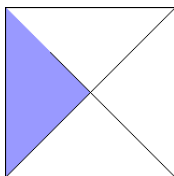


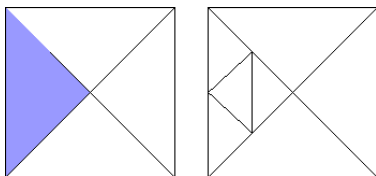
Hanging nodes

- Refinement of regular mesh



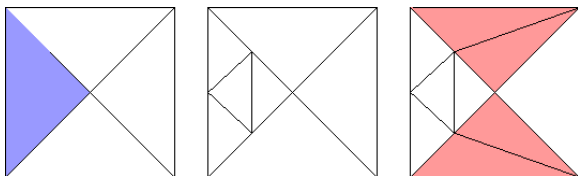
Hanging nodes

- Refinement of regular mesh



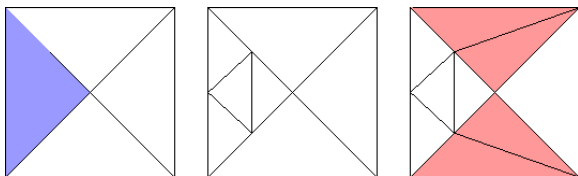
Hanging nodes

- Refinement of regular mesh

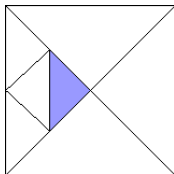


Hanging nodes

- Refinement of regular mesh

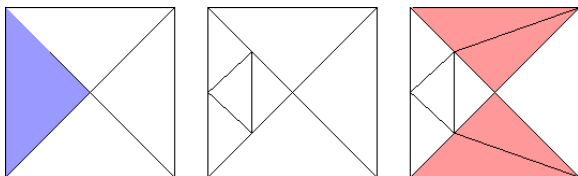


- Using one-level hanging nodes (1-irregular mesh)

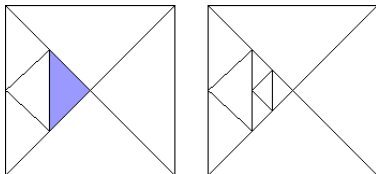


Hanging nodes

- Refinement of regular mesh

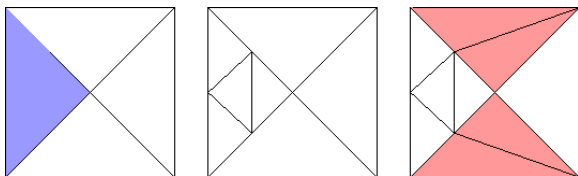


- Using one-level hanging nodes (1-irregular mesh)

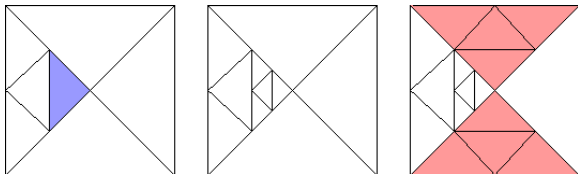


Hanging nodes

- Refinement of regular mesh



- Using one-level hanging nodes (1-irregular mesh)

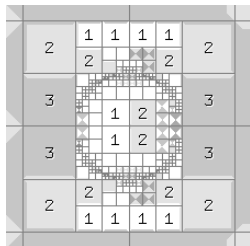


Forced refinements

- Create unnecessary DOF
- Spoil element shapes
- Cannot use just quads
- Have non-local, recursive nature
- Make hp -adaptivity difficult

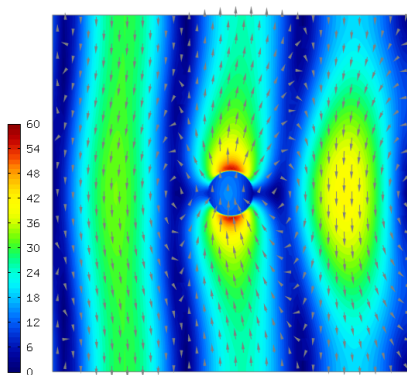
⇒ introduce arbitrary-level hanging nodes.

Arbitrary-level hanging nodes

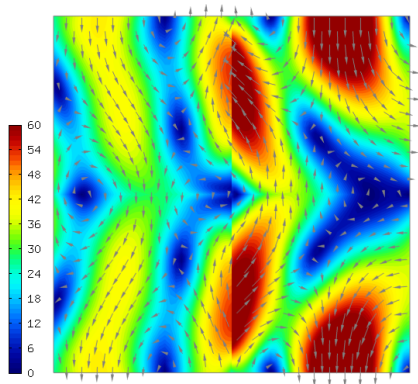
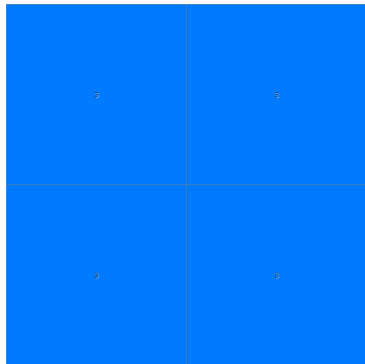


- Make element refinement a *local operation*.
- *hp*-adaptivity becomes way easier.
- P.S., J. Cervený, I. Doležel: *Arbitrary-Level Hanging Nodes and Automatic Adaptivity in the hp-FEM*, *Math. Comput. Simul.* 77 (2008), 117 - 132.

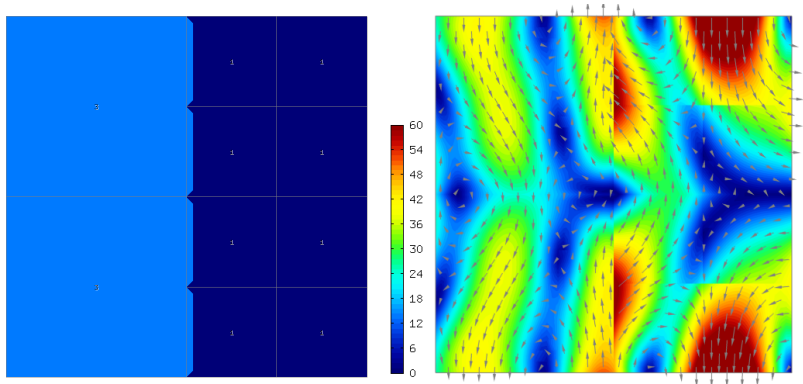
Waveguide problem



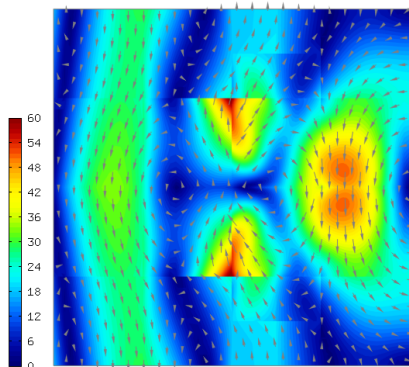
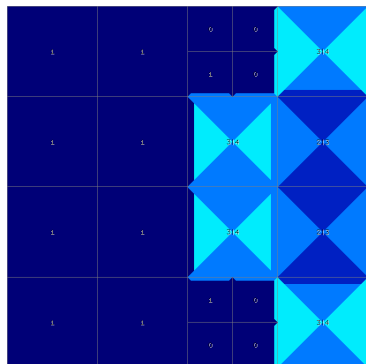
Waveguide problem (step 1)



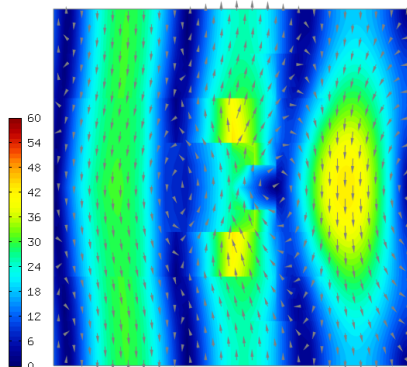
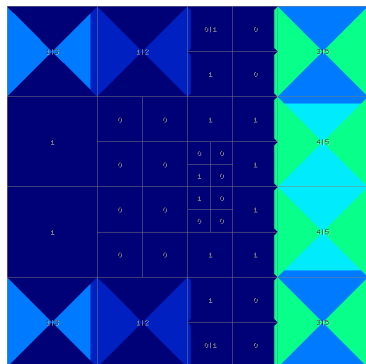
Waveguide problem (step 2)



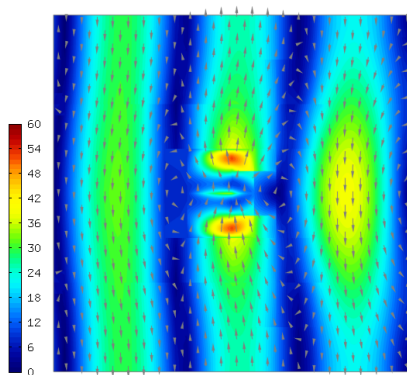
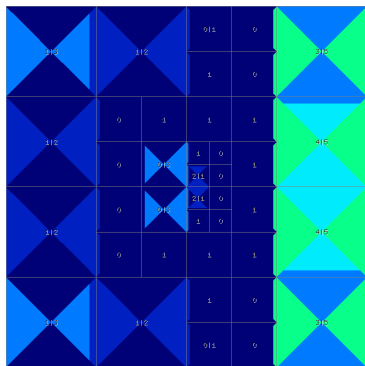
Waveguide problem (step 3)



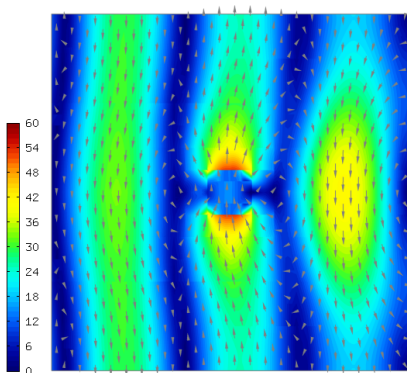
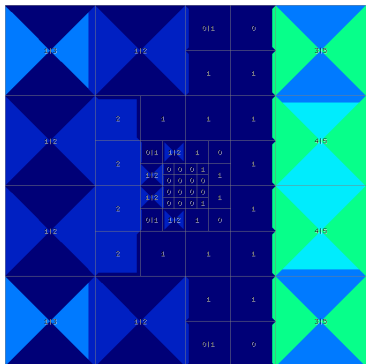
Waveguide problem (step 4)



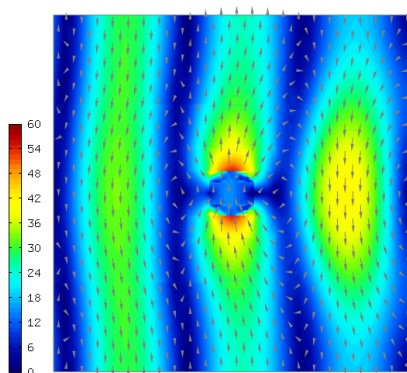
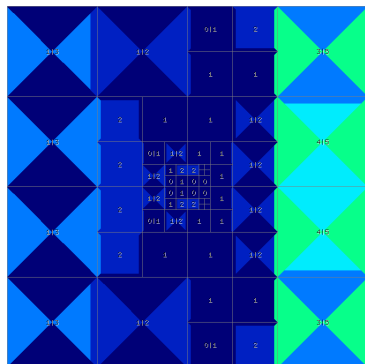
Waveguide problem (step 5)



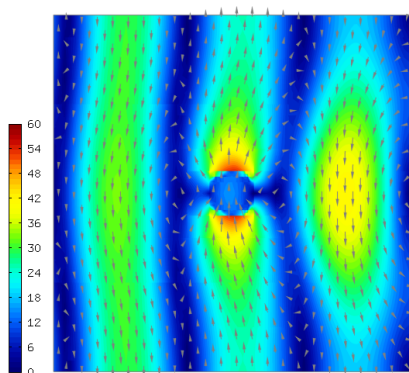
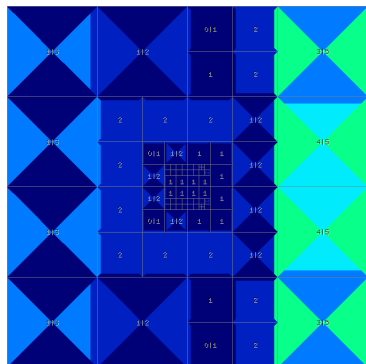
Waveguide problem (step 6)



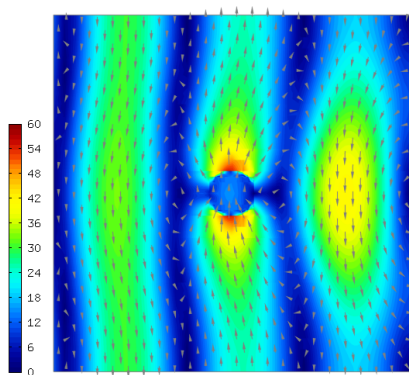
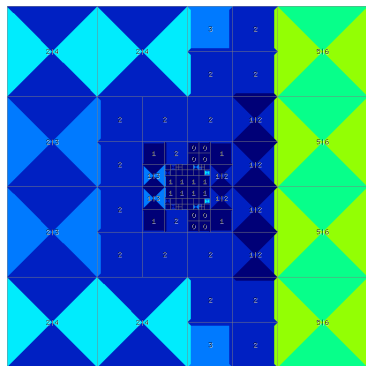
Waveguide problem (step 7)



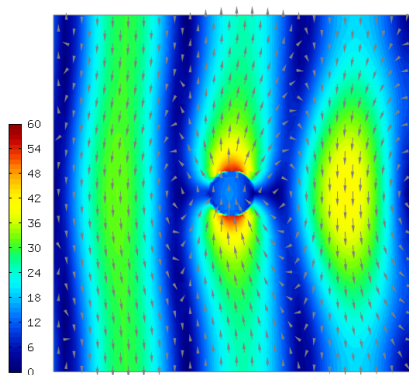
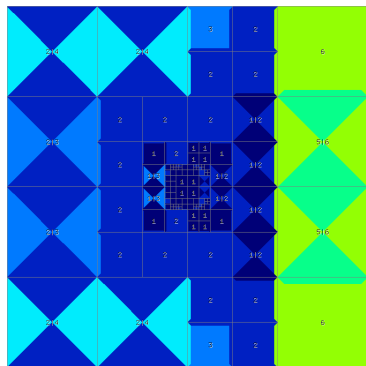
Waveguide problem (step 8)



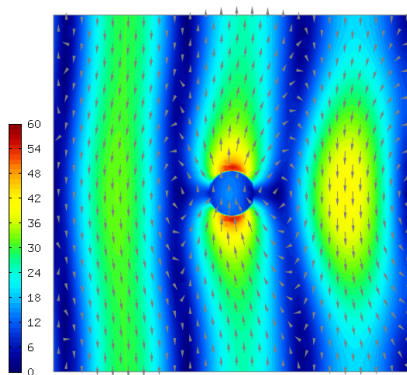
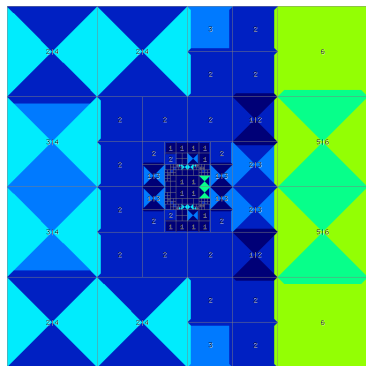
Waveguide problem (step 9)



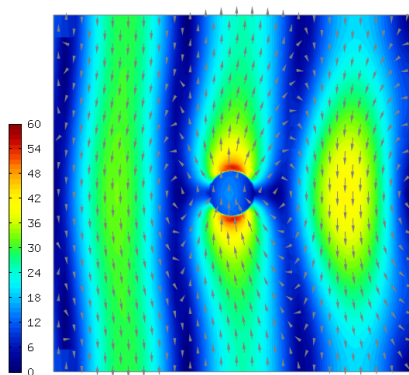
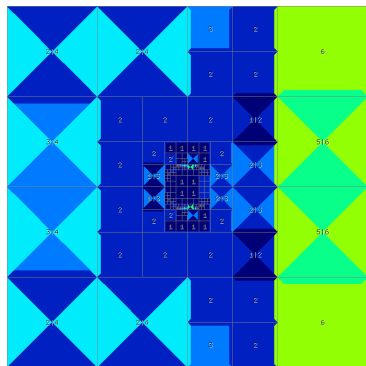
Waveguide problem (step 10)



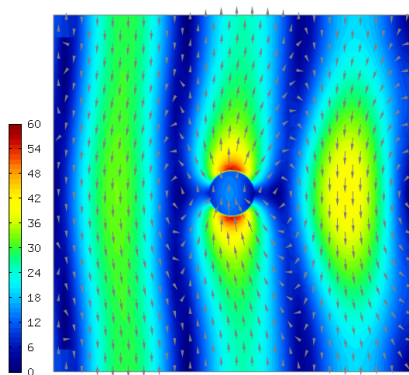
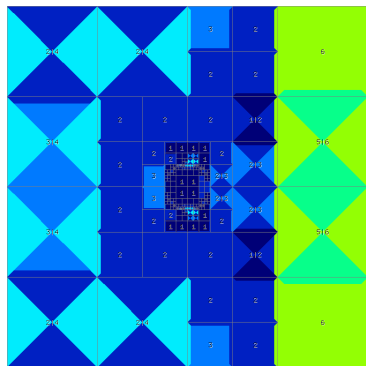
Waveguide problem (step 11)



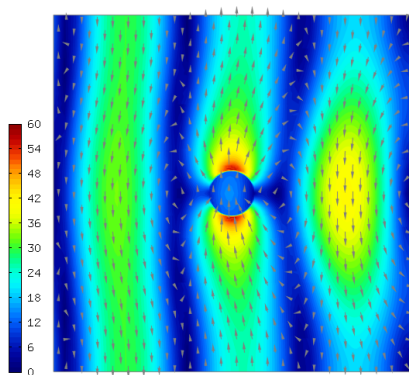
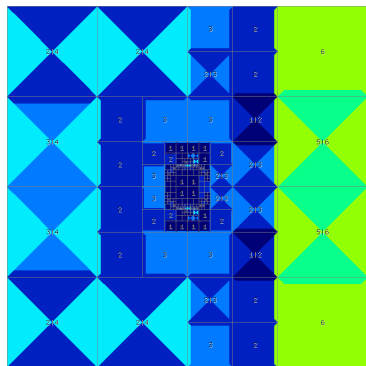
Waveguide problem (step 12)



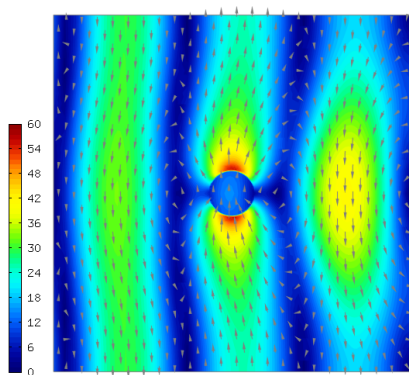
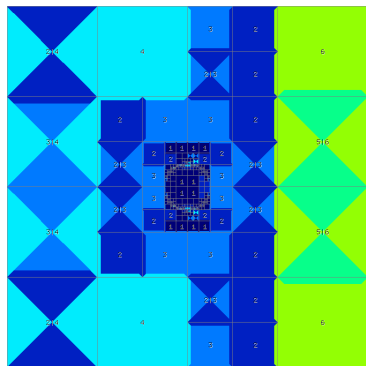
Waveguide problem (step 13)



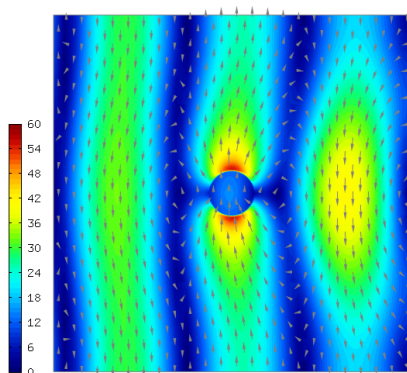
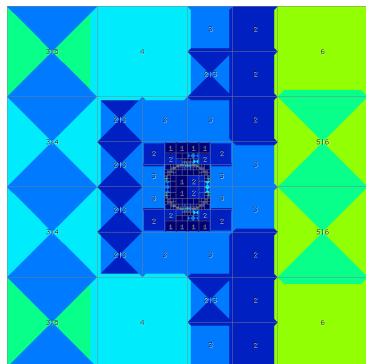
Waveguide problem (step 14)



Waveguide problem (step 15)



Waveguide problem (step 16)



Mesh regularity vs. performance

