CATEGORY: COMPUTATIONAL PHYSICS - CP20
POSTER P5286
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GPU TECHNOLOGY CONFERENCE

Saving Energy in Data Centers Using Real-Time Simulation

(and other engineering applications)

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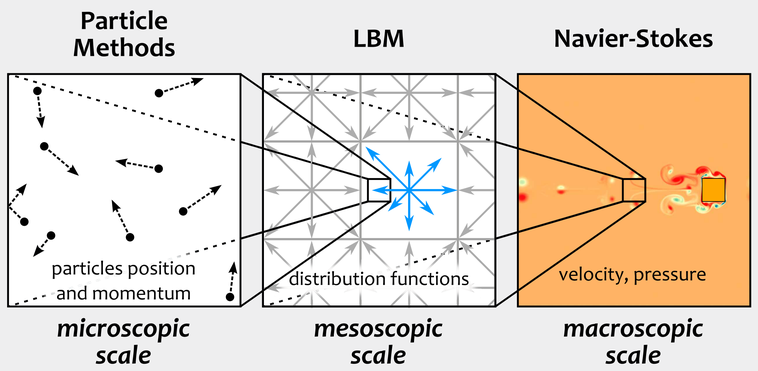
Motivations

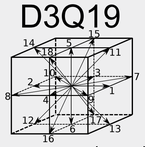
Context: up to 40% of the energy spent in Data Centres is on cooling.
Objective: to develop a real-time indoor airflow simulation tool allowing:

- optimisation of ventilation system design,
- control and prediction of thermal loads.

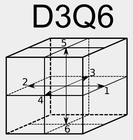
Lattice Boltzmann Method



D3Q19



D3Q6



Coupled Model

$$\frac{\partial \vec{v}}{\partial t} + \left(\vec{v}\cdot\vec{\nabla}\right)\vec{v} = -\vec{\nabla}p + \nu\vec{\nabla}^2\vec{v}$$ advection $$\frac{\partial T}{\partial t} + \vec{\nabla}\cdot(\vec{v}T) = \mathcal{D}\nabla^2 T$$

Velocity ⇄ Boussinesq ⇄ **Temperature**

$$f_i\left(\vec{x}+\vec{c}_i\Delta t, t+\Delta t\right) = f_i\left(\vec{x},t\right) - \frac{f_i - f_i^{(eq)}}{\tau}$$

$$f_i^{(eq)} = \rho\omega_i\left(1 + 3\frac{\vec{c}_i\cdot\vec{v}}{c^2} + \frac{9}{2}\frac{(\vec{c}_i\cdot\vec{v})^2}{c^4} - \frac{3}{2}\frac{\vec{v}^2}{c^2}\right)$$

$$T_i\left(\vec{x}+\vec{c}_i\Delta t, t+\Delta t\right) = T_i - \frac{T_i - T_i^{(eq)}}{\tau_T}$$

$$T_i^{(eq)} = \frac{T}{6}\left(1 + 2\frac{\vec{c}_i\cdot\vec{v}}{c^2}\right)$$

Boussinesq forcing term:

$$\vec{F}_B = -\vec{g}\beta\left(T - T_0\right)$$

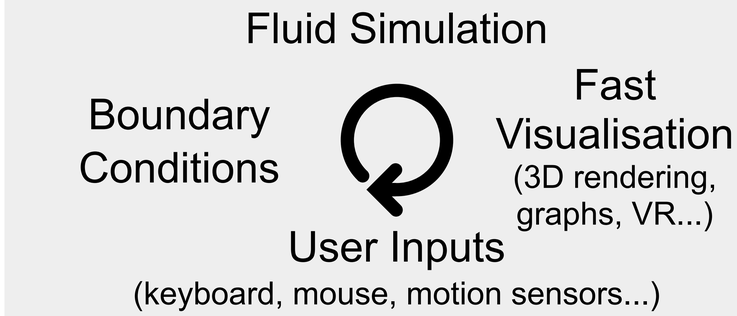
Turbulence Model: Smagorinsky LES

$$\Pi_{\alpha,\beta} = \sum \vec{e}_{i_\alpha}\vec{e}_{i_\beta}\left(f_i - f_i^{(eq)}\right)$$

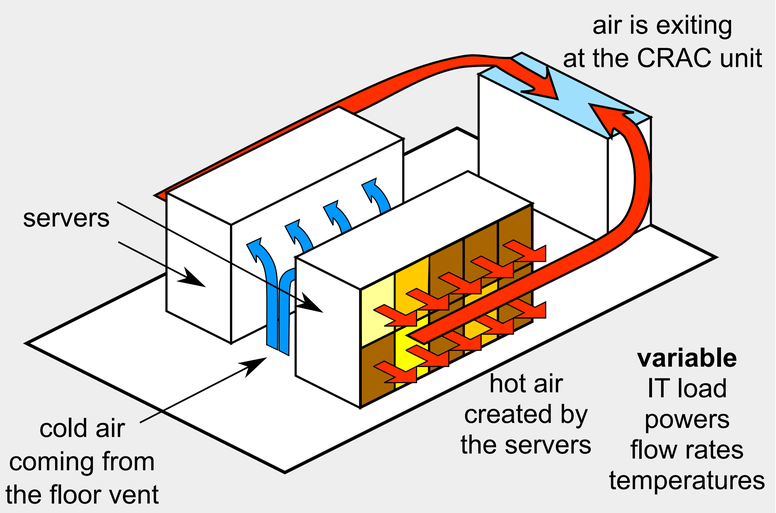
$$\tau \to \tau_S\left(\vec{x},t\right) \qquad S = \frac{1}{6C^2}\left(\sqrt{\nu^2 + 18C^2\sqrt{\Pi_{\alpha,\beta}\Pi_{\alpha,\beta}}} - \nu\right)$$

$$\tau_S = 3\left(\nu + C^2 S\right) + \frac{1}{2}$$

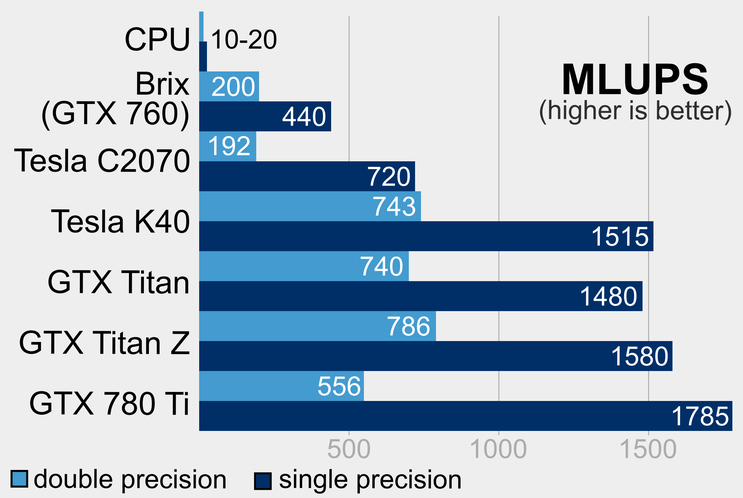
Real-Time CFD Model



Benchmark Data Center



Performances



Results (live demo)

Tricks for the Tesla K40

- disable ECC: (14% faster)

```
nvidia-smi -e 0
```

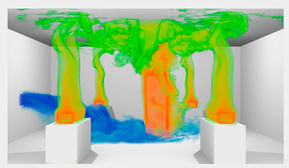
- disable GPU boost: (13% faster)

```
nvidia-smi -ac 3004,875
```

- **combined speed increase: +27%**

Other Applications

The framework can be used for other applications.



example: hospital

References

Optimized implementation graphics processing unit towards real-time fluid simulation. (CAMWA 2013)
http://dx.doi.org/10.1016/j.camwa.2013.10.002
http://www.efm.leeds.ac.uk/~mnnd/index.php

Acknowlegments

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