

Focused Beam Routing protocol for Underwater Acoustic Networks

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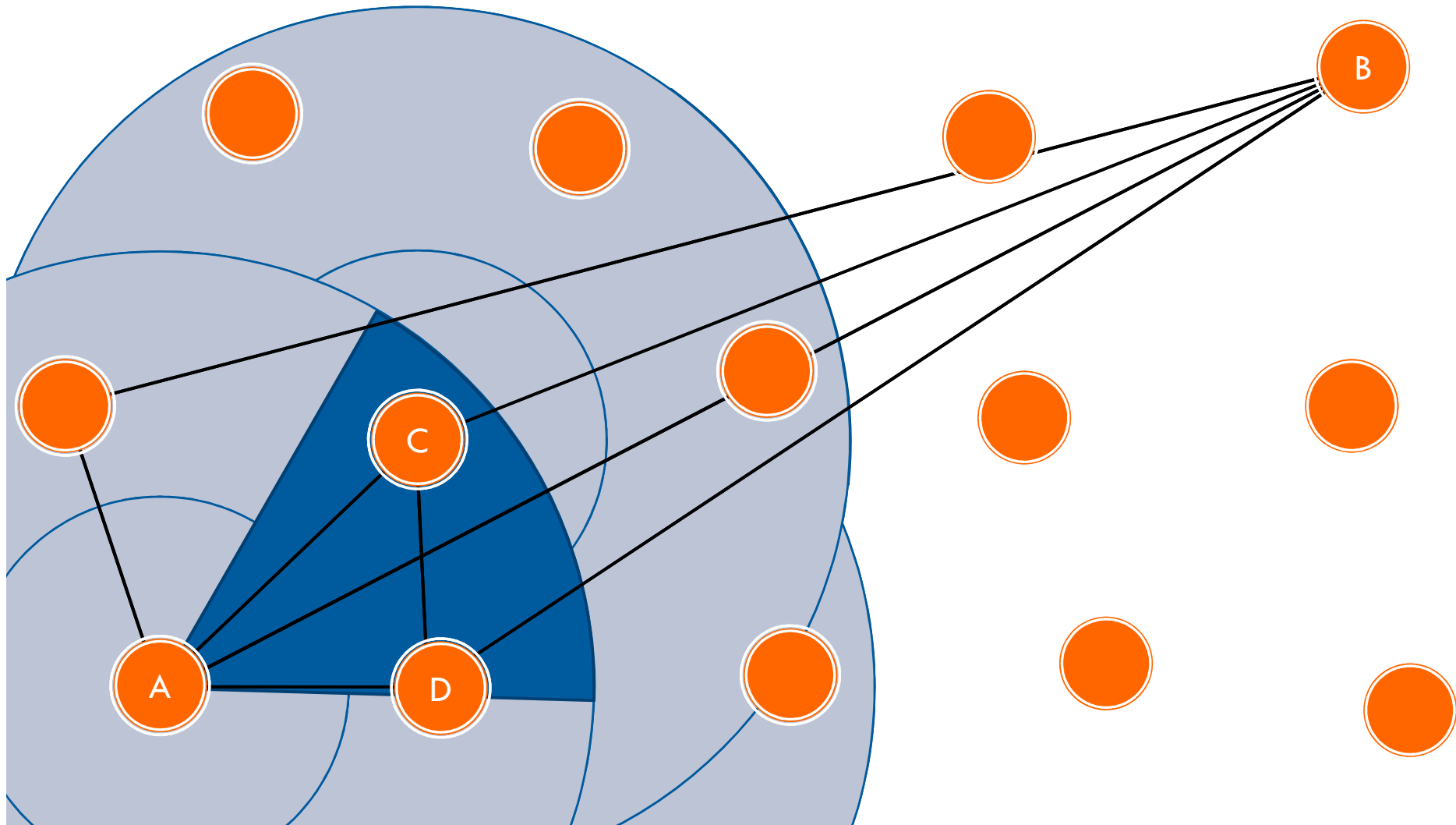
FBR

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- 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.

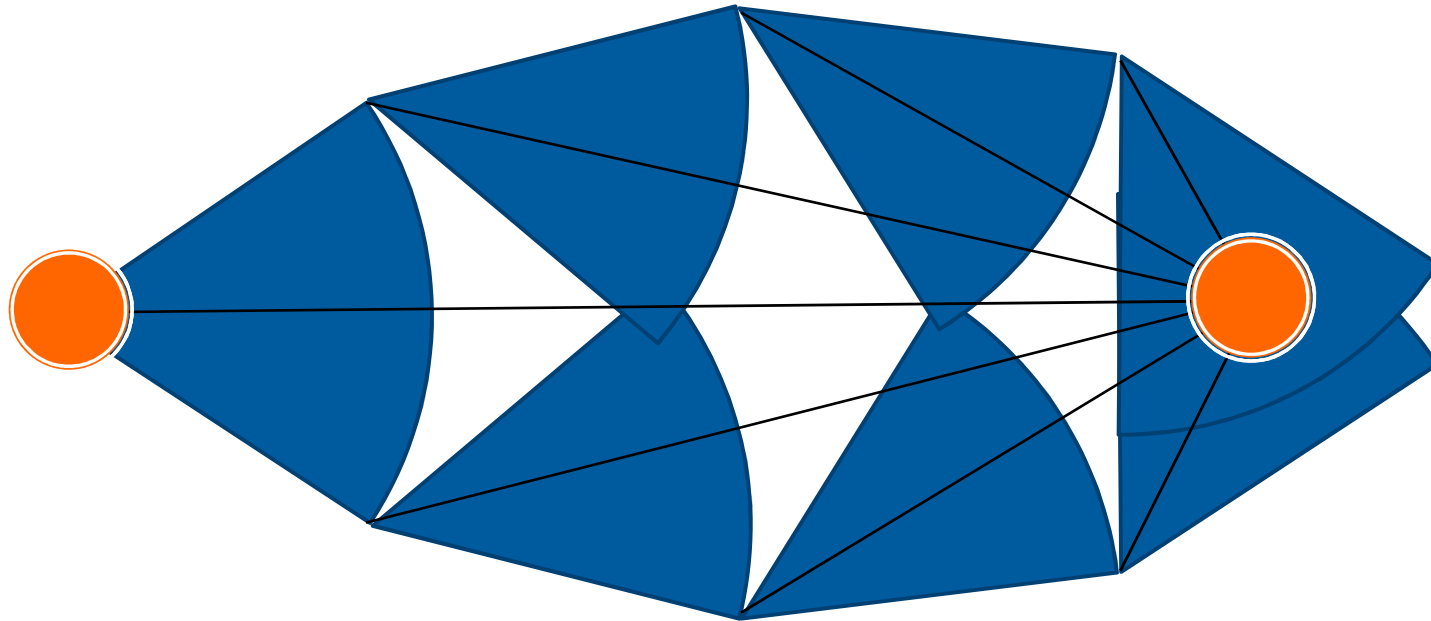
Routing and Power Control

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Focused and beam

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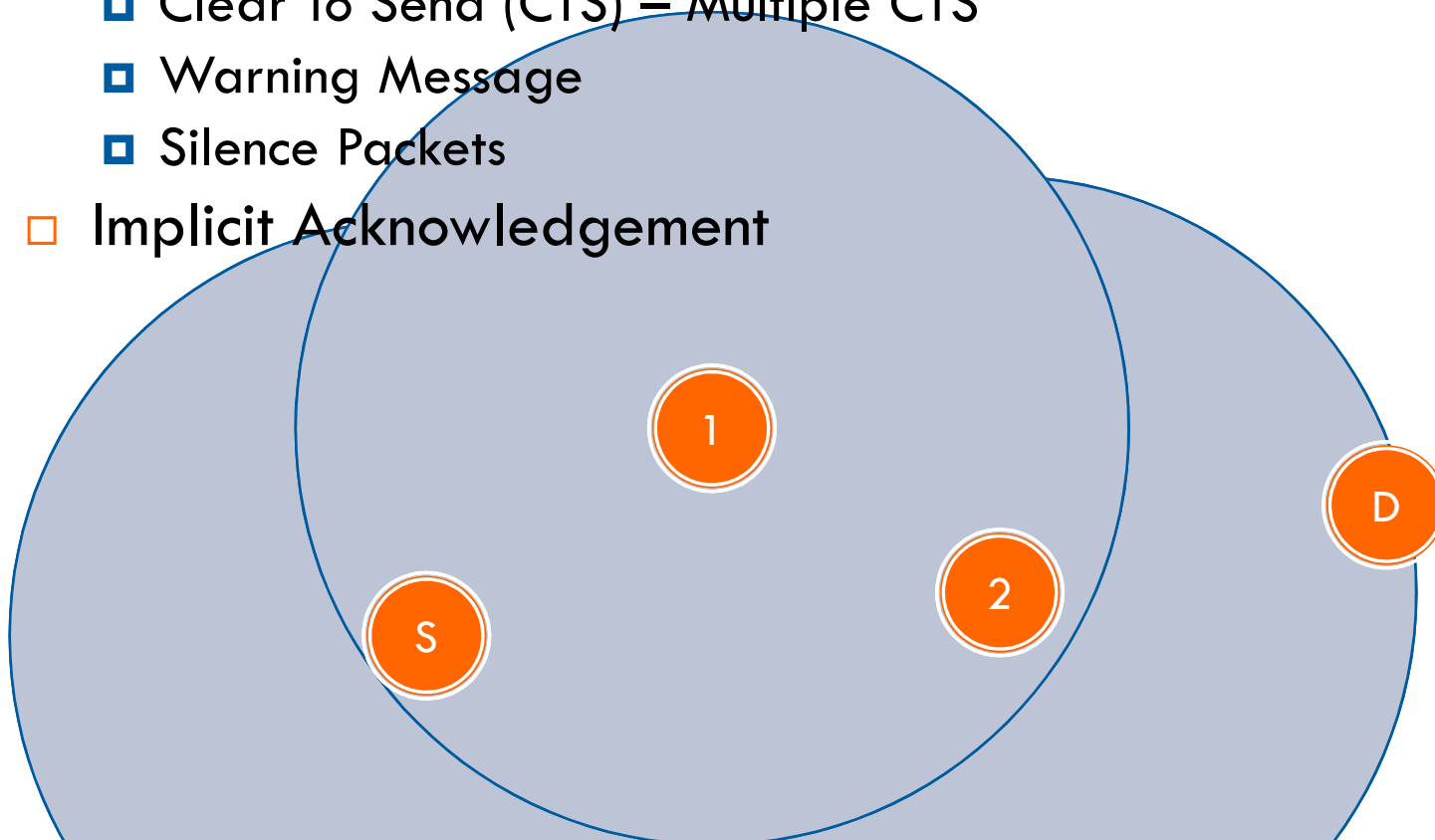
Medium Access Control

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

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- 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



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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.

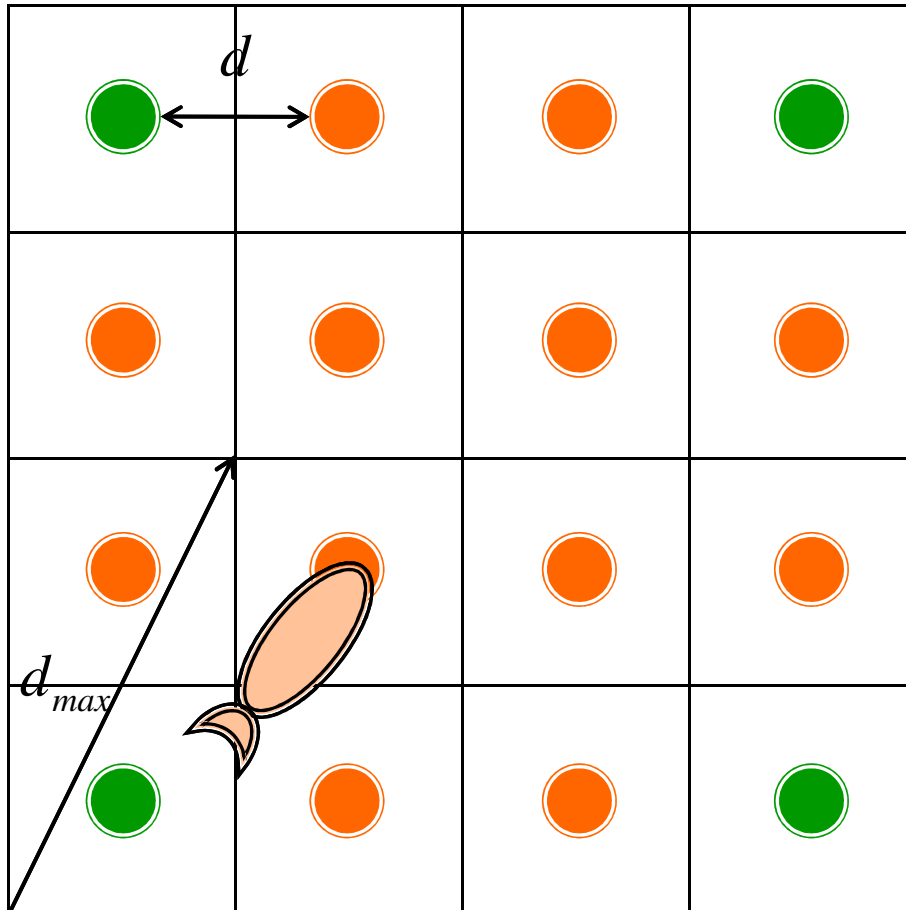
The Tool: AUVNetSim

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- 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

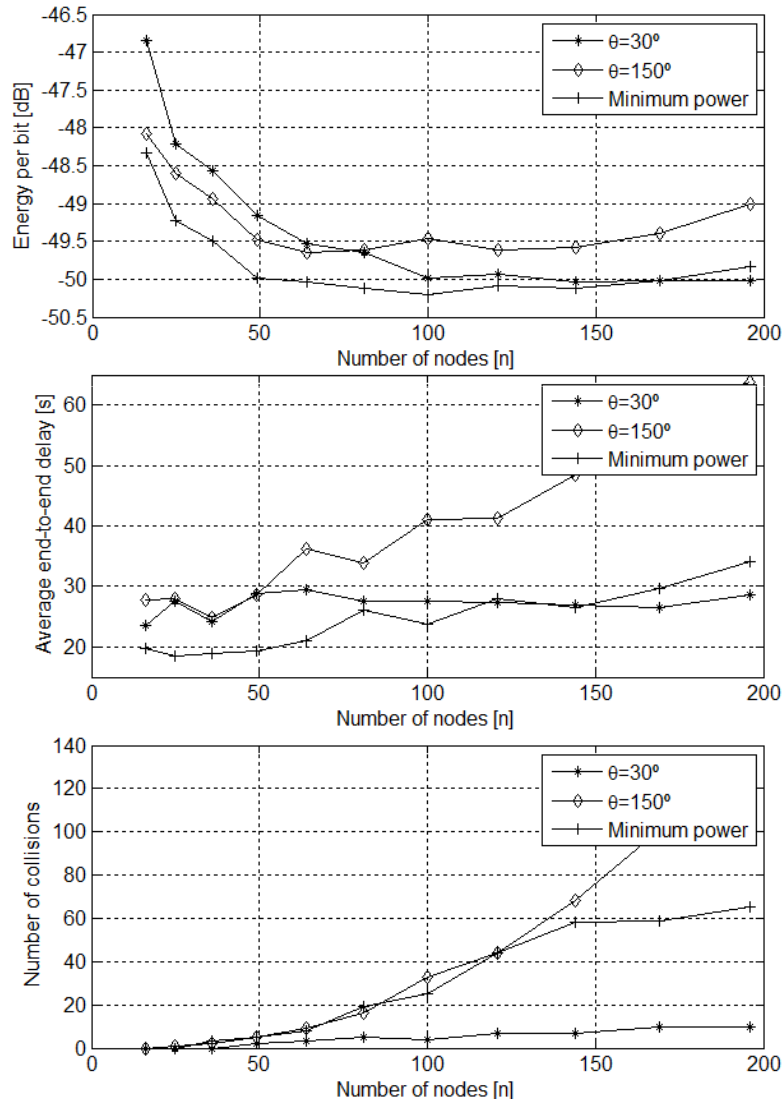
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- **Area of simulation:** 20km by 20km.
- **Sinks:** 4.
- **Active nodes:** 16-200 (variable number).
- Any node can also act as a relay.
- All the nodes are randomly located within a virtual grid.

Effects of node density

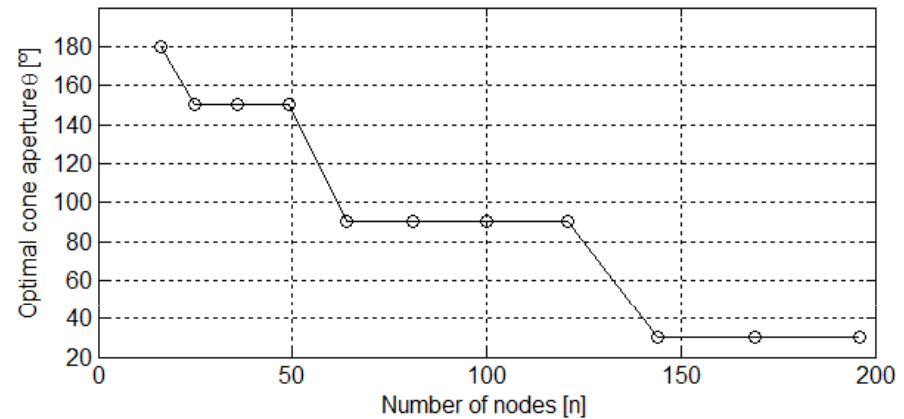
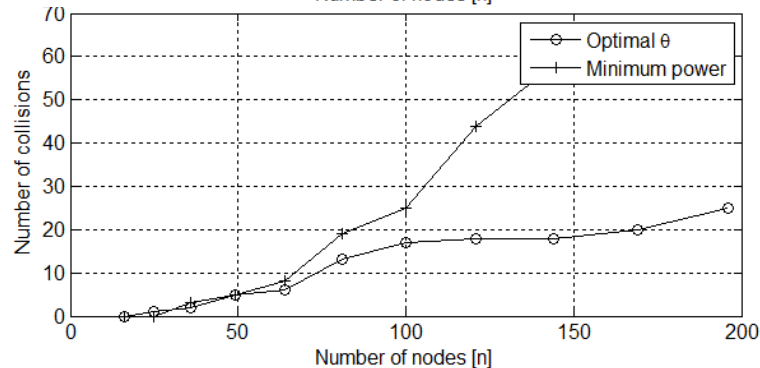
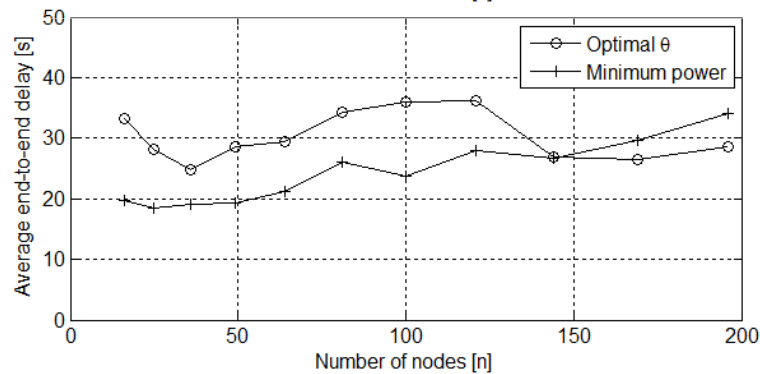
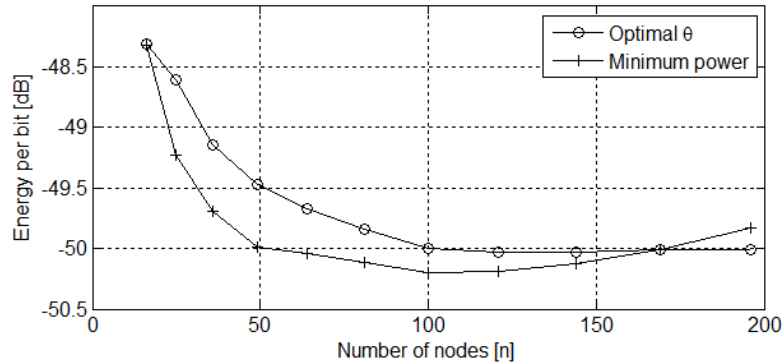
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- For each node density, we optimally allocate:
 - ▣ The power levels
 - ▣ The center frequency
 - ▣ The bandwidth
- The results are shown for two cone apertures and compared to the ones obtained when following static routes.
- Both the energy per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

Optimal Cone Aperture

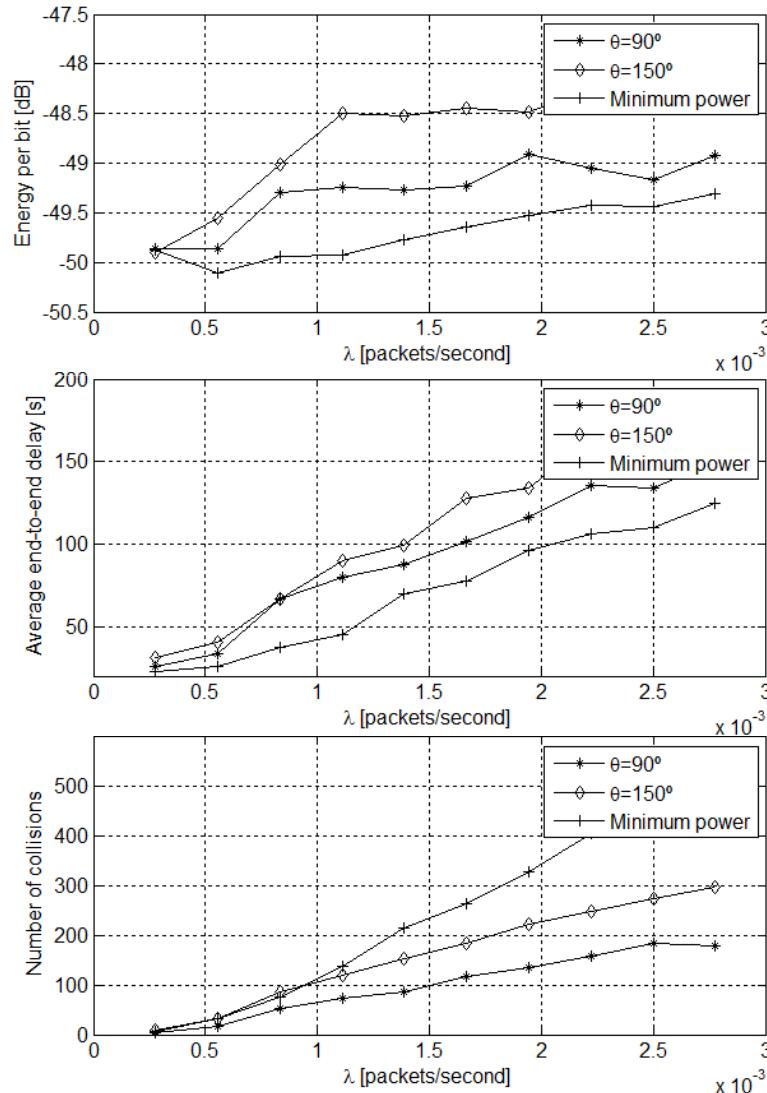
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- When closing the cone:
 - ▣ Fewer nodes propose themselves as relays.
 - ▣ Zigzagging is prevented.
 - ▣ Shorter delay.
 - ▣ Higher power levels may be used.

Packet Generation Rate

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- 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

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- 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

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