2 Column/Row-Major and Jagged Matrix Layouts

JAGBYCOL	JAGBYROW	COLMAJOR	ROWMAJOR	COLARRAY	ROWARRAY
3.41278	0.267367	7.01316	0.367482	1.06146	0.256136

3 Advanced Profiling

gprof:

	gauss solver invoked	average running time of gauss
JAGBYCOL	4	3.37s
JAGBYROW	4	285.24ms
COLMAJOR	4	6.94s
ROWMAJOR	4	357.82ms
COLARRAY	4	947.50ms
ROWARRAY	4	225.00ms

Is there any way with gprof to find out what is causing the timing differences at the cache/memory level?

No, we cannot. The gprof sample do not give any information about cache/memory allocation.

prof:

	cumulative time
JAGBYCOL	13.367765s
JAGBYROW	1.112490s
COLMAJOR	28.160481s
ROWMAJOR	1.493166s
COLARRAY	3.766956s
ROWARRAY	1.033367s

hw profiling

	JAGBYCOL	JAGBYROW	COLMAJOR	ROWMAJOR	COLARRAY	ROWARRAY
L1 hit	1261262803 (96.18%)	1911914214 (97.95%)	400400004 (90.91%)	530530086 (96.36%)	80080229 (100.00%)	2602607431 (98.48%)
L1 miss	2624840254 (99.88%)	54417180 (89.47%)	2362338894 (100.00%)	22407011 (87.50%)	2589630950 (99.51%)	0 (0. %)
L1 miss ratio	2.0811	0.0285	5.8999	0.0422	32.3380	0
L2 hit	2403969675 (100.00%)	44814152 (93.33%)	6402003 (100.00%)	0 (0. %)	2423177628 (100.00%)	0 (0. %)
L2 miss	221221411 (100.00%)	11011047 (84.62%)	2351385925 (99.91%)	22022010 (84.62%)	173173437 (99.43%)	3003020 (100.00%)
L2 miss ratio	0.0920	0.2457	367.2891	inf	0.0715	inf

n=4096 RUN=2

	JAGBYCOL	JAGBYROW	COLMAJOR	ROWMAJOR	COLARRAY	ROWARRAY
L1 hit	24304303958 (98.82%)	50840912166 (99.49%)	148048048332 (98.67%)	9629629908 (98.16%)	2342342105 (92.13%)	556357188888 (99.61%)
L1 miss	94324540978 (99.88%)	2906509156 (97.22%)	821312838000 (99.96%)	3450679047 (97.73%)	690327875554 (99.95%)	3290629357 (98.75%)
L1 miss ratio	3.8810	0.0572	5.5476	0.3583	29.4717	0.0591
L2 hit	13943645037 (99.73%)	2131866874 (96.66%)	83226028 (100.00%)	2416755758 (98.82%)	140844049 (100.00%)	3242614340 (98.83%)

L2 miss	80397540708 (99.94 %)	753753808 (96.05%)	820608201 49 (99.97%)	1035035016 (95.56%)	688775134 50 (99.94%)	45045052 (88.24%)
L2 miss ratio	5.7659	0.3536	985.9995	0.4283	489.0339	0.0139

Q:Explain your findings by referring to the algorithm's parts and the effect of the matrix layout on the memory hierarchy and observed timings for both problem sizes. Also explain your choices for the profiling settings and options.
S: By comparing the miss ration and timing, we will find out a rule that if the miss ratio is high the more time we need.
I choose dch,on,dcm,on,l2h,on,l2m,on as L1 and L2 cache hit and miss.
-fast -xinline=no -xarch=native -g as my setting.

4 Advanced Compiler Options for Parallelization and Vectorization

	JAGBYCOL	JAGBYROW	COLMAJOR	ROWMAJOR	COLARRAY	ROWARRAY
parallelized	2	3	2	3	2	3
vectorized	2	2	3	3	2	2

	JAGBYCOL	JAGBYROW	COLMAJOR	ROWMAJOR	COLARRAY	ROWARRAY
1	3.75154	0.285726	7.5391	0.401525	1.11812	0.253405
2	3.53154	0.312629	7.16104	0.436709	1.05141	0.251295
4	3.44712	0.276264	7.07141	0.465712	1.02495	0.261438
6	3.58707	0.284445	7.02249	0.400532	1.00014	0.25834
8	3.5972	0.27379	7.26041	0.454311	0.968416	0.24377
10	3.5917	0.265991	7.07563	0.426961	1.12956	0.249492
12	3.6774	0.276326	7.20675	0.429498	1.00259	0.282938
14	3.68074	0.285841	7.26232	0.452206	0.94879	0.277495
16	3.667	0.269018	7.09861	0.443266	0.958843	0.244471

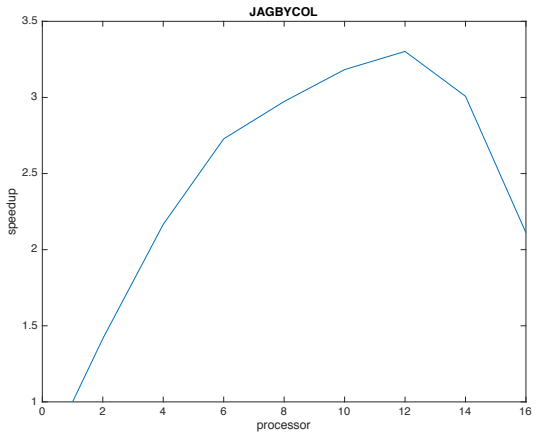
speedup: ts/tp=max(ts for all kinds of layout)/max(tp of all kinds of layout)=0.253405/0.24377=1.0395

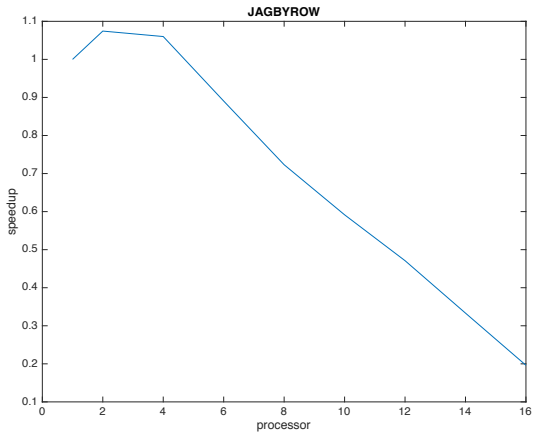
5 OpenMP Parallelization

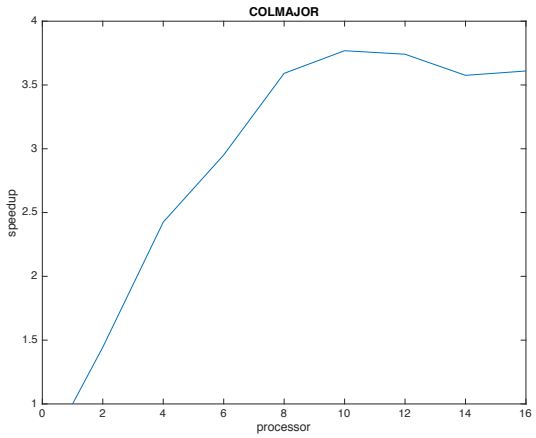
OpenMP

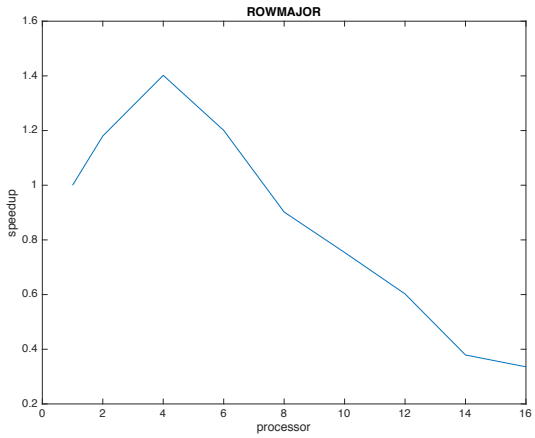
	JAGBYCOL	JAGBYROW	COLMAJOR	ROWMAJOR	COLARRAY	ROWARRAY
1	3.9899	0.277534	6.94561	0.359261	1.01045	0.297304
2	2.81946	0.258318	4.80827	0.304461	0.865106	0.247324
4	1.84188	0.261815	2.8641	0.256256	0.673759	0.241486
6	1.46261	0.311661	2.35339	0.299205	0.655744	0.303816
8	1.34194	0.383763	1.93398	0.398336	0.747511	0.407075
10	1.25358	0.469129	1.84299	0.476431	0.799757	0.536326
12	1.20822	0.589166	1.85655	0.596352	0.912458	0.582269
14	1.32652	0.832808	1.94249	0.947817	1.04464	0.77016
16	1.88984	1.41446	1.92415	1.07023	1.52335	1.42378

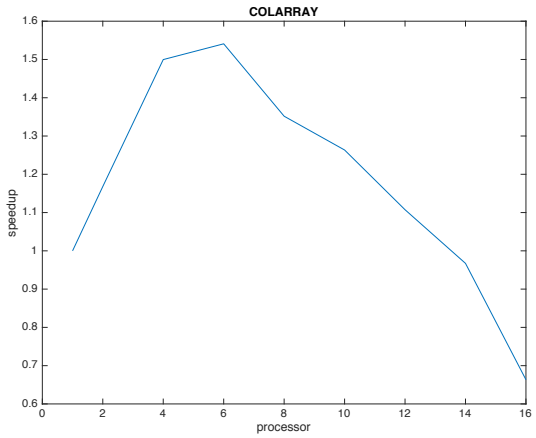
relative speedup plot

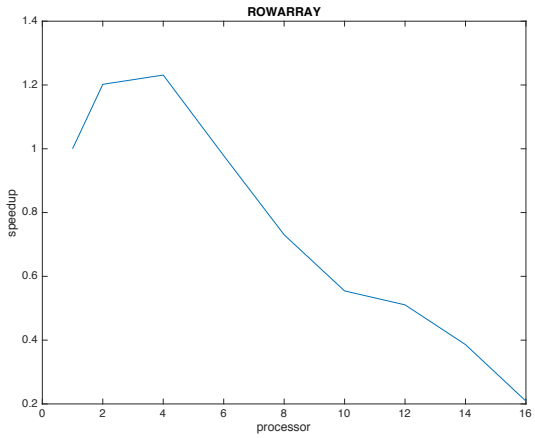












This parallel grogram speed up is 1.1493 is better than the sequence version 1.0395