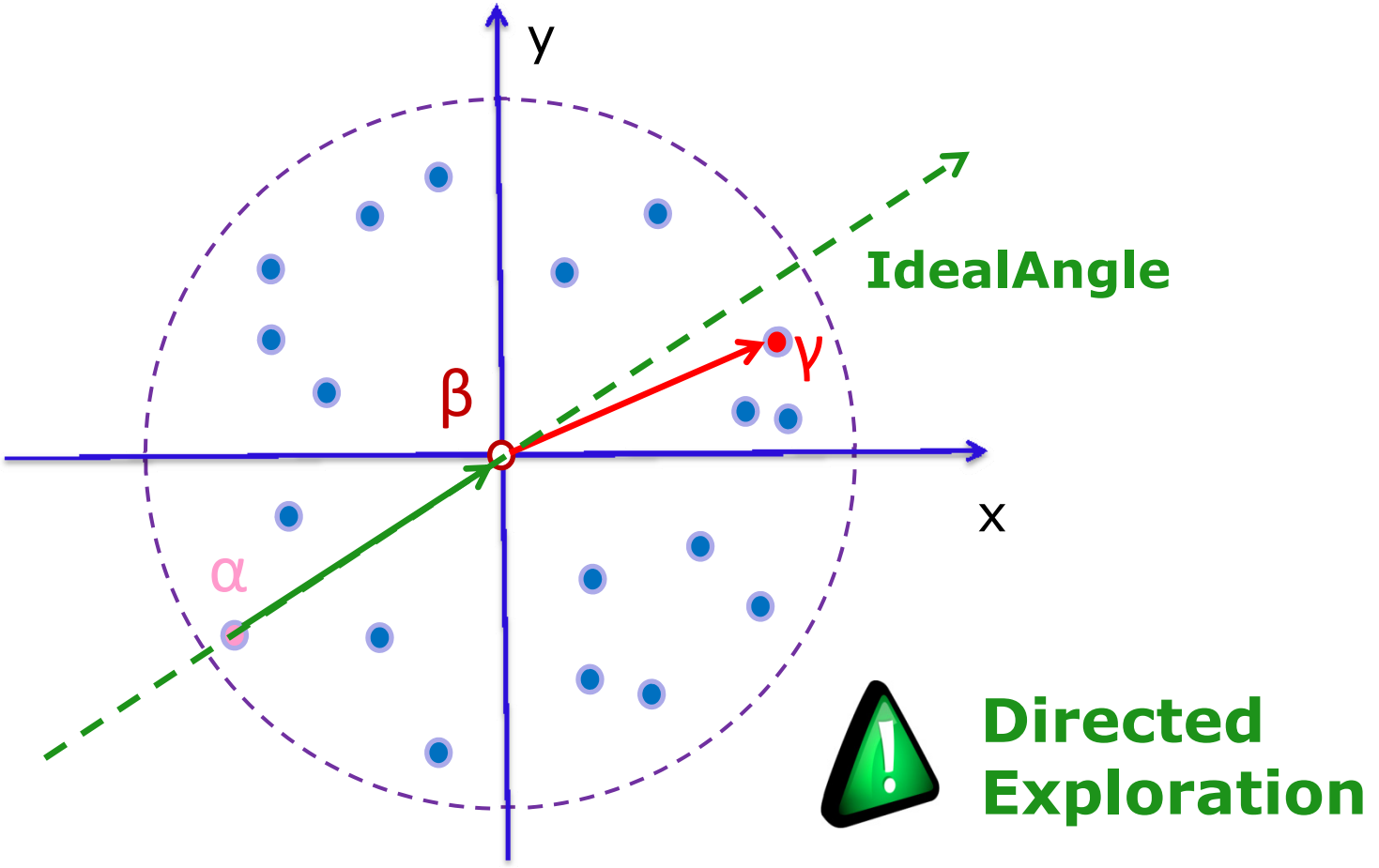
Proposed Protocol
Main Idea



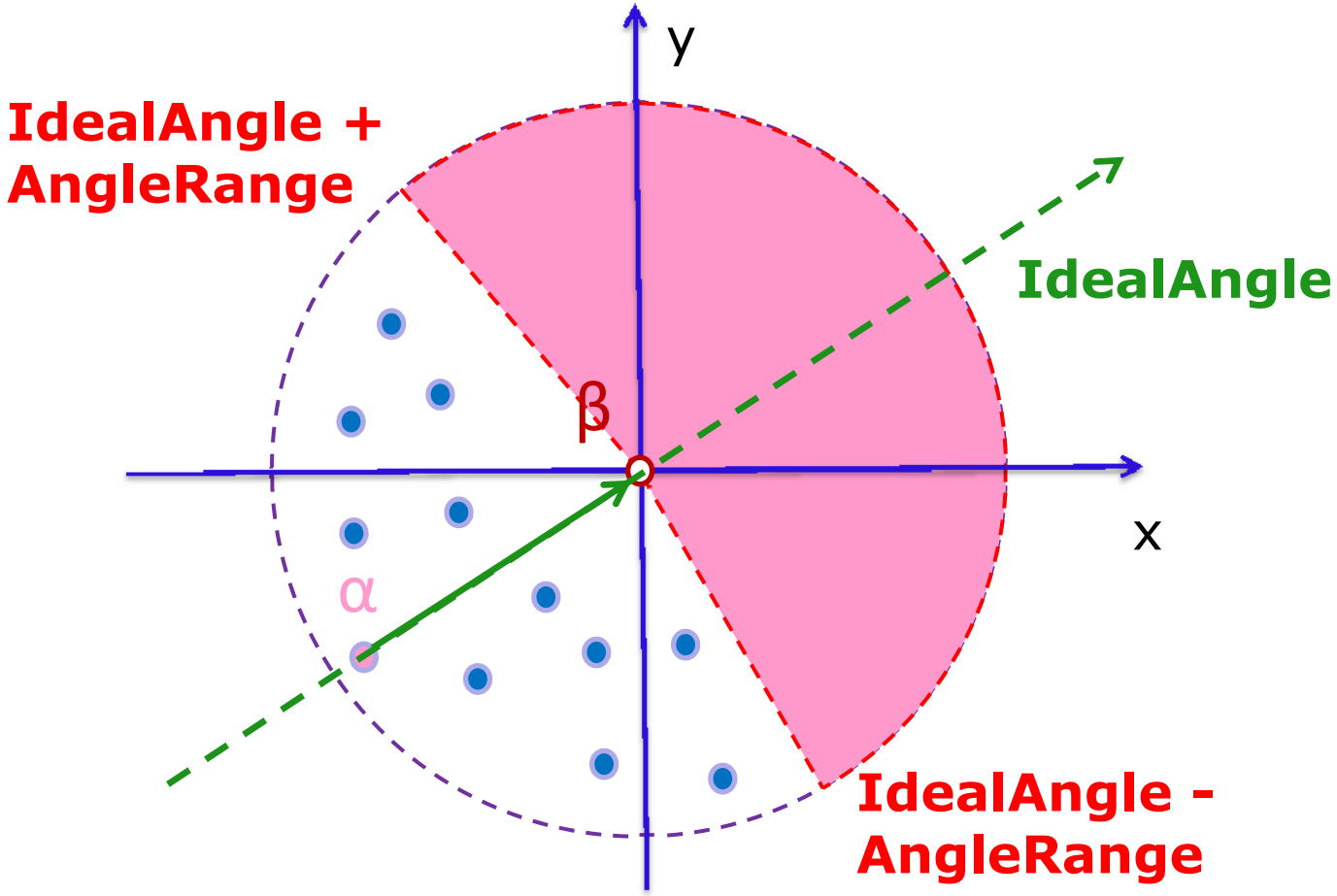
Initial Direction: Random



Forwarding Messages(Routing)



Boundary Case



Protocol Parameters

- ***TTL***--- time to live

- ***Type*** --- routing type
  - Type 1: Discard a message only if *ttl*=0
  - Type 2: In addition to *ttl* = 0, discard a message when it reaches a boundary.

    AngleRange

Algorithm: HandleMessage(M_α)

1: verify the signature of M_α
2: **if** found clone **then**
3: broadcast the evidence;
4: $ttl \Leftarrow ttl - 1$
5: **if** $ttl \leq 0$ **then**
6: discard M_α
7: **else**
8: $nextnode \Leftarrow getnextnode(M_\alpha)$
9: **if** $nextnode =$ NIL **then**
10: discard M_α
11: **else**
12: forward M_α to $nextnode$

$$M_\alpha = ttl, ID_\alpha, L_\alpha, NeighborList_\alpha, \{ID_\alpha, L_\alpha, NeighborList_\alpha\}_{K_\alpha^{-1}}$$

$$M_{evidence} = M_\alpha, M_\beta$$

Performance Comparison

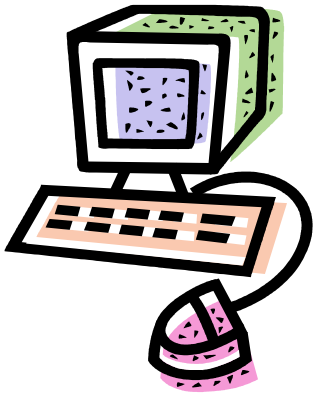
Protocol	Comm. Cost	Memory Cost
Node-To-Network Broadcasting	$O(N)$	$O(d)$
Randomized Multicast	$O(N)$	$O(\sqrt{N})$
Line-Selected Multicast	$O(\sqrt{N})$	$O(\sqrt{N})$
Randomized, Efficient, and Distributed	$O(\sqrt{N})$	$O(d\sqrt{N})$
Single Deterministic Cell	$O(\sqrt{N})$	$< O(\sqrt{N})$
Parallel Multiple Probabilistic Cells	$O(\sqrt{N})$	$< O(\sqrt{N})$
Randomly Directed Exploration	$O(\sqrt{N})$	$O(d)$

Security Analysis

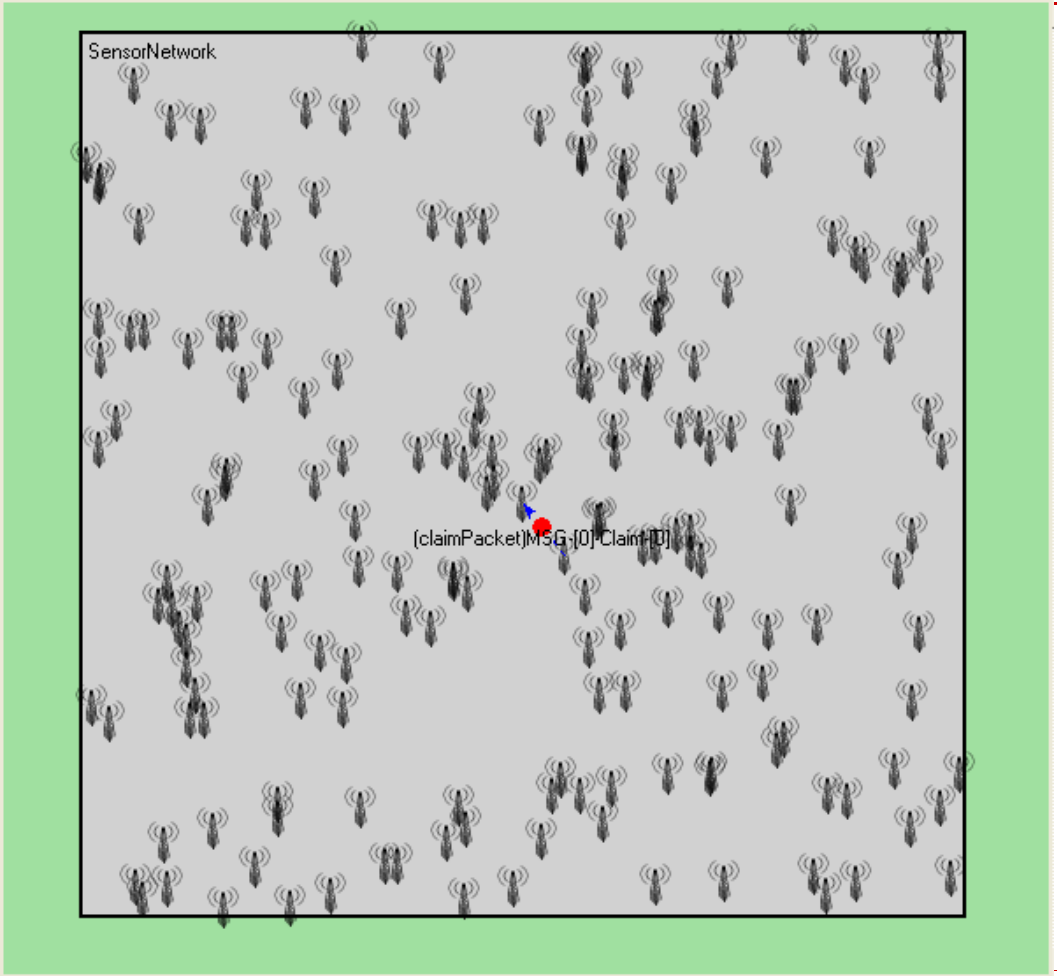
- Identity Authentication
- Message Authentication
- A cloned node cannot lie to its neighbors about its location

Simulations

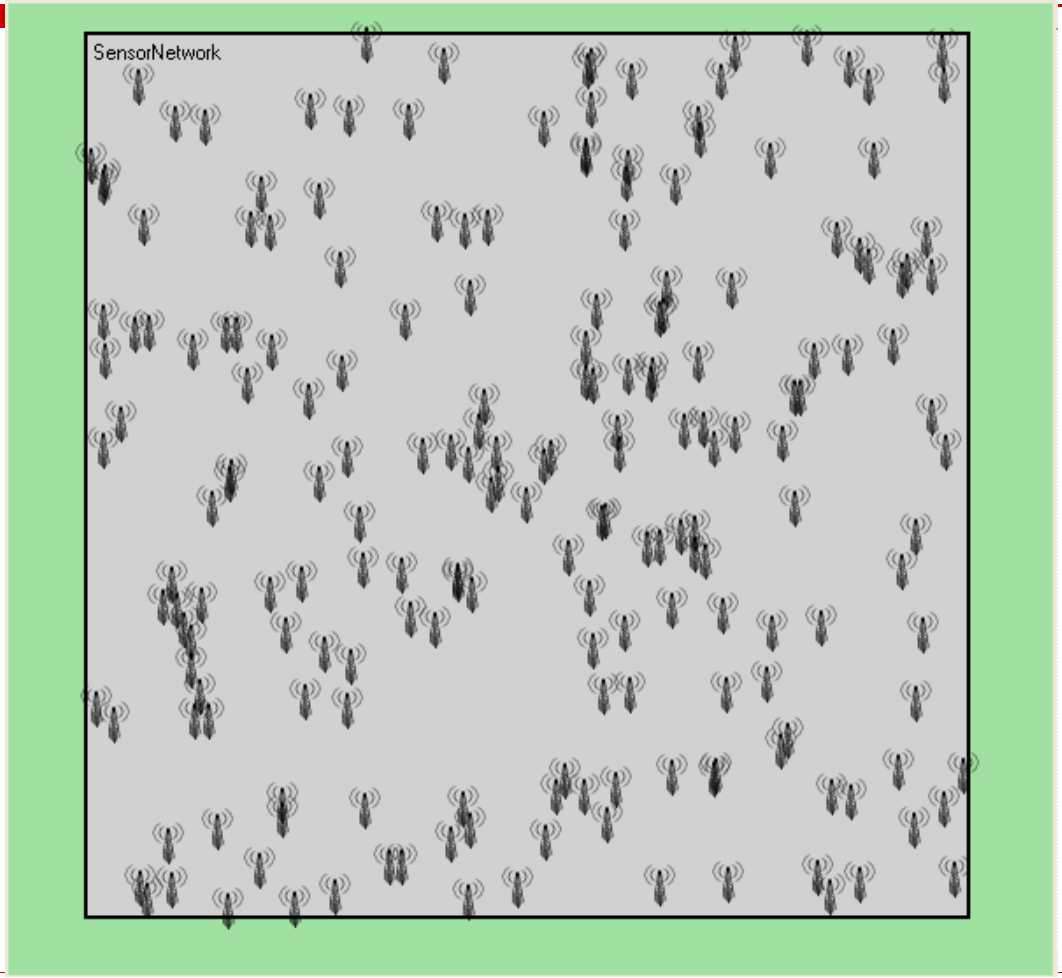
- OMNeT++ Platform
- Unit-Disc Graph
- Parameters:
  - $d = 20$
  - $ttl = \sqrt{N}$
  - Two cloned nodes



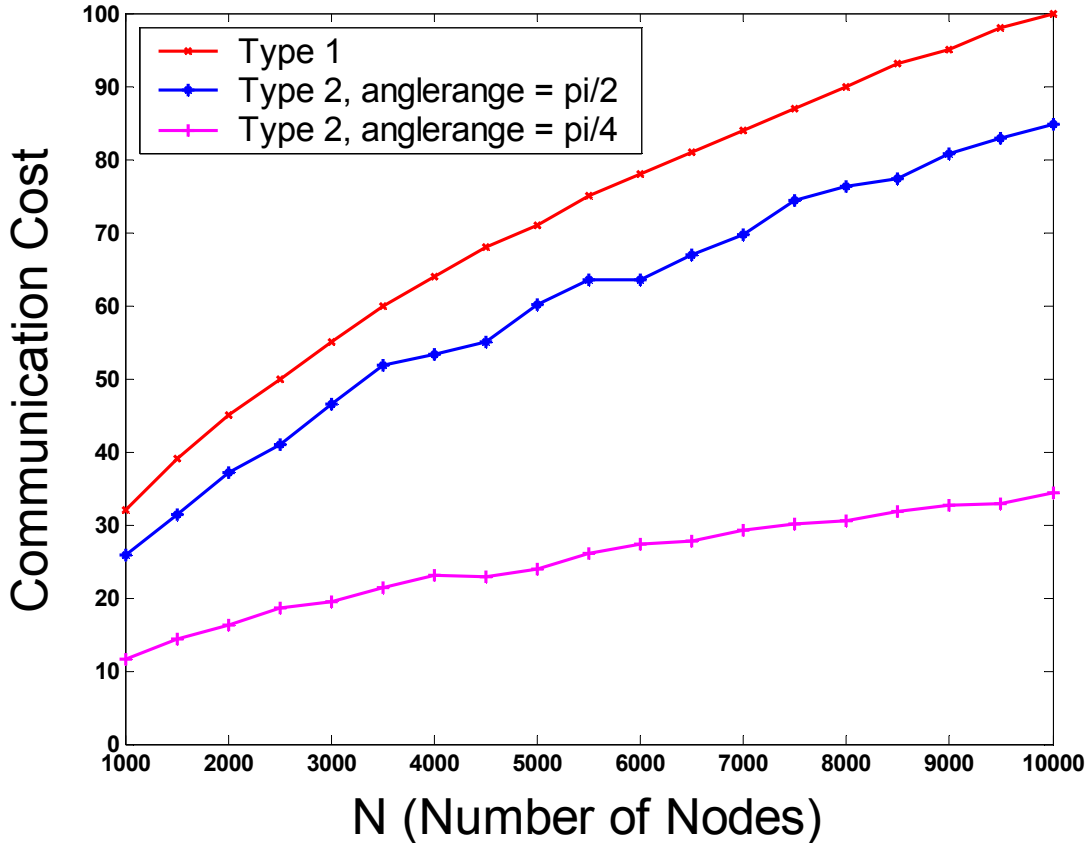
Simulation Demo: ***Type 1***



Simulation Demo: *Type 2*

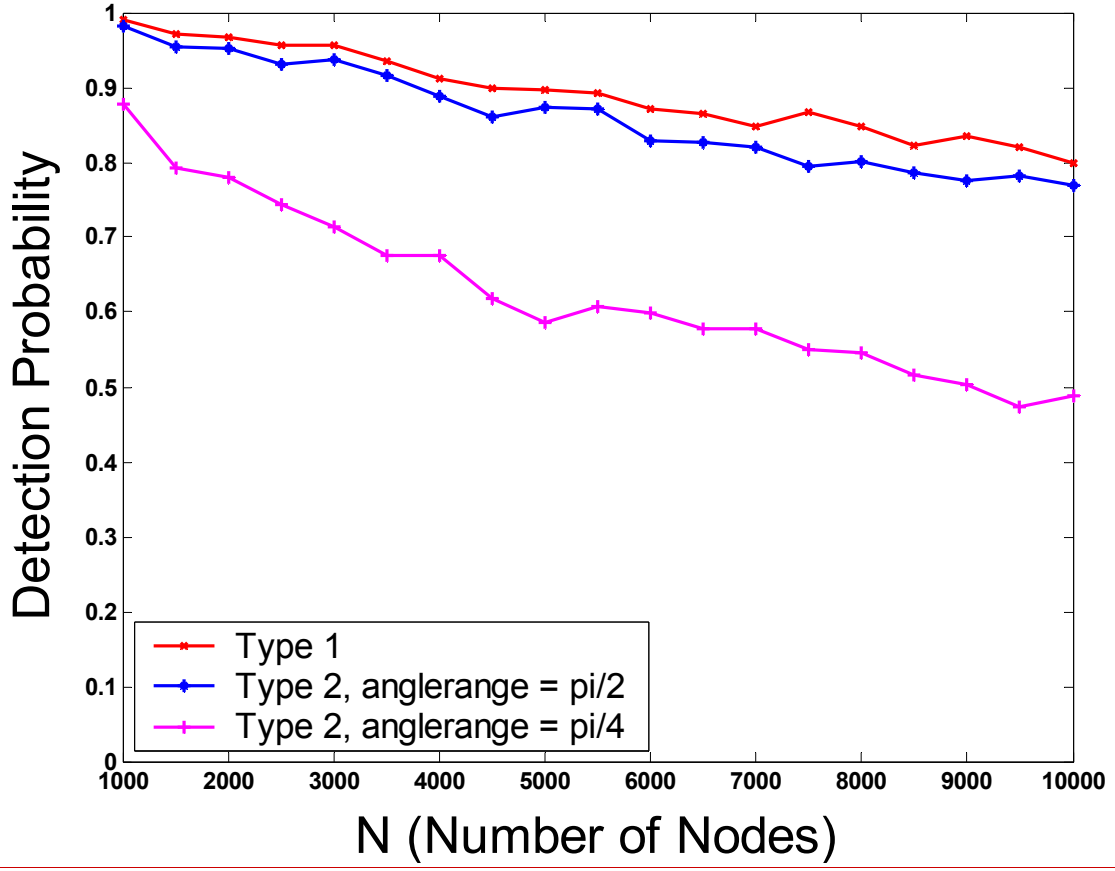


Simulation Results
Communication Cost



Simulation Results

Success Probability of Detection



Conclusions

- Directed-Forwarding
- Initial Randomness
- Achieves High Detection Probability
- Remarkable Communication and Memory costs

- Z.J. Li and G. Gong, Randomly Directed Exploration: An Efficient Node Clone Detection Protocol in Wireless Sensor Networks, Proceedings of IEEE 6th International Conference on Mobile Adhoc and Sensor Systems (MASS '09), October 12-15, 2009, Macau SAR, P.R.C, pp. 1030-1035