Parallel Performance of Immersed Boundary Method (IBM)

B. Gazi Yildirim, Lin Sun and Sanjay Mathur, Purdue University

PRISM
NNSA Center for Prediction
of Reliability, Integrity and
Survivability of Microsystems

Objective: Evaluate Parallel Performance of the Immersed Boundary Method and Conformal Mesh Calculations

- MEMOSA-FVM used to compute incompressible flow over a sphere
- BCs using analytical solution

$$u_r = U\cos\theta\left[1 - \frac{3}{4}\frac{D}{r} + \frac{1}{16}\frac{D^3}{r^3}\right]$$

$$u_\theta = -U\sin\theta\left[1 - \frac{3}{8}\frac{D}{r} - \frac{1}{32}\frac{D^3}{r^3}\right]$$

IBM Background Mesh :
5 M hexahedra

Surface: 175K triangles

Conformal Mesh:
~5M tetrahedra

IBM with BCGSTAB+AMG on LLNL Hera 4 Cores Mvapich2-gcc/1.6

#procs	#iters	time	time / iter	speedup	$\eta(\%)$	$\eta_{imp}(\%)$
1	2424	61856	25.52	1.0	100	100
2	2468	30231	12.24	2.0	102	104
4	2276	12754	5.604	4.8	121	114
8	2409	7169	2.976	8.6	108	107
16	2701	4256	1.576	14.5	91	101
32	3238	2560	0.790	24.2	76	101
64	3425	1330	0.388	46.5	73	103
128	3843	841	0.219	73.6	58	91
256	4610	575	0.125	108	42	80
512	4901	373	0.076	166	32	65
1024	6162	319	0.052	194	19	48

IBM with BCGSTAB+ILU0 on LLNL Hera 4 Cores Mvapich2-gcc/1.6

#procs	#iters	time	time / iter	speedup	$\eta(\%)$	$\eta_{imp}(\%)$
1	14973	69611	4.649	1.0	100	100
2	16519	38021	2.302	1.8	92	101
4	17503	20255	1.157	3.4	86	100
8	19178	11222	0.585	6.2	78	99
16	17806	6086	0.342	11.4	72	85
32	18898	3067	0.162	22.7	71	90
64	19723	1726	0.088	40.3	63	83
128	18268	1000	0.055	70.0	54	66
256	18581	619	0.033	112	44	55
512	18356	408	0.022	170	33	41
1024	20384	304	0.015	229	22	30

Conformal Mesh With BCGSTAB+AMG on LANL Lobo 4 Cores Openmpi-gcc/1.4.3

#procs	#iters	time	time / iter	speedup	$\eta(\%)$	$\eta_{imp}(\%)$
1	620	43556	70.25	1.0	100	100
2	438	15441	35.25	2.8	141	100
4	387	8757	22.63	5.0	124	78
8	416	3780	9.09	11.5	144	97
16	479	1184	3.93	23.1	145	112
32	692	1404	2.03	31.0	97	108
64	808	717	0.89	60.7	95	124
128	784	351	0.45	124	97	123
256	913	181	0.20	240	94	138
512	1013	102	0.10	427	83	136
1024	1083	62	0.06	708	69	121

IBM Speedup on Different Machines

Conformal Mesh Speedup on Different Machines

Conclusions

- Good scaling for both
- AMG preconditioner faster in wall clock time except for 1024 cores
- IBM takes more iterations because of explicit bc

PURDUE UNIVERSITY
Discovery Park