

Sensor Network Architectures

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Objectives

- Be familiar with how application needs impact deployment strategies
- Understand key benefits/costs associated with different topologies.
- Understand key benefits/costs associated with homogeneous and heterogeneous node deployments

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Objectives (cont.)

- Apply simple metrics to assess network connectivity
- Understand common routing protocols
- Synthesize these concepts to ascertain the energy requirements for various network topologies

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Outline

- Deployment strategies
- Network topologies
- Connectivity and Coverage
- Routing protocols
- Example Application: Energy use for various topologies

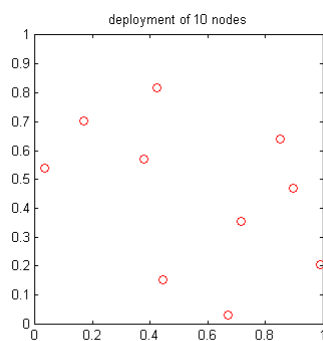
Deployment Strategies

- Motivation
- Application needs?

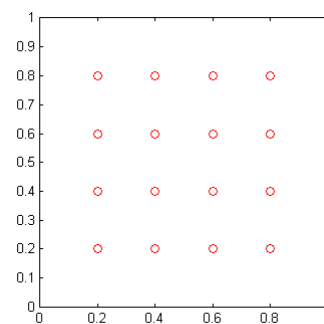
Deployment

Random vs. Structured

Random



Structured

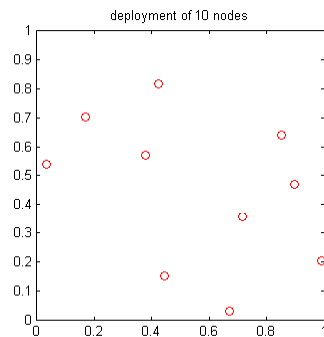


Deployment

Incremental vs. Over-deployment

Incremental

Over-deployment



Deployment

Outline

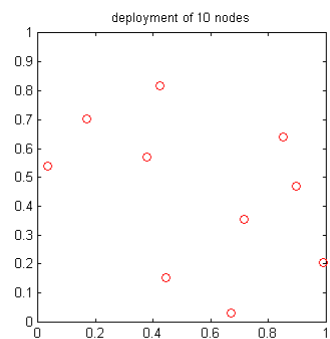
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Network Topologies

- Motivation
- Star – single hop
- Flat mesh – multi-hop
- Tiered – multi-hop

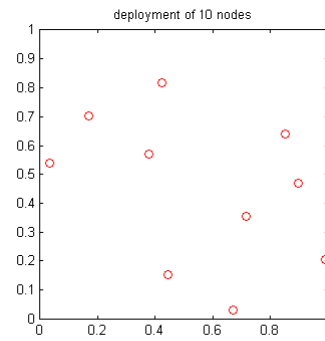
Topologies

Star



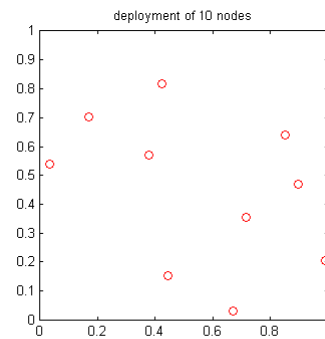
Topologies

Mesh



Topologies

Tiered



Topologies

Node Capabilities

Homogeneous

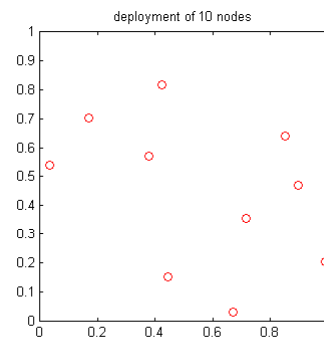
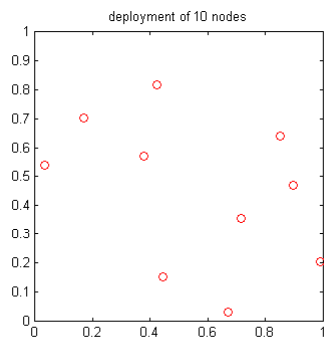
Heterogeneous

Topologies

Single vs. Multi-hop

Single hop

Multi-hop



Topologies

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Connectivity

- Motivation

- Graph Theory Tools

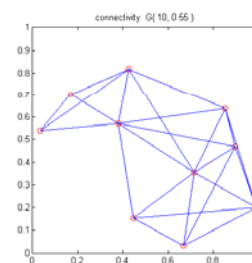
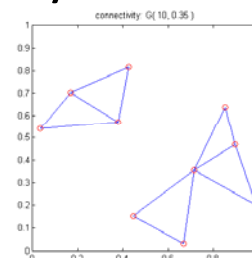
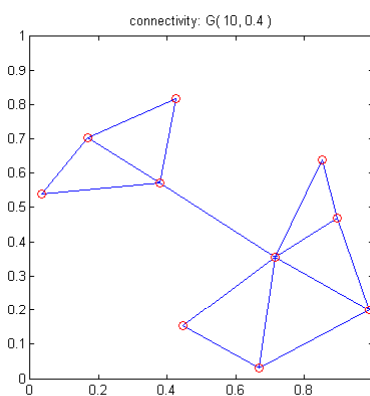
Connectivity

Random Graph Model

- $G(n,R)$

Connectivity

Graph Connectivity



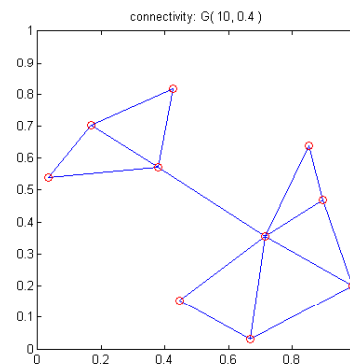
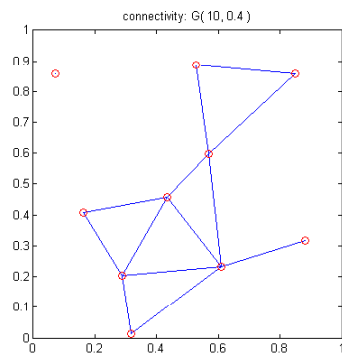
Connectivity

Problem with Random Graph Model

Propagation environments are not isotropic

Connectivity

K-connectivity



Connectivity

Improving connectivity

Approaches

Costs

Connectivity

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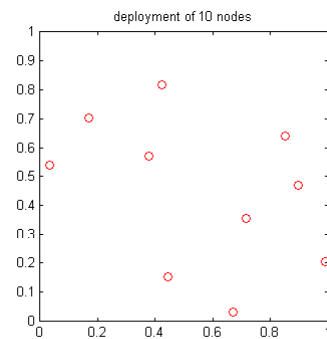
Coverage

- Motivation

- Tools

Coverage

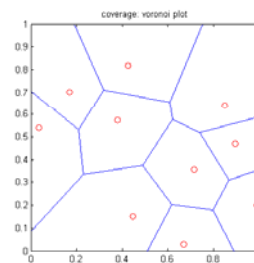
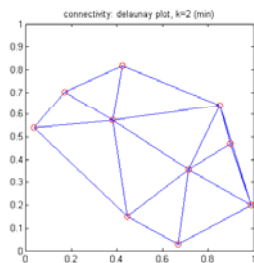
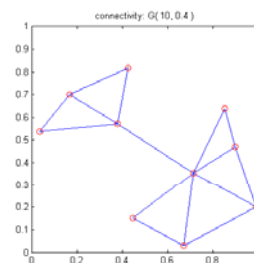
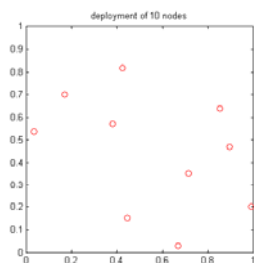
Voronoi Diagram



Coverage

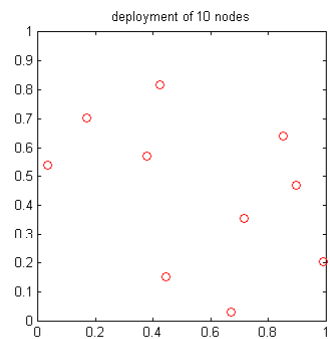
K-coverage

Coverage



Coverage

Problems with Coverage Metrics

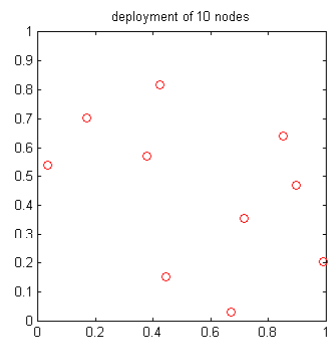


Coverage

Topology Control

Idea

Motivation



Topology Control

Method 1: PEAS

Topology Control

Method 2: ACK

Topology Control

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Routing protocols

- Motivation

- Metric-based
- Diversity-based

Routing protocols

Greedy Forwarding

Routing protocols

ETX Metric

Routing protocols

Opportunistic (ExOR)

Routing protocols

Gradient-based

Routing protocols

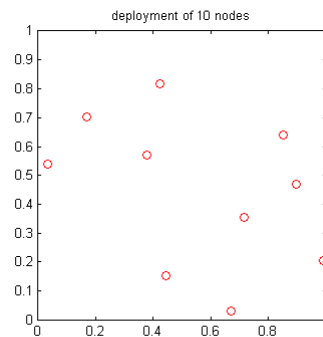
Lifetime and Load-balancing

Lifetime

Load

Routing protocols

Data Mules



Routing protocols

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Comparison: Single-hop vs. Double-hop

Scenario 2: Single-hop vs. Double-hop

Networking & Energy

Conclusions

- Multi-hop networks promise broader coverage and robustness at the cost of increased complexity
- Homogeneous node architectures simplify deployment strategies but may require more capable hardware
- Node connectivity is dependent on the node placement and the communication channel

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Conclusions - 2

- Network coverage requirements may not coincide with network connectivity requirements
- Routing schemes depend on defining an appropriate 'cost' metric
- Network architectures drive node and system design and therefore energy and bandwidth requirements

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Want to learn more?

- B. Krishnamachari, *Networking Wireless Sensors*, Cambridge Press (2005).
- H. Karl and A. Willig, *Protocols and Architectures for Wireless Sensor Networks*, Wiley (2007).