Focused Beam Routing protocol for Underwater Acoustic Networks

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Sep 2008

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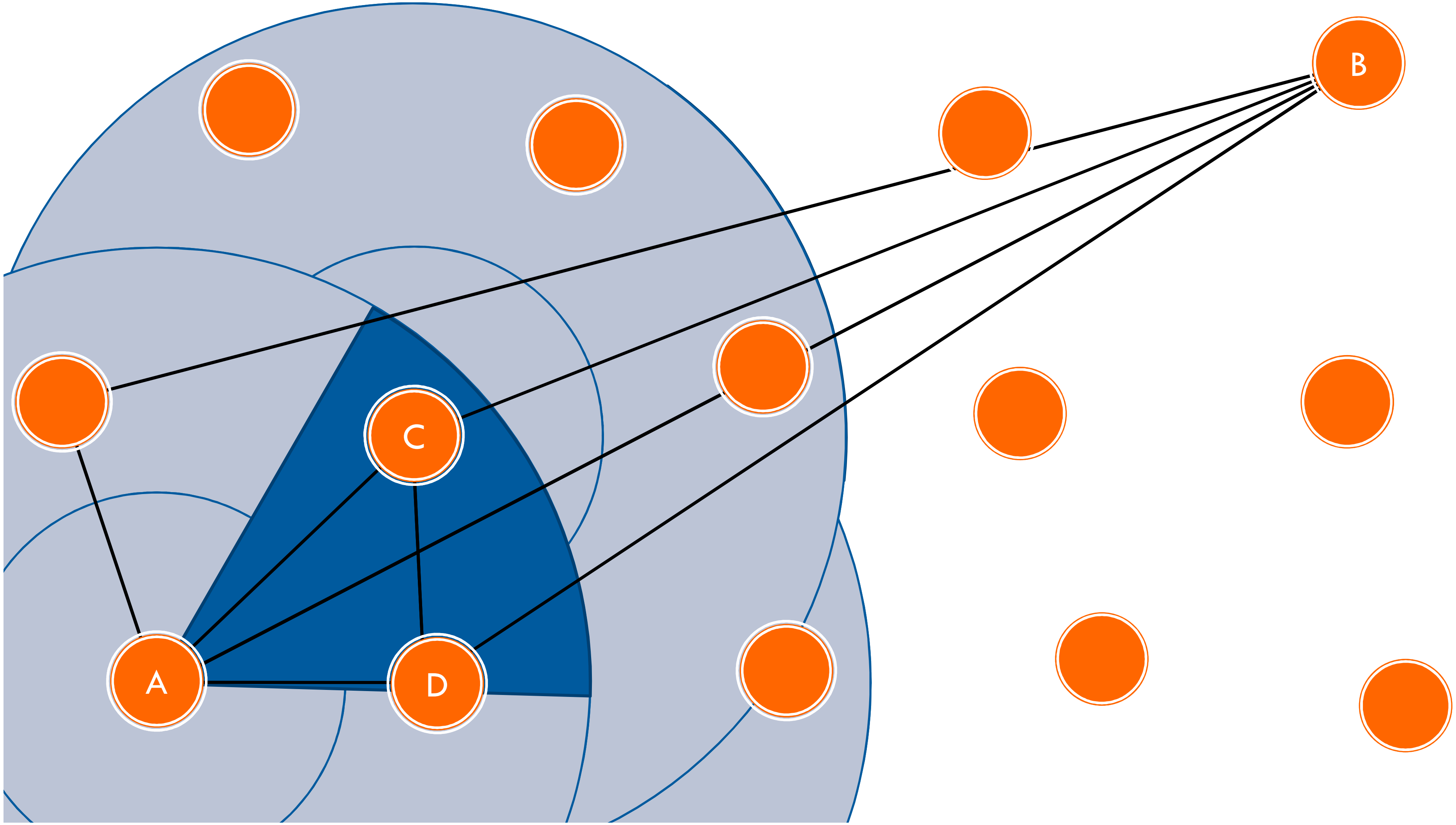
Contents

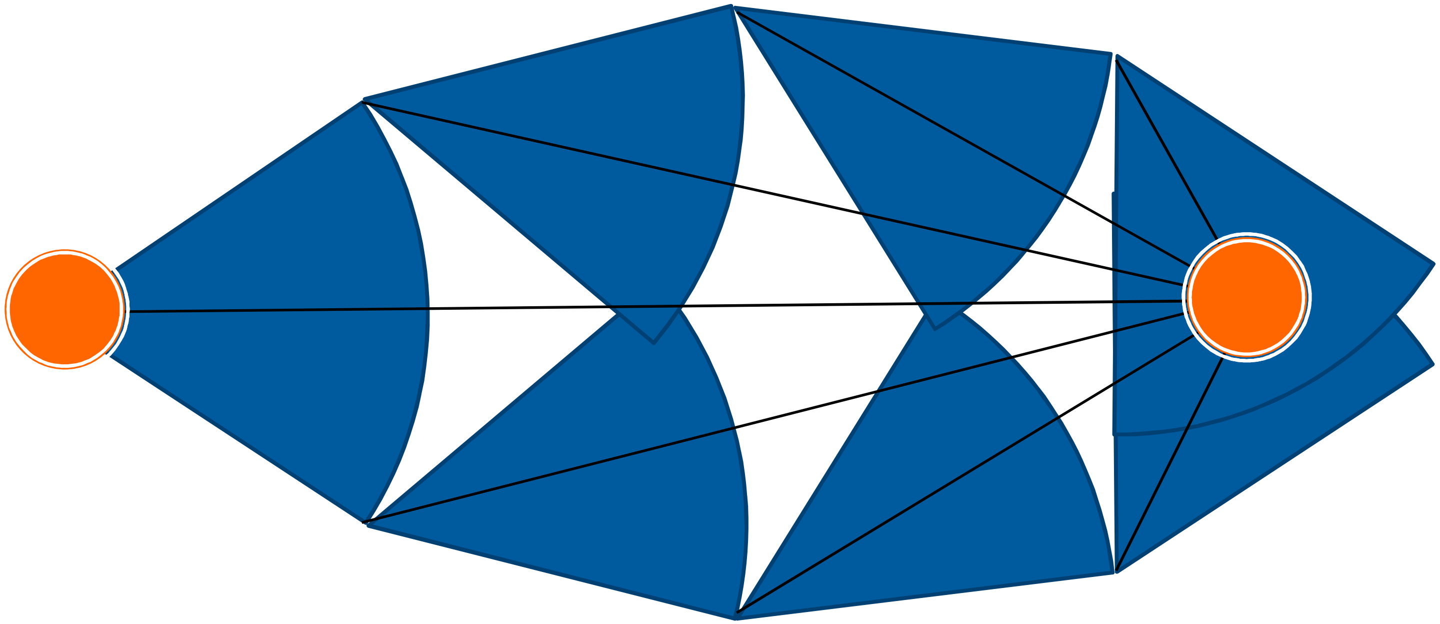
FBR

- A scalable routing technique for **multi-hop ad-hoc** networks based on **location information.**
  - Nodes must know their own position and the position of the final destination of the packet (common sink scenario).
  - Suitable for networks containing both **static and mobile nodes.**
- A **cross-layer** approach, in which the routing protocol, the medium access control and the physical layer functionalities are tightly coupled by **power control.**
- A **distributed** algorithm, in which a route is **dynamically** established as the data packet traverses the network towards its final destination.

Routing and Power Control



Focused and beam

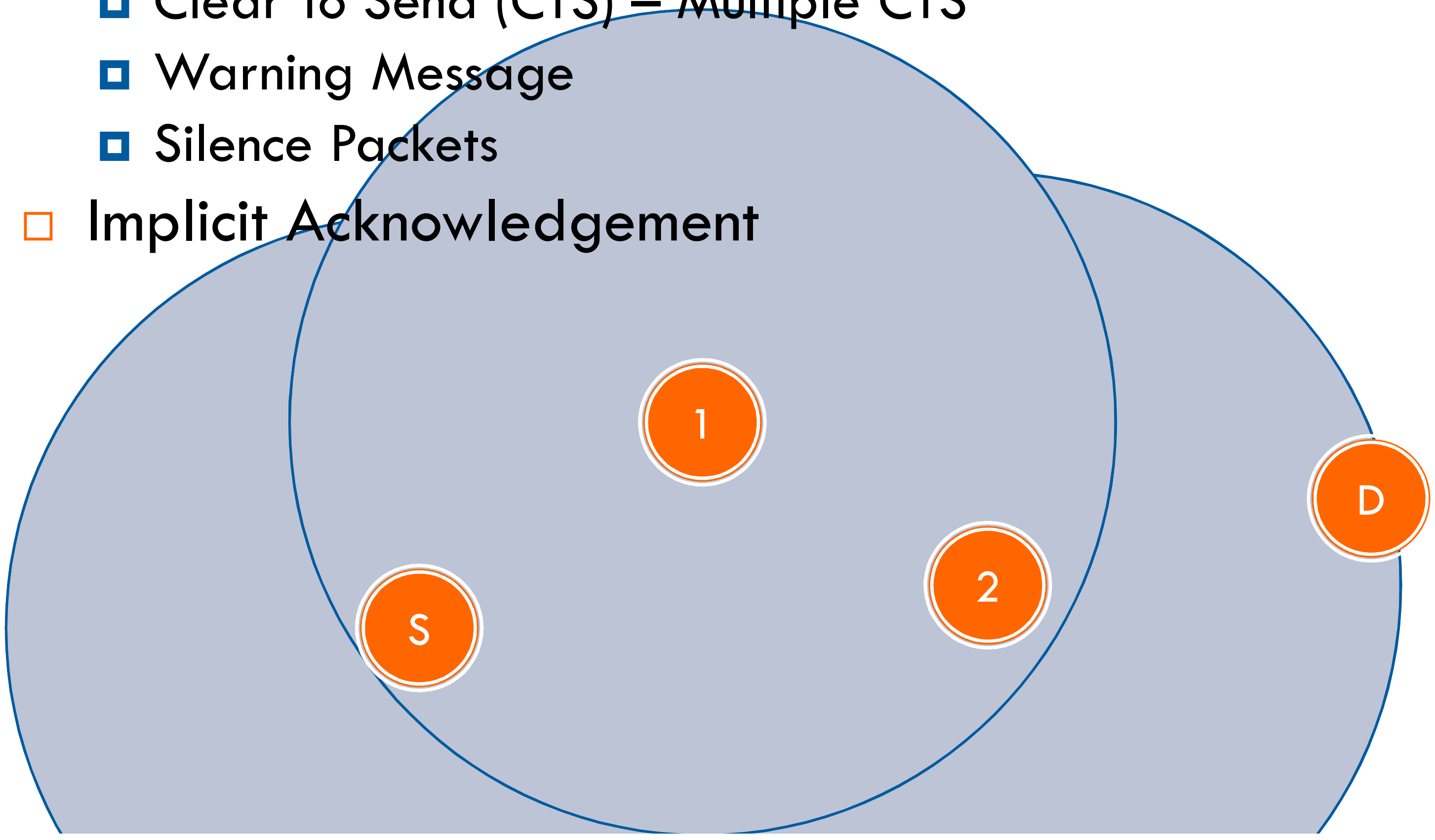


Medium Access Control

The FBR can be coupled with any MAC protocol. We have chosen DACAP, a collision avoidance protocol based on virtual carrier sensing.

Overview of DACAP

- Before transmitting the data packet, the channel is secured by the exchange of short control packets:
  - Request To Send (RTS) – Multicast RTS
  - Clear To Send (CTS) – Multiple CTS
  - Warning Message
  - Silence Packets
- Implicit Acknowledgement



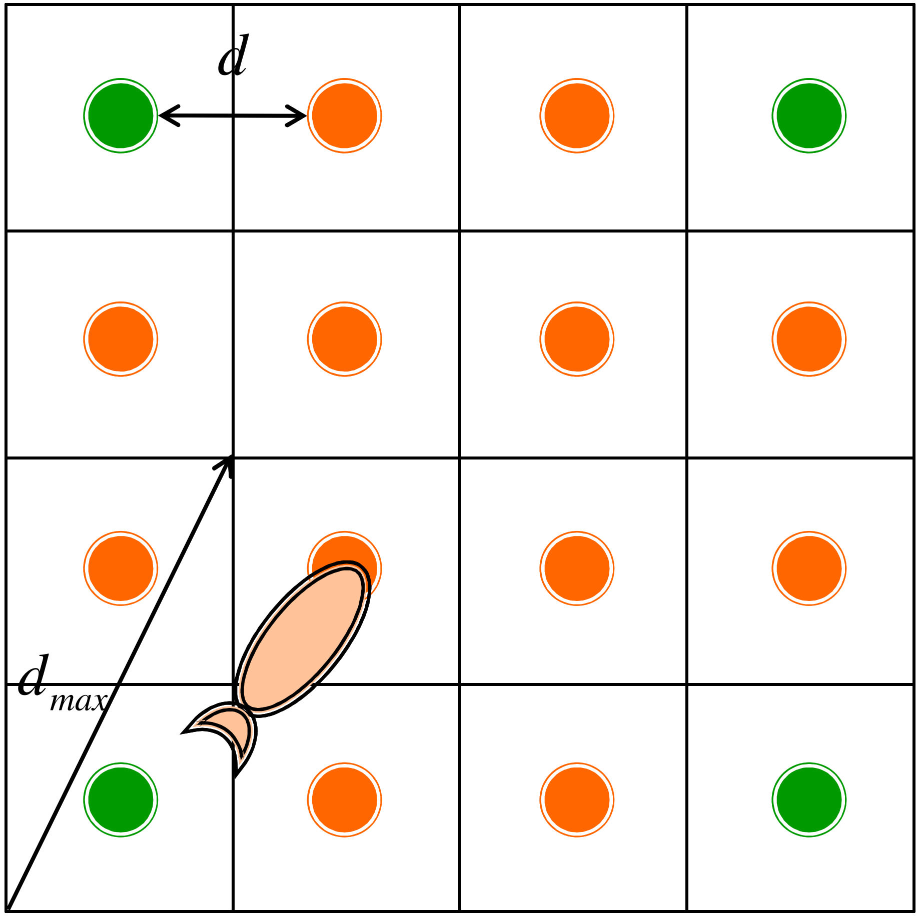
Performance Analysis

The system performance is measured in terms of average energy per bit consumption, total number of collisions and average packet end-to-end delay.

The Tool: AUVNetSim

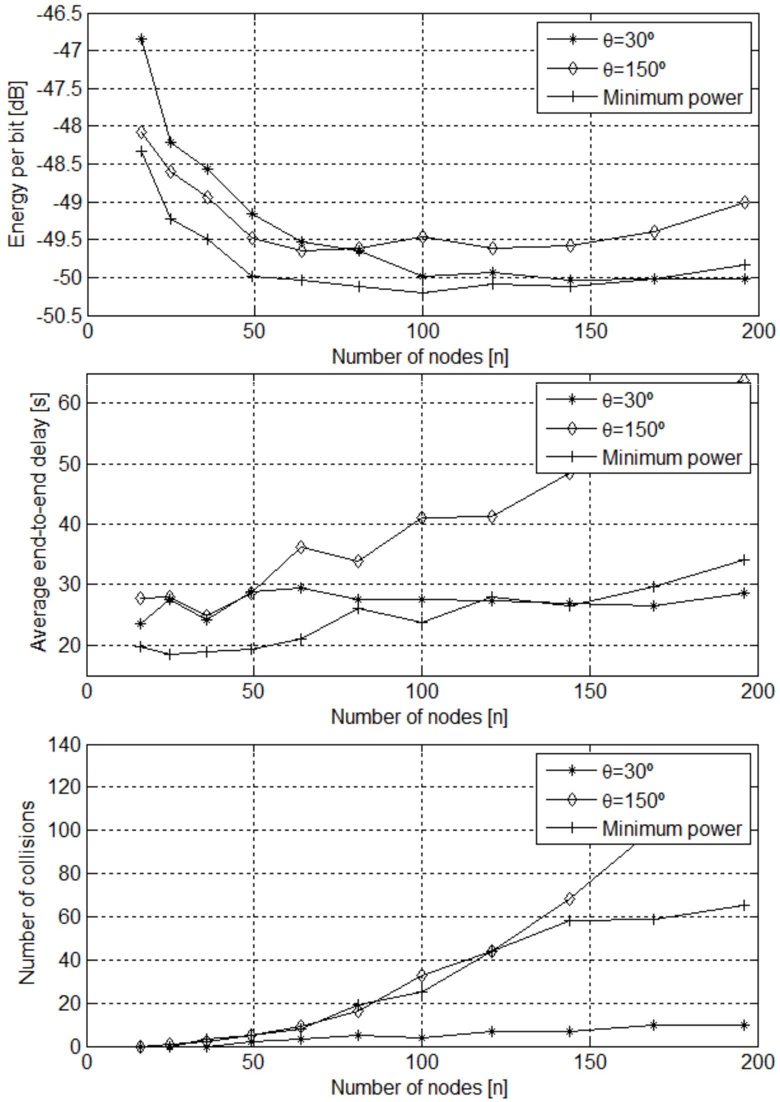
- A simulation library for testing acoustic networking algorithms, written in standard Python.
- Redistributed under the terms of the GNU General Public License.
- Interesting for:
  - **End-users:** run parameterized simulations.
  - **Developers:** include new functionalities.

Scenario for Simulation



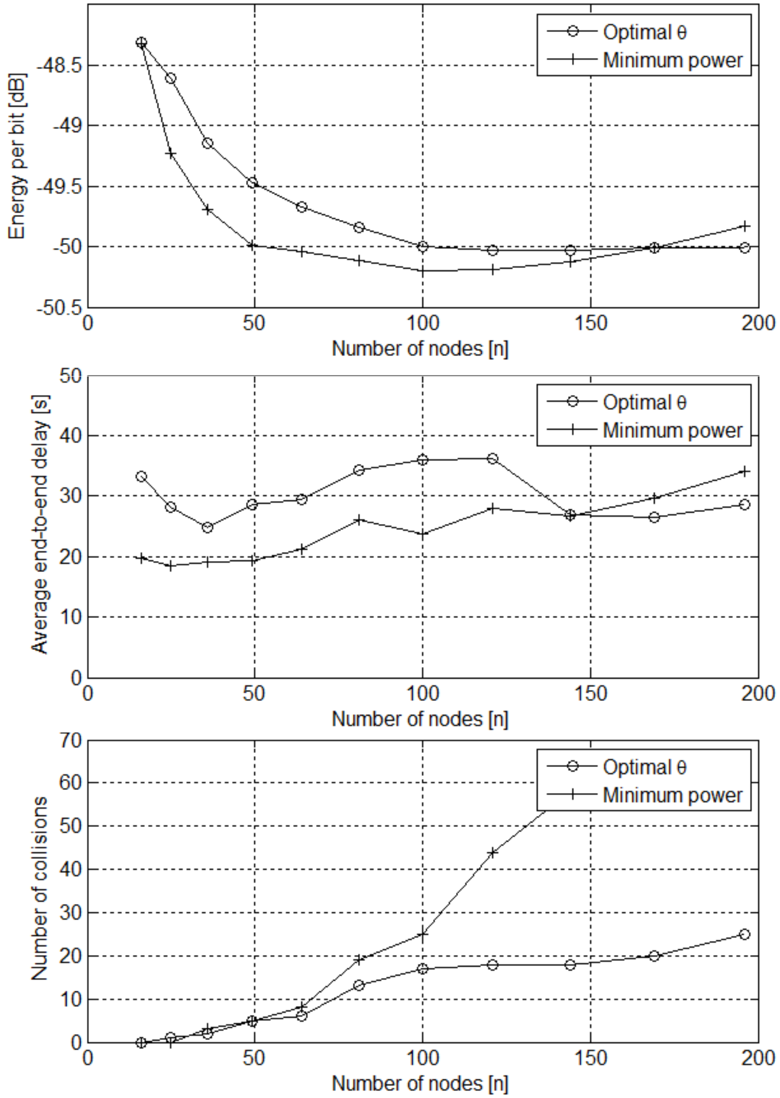
- **Area of simulation:** 20km by 20km.
- **Sinks:** 4.
- **Active nodes:** 16-200 (variable number).
- Any node can also act as a relay.
- All the nodes are randomly located within a virtual grid.

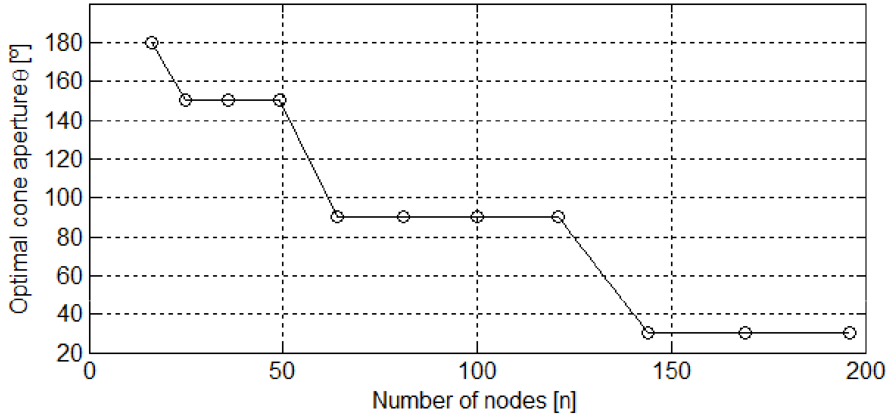
Effects of node density



- For each node density, we optimally allocate:
  - The power levels
  - The center frequency
  - The bandwidth
- The results are shown for two cone apertures and compared to the ones obtained when following static routes.
- Both the energy per bit and the average end-to-end delay are very close to the case when static routes are followed.

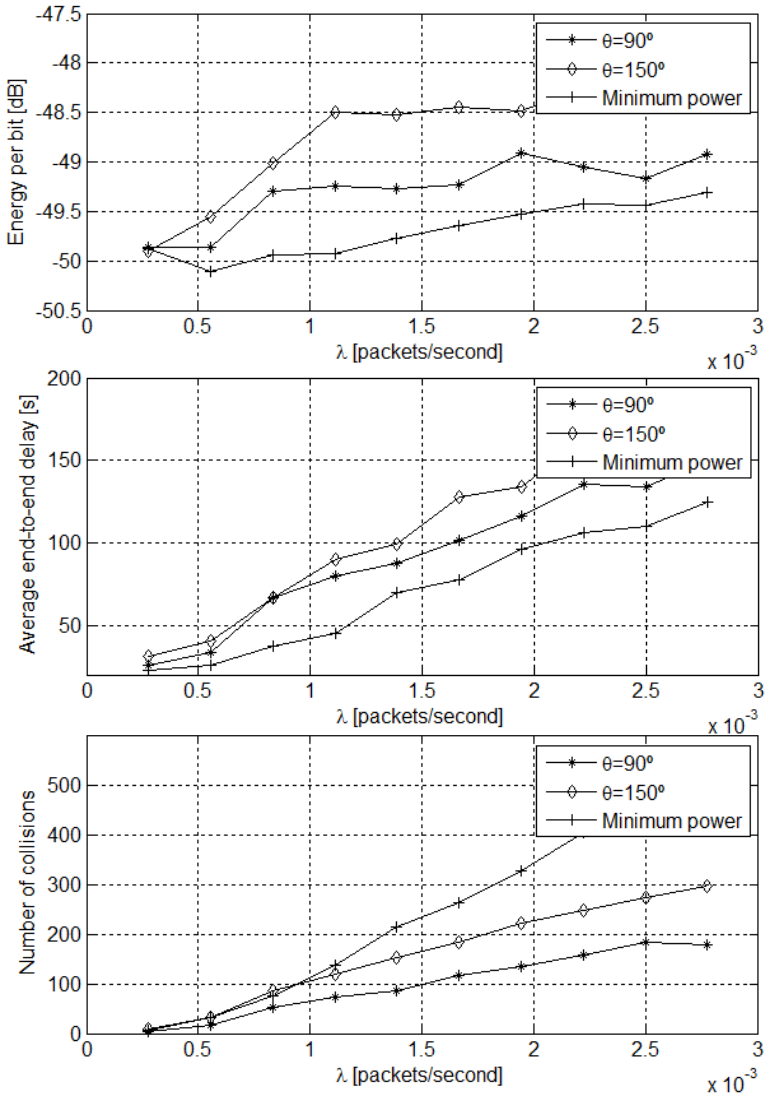
Optimal Cone Aperture





- When closing the cone:
  - Fewer nodes propose themselves as relays.
  - Zigzagging is prevented.
  - Shorter delay.
  - Higher power levels may be used.

Packet Generation Rate



- Only at high packet generation rates, can the lack of route information increase latency
  - In practice, routes will not change that fast.
    - Instead of having to discover them, nodes can just follow the last valid route and start the multicast query only if necessary.
    - We can use simpler protocols in that case: CS-ALOHA.

Conclusions and Future Work

- By properly **coupling** routing and MAC functionalities with **power control**, routes can be established **on demand** with a minimum impact on the network **performance.**
- The overall system performance is improved when the **frequency allocation** pattern takes into account the network **node density.**
- Future work:
  - Additional cost metrics in the candidate selection process.
  - Alternative MAC protocols.
  - Inclusion of sleeping modes – reduce listening energy consumption.

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Thank you very much for your attention

September 2008.