Joint Optimization of Routing and Radio Configuration in Fixed Wireless Networks

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Microwave radio links have become a common preference over leased lines to build broadband communication networks.

- Economical equipment cost
- Easy installation
- Disaster resiliency
- High-bandwidth applications
- Very bursty traffic behaviors
- Tremendous rise of energy

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Capacity & energy cost

Theoretical capacity:

\[ C[\text{bits/s}] = B[\text{Hz}] \times \log_2 \left( 1 + \frac{S[W]}{N[W]} \right) \]

Practical bitrate:

\[ C[\text{bits/s}] = B[\text{Hz}] \times \log_2 (m), \quad m = 2^n \]

In practice, as the modulation scheme changes to accommodate higher data rates, the SNR requirement increases to preserve the BER performance!
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Power-efficient configuration

- Modulation scheme
- Transmission power level

Energy cost

- Step increasing energy cost functions on the links

For each modulation scheme, only the most right point of the curve represents a power-efficient configuration!
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Problem description

Network’s topology
- Nodes: radio base stations
- Arcs: radio links

Power-efficient configurations
- Link’s capacity
- Link’s energy cost

Traffic requirements

The network’s configuration and flows that minimize the total energy expenditure, while handling all the traffic requirements.
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Mathematical Models

**Exact formulation**
- MCMCF with step increasing cost functions
- Large scale integer linear programs
- Very hard to solve in practice
- Optimal feasible solutions
Mathematical Models

Model relaxation

- MCMCF with piecewise linear convex cost functions
- Large scale continuous linear programs
- Lower bounds on the energy consumption
- Feasible solutions based on the fractional optimum

Heuristic that assigns the lowest-level power-efficient configuration capable of routing the network’s flows.
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Simulation parameters

- **Channel Bandwidth**: 28 MHz
- **Operated Frequency**: 13 GHz
- **Antenna Gain**: 30 dBi
- **Receiver Sensitivity**: -90 dBm
- **Distance**: 1000 m

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<thead>
<tr>
<th>Modulation</th>
<th>Power</th>
<th>Capacity</th>
<th>Marginal Cost</th>
<th>SNR</th>
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<tbody>
<tr>
<td>QPSK</td>
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Computational results

Grid 5 × 5

Grid 10 × 10

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Conclusion & future work

Joint optimization of data routing and radio configuration

- An exact mathematical formulation
- A model relaxation
  - Lower bounds on the energy consumption
  - Heuristic feasible solutions

Future work

- More realistic scenarios
- Alternative relaxations and heuristics
- Decrease the gap to the exact solution
Merci !
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