Scalable and Reliable Sensor Network Routing: Performance Study from Field Deployment

INFOCOM 2007

Presented by Chi-Han Lin in 10/4

Outline

- Introduction
- Directed Transmission Routing Protocol(DTRP)
- Implementation
- Performance Evaluation
- Conclusion
- Discussion

Introduction

- There are two requirements in a sensor network.
  - Scalability
  - Reliability
- But there is an important trade-off between reliability and scalability in sensor network routing.
- A working solution should not compromise one goal for the other.

Introduction

- A number of routing protocol in ad hoc network(i.e., table-driven and on-demand) can’t satisfy the requirements.
- To achieve the two goals, various sensor network routing scheme have been proposed.
  - Gossiping(an efficient way of broadcasting, probabilistic transmission).
  - MINTRoute(the standard routing protocol software for TinyOS).

Introduction

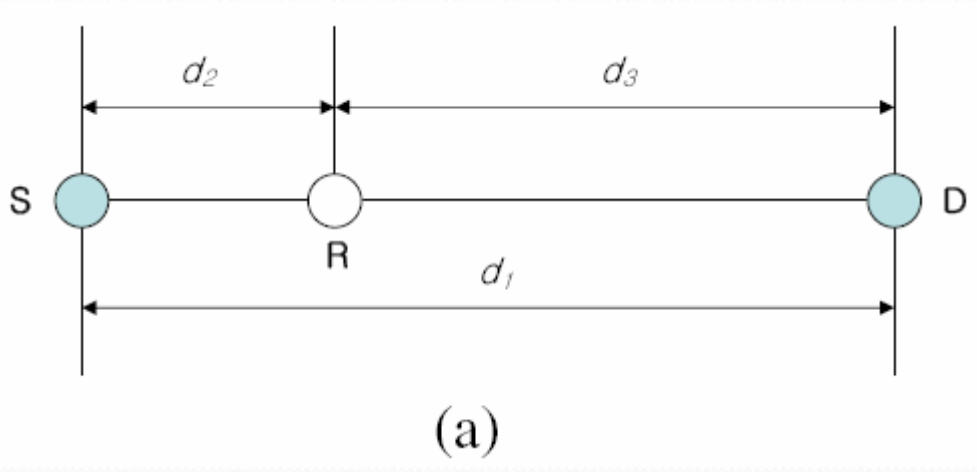
- In this paper, the main routing protocol is a real world implementation of the parametric and probabilistic approaches.
- Here, reliability defines as resiliency against changes in network status due to various factors including but not limited to
  - Node failures
  - Mobility
  - Volatile wireless links
  - Harsh environments
  - Malicious nodes

Directed Transmission Routing Protocol(DTRP)

- DTRP is a multipath proactive routing protocol specially designed for WSN to provide improved scalability and reliability.
- DTRP does not use the beacon packet to resolve the next hop node for the destination (i.e., the sink).
- The beacon provides only the hop-count distance value between the sink and other sensor nodes.

Directed Transmission Routing Protocol(DTRP)

- Define three values d_1, d_2, d_3.

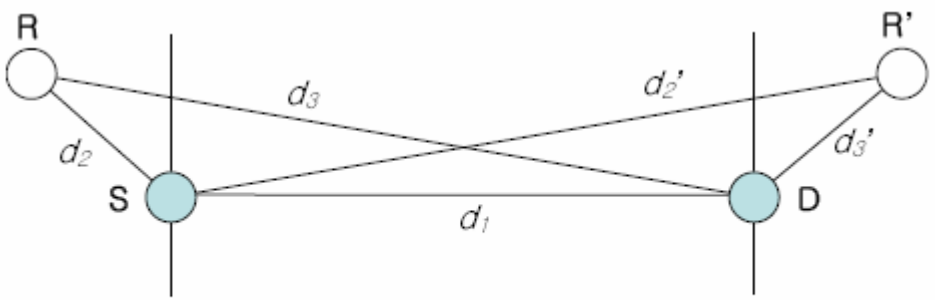


Directed Transmission Routing Protocol(DTRP)

- Transmission probability p^{tx} defined as follows:

$$p^{tx} = e^{k\alpha} \quad (1)$$

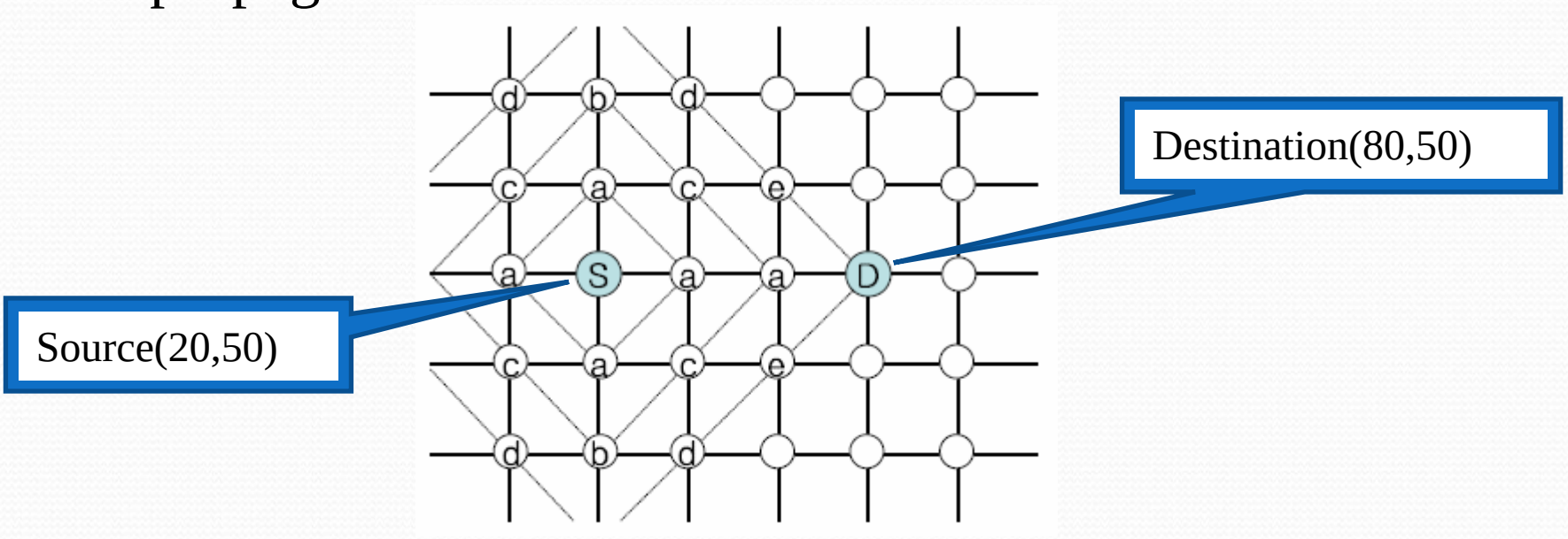
- Where $\alpha = d_1 - (d_2 + d_3)$ and k is the tunable parameter that determines the reliability and the scalability of the packet.



(c)

Directed Transmission Routing Protocol(DTRP)

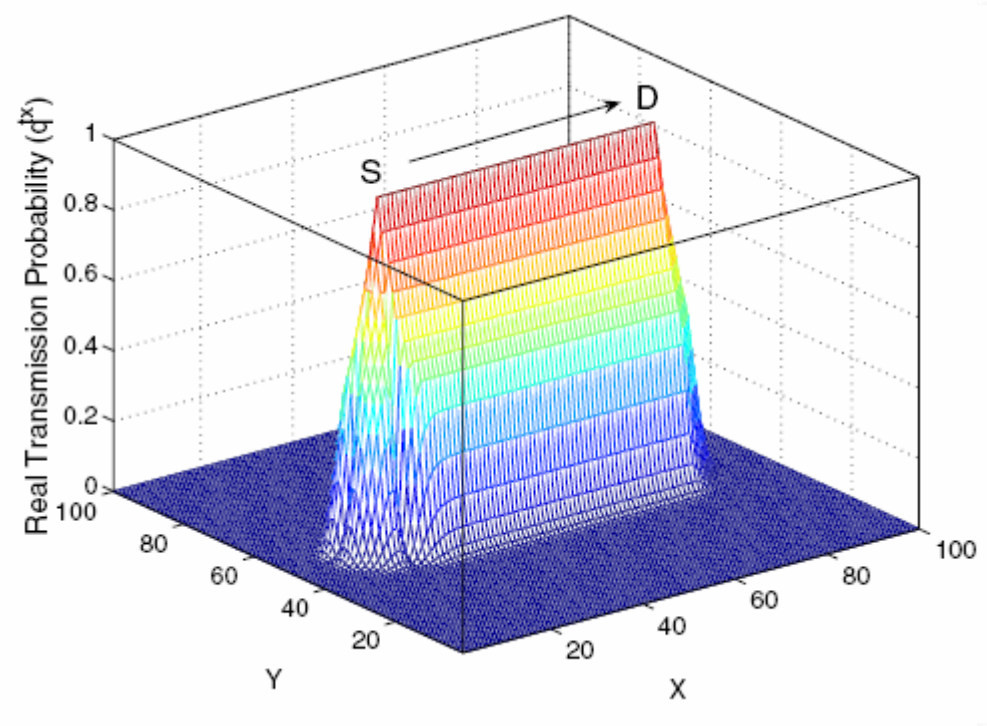
- The propagation model



- The reception probability p^{rx} has a recursive definition.

$$p^{rx}_{(i+1,j)} = \min\Big(\sum_{\forall j: j \leftrightarrow k} p^{rx}_{(i,k)} \cdot p^{tx}_{(i,k)},\ 1\Big), \quad p^{rx}_{(0,k)} = 1 \qquad (2)$$

Directed Transmission Routing Protocol(DTRP)



(c) The real packet transmission probability(q^{tx})

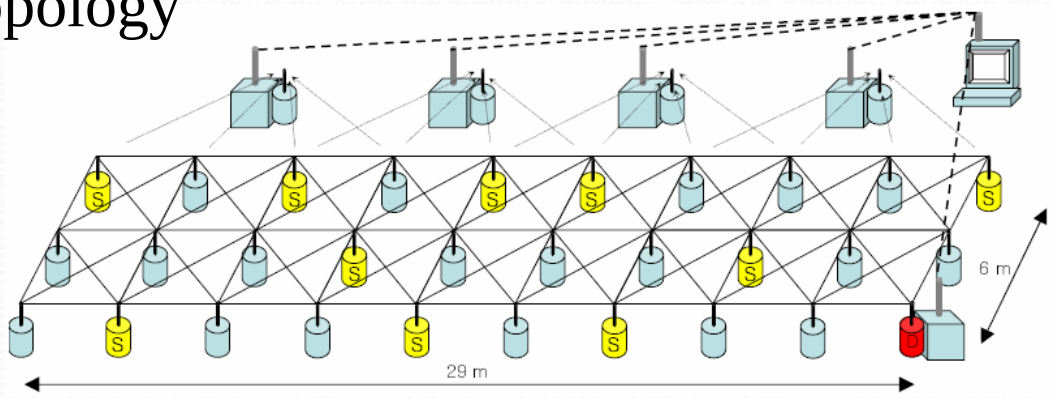
$$q^{tx} = p^{rx} \cdot p^{tx}$$

Implementation

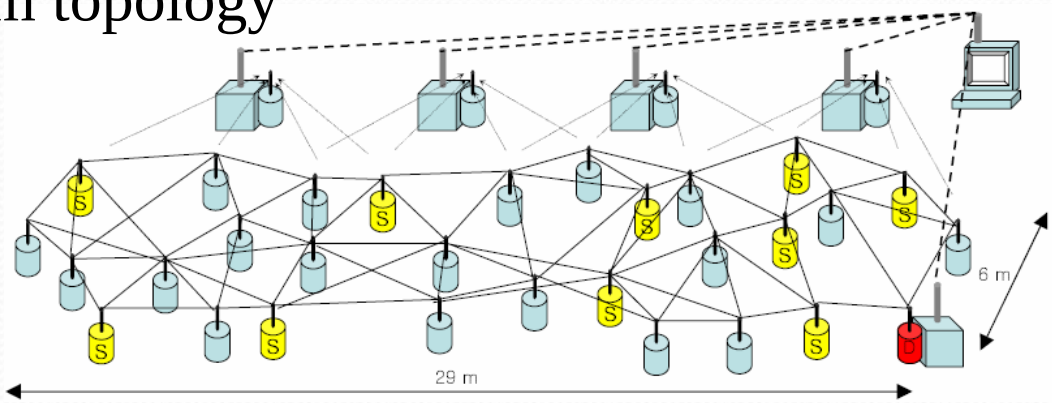
- Hardware: Mica2 motes +Stargates(monitoring system)
- Software: TinyOS 1.1.15
- Environment:
  - Small network scenario(3×5 nodes)
  - Large network scenario(3×10 nodes)
- Protocols:
  - DTRP
  - MINTRoute
  - Gossiping(probability is set to 0.7)

Implementation

- Two topologies:
  - Grid topology



  - Random topology

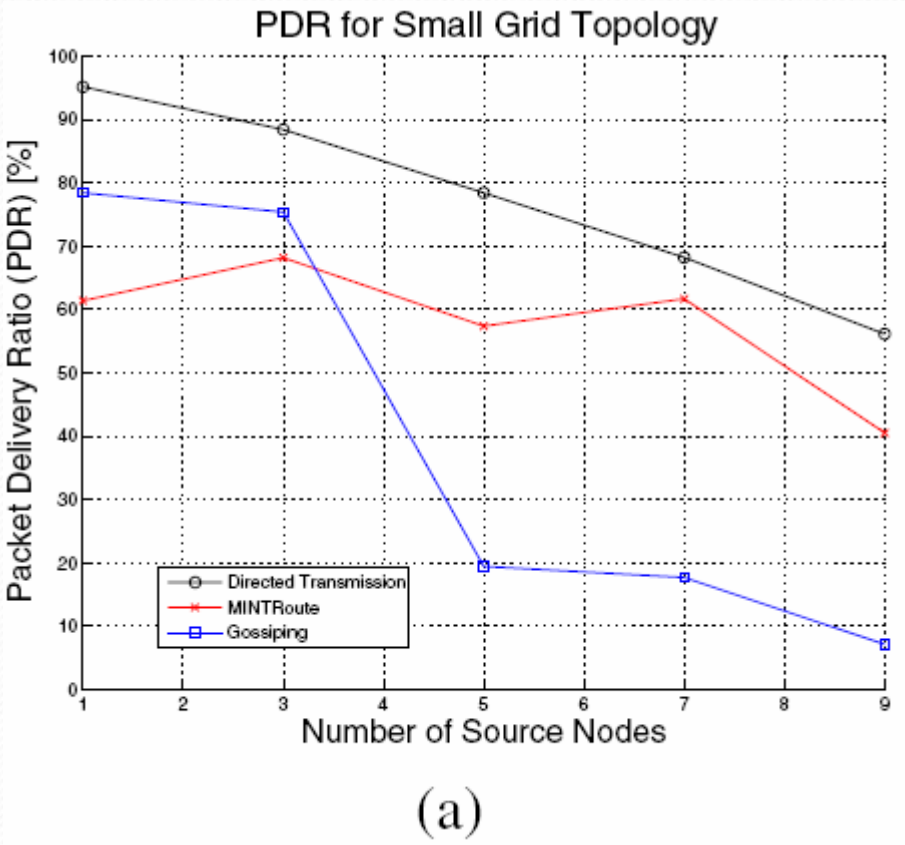


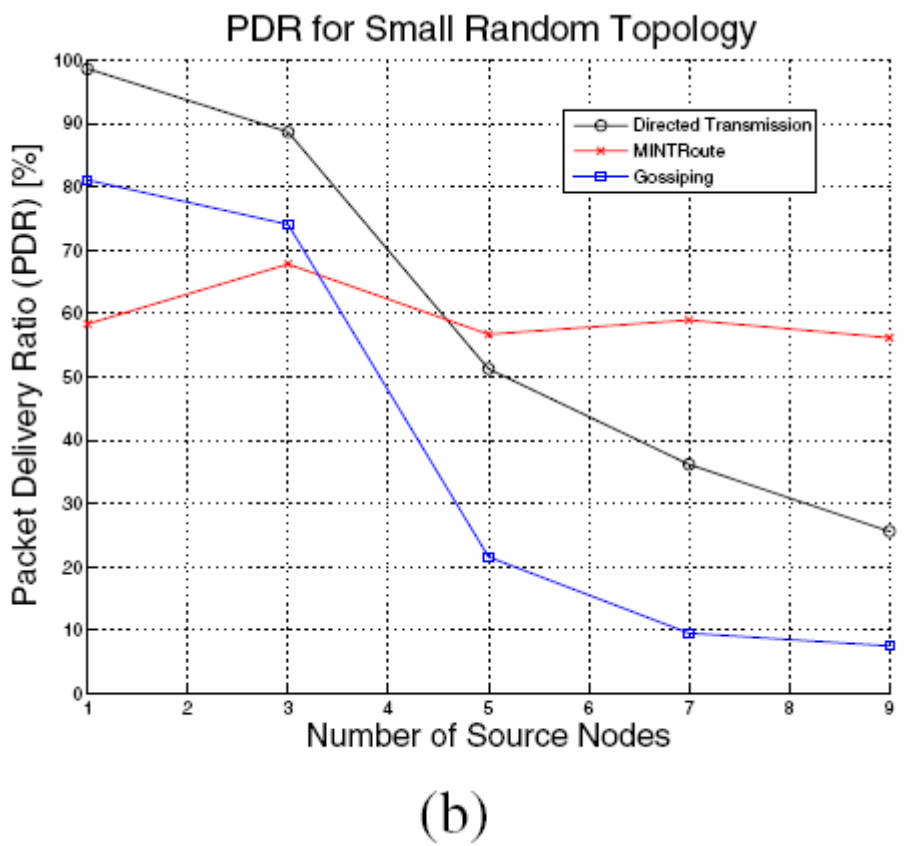
Implementation

- The number of sources: 1, 3, 5, 7, 9
- Every experiment time : 10 minutes
- Two specific network measure:
  - Packets delivery ratio(PDR)
  - Total network load

Performance evaluation

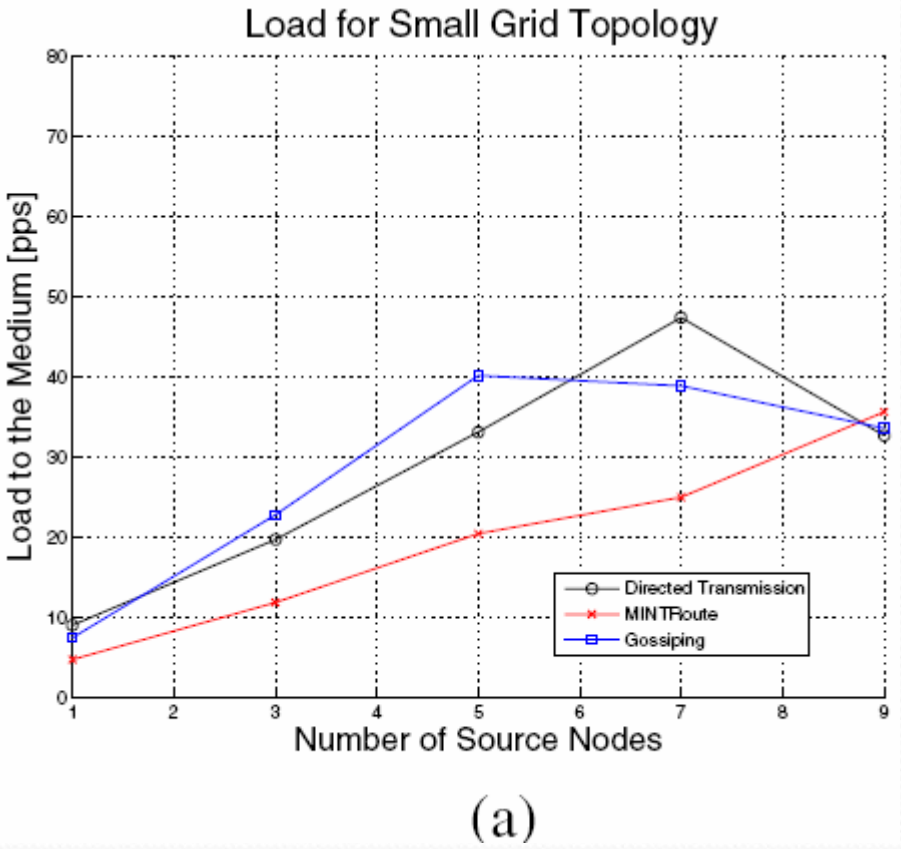
- Small networks-PDR

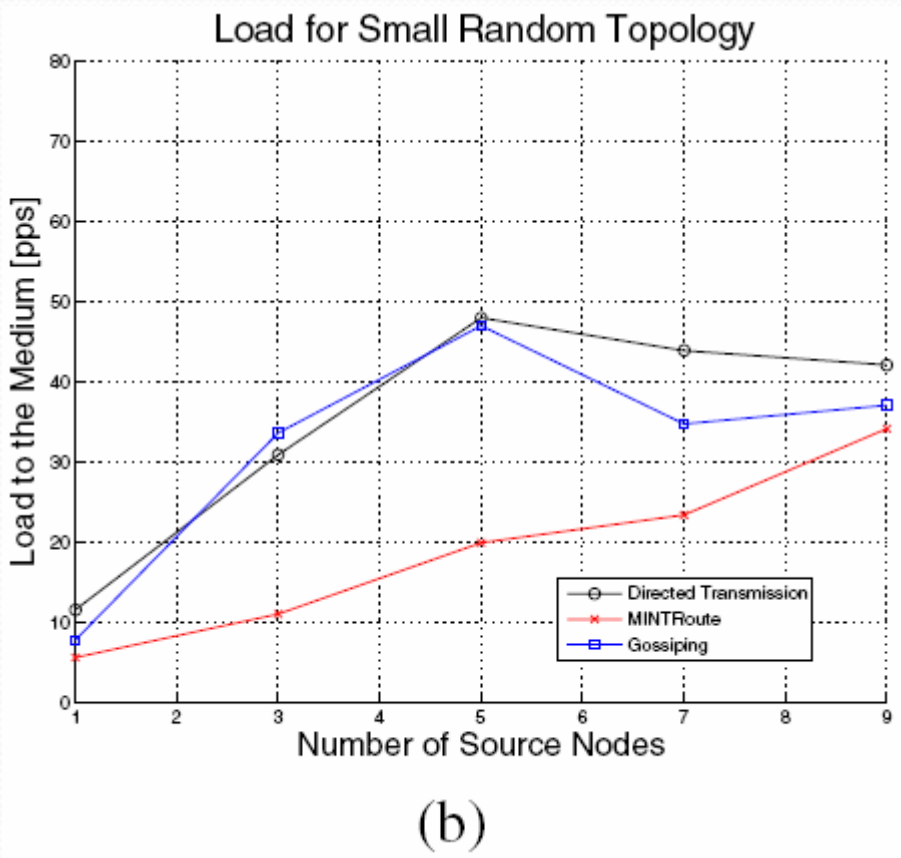




Performance evaluation

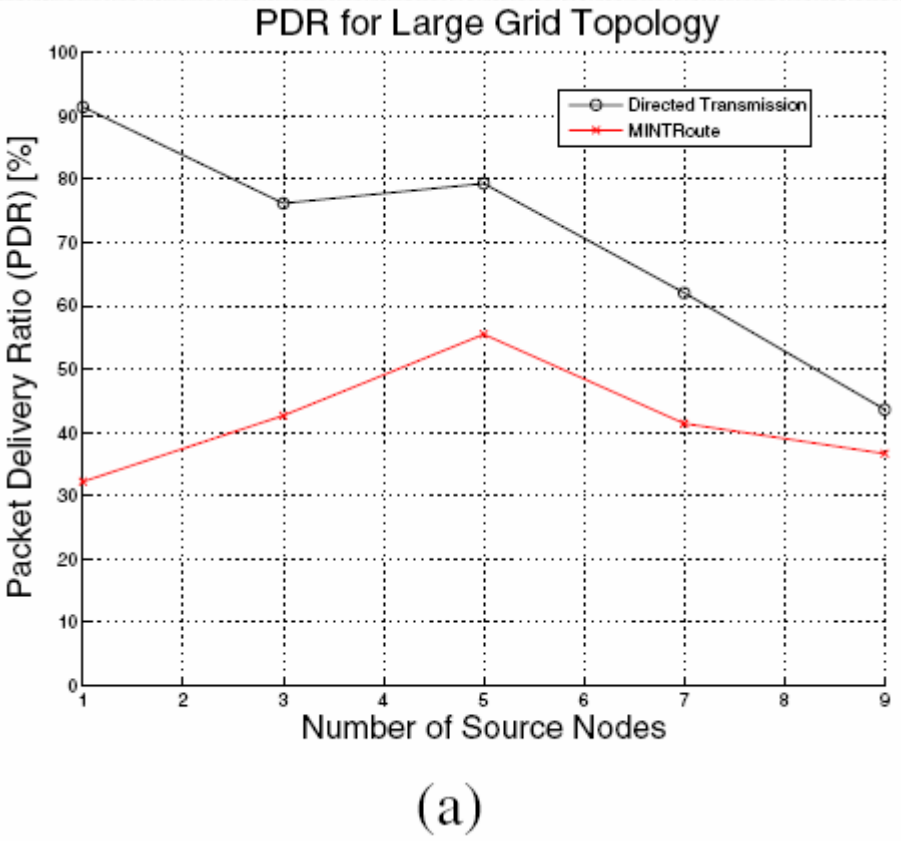
- Small networks-Total network load

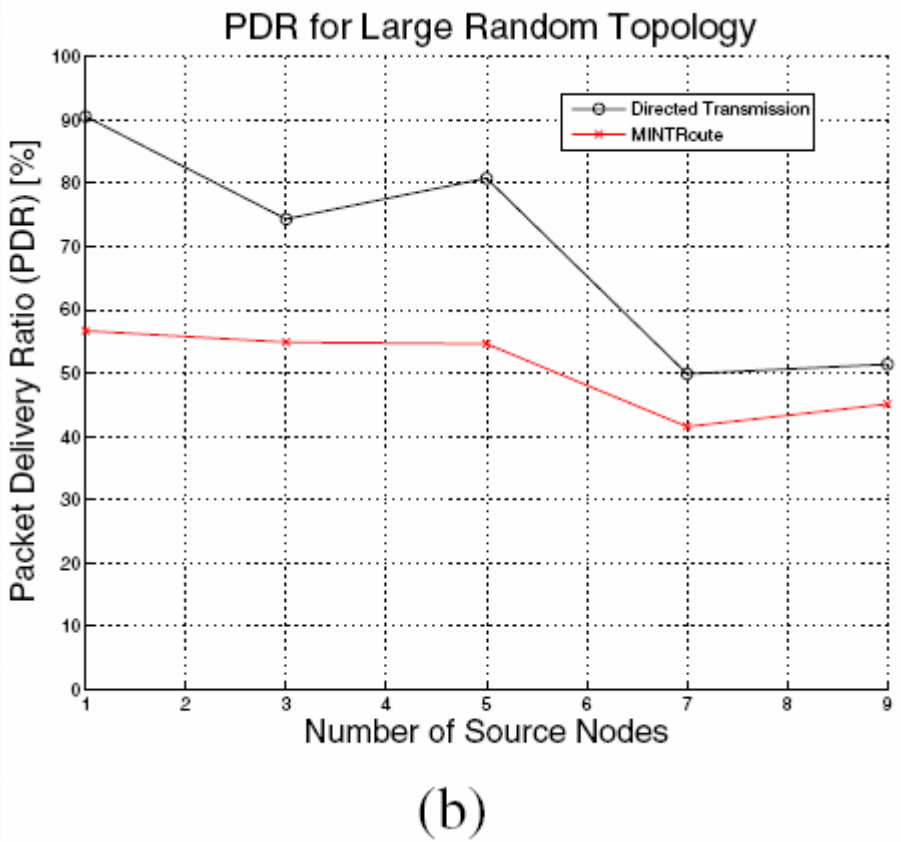




Performance evaluation

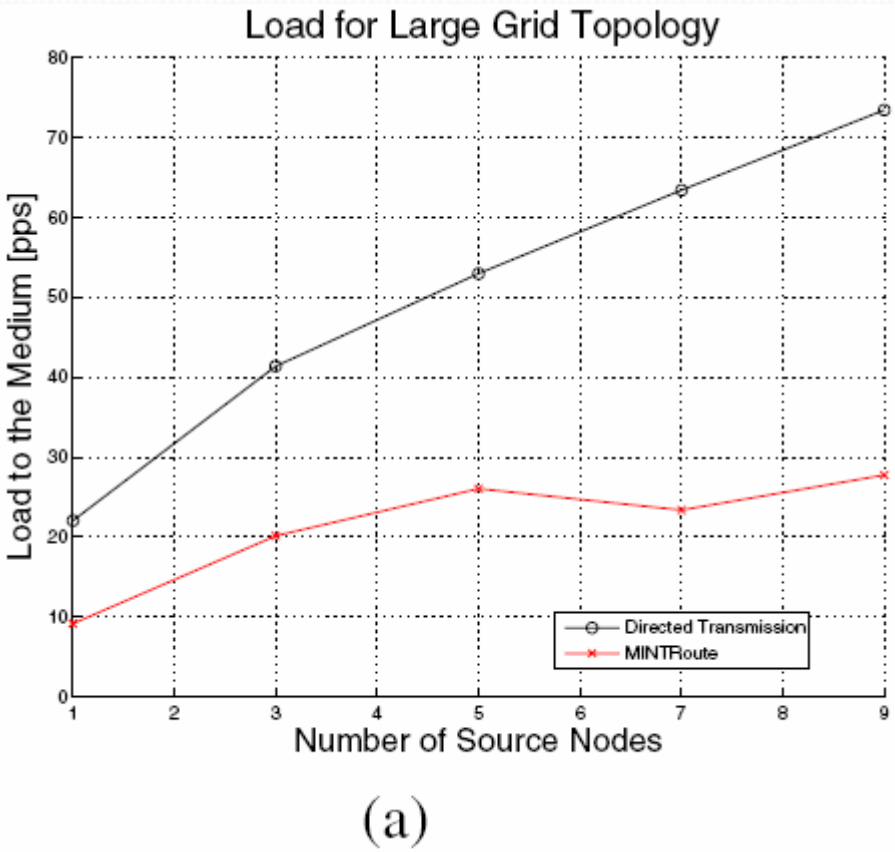
- Large networks-PDR

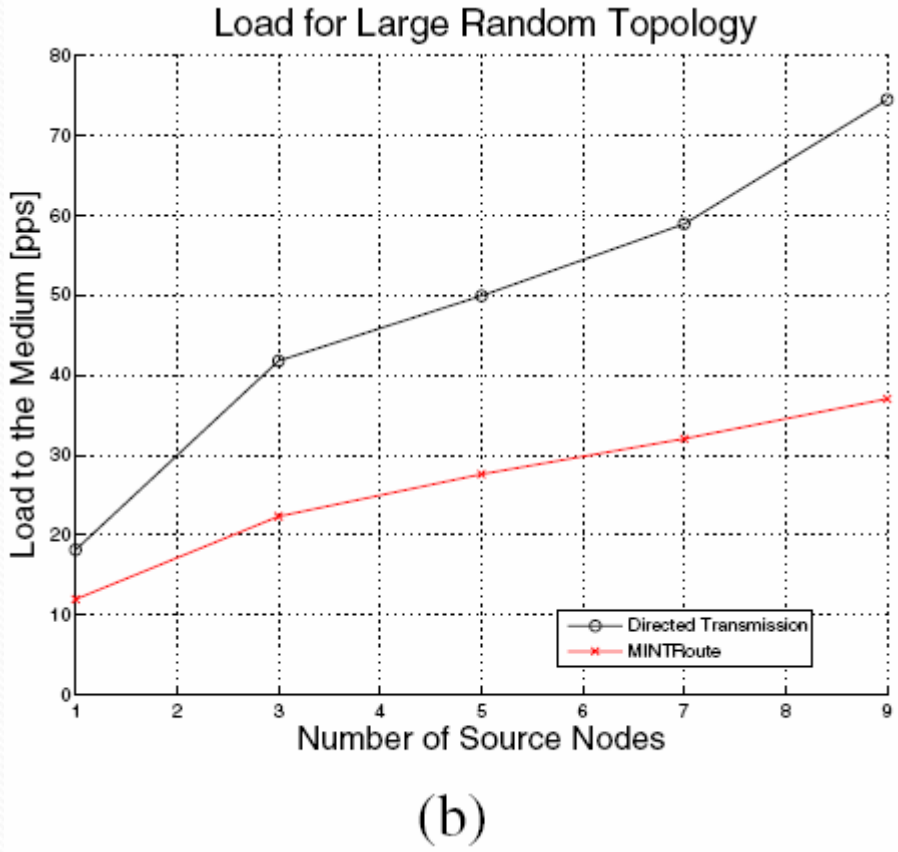




Performance evaluation

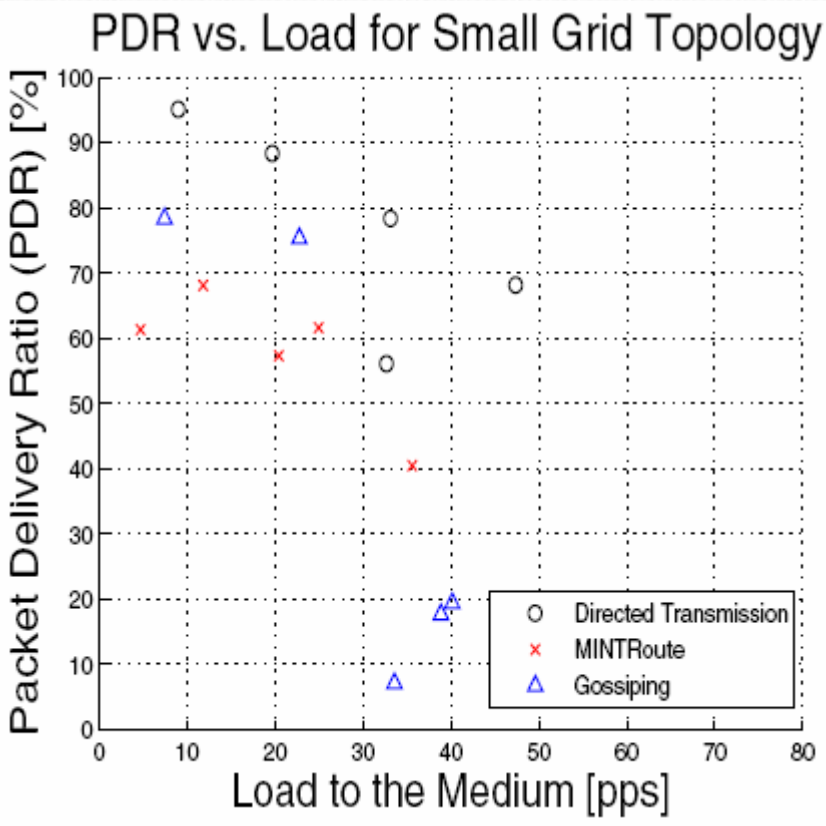
- Large networks-Total network load

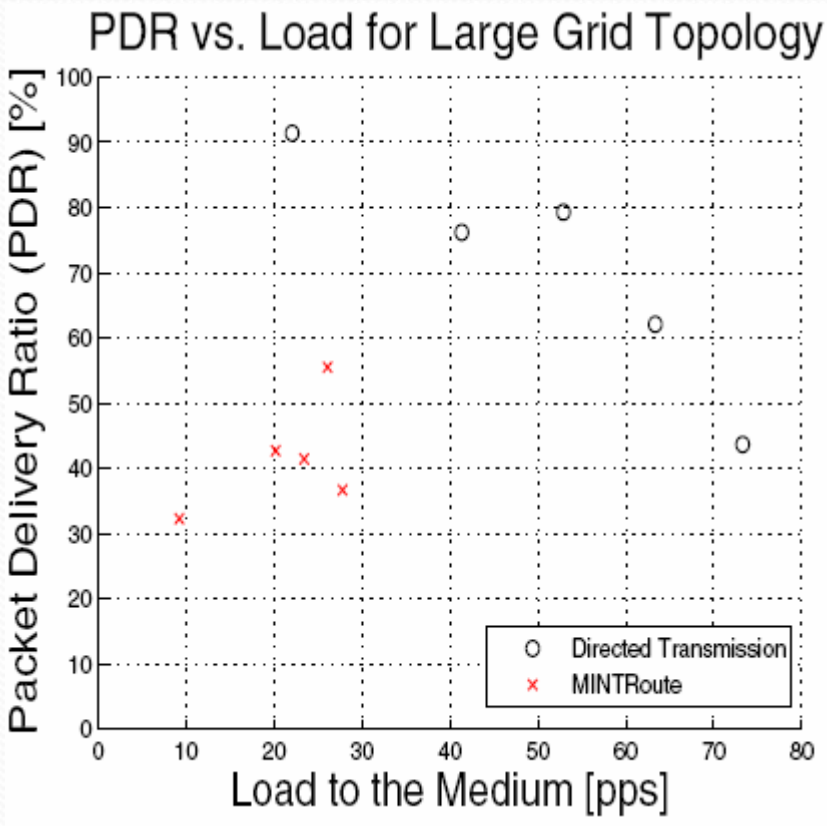




Performance evaluation

- PDR vs. Load for Grid Topology





Conclusion

- In this paper, DTRP is a simple but powerful sensor network routing and implemented in real world.
- DTRP satisfies reliability and scalability and provides greater performance than Gossiping.
- DTRP deliver markedly greater percentage of packets than MINTRoute and Gossiping at the same load.

Discussion

- Expected value vs. probability.
- DTRP is difficult to adapt to no sink networks(i.e., ad hoc network).