Simulation of the air flow in the MI building with LBM

CFD Lab Project: midterm presentation

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Contents

The idea

- Parallel approach for arbitrary geometries.
- Do not waste effort for large “inactive” areas.
- Case study: Mathematics-Informatics building-like geometry.

Real life

Approximation

Approximation

Approximation

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The model

- Real life
  - Main hall: approx. 150m long, 12-26m wide (mean: 19m).
  - Wings: approx. 10m long, 40-50m wide.
  - Mass, momentum and heat transfer laws in 3D.
  - Flow due to pressure and density differencies.
  - Air with very low speed.
  - Doors mainly closed.

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  - Mass, momentum and heat transfer laws in 3D.
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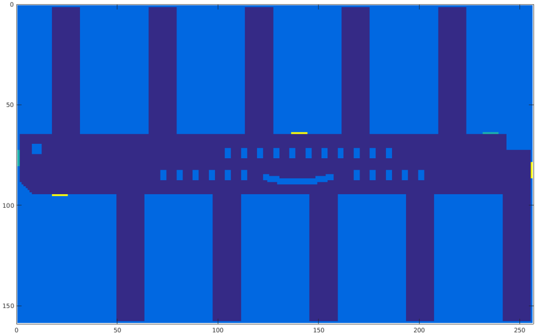
  - Air with very low speed.
  - Doors mainly closed.
- Model
  - Main hall: rectangle, 16x long, 2x wide (ratio 16:2).
  - Wings: rectangles, 1x long, 4x wide (ratio 1:4).
  - LBM with BGK approximation in pseudo-3D (2D).
  - Flow due to constant inflow velocities.
  - BGK-compatible relaxation time (τ parameter).
  - Larger doors, always (or randomly) open.

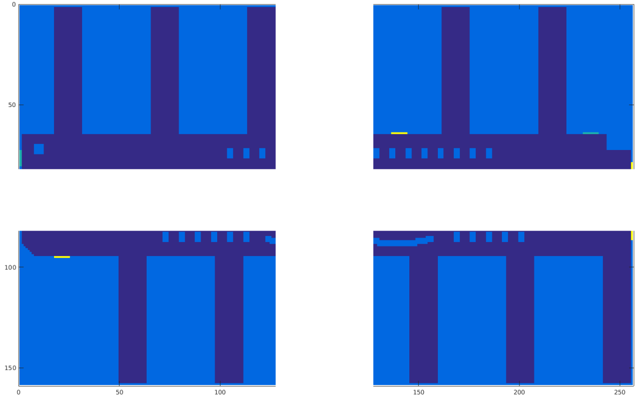
The geometry

The geometry (pgm files of flagfield) is produced in Matlab, for given x. Various boundary conditions and obstacles can be defined.



Partitioning: Worksheet 4 - style

Let's divide the geometry in 4 parts intuitively:



Total area: $160x^2$

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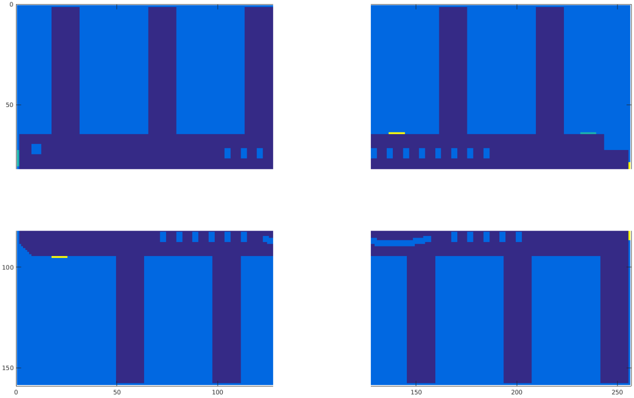

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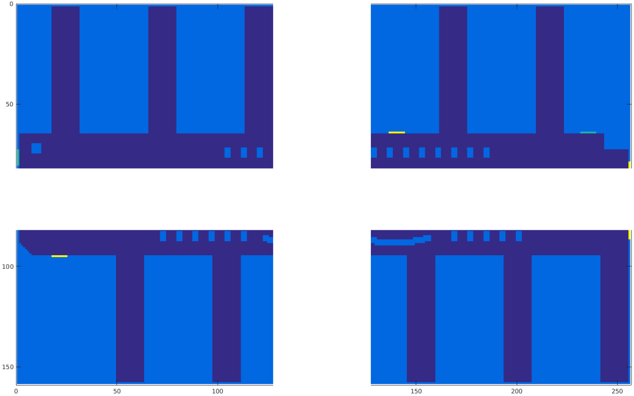
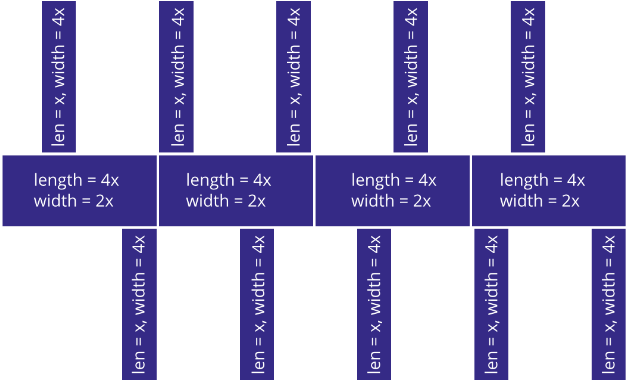


Total area: $160x^2$, active area: $72x^2$ (45%) , inactive area: $88x^2$ (55%).

Partitioning: our approach

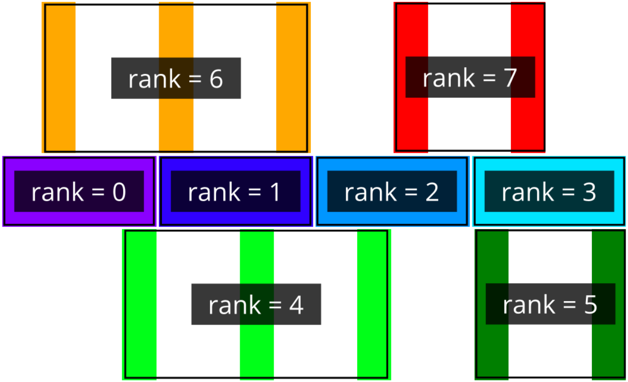
Try to eliminate the inactive area:



Total area: $72x^2$, active area: $72x^2$ (100%) - approximately.

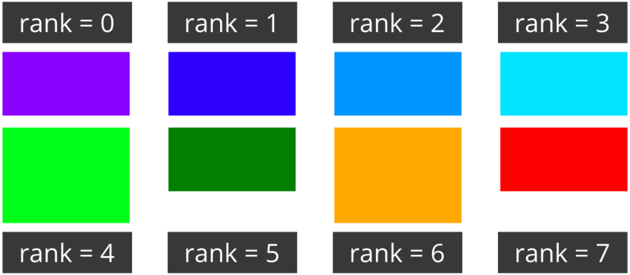
Distribution to CPUs

Each process (we assume np=8) is assigned one or more partitions-chunks in order to keep the work balanced. All the chunks are stored in the same array, with known offsets.



Work balance

With the proposed partitioning and distribution, each process is assigned with $8x^2$ lattice cells in the normal case, or $12x^2$ in the worst case, including no large inactive areas.

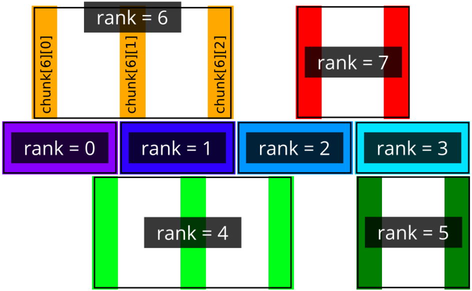


Communication

Every process has to communicate with one or more neighbors, for one or more partitions. Every process knows:

- the ids of the chunks it has to process,
- the neighboring processes (number and ids) and chunks.

The processes communicate asynchronously, waiting for the whole communication to complete.



What we did

Main tasks:

- Physical geometry definition (measurements)
- Problem geometry definition (well separable)
- **Domain partitioning**
- **(Automated) geometry files creation**
- Work scheduling
- Generalization of the WS3 code (multiple inlets)
- Randomly opening doors
- Merging of WS3 and WS4
- **Definition of chunks, offsets, neighbors**
- **Communication for multiple neighbors and chunks**
- Visualization of multiple chunks

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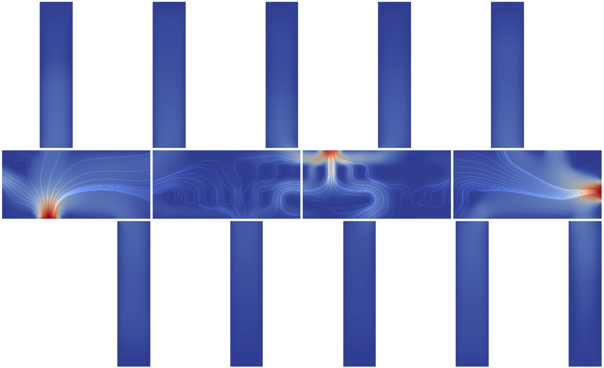
- Visualization of multiple chunks
- **Much much much debugging...**

Results

Grab your popcorn, it’s movie time!

Results (example)

For those who slept during the movie, this is an example timestep of our simulation, with $\tau = 0.6$, inlets with perpendicular velocity = 0.1 and $x = 16$ lattice cells. The color shows the velocity magnitude.



Thank you!

It is hot today! We understand you and thanks for the attention!

Find our work on GitHub: `github.com/MakisH/CFDLab`
(expect some rough edges)