

# Simulation of the air flow in the MI building with LBM

CFD Lab Project: midterm presentation

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## The idea

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

## Real life



## Approximation



## Approximation



## Approximation



## Approximation





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## Approximation



## The model

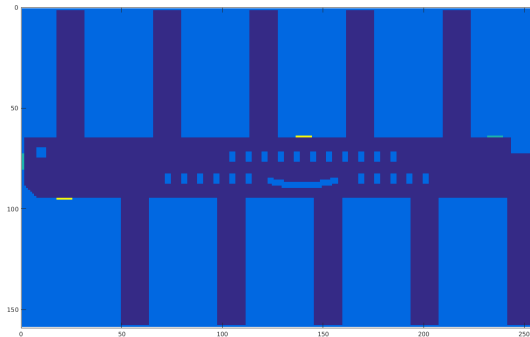
- Real life
  - Main hall: approx. 150m long, 12-26m wide (mean: 19m).
  - Wings: approx. 10m long, 40-50m wide.
  - Mass, momentum and heat transfer laws in 3D.
  - Flow due to pressure and density differences.
  - Air with very low speed.
  - Doors mainly closed.

## The model

- Real life
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  - 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 ( $\tau$  parameter).
  - Larger doors, always (or randomly) open.

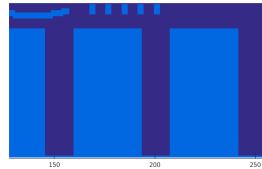
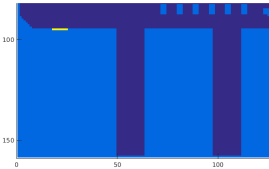
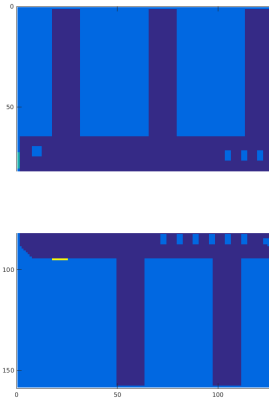
## The geometry

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

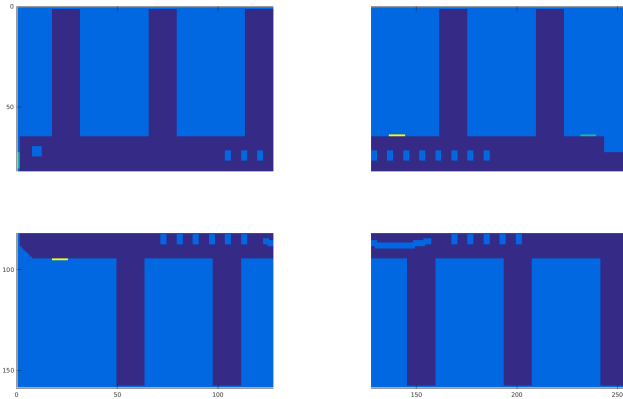
Let's divide the geometry in 4 parts intuitively:



Total area:  $160x^2$

## Partitioning: Worksheet 4 - style

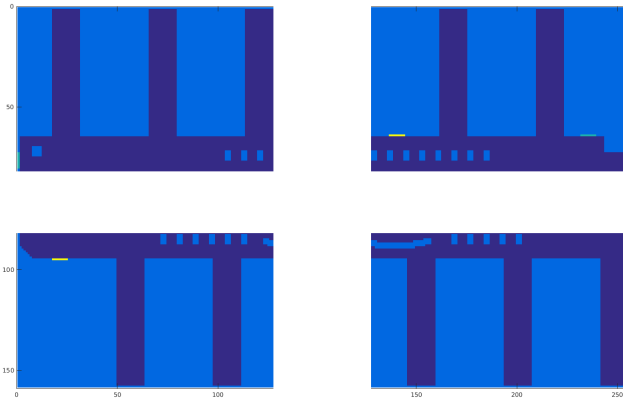
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Total area:  $160x^2$ , active area:  $72x^2$  (45%)

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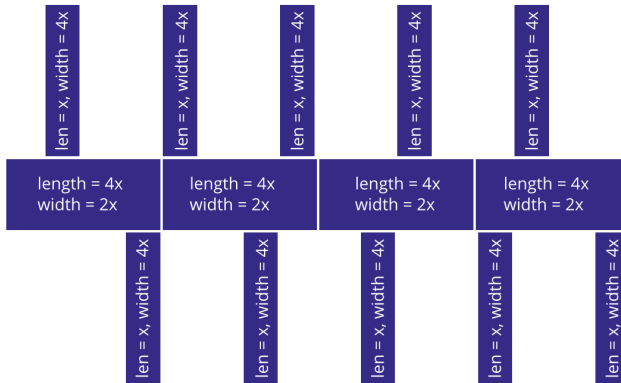


Total area:  $160x^2$ , active area:  $72x^2$  (45%) , inactive area:  $88x^2$  (55%).



## Partitioning: our approach

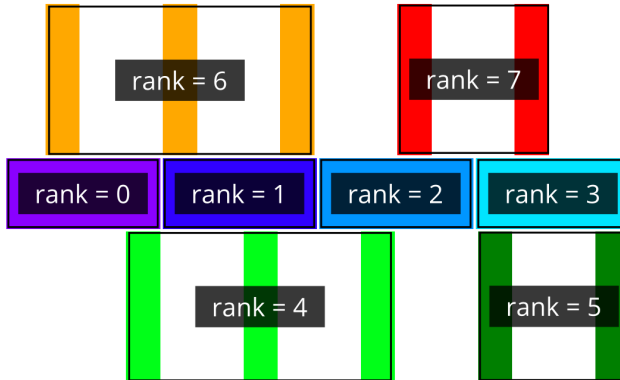
Try to eliminate the inactive area:



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

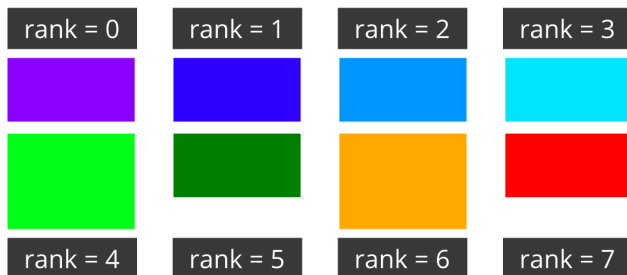
## Distribution to CPUs

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.

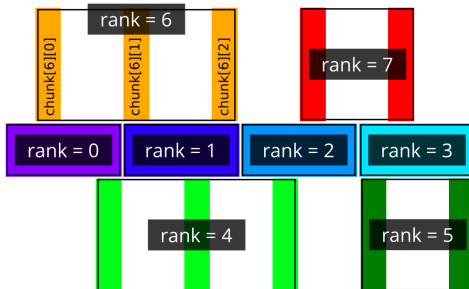


## Communication

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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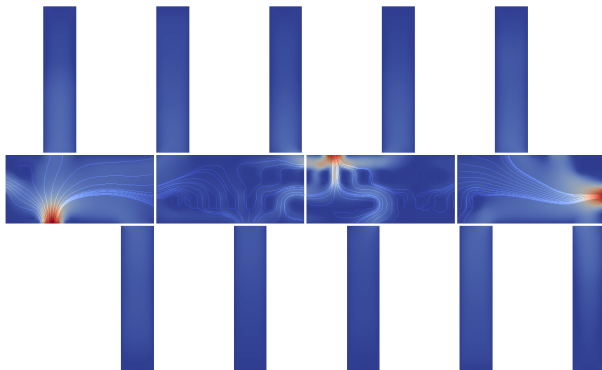
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- **Communication for multiple neighbors and chunks**
- Visualization of multiple chunks
- **Much much much debugging...**

# 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: <https://github.com/MakisH/CFDLab>  
(expect some rough edges)