Tree-Based Data Broadcast in IEEE 802.15.4 and ZigBee Networks

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Outline

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Introduction(1/2)

- Flooding is one of the most fundamental operations in MANET.

- Blind flooding
  - Collision--Broadcast storm problem
  - Consume a lot of energy resource

Introduction(2/2)

- ZigBee device
  - Limited computation and storage capacity
  - Small size and low cost
  - Low data rate and low power applications

- In a typical ZigBee network, the network addresses are organized in a hierarchical manner so that one node can easily identify addresses of its tree neighbors

Related work(1/2)

- The problem of selecting the minimum number of forward nodes is essentially the well-studied set cover problem
  - NP-hard problem!!
- The solution can be approximation by greedy algorithms

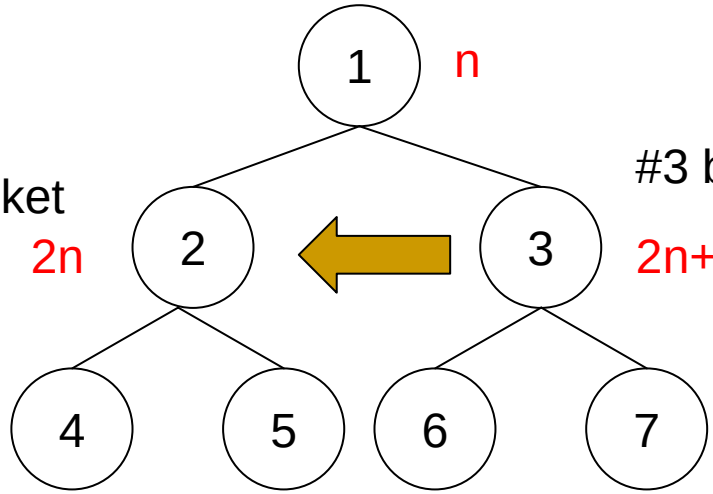
Related work(2/2)

- Scalable Broadcast Algorithm (SBA)
  - Self-pruning
  - If the node's 1-hop neighbors were covered, it will stop rebroadcasting
- Ad Hoc Broadcast Protocol (AHBP)
  - Forward nodes selection
  - The node selects its 1-hop neighbors to cover all its 2-hop neighbors greedily

ZigBee On-Tree Self-Pruning Algorithm

- Self-pruning needs 2-hop neighbor information
  - ZigBee network is not available
- By exploiting the tree structure of ZigBee address space, a node can find addresses of a partial list of 2-hop neighbors

Example of ZigBee address space



If #1, #6, and #7 are #2's neighbors, they will be pruned.

Example of OSR

v only needs to check v1~v4

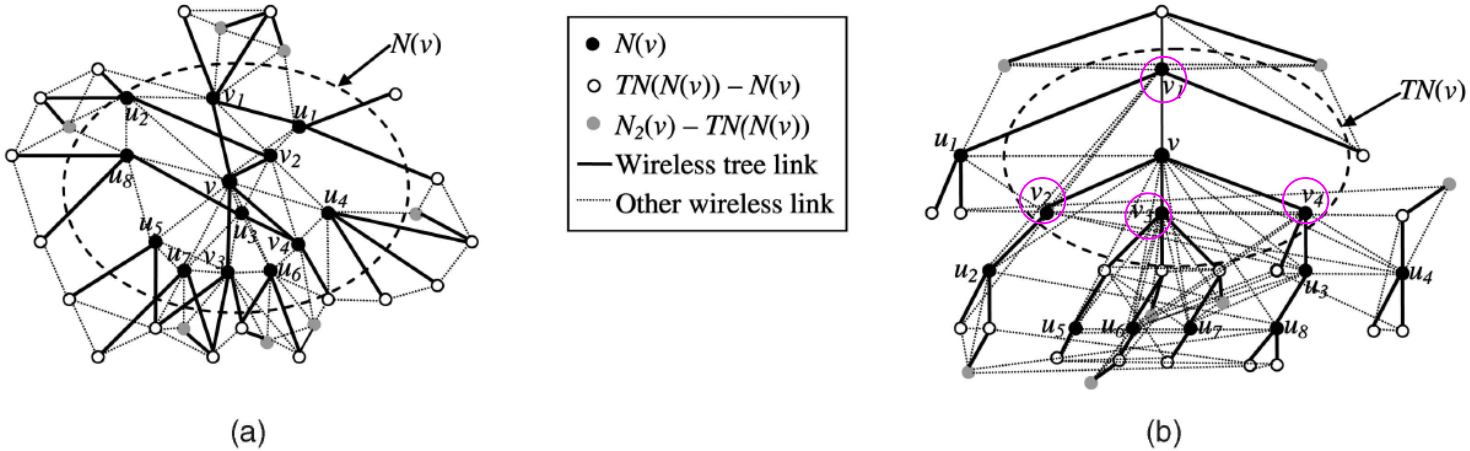


Fig. 2. A ZigBee network topology. (a) Physical topology. (b) Logical ZigBee tree topology.

ZigBee On-Tree Selection Algorithm

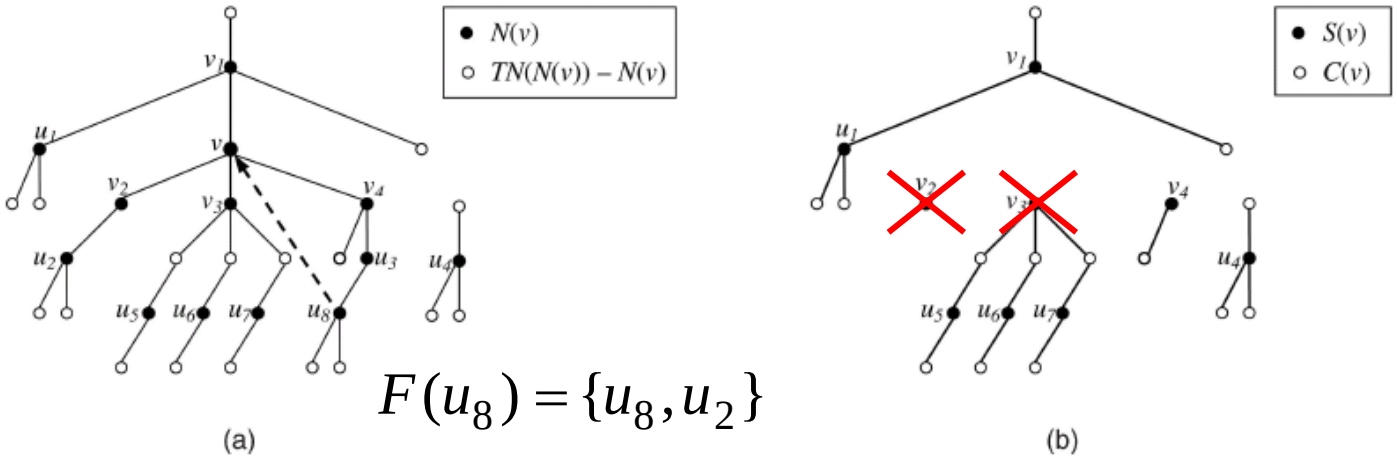
- To find the smallest forward node set to cover the tree node's 2-hop neighbors.

- Since a large part of the memory has already been used by the routing table and neighbor table
  - May not have enough space to store the whole forest
  - By ZOS can resolve it!!

- For Optimal On-tree Selection (OOS)
  - Needs to store S(v) and C(v)
- For ZigBee On-Tree Selection Algorithm (ZOS)
  - Only needs to store S(v)
  - C(v) can be calculated by ZigBee address space

Example of ZOS

$$F(v) = \{v_1, v_4, u_1, u_4, u_5, u_6, \text{ and } u_7\}$$



$$F(u_8) = \{u_8, u_2\}$$

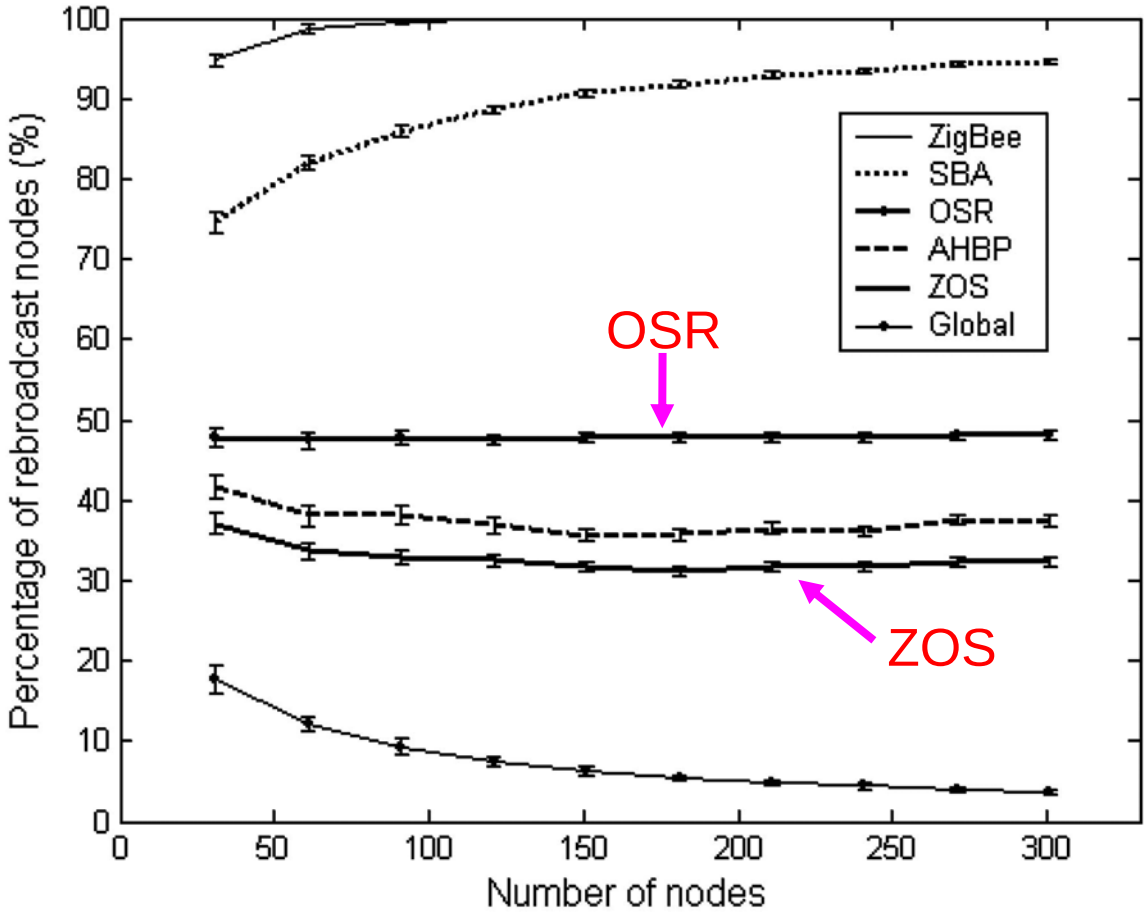
Fig. 5. An example of using the OOS algorithm. (a) The local ZigBee tree topology known by node v. (b) Step 2 in the OOS algorithm.

Performance evaluation

- Simulated algorithms
  - Self-pruning：
    - SBA
    - OSR
  - Forward nodes selection：
    - AHBP
    - ZOS
  - ZigBee broadcast with tree neighbors
  - Global algorithm with greedy method

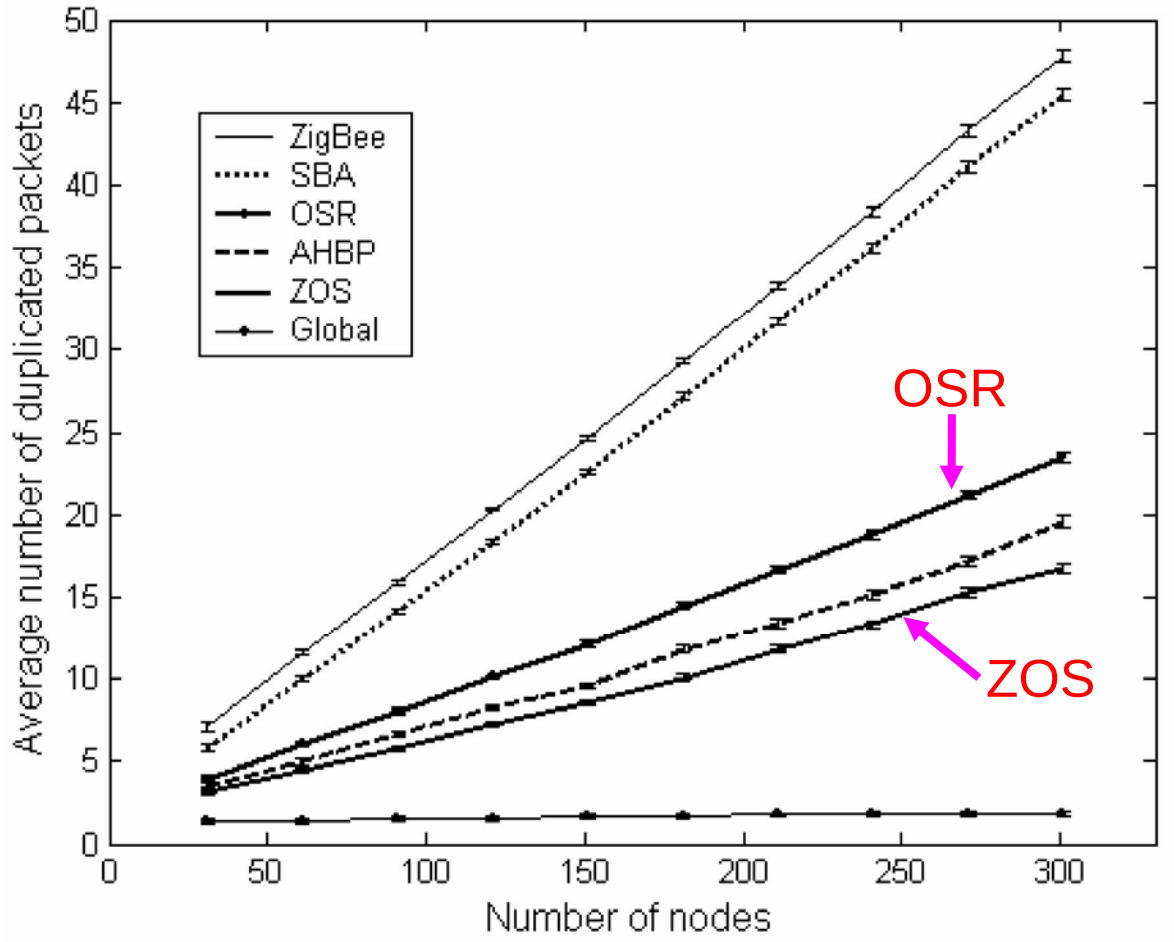
The number of rebroadcast nodes

Global < ZOS < AHBP < OSR < SBA < ZigBee



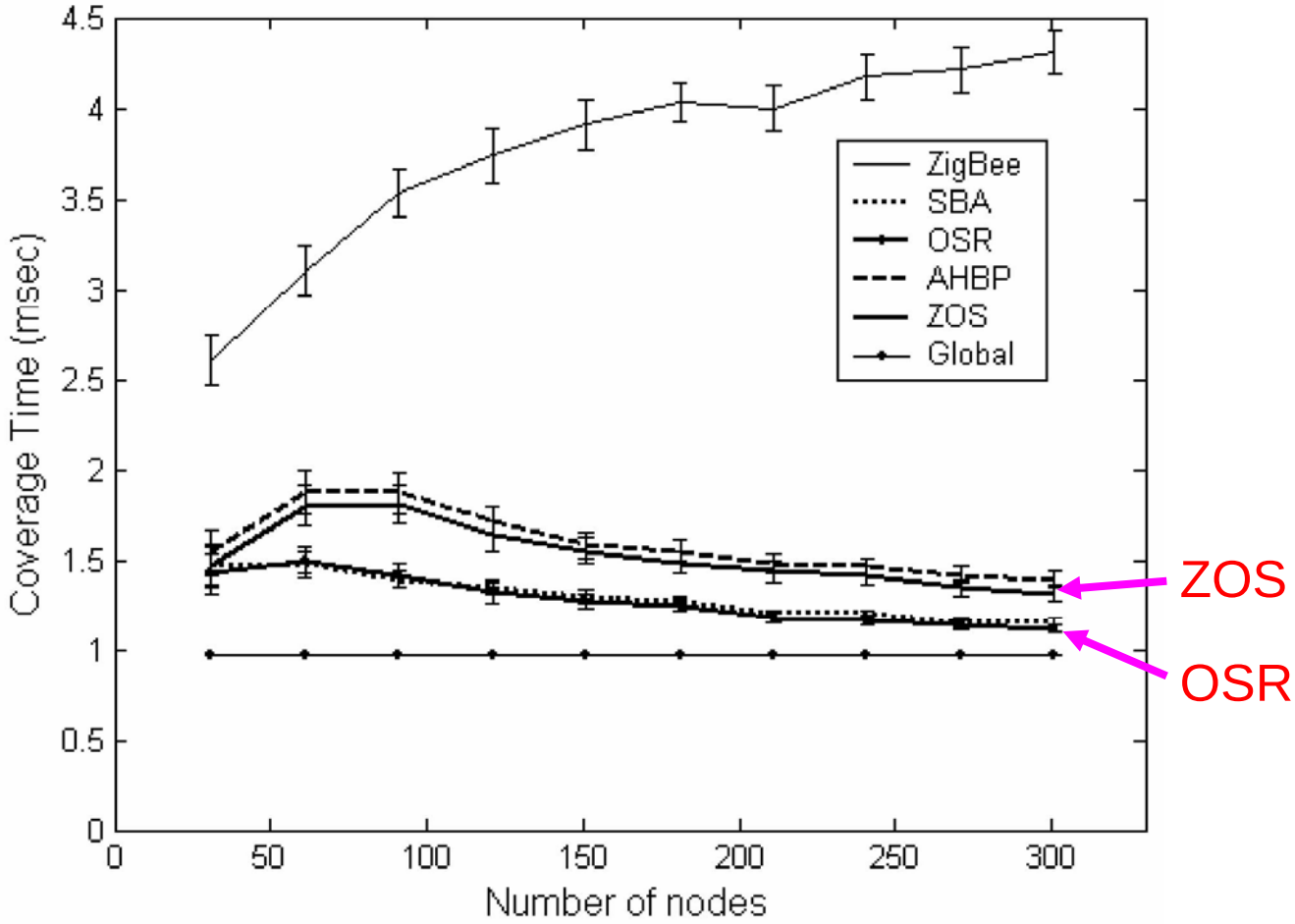
Average duplicated packets

Global < ZOS < AHBP < OSR < SBA < ZigBee



Coverage time

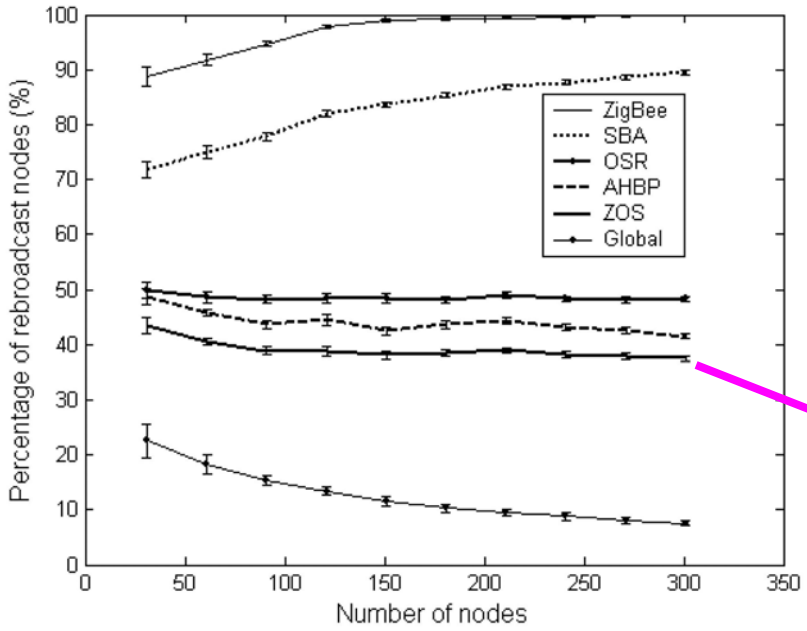
Global < OSR < SBA < ZOS < AHBP < ZigBee



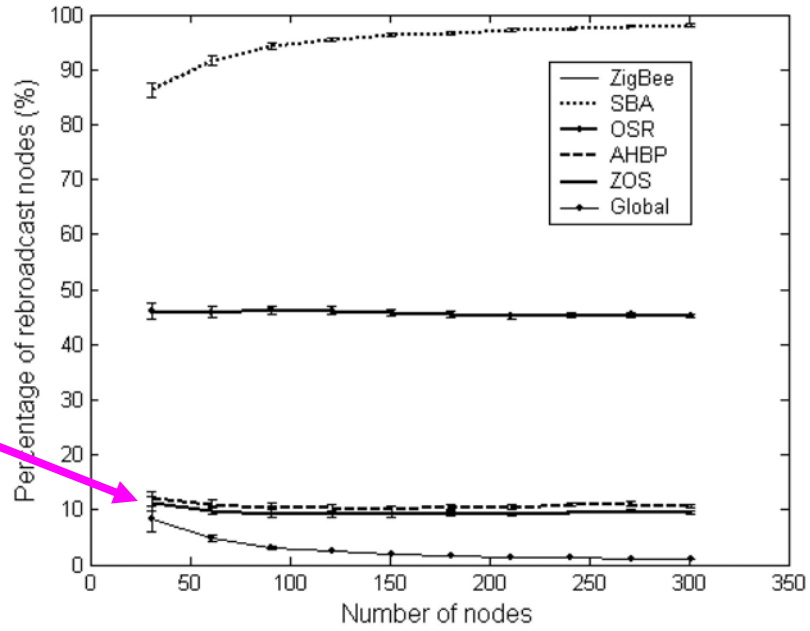
Transmission range(10m v.s 55m)

When transmission range increases,

the performance of the ZOS is significant increased.

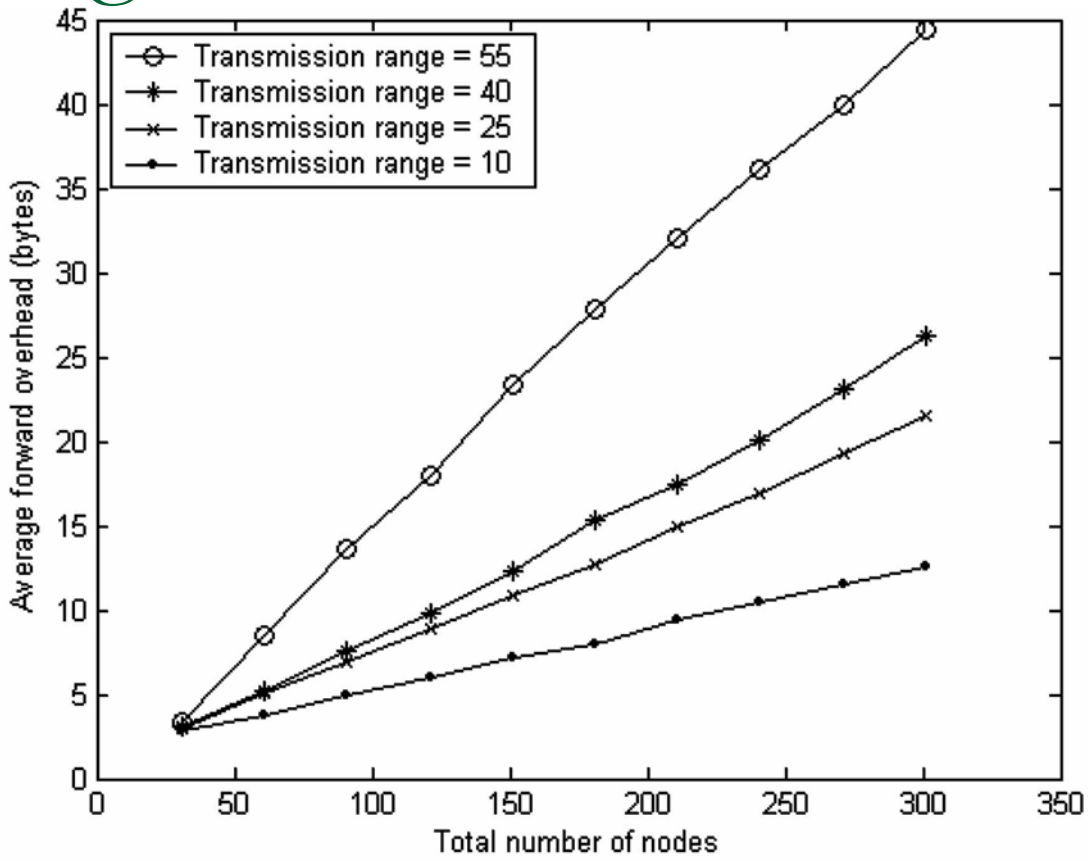


(a) 10m



(b) 55m

The communication overhead of the ZOS algorithm



(a)

Total nodes ↑

Overhead ↑

Conclusion

- Only physical 1-hop neighbors and logical tree neighbors are known in ZigBee networks.

- This paper has proposed two broadcast algorithms for IEEE 802.15.4 and ZigBee networks.
  - For self-pruning：OSR > SBA
  - For forward nodes selection：ZOS > AHBP

Thank You!!