Simultaneous channel and power optimization for planning wireless cities

Keith Briggs & Martin Tijmes

Complexity Research Group
BT Mobility Research Centre
http://keithbriggs.info

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Outline

802.11b spectral characteristics

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$$\begin{aligned}
s(f) &\equiv |\sin(2\pi f)/(2\pi f)| \\
\mathrm{flt}(x) &\equiv 1/(1 + (2.6x)^6) \\
\mathrm{ol}(n, m, x) &\equiv \mathrm{flt}(ch(n, x))s(ch(n, x))\mathrm{flt}(ch(m, x))s(ch(m, x)) \\
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- this gives (taking $20\log_{10}(\mathsf{olf}_k)$ to get dB) the vector of overlap factors as: $[0, -2.767, -11.329, -28.525, -45.296, -61.560, -74.686, \ldots$

802.11b interference

- the interference at node j caused by node i is
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- T_j is the transmit power, typically 20dBm (100mW)
- P_{ref} is the reference loss at 1m, typically 40.2dB
- m is the path loss exponent, typically about 2.86

Objectives

- Optimization problem:

$$\min_x f(x)$$

- Minimizing the average interference:

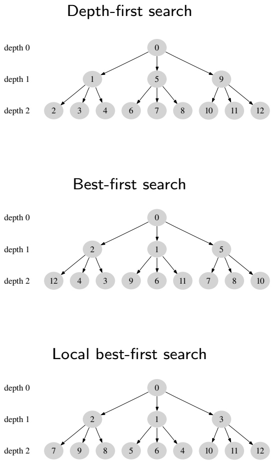
$$f(x) = \frac{1}{n} \sum_i I_i(x)$$

- Minimizing the maximum interference:

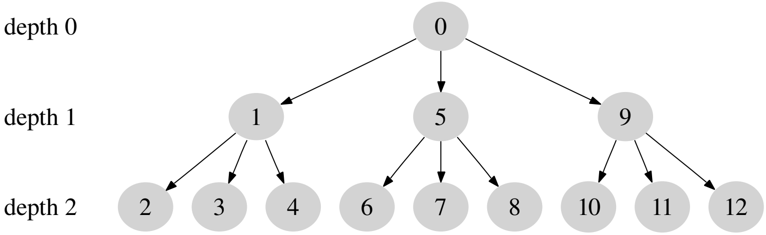
$$f(x) = \max_i I_i(x)$$

Local best-first search

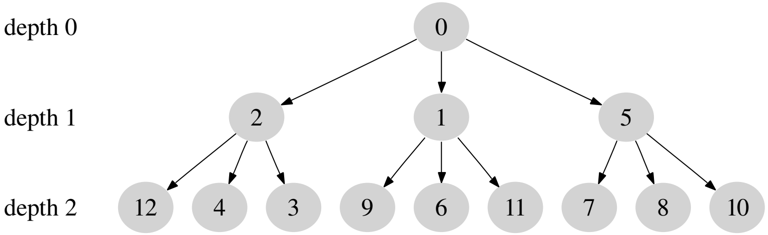
- Branch-and-bound
  - Exact and enumerative method
- Combination depth-first and best-first
  - Depth-first: find feasible solution fast
  - Best-first: find best solution fast



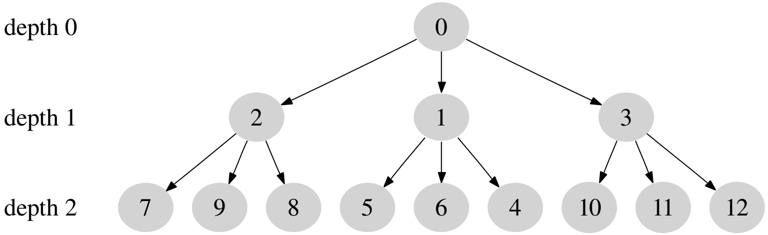
Depth-first search



Best-first search

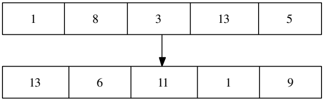


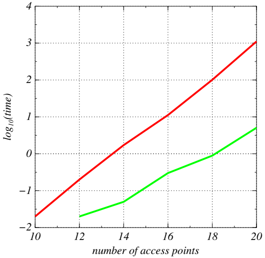
Local best-first search



Speed-up tricks [1]

- Complementary solutions
  - Symmetric channels
  - Omit similar assignments
- Channel spacing
  - Reduce channel overlap and number of channels
  - Reduce complexity
- Pre-ordering
  - Critical access points
  - Improve optimization process





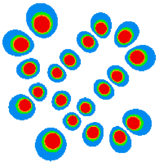
Speed-up tricks [2]

- Initial random solution
  - Find a good upper bound for pruning
- Incremental objectives
  - Reduce time complexity
  - Only applicable on certain objectives
- Symmetric AP distance matrix
  - If measuring point is at AP
  - Transmit power is left out

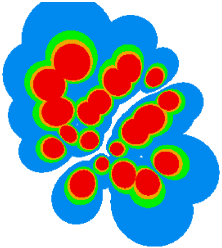
Results [1]

Comparison of the throughput area

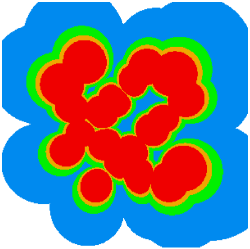
Modulation schemes: 11Mbps, 5.5Mbps, 2Mbps, 1Mbps



(a) 20 APs using the same power level and channel



(b) 20 APs with randomly assigned channels

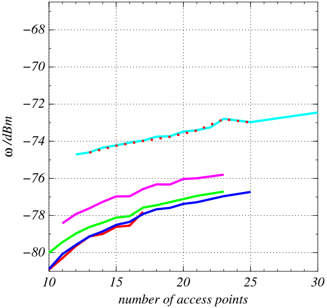


(c) 20 APs using the same power level, but with an optimized channel allocation (13 channels)

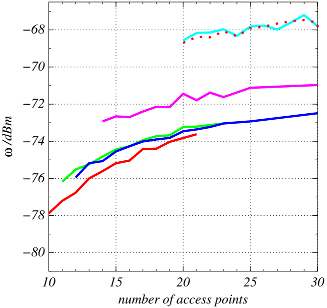
Results [2]

Comparison of two objectives

Channel spacings: 1 (red), 2 (green), 3 (blue), 4 (magenta), 5 (cyan), 6 (dotted red)



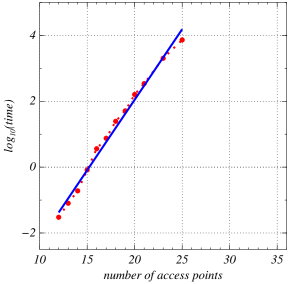
Minimizing the average interference



Minimizing the maximum interference

Results [3]

Comparison of computational time for channel spacing 3



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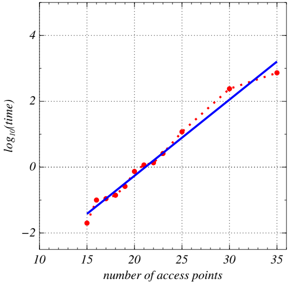
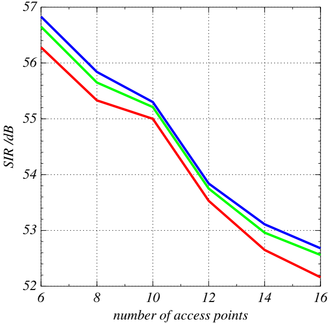


Minimizing the maximum interference

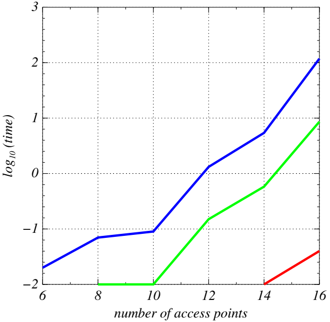
Results [1]

Using multiple transmitter powers

Number of power levels: 1 (red), 2 (green), 3 (blue)



Maximizing the SIR

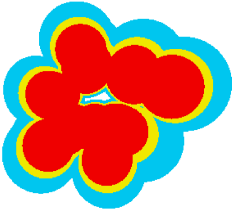


Time dependency

Results [2]

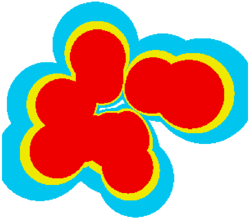
Soho: extreme power control

Modulation schemes: 11Mbps, 5.5Mbps, 2Mbps, 1Mbps



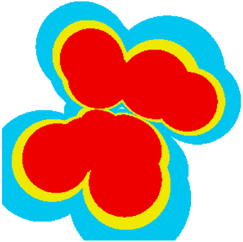
(d) 1 transmit power

Min. SIR:	24.2 dB
Mode 3 or 4:	36%
Mode 4:	28%
Time:	0.02s



(e) 2 transmit powers

Min. SIR:	24.5 dB
Mode 3 or 4:	37%
Mode 4:	29%
Time:	1.26s



(f) 2 transmit powers, omitting 1 access point

Min. SIR:	26.2 dB
Mode 3 or 4:	44%
Mode 4:	34%
Time:	0.24s

Summary

- Exact optimization algorithm
  - Speed-up tricks
  - Up to 50 access points
- Applicability
  - Pseudo-random generator
  - Real-life configurations
- Trade-off between time and objective (channel optimization)
  - Increase channel spacing to speed-up optimization
  - Spacing 3 outperforms spacing 2
- Joint channel and power optimization
  - Only small improvements for extra transmit powers
  - Larger increments for extreme power control