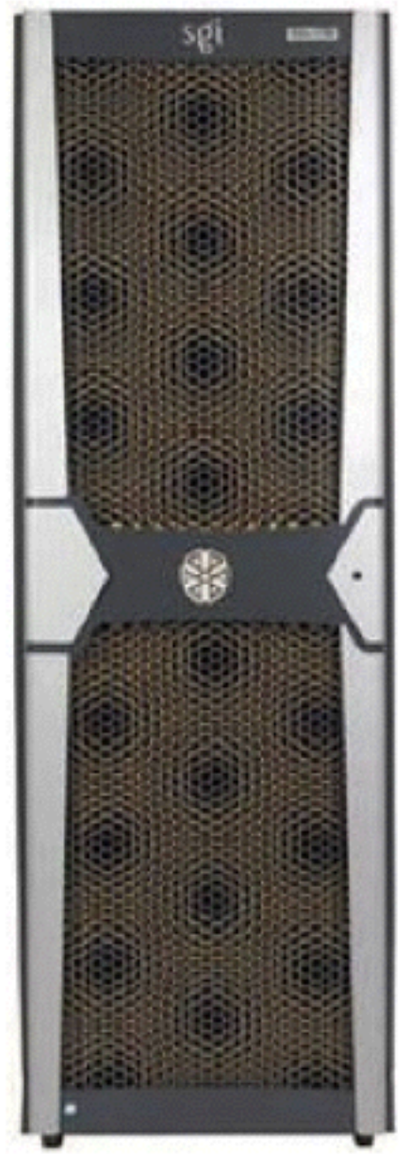
Optimization of parameter settings for GAMG solver in simple solver

Masashi Imano (OCAEL Co.Ltd.)

Test cluster condition

- **Hardware:** SGI Altix ICE8200
- **CPU:** Intel Xeon X5365 3.00GHz 4cores x 2
- **Node:** 16 nodes
- **Memory:** 16GB/node (No swap memory)
- **Interconnect:** InfiniBand DDR
- **OS:** SUSE LINUX ENTERPRISE SERVER 10.3
- **MPI:**
  - ✓ SGI MPT (1.2.6)



Guideline for Practical Applications

OCAEL Open CAE Laboratory

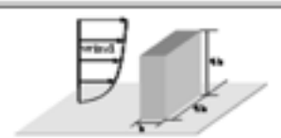
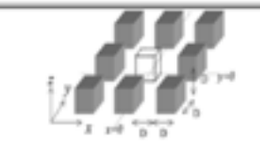
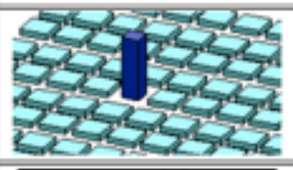
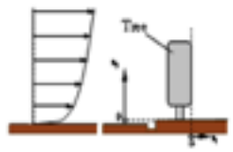
Working Group in Architectural Institute of Japan

AIJ

Akashi Mochida, Yoshihide Tominaga, et al.

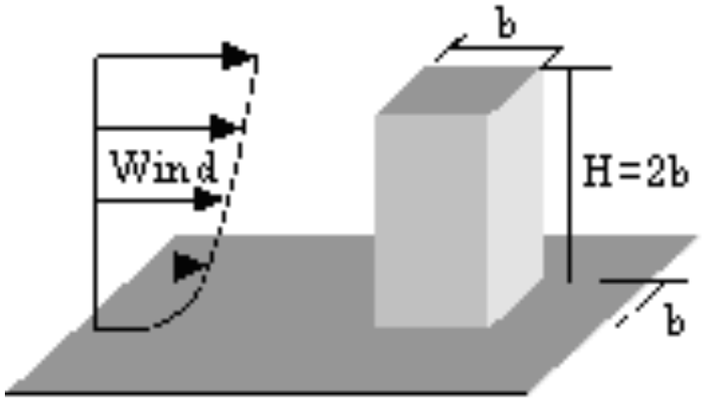
"Guidebook for Practical Applications of CFD to Pedestrian Wind Environment around Buildings"

(in Japanese)

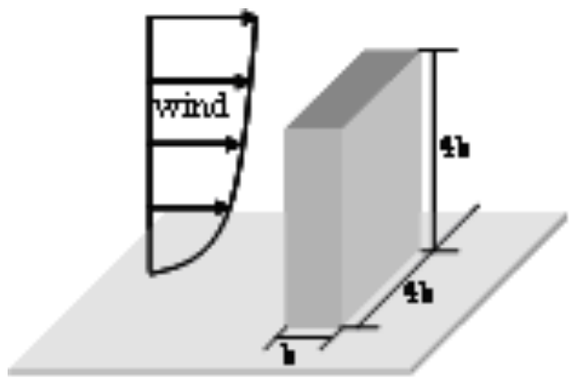
	test case		dataset	Ref.
A	2:1:1 shape building model		Data file :CaseA(1_1_2).xls	[1]
B	4:4:1 shape building model		Data file : CaseB(4_4_1).xls	[2][3]
C	Simple Building blocks		Data file : CaseC(City_blocks).xls	-
D	A high-rise building in city blocks		Data file : CaseD(Highrise+Blocks).xls CAD File(DXF) : CaseD_dxf.zip CAD File(MCD) : CaseD_mcd.zip	[5]
E	Building complexes with simple building shape in actual urban area (Niigata)		Data file : CaseE(Niigata).xls CAD File(DXF) :CaseE_dxf.zip CAD File(MCD) : CaseE_mcd.zip	[6]
F	Building complexes with complicated building shape in actual urban area (Shinjuku)		Data file : CaseF(Shinjuku).xls CAD File(DXF) :CaseF_dxf.zip CAD File(MCD) : CaseF_mcd.zip CAD File(STL) : CaseF_stl.zip	[6]
G	Two-dimensional pine tree		Data file : CaseG(Tree).xls	[7]

Web site **(in Japanese and English)**

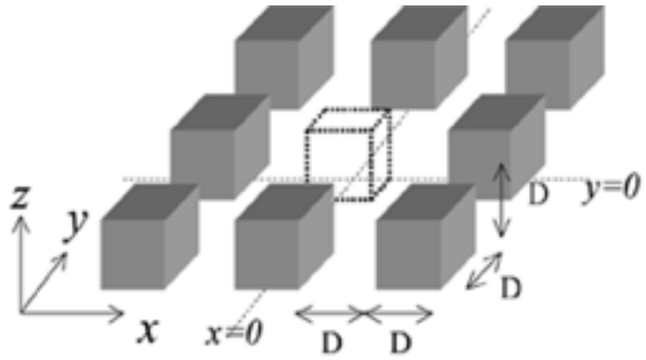
Benchmark tests



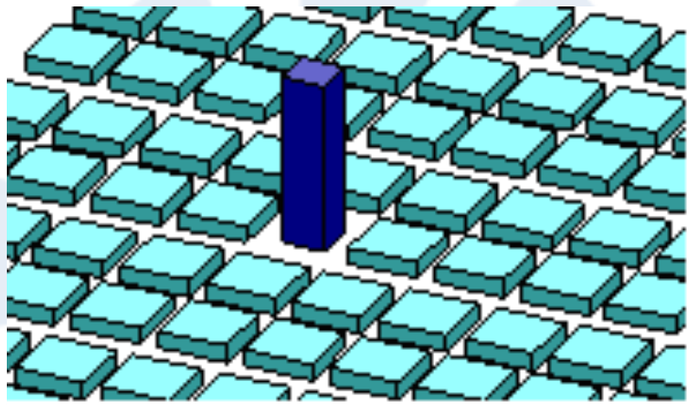
Case A
(2:1:1 shape)



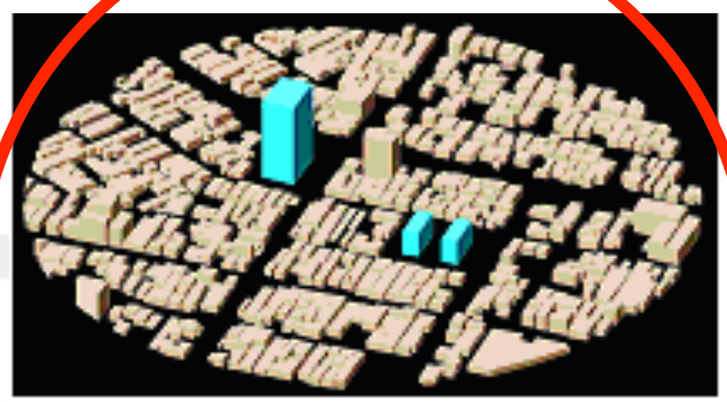
Case B
(4:4:1 shape)



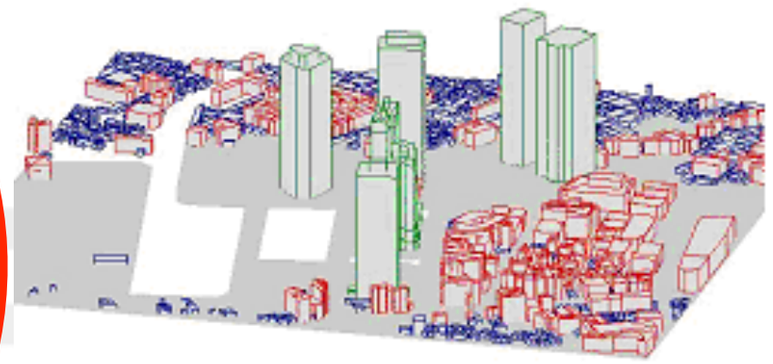
Case C
(Simple blocks)



Case D
(High-rise bldg.)



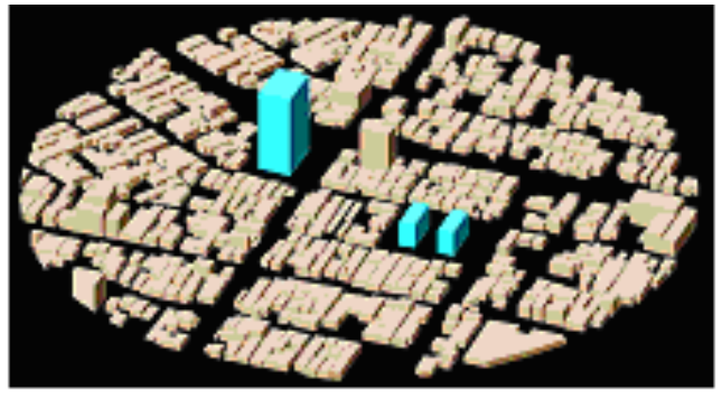
Case E
(Niigata)



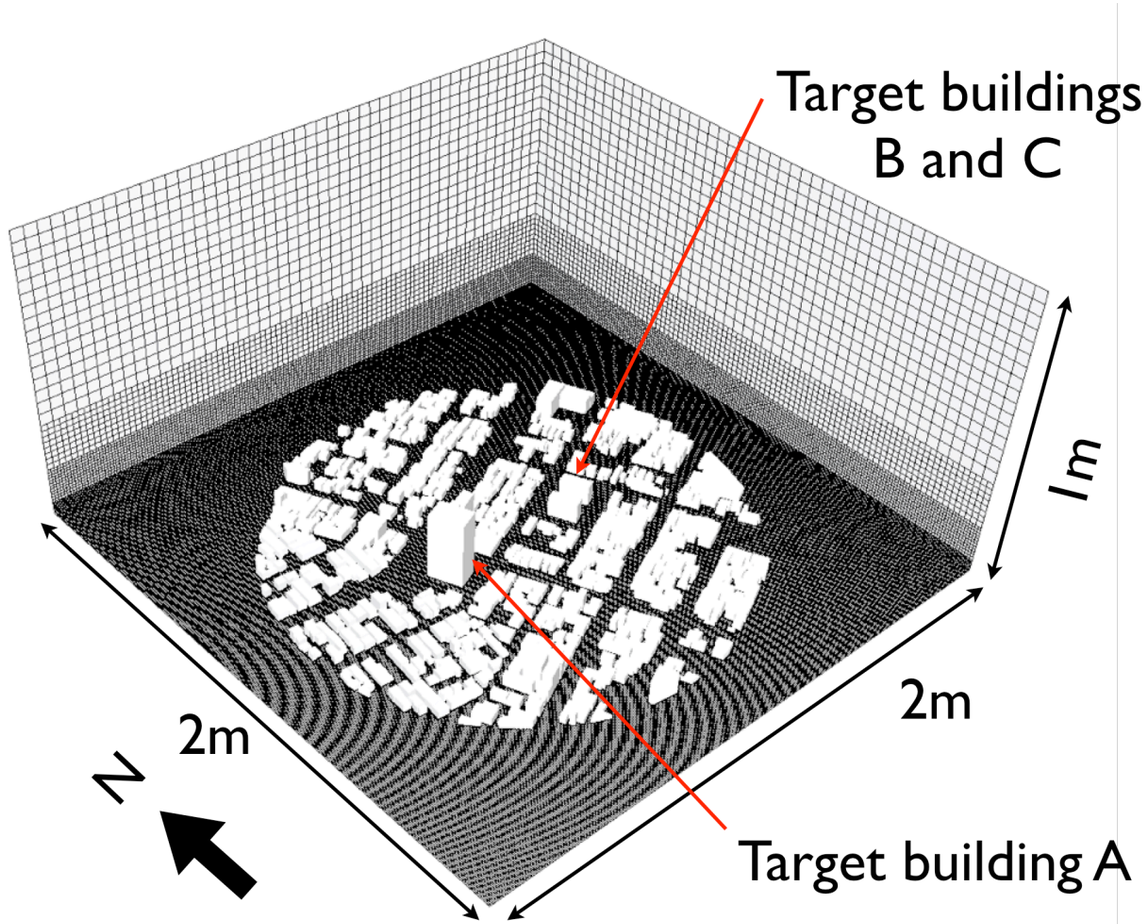
Case F
(Shinjuku, Tokyo)

Case E - Calculation condition

Mesh	Cartesian mesh (snappyHexMesh) **2.2 millions**
Inflow	Interpolate from wind tunnel results
Top & Side wall	Zero gradient
Ground and bldg. wall	Generalized log law for a smooth wall
Turbulence model	Standard k-epsilon
Advection scheme	Upwind
Algorithm	SIMPLE (simpleFoam)
Wind direction	**NNE**



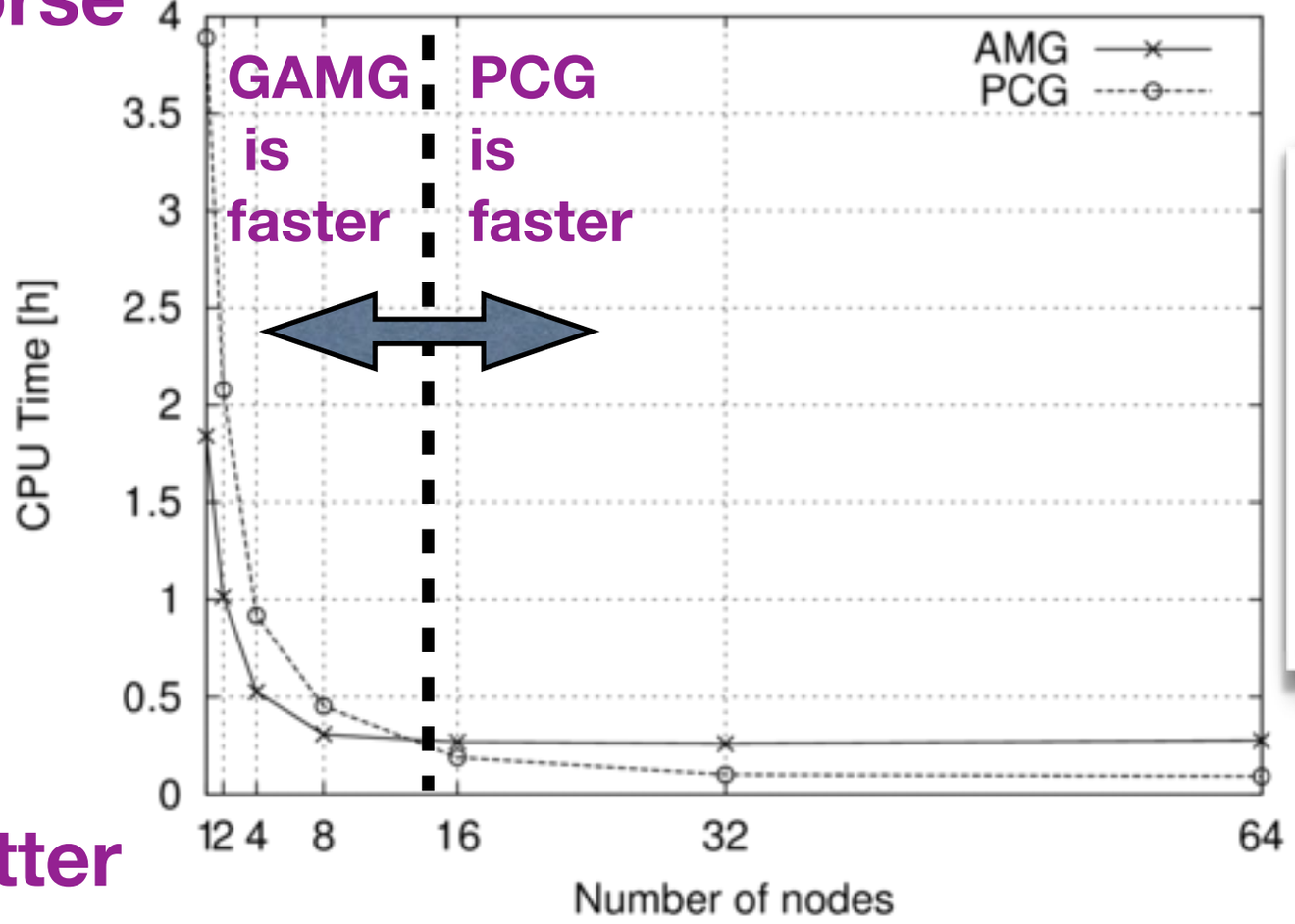
Building complexes with simple building shape in actual urban area (Niigata)



Accelerate incompressible solver

- **CPU time of linear solver for pressure is dominant:**
  - ✓ Many nodes : **PCG** is faster
  - ✓ Not so many nodes : **GAMG** is faster
    - ➡ Need to optimize of parameter for GAMG

Worse



Better

T2K at The University of Tokyo
Node: 16 cores
Interconnect: Myrinet 2.5GB/s X 2
Solver: ChannelFoam
Mesh: 256x256x256
Pre-conditioner for GAMG: DIC

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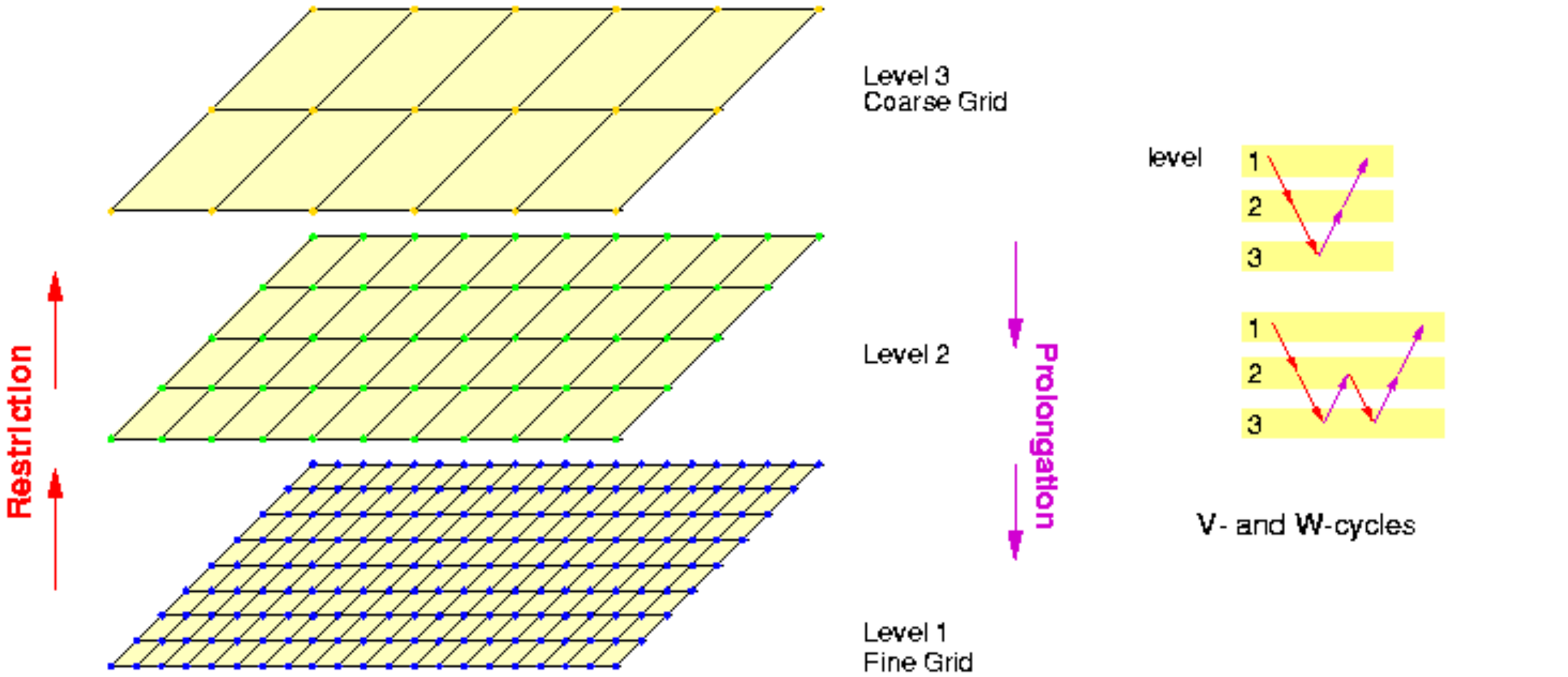
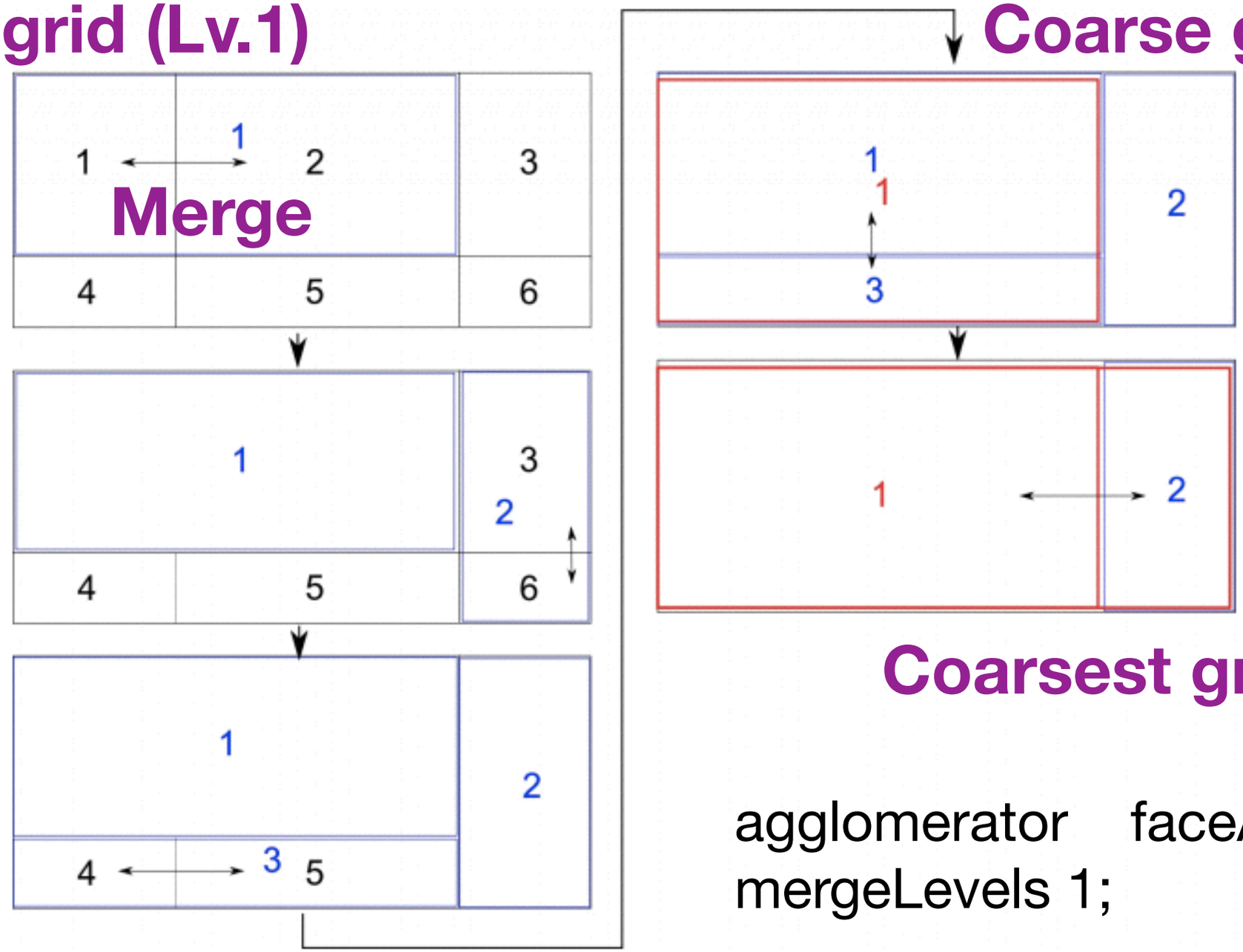
Geometric agglomerated algebraic multi-grid solver (Generalised geometric-algebraic multi-grid in Userguide)



http://www.lrr.in.tum.de/Par/appls/apps/amg.html

Geometric agglomeration process




```
agglomerator    faceAreaPair;
mergeLevels 1;
```

Tim Behrens: OpenFOAM's basic solvers for linear systems of equations Solvers, preconditioners, smoothers, PhD course in CFD with OpenSource software, Technical University of Denmark, February 18, 2009

Parameter settings for AMG solver

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system/fvSolution:

smoother GaussSeidel, DIC, DICGaussSeidel; // GaussSeidel is usually best

directSolveCoarsest false, true; // false: Use ICCG/BICCG for coarsest grid, true: Solve directly in coarsest grid

agglomerator faceAreaPair, algebraicPair; // faceAreaPair is usually better than algebraicPair

mergeLevels 1, 2, 3, ..; // Usually 1 is better. For simple meshes setting 2 could be better.

nPreSweeps 0, 1, 2, ..; // Number of pre-smoothing sweeps

nPostSweeps 0, 1, 2, ..; // Number of post-smoothing sweeps

nFinestSweeps 0, 1, 2,..; // Number of smoothing sweeps on finest mesh

nCellsInCoarsestLevel 1, 2, ..; // Number of cells in coarsest level mesh

Study about nCellsInCoarsestLevel

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agglomerator faceAreaPair, algebraicPair; // faceAreaPair is usually better than algebraicPair
mergeLevels **1**, 2, 3, ..; // Usually 1 is better. For simple meshes setting 2 could be better.
nPreSweeps **0**, 1, 2, 3, ..; // Number of pre-smoothing sweeps
nPostSweeps 0, 1, **2**, 3, ..; // Number of post-smoothing sweeps
nFinestSweeps 0, 1, **2**, 3,..; // Number of smoothing sweeps on finest mesh
nCellsInCoarsestLevel **8, 16, 32, .., 256, .., 2048, 4096, 8192**; // Number of cells in coarsest level mesh

Other calculation conditions

system/fvSolution:

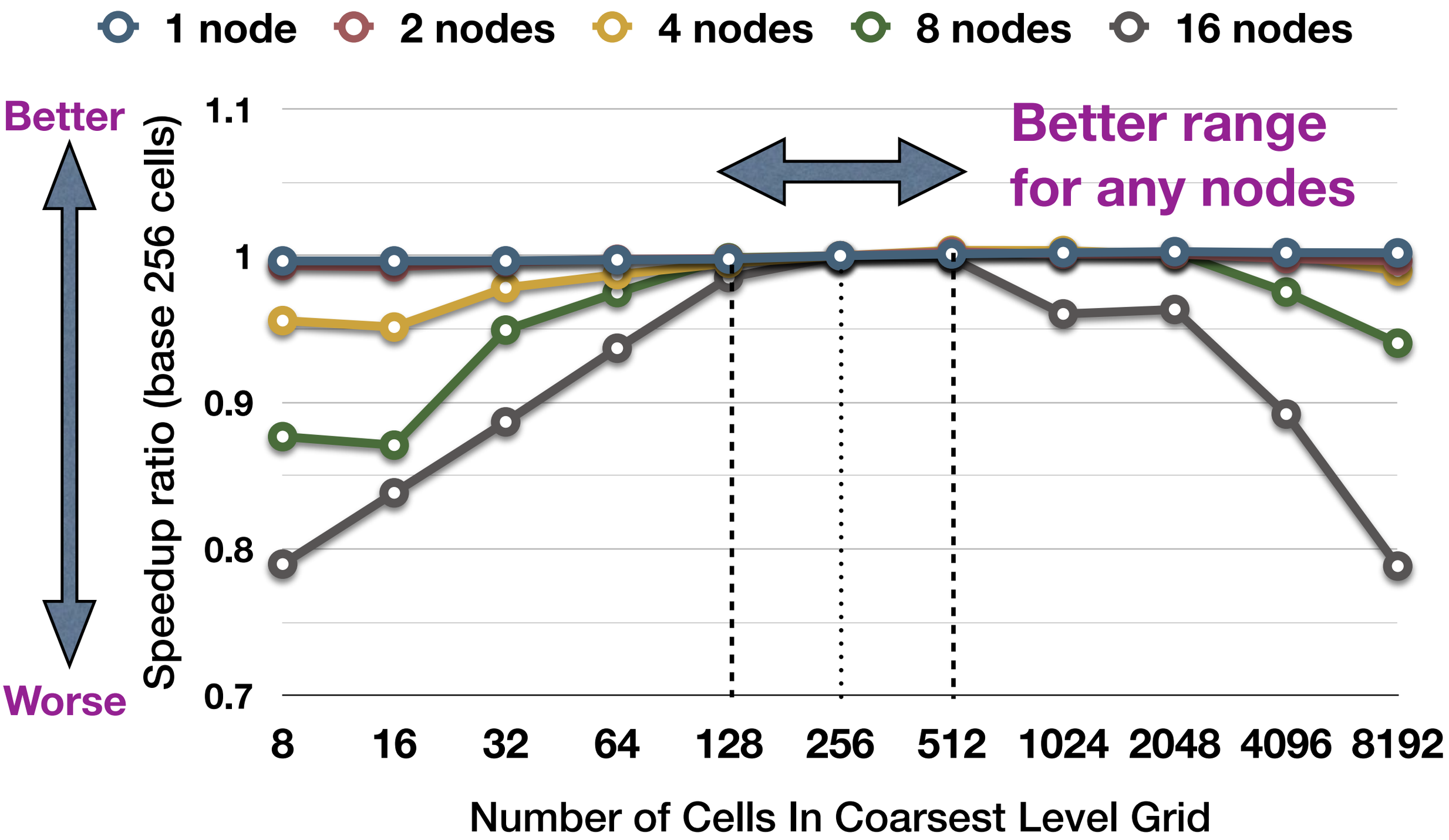
```
relaxationFactors // 0 < relaxationFactors <= 1
{
    p           0.3; // for pressure (important)
    U           0.5; // for velocity vectors (important)
    k           0.5; // for turbulence kinetic energy
    epsilon     0.5; // for turbulence kinetit energy
                     // dissipation rate
}
```

Solver: **simpleFoam**

litial field conditions: **potentialFoam**

CPU time: **50 steps** (No write result field)

Results of speedup ratio



Study about nCellsInCoarsestLevel

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Results of speedup ratio

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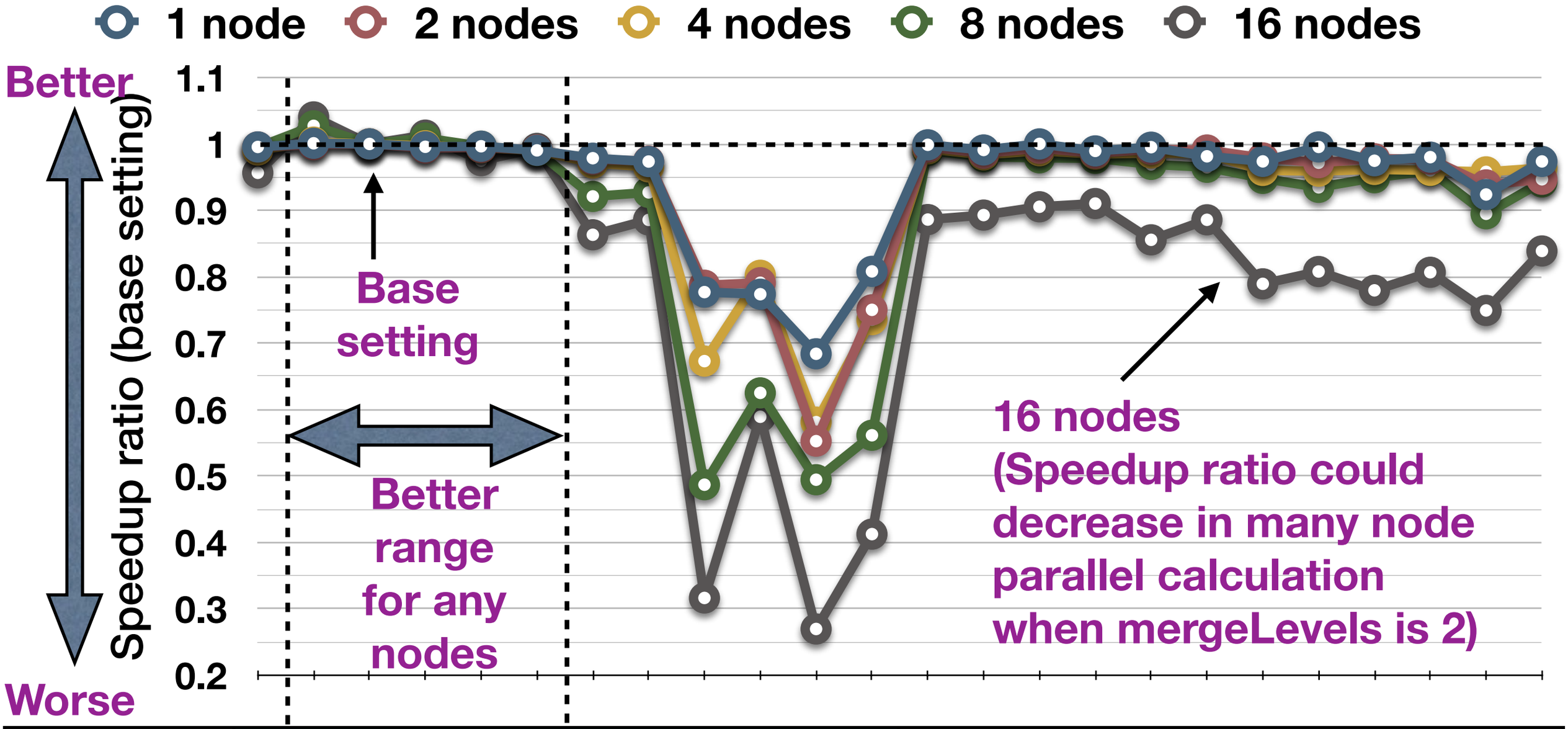

mergeLevels	1												2											
nPreSweeps	0						1						0						1					
nPostSweeps	1		2		3		1		2		3		1		2		3		1		2		3	
nFinestSwee	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3

Masashi Imano (OCAEL Co. Ltd.)

Any Questions?