f_par_pro_WiSe 2024/25;

2. Aufgabe: Matrix-Matrix Multiplikation;

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Verwendete Hardware:

- HP Victus TG02-2301ng
- NVIDIA® GeForce RTX™ 4060 (8 GB GDDR6 dediziert)

Verwendete Programmierung-Umgebung: Microsoft Visual Studio auf Windows 11 Home

Inhalt

Performance-Vergleich CudaMallocHost vs. Malloc ohne Shared-Memory

Werte: (CudaMallocHost-Malloc)/CudaMallocHost

1024	Min	Max	Avg	Median	StdDV
time*	32,83%	32,35%	33,34%	33,90%	23,73%
GFLOPS	-21,89%	-22,77%	-23,71%	-24,74%	-39,09%
Memcpy AB	12,30%	2,30%	14,62%	16,07%	-0,25%
Memcpy C	64,37%	71,71%	63,97%	63,34%	86,28%
Kernel	32,79%	31,72%	32,87%	33,01%	12,00%
CudaMalloc	0,00%	0,00%	0,00%	0,00%	0,00%
CudaDevSync	0,00%	56,58%	77,10%	0,00%	68,82%
CudaFree	0,00%	0,00%	0,00%	0,00%	0,00%

4096	Min	Max	Avg	Median	StdDV
time*	1,38%	-0,10%	1,37%	1,46%	-70,08%
GFLOPS	0,10%	-1,40%	-1,40%	-1,48%	-72,26%
Memcpy AB	-3,34%	0,37%	-0,48%	-0,86%	5,27%
Memcpy C	58,18%	61,32%	59,34%	59,31%	90,48%
Kernel	0,03%	-2,09%	-0,09%	0,03%	-142,36%
CudaMalloc	0,00%	0,00%	0,00%	0,00%	0,00%
CudaDevSync	100,00%	-4,81%	-9,89%	-31,55%	8,94%
CudaFree	0,00%	-12,31%	-800,06%	0,00%	-146,58%

2048	Min	Max	Avg	Median	StdDV
time*	3,29%	3,30%	3,81%	3,79%	5,30%
GFLOPS	-3,41%	-3,40%	-3,96%	-3,94%	-1,67%
Memcpy AB	0,01%	-2,50%	0,84%	0,21%	-4,29%
Memcpy C	58,01%	60,56%	57,99%	57,65%	66,55%
Kernel	0,20%	1,14%	0,62%	0,65%	26,11%
CudaMalloc	0,00%	0,00%	0,00%	0,00%	0,00%
CudaDevSync	0,00%	12,91%	26,77%	40,00%	23,08%
CudaFree	0,00%	0,00%	0,00%	0,00%	0,00%

8192	Min	Max	Avg	Median	StdDV
time*	0,86%	0,45%	0,74%	0,68%	-33,78%
GFLOPS	-0,46%	-0,87%	-0,75%	-0,69%	-35,64%
Memcpy AB	-0,20%	-20,32%	-1,23%	1,63%	-178,18%
Memcpy C	57,67%	59,61%	58,46%	58,25%	90,88%
Kernel	0,21%	-0,02%	0,04%	0,00%	-14,83%
CudaMalloc	0,00%	0,00%	0,00%	0,00%	0,00%
CudaDevSync	9,71%	0,17%	-16,19%	-22,25%	4,75%
CudaFree	0,00%	0,00%	0,00%	0,00%	0,00%

Bei der Matrix-Größe von 1024 ist ein Leistungsgewinn von ca. 33 % (Zeit) bwz.ca. 23 % (GFLOPS) auffallend groß. Mit zunehmender Matrix-Größe sinkt dieser deutlich. Bereits bei 2048 beträgt er nur noch knapp 4 % (Zeit und GFLOPS), bei 4096 nur noch etwas mehr als 1 % (Zeit und GFLOPS), bei 8192 sinkt er unter 1 % (Zeit und GFLOPS). Ein wesentlicher Faktor ist die deutlich verkürzte Zeit Memcpy-Zeit für C, welche in der kleineren Matrix etwas über 60 % beträgt, dann jedoch auf etwas unter 60 % fällt. Bei 1024 ergeben sich noch deutliche Reduktionspotentiale für Memcpy für A und B, obwohl diese immer über malloc alloziert wurden. Dieser Effekt verschwindet jedoch bei größeren Matrizen. Die Auswirkungen auf die Synchronisierung dürften zufällig sein. Dasselbe gilt für die Leistung direkt des Kernels.

Performance-Vergleich CudaMallocHost vs. Malloc mit Shared-Memory

Werte: (CudaMallocHost-Malloc)/CudaMallocHost

1024	Min	Max	Avg	Median	StdDV
time*	12,90%	12,10%	13,04%	13,07%	28,64%
GFLOPS	-13,76%	-14,81%	-14,90%	-15,04%	4,37%
Memcpy AB	-0,74%	-1,64%	-3,88%	-1,34%	-34,35%
Memcpy C	60,33%	63,57%	60,79%	59,31%	78,15%
Kernel	-0,79%	4,83%	0,91%	-0,39%	37,59%
CudaMalloc	0,00%	0,00%	0,00%	0,00%	0,00%
CudaDevSync	0,00%	-13,93%	20,66%	0,00%	7,83%
CudaFree	0,00%	0,00%	0,00%	0,00%	0,00%

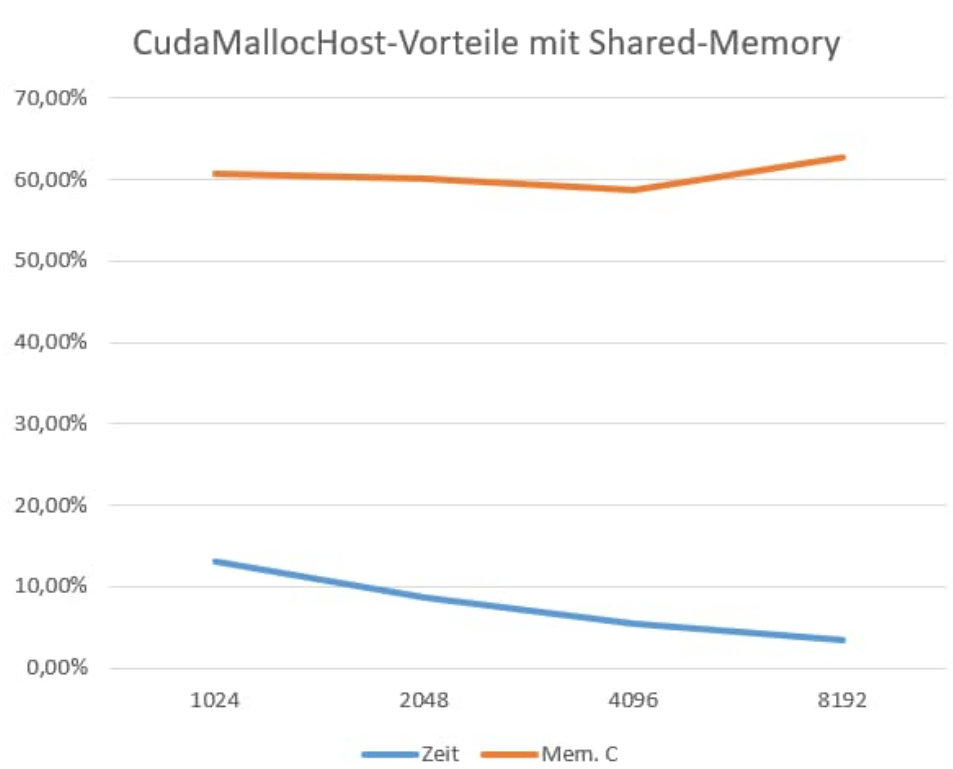
4096	Min	Max	Avg	Median	StdDV
time*	4,75%	7,02%	5,53%	4,99%	41,93%
GFLOPS	-7,55%	-4,99%	-5,82%	-5,25%	34,89%
Memcpy AB	-4,45%	1,41%	-2,42%	-3,67%	26,57%
Memcpy C	57,64%	65,07%	58,76%	57,90%	92,39%
Kernel	0,07%	0,43%	0,59%	0,06%	32,17%
CudaMalloc	0,00%	0,00%	0,00%	0,00%	0,00%
CudaDevSync	0,00%	20,09%	10,56%	-8,05%	14,71%
CudaFree	0,00%	-5,06%	-260,69%	0,00%	-58,43%

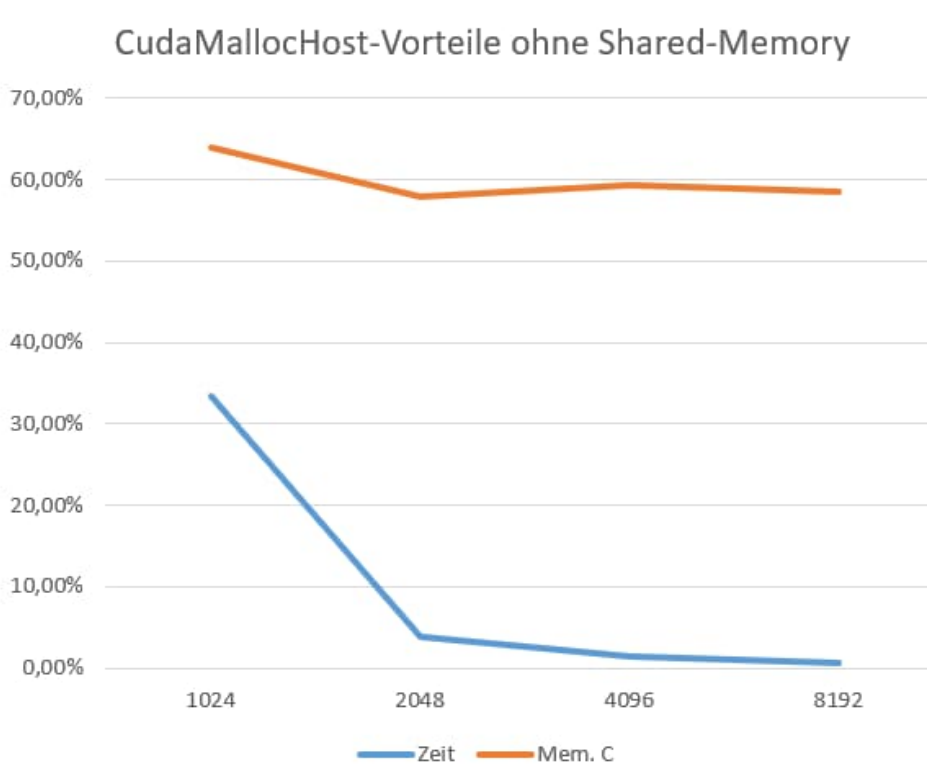
2048	Min	Max	Avg	Median	StdDV
time*	8,19%	8,27%	8,67%	9,15%	17,94%
GFLOPS	-9,02%	-8,93%	-9,49%	-10,07%	2,21%
Memcpy AB	0,29%	-3,74%	-1,15%	0,82%	-40,79%
Memcpy C	58,29%	65,47%	60,06%	58,65%	91,25%
Kernel	-0,07%	-0,82%	0,08%	0,12%	1,36%
CudaMalloc	0,00%	0,00%	0,00%	0,00%	0,00%
CudaDevSync	0,00%	-217,20%	-114,22%	0,00%	-131,62%
CudaFree	0,00%	0,00%	0,00%	0,00%	0,00%

8192	Min	Max	Avg	Median	StdDV
time*	3,04%	4,09%	3,36%	3,36%	58,05%
GFLOPS	-4,27%	-3,13%	-3,48%	-3,48%	54,99%
Memcpy AB	0,27%	2,27%	-0,27%	-1,65%	12,44%
Memcpy C	58,48%	67,82%	62,71%	61,36%	98,62%
Kernel	-0,09%	-0,23%	-0,10%	-0,09%	-4,81%
CudaMalloc	0,00%	0,00%	0,00%	0,00%	0,00%
CudaDevSync	100,00%	6,74%	21,37%	1,84%	20,91%
CudaFree	0,00%	0,00%	0,00%	0,00%	0,00%

Auch hier trägt die Reduktion in Memcpy für C im Wesentlichen zum Leistungsgewinn von jeweils ca. 60 % bei. Mit zunehmender Größe fällt der Leistungsgewinn insgesamt leicht ab, wobei der Übergang von 2048 zu 4096 insoweit eine allerdings nur geringfügige Abweichung aufweist. Die Auswirkungen auf die Kernelzeit sind unwesentlich, ebenso die Veränderungen bei den übrigen Stationen.

Im Ergebnis zeigt sich die optimierende Wirkung von CudaMallocHost hinreichend deutlich.





Verwendet wurden die Average-Werte.

Die Abnahme im Zeitgewinn erklärt sich daraus, dass mit zunehmender Matrixgröße der lineare Performance-Gewinn in der Übertragung hinter der höherkomplexen Berechnung (Matrixmultiplikation: grundsätzlich $O(n^3)$, mit Parallelität in den hier verwendeten Modellen auf bis zu $O(n^2)$ reduzierbar) zurückfällt.

Performance-Vergleich Shared-Memory mit Malloc

1024	Min	Max	Avg	Median	StdDV
time*	54,64%	50,12%	53,65%	54,35%	0,25%
GFLOPS	-100,46%	-120,46%	-116,04%	-119,06%	-350,70%
Memcpy AB	-0,20%	7,01%	-2,83%	-0,44%	-1,15%
Memcpy C	-0,14%	-17,93%	0,80%	1,22%	-80,52%
Kernel	68,71%	64,64%	68,35%	68,55%	33,07%
CudaMalloc	0,00%	0,00%	0,00%	0,00%	0,00%
CudaDevSync	0,00%	2,97%	-123,78%	0,00%	-37,06%
CudaFree	0,00%	0,00%	0,00%	0,00%	0,00%

4096	Min	Max	Avg	Median	StdDV
time*	74,63%	73,62%	74,52%	74,52%	45,22%
GFLOPS	-279,07%	-294,20%	-292,49%	-292,41%	-718,69%
Memcpy AB	-1,23%	9,81%	0,69%	-0,37%	50,14%
Memcpy C	-0,34%	-1,86%	-0,28%	0,04%	-31,49%
Kernel	78,67%	77,54%	78,57%	78,62%	46,98%
CudaMalloc	0,00%	0,00%	0,00%	0,00%	0,00%
CudaDevSync	0,00%	25,96%	30,28%	23,25%	11,77%
CudaFree	0,00%	-18,71%	5,28%	0,00%	-5,44%

2048	Min	Max	Avg	Median	StdDV
time*	64,38%	64,04%	63,89%	64,00%	43,93%
GFLOPS	-178,09%	-180,71%	-177,01%	-177,77%	-337,58%
Memcpy AB	0,38%	18,50%	0,97%	0,53%	34,57%
Memcpy C	1,24%	5,53%	3,07%	3,28%	48,42%
Kernel	72,26%	71,54%	72,15%	72,27%	25,44%
CudaMalloc	0,00%	0,00%	0,00%	0,00%	0,00%
CudaDevSync	0,00%	-226,66%	-18,49%	100,00%	-156,70%
CudaFree	0,00%	0,00%	0,00%	0,00%	0,00%

8192	Min	Max	Avg	Median	StdDV
time*	75,79%	75,81%	75,77%	75,78%	73,25%
GFLOPS	-313,36%	-313,02%	-312,66%	-312,92%	-356,07%
Memcpy AB	0,72%	14,85%	1,02%	-1,16%	51,39%
Memcpy C	0,04%	-0,19%	0,04%	-0,02%	5,35%
Kernel	77,67%	77,67%	77,72%	77,73%	81,80%
CudaMalloc	0,00%	0,00%	0,00%	0,00%	0,00%
CudaDevSync	100,00%	2,05%	8,60%	6,07%	-19,00%
CudaFree	0,00%	0,00%	0,00%	0,00%	0,00%

Durch shared konnten deutlich Gewinne erzielt werden, welche mit zunehmender Größe zunahmen, jedoch in den Matrixgrößen von 4096 zu 8192 keine wesentliche Steigerung mehr aufwiesen bzw. beim Kernel sogar ein leichter Rückgang. Die Steigerung ist möglicherweise zufällig (siehe nachfolgenden Vergleich mit CudaMallocHost, welcher insoweit keinen Unterschied ausmachen dürfte). Der wesentliche Anteil macht der Zugewinn direkt im Kernel aus. Die Werte im Speicherübertragungen sind unwesentlich, die übrigen Werte sind ebenfalls aussagelos.

Performance-Vergleich Shared-Memory mit CudaMallocHost

Malloc

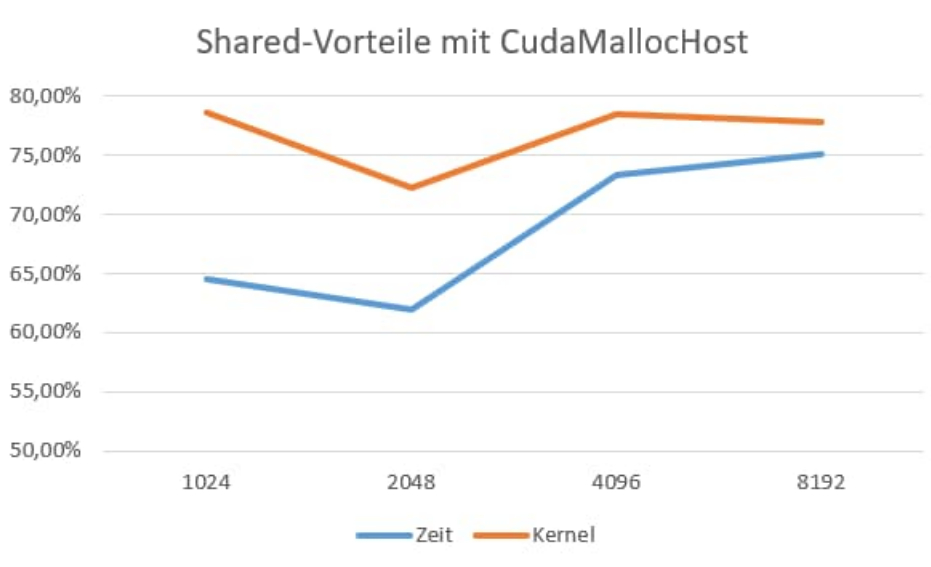
1024	Min	Max	Avg	Median	StdDV
time*	65,02%	61,61%	64,47%	65,29%	-6,61%
GFLOPS	-114,78%	-135,75%	-132,60%	-137,54%	-555,52%
Memcpy AB	12,77%	10,61%	15,49%	16,82%	24,52%
Memcpy C	10,06%	8,41%	8,86%	11,00%	-13,30%
Kernel	79,14%	74,63%	78,56%	79,01%	5,62%
CudaMalloc	0,00%	0,00%	0,00%	0,00%	0,00%
CudaDevSync	0,00%	63,02%	35,41%	0,00%	53,62%
CudaFree	0,00%	0,00%	0,00%	0,00%	0,00%

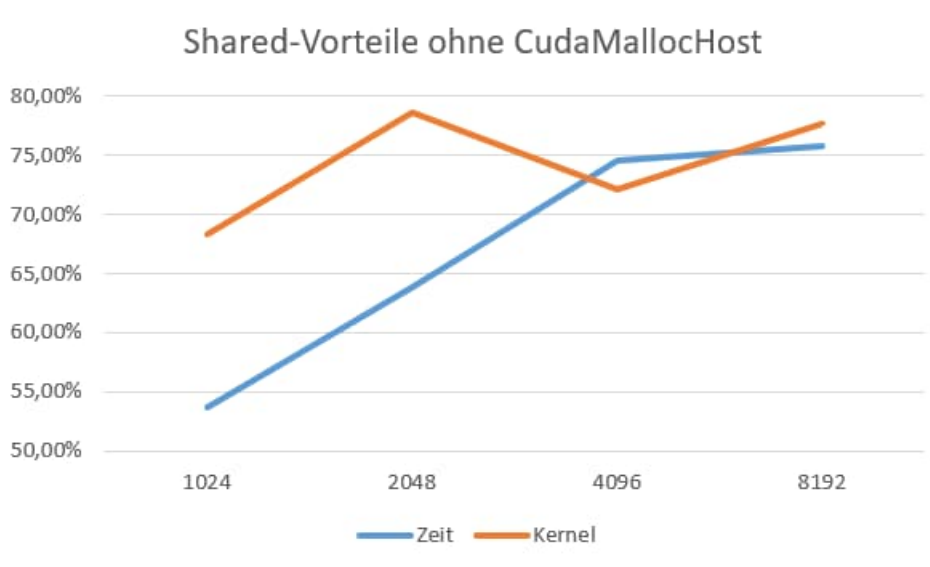
4096	Min	Max	Avg	Median	StdDV
time*	73,74%	71,60%	73,40%	73,57%	-60,45%
GFLOPS	-252,11%	-280,74%	-276,09%	-278,35%	-2065,97%
Memcpy AB	-0,15%	8,87%	2,56%	2,35%	35,68%
Memcpy C	0,94%	-12,80%	1,12%	3,39%	-64,42%
Kernel	78,66%	76,98%	78,42%	78,61%	-89,44%
CudaMalloc	0,00%	0,00%	0,00%	0,00%	0,00%
CudaDevSync	100,00%	2,89%	14,34%	6,55%	5,81%
CudaFree	0,00%	-26,90%	-136,37%	0,00%	-64,11%

2048	Min	Max	Avg	Median	StdDV
time*	62,47%	62,09%	61,97%	61,88%	35,30%
GFLOPS	-163,80%	-166,46%	-163,01%	-162,30%	-354,98%
Memcpy AB	0,09%	19,47%	2,91%	-0,08%	51,54%
Memcpy C	0,57%	-7,91%	-1,95%	0,95%	-97,20%
Kernel	72,34%	72,10%	72,29%	72,42%	44,14%
CudaMalloc	0,00%	0,00%	0,00%	0,00%	0,00%
CudaDevSync	0,00%	10,31%	59,49%	100,00%	14,75%
CudaFree	0,00%	0,00%	0,00%	0,00%	0,00%

8192	Min	Max	Avg	Median	StdDV
time*	75,25%	74,89%	75,11%	75,11%	14,67%
GFLOPS	-298,26%	-303,97%	-301,77%	-301,78%	-1274,34%
Memcpy AB	0,26%	-4,83%	0,08%	2,10%	-54,42%
Memcpy C	-1,91%	-25,76%	-11,34%	-8,05%	-526,61%
Kernel	77,73%	77,71%	77,75%	77,75%	80,06%
CudaMalloc	0,00%	0,00%	0,00%	0,00%	0,00%
CudaDevSync	-5,51%	-4,85%	-35,04%	-16,99%	-43,31%
CudaFree	0,00%	0,00%	0,00%	0,00%	0,00%

Auch hier konnte durch shared eine deutliche Leistungssteigerung mit ähnlichen Ausprägungen erreicht werden. Eine Tendenz einer Gewinnzunahme zeigte sich hier nicht. Der wesentliche Anteil macht der Zugewinn direkt im Kernel aus. Die Werte im Speicherübertragungen sind unwesentlich, die übrigen Werte sind ebenfalls aussagelos.





Verwendet wurden die Average-Werte. Die Zeitvorteile nehmen zu. Dies dürfte damit zusammenhängen, dass die eigentliche Arbeit in der höherkomplexen Matrixmultiplikation stattfindet.

Anlage 1 Zusammengefasste Werte

Zusammenfassungen aus Anlage 4

Performance-Werte (time* bezeichnet die Zeitmessung aus der Vorlage) **ohne** shared-Memory

Simple Host

1024	Min	Max	Avg	Median	StdDV
time*	7,98547	8,60432	8,1513844	8,07581	0,164170204
GFLOPS	124,791	134,462	131,77736	132,958	2,595518582
Memcpy AB	1,21642	1,67936	1,2912812	1,26272	0,097580246
Memcpy C	0,361664	0,409344	0,3889216	0,389408	0,011823515
Kernel	6,34422	6,76963	6,4485728	6,40506	0,121283262
CudaMalloc	0	0	0	0	0
CudaDevSync	0	0,015104	0,0008128	0	0,003090769
CudaFree	0	0	0	0	0

Simple Malloc

1024	Min	Max	Avg	Median	StdDV
time*	11,8891	12,7185	12,22786	12,2172	0,215252525
GFLOPS	102,384	109,526	106,52492	106,585	1,866014553
Memcpy AB	1,38707	1,71882	1,5124652	1,50448	0,097338132
Memcpy C	1,01501	1,44685	1,0795176	1,06221	0,08620063
Kernel	9,43962	9,91462	9,6066484	9,56131	0,137823885
CudaMalloc	0	0	0	0	0
CudaDevSync	0	0,034784	0,00354944	0	0,009911416
CudaFree	0	0	0	0	0

2048	Min	Max	Avg	Median	StdDV
time*	57,583	60,512	58,126996	57,9873	0,639609504
GFLOPS	141,954	149,175	147,7962	148,135	1,586410842
Memcpy AB	4,97482	7,30877	5,3486816	5,14538	0,510035246
Memcpy C	1,3304	1,50906	1,4003588	1,39853	0,046457651
Kernel	51,1339	51,8365	51,353712	51,3324	0,199522829
CudaMalloc	0	0	0	0	0
CudaDevSync	0	0,033248	0,00748416	0,006624	0,008572701
CudaFree	0	0	0	0	0

2048	Min	Max	Avg	Median	StdDV
time*	59,5396	62,5772	60,426904	60,2699	0,675404242
GFLOPS	137,27	144,273	142,1716	142,525	1,560327889
Memcpy AB	4,97507	7,13053	5,39386	5,1561	0,489070996
Memcpy C	3,16845	3,82646	3,3337184	3,3023	0,13887953
Kernel	51,238	52,4349	51,674404	51,6692	0,270010691
CudaMalloc	0	0	0	0	0
CudaDevSync	0	0,038176	0,01021952	0,01104	0,011144438
CudaFree	0	0	0	0	0

4096	Min	Max	Avg	Median	StdDV
time*	507,455	525,053	509,84392	508,808	3,398411746
GFLOPS	130,881	135,42	134,79124	135,06	0,87758839
Memcpy AB	19,9708	24,3702	21,181552	21,0622	1,105248413
Memcpy C	5,13712	5,32262	5,2417004	5,25046	0,041524602
Kernel	481,653	499,478	483,389	482,724	3,354199076
CudaMalloc	0	0	0	0	0
CudaDevSync	0	0,038336	0,01862784	0,017344	0,007464334

4096	Min	Max	Avg	Median	StdDV
time*	514,569	524,527	516,94484	516,332	1,99809917
GFLOPS	131,012	133,548	132,93592	133,092	0,509450835
Memcpy AB	19,3245	24,4618	21,079392	20,8825	1,166793023
Memcpy C	12,2825	13,7599	12,89102	12,9048	0,436246422
Kernel	481,78	489,275	482,94828	482,884	1,383988396
CudaMalloc	0	0	0	0	0
CudaDevSync	0,012128	0,036576	0,01695104	0,013184	0,008197031

CudaFree	0	1,01402	0,32505744	0	0,43625974

CudaFree	0	0,90288	0,0361152	0	0,176927624

8192	Min	Max	Avg	Median	StdDV
time*	3949,53	3988,54	3964,9116	3965,5	8,695895896
GFLOPS	137,834	139,195	138,65588	138,635	0,303715172
Memcpy AB	76,9239	98,4075	79,960516	78,1223	4,32317834
Memcpy C	20,4188	20,6686	20,538116	20,5292	0,065574237
Kernel	3846,57	3877,6	3864,3736	3864,96	7,383889425
CudaMalloc	0	0	0	0	0
CudaDevSync	0,011008	0,037536	0,01881728	0,016352	0,007094899
CudaFree	0	0	0	0	0

8192	Min	Max	Avg	Median	StdDV
time*	3983,9	4006,73	3994,4588	3992,82	6,499977428
GFLOPS	137,208	137,994	137,62992	137,686	0,223917113
Memcpy AB	76,7736	81,7884	78,99184	79,419	1,554093247
Memcpy C	48,2359	51,1697	49,44482	49,1739	0,718859963
Kernel	3854,8	3876,66	3865,9988	3865,09	6,430167849
CudaMalloc	0	0	0	0	0
CudaDevSync	0,012192	0,0376	0,01619584	0,013376	0,007448843
CudaFree	0	0	0	0	0

<u>Performance-Werte</u> (time* bezeichnet die Zeitmessung aus der Vorlage) **mit** shared-Memory

Shared Host

1024	Min	Max	Avg	Median	StdDV
time*	3,62211	4,29219	3,7783392	3,6865	0,163765251
GFLOPS	250,162	296,441	284,6898	291,264	11,69794684
Memcpy AB	1,21885	1,56163	1,3278008	1,26822	0,09869893
Memcpy C	0,362176	0,48272	0,38580736	0,38464	0,021344105
Kernel	1,98515	2,3936	2,0410916	2,01462	0,081180237
CudaMalloc	0	0	0	0	0
CudaDevSync	0	0,014656	0,00181888	0	0,004236304
CudaFree	0	0,362624	0,01450496	0	0,071059501

Shared Malloc

1024	Min	Max	Avg	Median	StdDV
time*	4,15846	4,88282	4,3447688	4,24099	0,229480125
GFLOPS	219,902	258,206	247,78	253,182	12,23203663
Memcpy AB	1,20989	1,53648	1,2782032	1,25149	0,073466511
Memcpy C	0,912896	1,32522	0,9838672	0,945376	0,097668909
Kernel	1,9695	2,5152	2,059862	2,00685	0,130080838
CudaMalloc	0	0	0	0	0
CudaDevSync	0	0,012864	0,00229248	0	0,00459642
CudaFree	0	0	0	0	0

2048	Min	Max	Avg	Median	StdDV
time*	20,5134	21,7598	20,987168	20,8759	0,358626387
GFLOPS	394,762	418,748	409,41316	411,476	6,94188667
Memcpy AB	4,95606	5,9567	5,297008	5,11811	0,333700134
Memcpy C	1,31389	1,42566	1,3574112	1,35267	0,023962269
Kernel	14,183	14,7505	14,304528	14,2352	0,148768969
CudaMalloc	0	0	0	0	0
CudaDevSync	0	0,108608	0,00886784	0	0,022006011
CudaFree	0	0,673984	0,02695936	0	0,132073352

2048	Min	Max	Avg	Median	StdDV
time*	22,3443	23,7217	22,980648	22,9775	0,437014872
GFLOPS	362,113	384,435	373,92476	373,841	7,099106238
Memcpy AB	4,97056	5,74202	5,236666	5,16032	0,237015216
Memcpy C	3,15037	4,12915	3,398742	3,27091	0,273863951
Kernel	14,1737	14,6306	14,316608	14,2516	0,150822725
CudaMalloc	0	0	0	0	0
CudaDevSync	0	0,03424	0,00413952	0	0,009500976
CudaFree	0	0	0	0	0

4096	Min	Max	Avg	Median	StdDV
time*	128,73	138,511	129,92036	129,663	1,861649438
GFLOPS	496,131	533,828	529,03892	529,987	7,184749058
Memcpy AB	20,2156	21,9794	21,035804	21,1395	0,551111471
Memcpy C	5,15437	5,42182	5,2562572	5,24861	0,054598915
Kernel	102,717	112,167	103,60064	103,211	1,778409984
CudaMalloc	0	0	0	0	0
CudaDevSync	0	0,028384	0,01298688	0,013312	0,006585489
CudaFree	0	1,20374	0,3079064	0	0,459999848

4096	Min	Max	Avg	Median	StdDV
time*	135,148	148,967	137,52176	136,47	3,205880912
GFLOPS	461,306	508,476	499,95612	503,549	11,03456726
Memcpy AB	19,3543	22,2931	20,53936	20,3917	0,750488804
Memcpy C	12,1672	15,5209	12,746584	12,4671	0,717270904
Kernel	102,793	112,647	104,2114	103,269	2,62179183
CudaMalloc	0	0	0	0	0
CudaDevSync	0	0,03552	0,01452032	0,01232	0,007720954
CudaFree	0	1,14576	0,08536704	0	0,290347645

8192	Min	Max	Avg	Median	StdDV
time*	956,253	964,911	960,83008	960,345	2,326460624
GFLOPS	569,748	574,906	572,17096	572,457	1,385157391
Memcpy AB	76,3688	83,796	79,143628	79,0311	2,101412221
Memcpy C	20,4099	20,7083	20,52904	20,5323	0,062062755
Kernel	859,092	865,905	861,11724	860,774	1,343627903
Malloc	0	0	0	0	0
CudaDevSync	0	0,036768	0,01719808	0,01536	0,008442685
CudaFree	0	0	0	0	0

8192	Min	Max	Avg	Median	StdDV
time*	986,193	1006,07	994,25356	993,78	5,546420886
GFLOPS	546,438	557,453	552,9504	553,197	3,077372126
Memcpy AB	76,5748	85,7419	78,928396	77,7516	2,399840171
Memcpy C	49,1576	64,3524	55,051784	53,1342	4,504450655
Kernel	858,295	863,96	860,24284	860,03	1,281933998
CudaMalloc	0	0	0	0	0
CudaDevSync	0,012864	0,039424	0,02187136	0,015648	0,010674725
CudaFree	0	0	0	0	0

Anlage 2 Zeitmessung

Programmergänzungen zur Zeitmessung (hierfür wurde zur Vereinfachung C++ statt C verwendet) am Beispiel für shared CudaMallocHost, für die Zeitmessung relevante Ergänzungen blau gefärbt.

#include <stdio.h>

```
#include <stdlib.h>
#include <assert.h>
#include <cuda.h>
#include <fstream>
// Thread block size: BLOCK_SIZE * BLOCK_SIZE
#define BLOCK_SIZE 16
__global__ void dgemm_gpu_simple(const float* a, const float* b, float* c, const int n) {
        //Todo: implement Kernel Here
        int x = threadIdx.x + blockIdx.x * blockDim.x;
        int y = threadIdx.y + blockIdx.y * blockDim.y;
        int id = x + y * blockDim.x * gridDim.x;
        int vx = id % n; // Spalte
        int vy = id - vx; // Zeile
        for (int i = 0; i < n; ++i)
                c[id] += a[vy + i] * b[vx + i * n];
}
// get compute performance
float getGflops(int width, float time) {
        float gf = (1.0e-6 * width * width * width / time);
        return gf;
```

```
}
int main(int argc, const char** argv) {
        int n = 8192; // dimension of square matrices
        float* h_a = 0, * h_b = 0, * h_c = 0;
        float* d_a, * d_b, * d_c;
        int row, col;
        float absError, maxAbsError = 0.0, sumAbsError = 0.0;
        size_t size;
        float time, timeFree, timeMemcpy, timeMemcpyC, timeMalloc, timeKernel, timeSync;
        cudaEvent_t start, stop;
        cudaEvent_t startFree, stopFree;
        cudaEvent_t startMemcpy, stopMemcpy, startMemcpyC, stopMemcpyC;
        cudaEvent_t startMalloc, stopMalloc;
        cudaEvent_t startKernel, stopKernel;
        cudaEvent_t startSync, stopSync;
        //Möglichkeit mit GPUs Zeit zu messen
        cudaEventCreate(&start);
        cudaEventCreate(&stop);
        cudaEventCreate(&startFree);
        cudaEventCreate(&stopFree);
```

```
cudaEventCreate(&startMemcpy);
cudaEventCreate(&stopMemcpy);
cudaEventCreate(&startMemcpyC);
cudaEventCreate(&stopMemcpyC);
cudaEventCreate(&startMalloc);
cudaEventCreate(&stopMalloc);
cudaEventCreate(&startKernel);
cudaEventCreate(&stopKernel);
cudaEventCreate(&startSync);
cudaEventCreate(&stopSync);
// Größe der Matrix kann als Argument  übergeben werden
if (argc > 1) {
        n = atoi(argv[1]);
}
size = n * n * sizeof(float);
//TODO  Allokiere Speicher auf dem host und GPU
h_a = (float*)malloc(size);
h_b = (float*)malloc(size);
h_c = (float*)malloc(size);
cudaEventRecord(startMalloc, 0);
```

```
cudaMalloc(&d_a, size);
cudaMalloc(&d_b, size);
cudaMalloc(&d_c, size);
cudaEventRecord(stopMalloc, 0);
cudaEventElapsedTime(&timeMalloc, startMalloc, stopMalloc);
cudaEventDestroy(startMalloc);
cudaEventDestroy(stopMalloc);
//Initialisierung, parallelisiert mit OpenMP
if (h_a && h_b) {
        //#pragma omp parallel for
        for (row = 0; row < n; row++) {
                for (col = 0; col < n; col++) {
                        h_a[row * n + col] = (row == col) ? 1.0 : 0.0;
                        h_b[row * n + col] = row * n + col;
                }
        }
}
else return;
// Führe die Matrix-Matrix Multiplikation aus
//16x16 ist vorgegeben
```

```
dim3 blockDim(BLOCK_SIZE, BLOCK_SIZE);
dim3 gridDim((n + BLOCK_SIZE - 1) / blockDim.x, (n + BLOCK_SIZE - 1) / blockDim.y);
cudaEventRecord(start, 0);
//TODO kopiere daten auf die GPU und Rufe den Kernel auf  und Kopiere das Ergebniss zurrück
cudaEventRecord(startMemcpy, 0);
cudaMemcpy(d_a, h_a, size, cudaMemcpyHostToDevice);
cudaMemcpy(d_b, h_b, size, cudaMemcpyHostToDevice);
cudaEventRecord(stopMemcpy, 0);
cudaEventRecord(startKernel, 0);
dgemm_gpu_simple << < gridDim, blockDim >> > (d_a, d_b, d_c, n);
cudaEventRecord(stopKernel, 0);
cudaEventRecord(startMemcpyC, 0);
cudaMemcpy(h_c, d_c, size, cudaMemcpyDeviceToHost);
cudaEventRecord(stopMemcpyC, 0);
cudaEventRecord(startSync, 0);
cudaDeviceSynchronize();
cudaEventRecord(stopSync, 0);
cudaEventRecord(stop, 0);
cudaEventElapsedTime(&timeMemcpy, startMemcpy, stopMemcpy);
cudaEventDestroy(startMemcpy);
```

```
cudaEventDestroy(stopMemcpy);
cudaEventElapsedTime(&timeMemcpyC, startMemcpyC, stopMemcpyC);
cudaEventDestroy(startMemcpyC);
cudaEventDestroy(stopMemcpyC);
cudaEventElapsedTime(&timeKernel, startKernel, stopKernel);
cudaEventDestroy(startKernel);
cudaEventDestroy(stopKernel);
cudaEventElapsedTime(&timeSync, startSync, stopSync);
cudaEventDestroy(startSync);
cudaEventDestroy(stopSync);
// Teste das Ergebnis
for (row = 0; row < n; ++row) {
        for (col = 0; col < n; ++col) {
                absError = fabs(h_c[row * n + col] - h_b[row * n + col]);
                sumAbsError += absError;
                if (absError > maxAbsError)
                        maxAbsError = absError;
        }
}
cudaEventElapsedTime(&time, start, stop);
```

```
cudaEventDestroy(start);
cudaEventDestroy(stop);
//TODO Gebe den Speicher auf GPU und Host frei
cudaEventRecord(startFree, 0);
cudaFree(d_c);
cudaFree(d_b);
cudaFree(d_a);
cudaEventRecord(stopFree, 0);
cudaEventElapsedTime(&timeFree, startFree, stopFree);
cudaEventDestroy(startFree);
cudaEventDestroy(stopFree);
free(h_c);
free(h_b);
free(h_a);
printf("\nmaxAbsError: %4.4f, sumAbsError: %4.4f\n", maxAbsError, sumAbsError);
if (maxAbsError < 2.0e-5) {
        printf("\nProgram terminated SUCCESSFULLY.\n");
        printf("\nKernel Execution Time: %f ms (dim C: %d * %d)", time, n, n);
        printf("\nThis corresponds to: %4.4f GFLOPS\n\n", getGflops(n, time));
}
```

```
	else {
		printf("\n--> Result not correct:  check your code\n\n");
	}
	std::ofstream file("C:/Users/nbaum/Documents/fu_hagen/parallel/Aufgabe 2/Zeitmessung/simple1024.dat", std::ios::out | std::ios::app);
	if (file.fail()) {
		printf("\Schreibfehler Datei\n"); return 0;
	}
	file << time<<std::endl;
	file << getGflops(n, time)<<std::endl;
	file << timeMemcpy<< std::endl;
	file << timeMemcpyC<< std::endl;
	file << timeKernel << std::endl;
	file << timeMalloc<< std::endl;
	file << timeSync<< std::endl;
	file << timeFree << std::endl;
	file << "******\n";
	file.close();
	return 0;
}
```

Anlage 3 Kernelvarianten

3.1 Im Kernel wird nicht nur eine C-Zelle, sondern ein Block von C-Zellen befüllt.

```
// Thread block size: BLOCK_SIZE * BLOCK_SIZE

#define BLOCK_SIZE 16

// number of partial blocks

#define PART_BLOCKS

__global__ void dgemm_gpu_shared(const float* a, const float* b, float* c, const int n, const int by, const int bx, const int anzahl_bl, const int m_block_x, const int m_block_y, const int m_block_z) {

        //Todo: implement Kernel Here

        int x = threadIdx.x + blockIdx.x * blockDim.x;

        int y = threadIdx.y + blockIdx.y * blockDim.y;

        int id = x + y * blockDim.x * gridDim.x;

        __shared__ float shared_a[BLOCK_SIZE * BLOCK_SIZE];

        __shared__ float shared_b[BLOCK_SIZE * BLOCK_SIZE];

        __shared__ float shared_c[BLOCK_SIZE * BLOCK_SIZE];

        if (y >= m_block_y)return;

        if (x >= m_block_x)return;

        int cid = bx + by * n;

        int aid, bid;

        int ix = x;
```

```
	int iy = y;
	int t_id = threadIdx.x + threadIdx.y * blockDim.x;
	for (int imblock = 0; imblock < anzahl_bl; ++imblock)
		//for (int iy = 0; iy < M_BLOCK_Y; ++iy)
			//for (int ix = 0; ix < M_BLOCK_X; ++ix)
				for (int i = 0; i < m_block_z; ++i) {
					aid = n * by + m_block_x * imblock; // starting point
					aid += iy * n + i; // extend in partial matrix
					bid = bx + m_block_y * imblock * n; // starting point
					bid += ix + i * n; // extend in partial matrix
					//c[cid + ix + n * iy] += a[aid] * b[bid];
					shared_a[t_id] = a[aid];
					shared_b[t_id] = b[bid];
					shared_c[t_id] = shared_a[t_id] * shared_b[t_id];
					c[cid + ix + n * iy] += shared_c[t_id];
				}
}
```

Aufruf des Kernels in main:

```
int m_block_x, m_block_y, m_block_z; // dimension of partial matrix
m_block_x = m_block_y = m_block_z = n / PART_BLOCKS;
```

```
// dimension smaller thanbBlock_size is out of scope
if (n < BLOCK_SIZE||n<m_block_x||n<m_block_y||n<m_block_z) {
        printf("invalid parameters\n");
        return -1;
}
// number of partial martices
int anz_m_bl_x = n / m_block_x;
int anz_m_bl_y = n / m_block_y;
int anz_m_bl_z = n / m_block_z;
#pragma omp parallel for
for (int y = 0; y < anz_m_bl_y; ++y) {
        for (int x = 0; x < anz_m_bl_x; ++x) {
                dgemm_gpu_shared << < gridDim, blockDim >> > (d_a, d_b, d_c, n, y*m_block_y, x*m_block_x,
                        anz_m_bl_y, m_block_x, m_block_y, m_block_z);
        }
}
```

3.2 Ähnlich wie die Ausgangsvariante, jedoch Verwendung von Shared-Memory auch für C

```
__global__ void dgemm_gpu_shared_(const float* a, const float* b, float* c, const int n) {
        //Todo: implement Kernel Here
        int x = threadIdx.x + blockIdx.x * blockDim.x;
        int y = threadIdx.y + blockIdx.y * blockDim.y;
        int id = x + y * blockDim.x * gridDim.x;
        int numb_bl = n / BLOCK_SIZE; // increment
        int tx = threadIdx.x;
        int ty = threadIdx.y;
        __shared__ float shared_A[BLOCK_SIZE][BLOCK_SIZE];
        __shared__ float shared_B[BLOCK_SIZE][BLOCK_SIZE];
        __shared__ float shared_C[BLOCK_SIZE][BLOCK_SIZE];
        int vx = x;
        int vy = id - vx; // Zeile
        shared_C[tx][ty] = 0;
        for (int j = 0; j < numb_bl; ++j) {
                //Load
                shared_A[tx][ty] = a[vy + tx + j * BLOCK_SIZE];
                shared_B[tx][ty] = b[vx + ty * n  + j * BLOCK_SIZE * n];
                __syncthreads();
```

```
            // Calc
            for (int i = 0; i < BLOCK_SIZE; ++i)
                shared_C[tx][ty] += shared_A[i][ty] * shared_B[tx][i];
        }
        //Store
        c[id] += shared_C[tx][ty];
}
```

Anlage 4 Messeinzeldaten

Es wurden pro Matrixgröße, pro mit/ohne shared, pro CudaMallocHost/Malloc jeweils 25 Versuche durchgeführt. Vor Durchführung wurden jeweils drei Durchläufe durchgeführt, um Initialisierungsverzögerungen zu vermeiden.

1024,00000	simple	Host										
time*	8,06150	8,33587	8,10464	8,10995	8,60432	8,06502	7,98547	8,07581	8,20650	8,02554	8,45219	8,03613
GFLOPS	133,19400	128,81000	132,48500	132,39800	124,79100	133,13600	134,46200	132,95800	130,84000	133,79100	127,03700	133,61400
Memcpy AB	1,22678	1,21642	1,24374	1,26573	1,67936	1,26701	1,24992	1,26218	1,38819	1,23786	1,26426	1,26080
Memcpy C	0,39715	0,39446	0,39414	0,38928	0,39443	0,40243	0,36166	0,38816	0,39350	0,38774	0,39680	0,38941
Kernel	6,41680	6,70618	6,44608	6,43421	6,50957	6,37536	6,35286	6,40506	6,40480	6,38026	6,76963	6,36470
Malloc	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
Sync	0,00000	0,00000	0,00000	0,00000	0,00000	0,00522	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
Free	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
8,40349	8,30618	8,11942	8,01686	8,34643	8,01245	8,24125	8,02762	8,03002	7,98806	8,16704	8,00419	8,05866
127,77300	129,27000	132,24400	133,93500	128,64700	134,00900	130,28900	133,75600	133,71600	134,41800	131,47300	134,14700	133,24100
1,45206	1,26941	1,27146	1,26397	1,23222	1,25869	1,40861	1,26272	1,24554	1,21997	1,32499	1,24563	1,26451
0,38186	0,36512	0,38890	0,36608	0,40608	0,38397	0,37453	0,39072	0,38467	0,40291	0,40934	0,38611	0,39357
6,53082	6,65046	6,43715	6,36490	6,68666	6,34842	6,41802	6,35354	6,37859	6,34422	6,40630	6,35066	6,37907
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,01510	0,00000	0,00000
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
******	******	******	******	******	******	******	******	******	******	******	******	******
2048,00000	simple	Host										
time*	57,98730	57,99530	60,51200	58,53820	57,60390	58,44380	57,58890	58,21170	57,70800	57,58300	57,70910	57,82310
GFLOPS	148,13500	148,11400	141,95400	146,74100	149,12100	146,97800	149,16000	147,56400	148,85200	149,17500	148,84900	148,55500
Memcpy AB	5,19450	5,15277	7,30877	5,85030	5,05581	5,63210	4,99443	5,63302	5,01107	4,97482	5,04928	4,99194
Memcpy C	1,38246	1,48435	1,33040	1,37414	1,35344	1,35021	1,41802	1,35507	1,50906	1,41517	1,50544	1,42026
Kernel	51,38520	51,33450	51,83650	51,29330	51,15060	51,43630	51,15520	51,20330	51,16720	51,16520	51,13390	51,38690
Malloc	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000

Sync	0,00662	0,00000	0,02589	0,01110	0,03325	0,01549	0,00000	0,01091	0,01162	0,00675	0,00000	0,00000
Free	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
58,00160	57,65560	57,80410	58,06650	58,36410	57,89450	57,99500	57,80820	57,78460	58,84010	57,80400	58,05500	59,39730
148,09800	148,98700	148,60400	147,93300	147,17800	148,37200	148,11500	148,59400	148,65400	145,98800	148,60400	147,96200	144,61800
5,21187	5,04013	5,14064	5,04035	5,50845	5,10893	5,42966	5,14538	5,00144	5,65792	5,21037	5,11306	6,26003
1,42096	1,41712	1,35133	1,37891	1,42170	1,41600	1,37200	1,40944	1,42806	1,38995	1,35642	1,35053	1,39853
51,34390	51,17690	51,28530	51,62640	51,41280	51,34860	51,17240	51,23150	51,33240	51,76560	51,21550	51,56930	51,71410
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
0,00000	0,00000	0,00637	0,01078	0,00000	0,00000	0,01078	0,00000	0,00000	0,01152	0,01066	0,00000	0,01536
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
******	******	******	******	******	******	******	******	******	******	******	******	******
4096,00000	simple	Host										
time*	525,05300	513,31200	507,45500	508,57200	507,68100	508,52100	510,26300	509,68900	508,19100	508,83900	508,33300	509,47400
GFLOPS	130,88100	133,87500	135,42000	135,12200	135,35900	135,13600	134,67500	134,82600	135,22400	135,05200	135,18600	134,88300
Memcpy AB	20,29720	23,11370	20,52410	20,57820	20,09630	20,21260	23,10760	21,55120	21,06220	19,97080	20,77070	21,42180
Memcpy C	5,24954	5,26915	5,25059	5,24787	5,26202	5,25376	5,27734	5,26525	5,18006	5,19334	5,25046	5,24963
Kernel	499,47800	484,90000	481,65300	482,72400	482,29100	483,03000	481,85600	482,84300	481,88200	483,64900	482,28300	482,77700
Malloc	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
Sync	0,01789	0,01456	0,01766	0,01632	0,01520	0,01811	0,01488	0,01930	0,03482	0,01648	0,01971	0,01629
Free	0,86502	0,00000	0,00000	0,00000	0,00000	0,86202	0,89590	0,00000	0,86454	0,00000	0,00000	0,00000
508,80800	508,39700	510,88700	512,58100	508,98200	510,32300	508,08700	508,63500	509,27100	508,06300	508,52100	508,18900	509,97100
135,06000	135,16900	134,51000	134,06600	135,01400	134,65900	135,25100	135,10600	134,93700	135,25800	135,13600	135,22400	134,75200
21,62540	20,54200	22,59290	24,37020	21,51000	21,44660	20,35380	20,21620	21,44860	20,01950	21,06390	20,01450	21,62880
5,25034	5,27053	5,25152	5,28192	5,24707	5,13712	5,26781	5,16880	5,27523	5,32262	5,19667	5,24701	5,17686
481,90600	482,56100	483,02000	482,89800	482,20000	483,71400	482,43600	483,22400	482,52000	482,67000	482,18200	482,90200	483,12600
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
0,01869	0,01629	0,01616	0,01763	0,01226	0,01840	0,01536	0,01629	0,01734	0,03834	0,03405	0,00000	0,02368
0,95635	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	1,01402	0,00000	0,98870	0,00000	0,95578	0,72410
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8192,00000	simple	Host										

time*	3955,08000	3949,53000	3952,07000	3959,15000	3954,02000	3961,71000	3966,15000	3960,04000	3968,80000	3958,63000	3970,18000	3965,50000
GFLOPS	139,00000	139,19500	139,10600	138,85700	139,03700	138,76700	138,61200	138,82600	138,51900	138,87500	138,47100	138,63500
Memcpy AB	79,90680	82,32530	79,98840	77,65770	77,06790	77,87470	77,24710	82,09750	83,30100	78,07610	76,92390	77,94030
Memcpy C	20,53290	20,60600	20,61060	20,59480	20,50970	20,66860	20,59780	20,60160	20,50890	20,60660	20,51300	20,45180
Kernel	3854,61000	3846,57000	3851,44000	3860,87000	3856,42000	3863,13000	3868,27000	3857,30000	3864,96000	3859,91000	3872,71000	3867,09000
Malloc	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
Sync	0,01197	0,01549	0,01779	0,01606	0,01629	0,01350	0,01725	0,02112	0,01642	0,01642	0,01475	0,01744
Free	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
3965,90000	3957,84000	3958,92000	3969,12000	3961,86000	3962,81000	3970,72000	3974,78000	3977,27000	3966,68000	3974,89000	3972,60000	3988,54000
138,62100	138,90300	138,86500	138,50800	138,76200	138,72900	138,45200	138,31100	138,22500	138,59300	138,30700	138,38700	137,83400
78,12230	77,02920	77,59010	78,15490	80,89250	77,58560	77,94140	79,25030	79,11570	77,70820	84,39200	82,41650	98,40750
20,51890	20,53250	20,58430	20,50730	20,44470	20,61420	20,43520	20,41880	20,52220	20,44450	20,52920	20,50960	20,58920
3867,22000	3860,24000	3860,72000	3870,43000	3860,42000	3864,58000	3872,28000	3875,08000	3877,60000	3868,50000	3869,90000	3869,61000	3869,48000
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
0,01853	0,01626	0,01635	0,01552	0,03040	0,01840	0,03155	0,01126	0,01101	0,01622	0,03664	0,01626	0,03754
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
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1024,00000	simple	Malloc										
time*	11,88910	11,95930	12,05540	11,99700	12,42080	11,91240	12,19110	12,23660	12,28600	12,58040	12,21720	11,96960
GFLOPS	109,52600	108,88400	108,01600	108,54200	104,83800	109,31200	106,81300	106,41600	105,98800	103,50700	106,58500	108,79000
Memcpy AB	1,39491	1,42550	1,42717	1,43450	1,50448	1,40733	1,52794	1,54413	1,48218	1,71882	1,43760	1,47312
Memcpy C	1,03718	1,04566	1,01507	1,02026	1,07136	1,02432	1,09011	1,08077	1,06221	1,15712	1,05786	1,01501
Kernel	9,43962	9,46768	9,59085	9,52186	9,80272	9,46298	9,53453	9,56941	9,72246	9,65923	9,70301	9,45958
Malloc	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
Sync	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,03478	0,00000	0,00000
Free	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
12,33540	12,00820	12,31180	12,19790	12,71850	12,45850	12,20210	12,38510	12,11510	12,24170	12,52030	12,05670	12,43030
105,56400	108,44000	105,76600	106,75400	102,38400	104,52000	106,71700	105,14000	107,48400	106,37100	104,00500	108,00400	104,75700
1,67974	1,38707	1,70598	1,39322	1,57827	1,53754	1,52506	1,43078	1,51606	1,58701	1,53091	1,49002	1,67229
1,07251	1,04960	1,01677	1,03277	1,20106	1,04534	1,07680	1,44685	1,09040	1,08749	1,07590	1,02701	1,08851

9,56131	9,55059	9,56781	9,75126	9,91462	9,85264	9,55808	9,47232	9,46490	9,52253	9,86963	9,52067	9,62592
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,01971	0,00000	0,00000	0,00000	0,00000	0,03424
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
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2048,00000	simple	Malloc										
time*	62,57720	60,07140	60,12200	60,59010	61,00300	61,22230	60,06940	60,08520	62,03680	60,53180	60,29260	59,53960
GFLOPS	137,27000	142,99500	142,87500	141,77100	140,81200	140,30700	143,00000	142,96200	138,46500	141,90800	142,47100	144,27300
Memcpy AB	7,13053	5,04384	5,01715	5,13088	5,70106	6,12822	5,35021	5,03517	5,72710	5,56906	5,15085	4,97507
Memcpy C	3,25520	3,30864	3,52589	3,37366	3,48397	3,40032	3,16845	3,24934	3,82646	3,29757	3,18490	3,30435
Kernel	52,17190	51,69810	51,53560	52,06310	51,76950	51,67510	51,52970	51,78000	52,43490	51,64100	51,93810	51,23800
Malloc	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
Sync	0,00000	0,01104	0,03306	0,01328	0,03818	0,01158	0,00000	0,01370	0,03654	0,01373	0,00000	0,00000
Free	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
59,75440	60,35700	60,26990	60,63890	60,71180	59,97520	60,34590	60,14310	59,91730	60,48600	60,12360	60,14520	59,66290
143,75400	142,31900	142,52500	141,65700	141,48700	143,22500	142,34500	142,82500	143,36300	142,01500	142,87100	142,82000	143,97500
5,00803	5,59994	5,15610	5,95859	5,61056	4,99021	5,57552	5,41024	4,98758	5,59798	4,98134	5,03274	4,97853
3,23670	3,21763	3,30230	3,26954	3,41091	3,28794	3,26090	3,17696	3,45475	3,41427	3,34915	3,19814	3,38502
51,48720	51,51930	51,79120	51,38510	51,66920	51,67520	51,48820	51,53370	51,45280	51,44760	51,77130	51,88690	51,27740
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
0,01306	0,01104	0,01286	0,00000	0,01174	0,00000	0,01091	0,00000	0,00000	0,00000	0,01197	0,01280	0,00000
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
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4096,00000	simple	Malloc										
time*	524,52700	520,67700	516,33200	518,27300	514,56900	515,97900	514,59900	516,03300	515,77300	515,87200	517,38700	515,74100
GFLOPS	131,01200	131,98100	133,09200	132,59300	133,54800	133,18300	133,54000	133,16900	133,23600	133,21000	132,82000	133,24400
Memcpy AB	22,94580	24,46180	21,26210	22,11770	20,23380	19,81760	20,45480	19,32450	19,50780	20,03820	22,02210	20,60420
Memcpy C	12,28250	13,02400	13,12090	12,96280	12,44210	12,48840	12,34550	13,35610	13,22350	13,59530	13,17480	12,64840
Kernel	489,27500	483,16000	481,92700	483,17100	481,87300	483,65100	481,78000	483,32700	483,01900	482,21900	482,17000	482,46200
Malloc	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000

Sync	0,01318	0,01322	0,01402	0,01286	0,01341	0,01315	0,01280	0,01722	0,01363	0,01232	0,01251	0,01354
Free	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
516,15500	517,64200	517,36000	515,56500	516,50600	518,28700	517,42100	516,08000	516,84200	516,48600	515,73900	517,70500	516,07100
133,13700	132,75500	132,82700	133,29000	133,04700	132,59000	132,81200	133,15700	132,96000	133,05200	133,24500	132,73900	133,15900
20,88250	22,55260	22,13730	20,05190	21,14360	22,01000	21,06140	20,22220	20,66570	21,04100	20,41110	21,69140	20,32370
12,71580	12,34490	12,90480	12,55230	12,78350	13,34920	13,40860	12,36480	13,46900	12,51890	12,40990	13,02960	13,75990
482,52700	482,72400	482,29800	482,94100	482,53500	482,88400	482,90300	483,47200	482,68400	482,90600	482,89300	482,96100	481,94500
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
0,01638	0,01222	0,01306	0,01248	0,03459	0,03658	0,03485	0,01213	0,01277	0,01242	0,01549	0,01293	0,03603
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,90288	0,00000	0,00000	0,00000	0,00000	0,00000
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8192,00000	simple	Malloc										
time*	3988,34000	3985,55000	3998,05000	3989,72000	3994,29000	3983,90000	3988,22000	3987,88000	3989,10000	3991,17000	4002,30000	3990,79000
GFLOPS	137,84100	137,93700	137,50600	137,79300	137,63500	137,99400	137,84500	137,85700	137,81500	137,74300	137,36000	137,75600
Memcpy AB	80,30610	81,78840	81,25620	77,24870	79,43480	78,21990	80,05680	79,59750	79,62140	79,41900	79,92410	80,86450
Memcpy C	48,64060	48,93850	49,80340	49,17390	49,87780	48,81130	49,15750	48,84500	50,13970	50,86750	48,88500	49,17130
Kernel	3859,38000	3854,80000	3866,97000	3863,28000	3864,93000	3856,85000	3858,98000	3859,42000	3859,31000	3860,84000	3873,47000	3860,73000
Malloc	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
Sync	0,01312	0,01539	0,01283	0,01309	0,03760	0,01286	0,01318	0,01376	0,01318	0,03699	0,01232	0,01418
Free	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
4004,58000	3988,22000	3994,06000	3989,85000	4003,31000	3997,61000	4000,81000	4003,52000	3991,35000	3997,98000	4006,73000	4001,32000	3992,82000
137,28200	137,84500	137,64300	137,78900	137,32500	137,52100	137,41100	137,31800	137,73700	137,50800	137,20800	137,39300	137,68600
80,42050	77,13740	76,79480	77,22220	77,40260	79,22350	77,46950	76,77360	77,62120	78,21680	79,88310	81,50520	77,38820
51,16970	49,04350	49,56420	49,12760	49,21950	49,32430	49,12260	50,32710	48,61770	48,23590	50,62690	49,71890	49,71110
3872,97000	3862,02000	3867,68000	3863,48000	3876,66000	3869,04000	3874,20000	3876,40000	3865,09000	3871,51000	3876,20000	3870,06000	3865,70000
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
0,01427	0,01539	0,01277	0,01411	0,01331	0,01338	0,01338	0,01322	0,01360	0,01254	0,01421	0,03402	0,01219
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
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1024,00000	shared	Host										

time*	3,82208	3,62704	3,62211	4,02938	3,71747	3,87136	3,76342	3,65174	3,62675	4,29219	3,67350	3,63597
GFLOPS	280,93100	296,03800	296,44100	266,47800	288,83700	277,35500	285,31000	294,03500	296,06200	250,16200	292,29400	295,31100
Memcpy AB	1,40502	1,22186	1,22675	1,48723	1,26205	1,40819	1,34026	1,25075	1,21885	1,48445	1,26822	1,24016
Memcpy C	0,38752	0,37021	0,38416	0,38560	0,38694	0,37181	0,38435	0,38365	0,38342	0,39434	0,38781	0,38448
Kernel	2,00848	2,01462	1,99024	2,13930	2,04883	2,05296	2,01802	1,99670	2,00426	2,39360	1,99856	1,98979
Malloc	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
Sync	0,00000	0,00000	0,00000	0,00000	0,01034	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
Free	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,36262	0,00000	0,00000	0,00000
3,88832	3,67830	3,65411	3,67398	3,66755	4,04458	3,88426	3,90749	3,68650	3,66672	3,87830	3,84541	3,64995
276,14500	291,91200	293,84500	292,25500	292,76800	265,47700	276,43400	274,79100	291,26400	292,83400	276,85900	279,22700	294,18000
1,36922	1,26925	1,24461	1,24970	1,26653	1,56163	1,40701	1,41677	1,26230	1,25062	1,39328	1,44586	1,24445
0,48272	0,38810	0,38762	0,38518	0,38845	0,36410	0,37354	0,37494	0,38464	0,38618	0,37424	0,38902	0,36218
2,01318	2,00128	2,00154	2,01747	1,98515	2,09667	2,06458	2,07773	2,01878	2,00982	2,07245	1,98982	2,02346
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
0,01466	0,00000	0,00000	0,00000	0,00000	0,01014	0,00000	0,00000	0,01034	0,00000	0,00000	0,00000	0,00000
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
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2048,00000	shared	Host										
time*	20,77410	20,66170	21,75980	20,64380	20,84840	20,84360	21,17630	21,64720	20,57080	21,21690	21,43870	20,53640
GFLOPS	413,49200	415,74200	394,76200	416,10200	412,02000	412,11300	405,63900	396,81400	417,57900	404,86400	400,67400	418,27900
Memcpy AB	4,98739	5,06957	5,94717	5,05242	5,05158	5,03674	5,48752	5,95670	4,98301	5,59597	5,73923	4,97437
Memcpy C	1,35152	1,36902	1,33971	1,34243	1,34317	1,35171	1,35523	1,38406	1,35984	1,32966	1,33229	1,35475
Kernel	14,41350	14,20270	14,45230	14,23190	14,43480	14,43480	14,21430	14,28490	14,20740	14,25550	14,32870	14,18630
Malloc	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
Sync	0,00982	0,00000	0,00000	0,00973	0,00000	0,00000	0,10861	0,01123	0,00000	0,02627	0,00000	0,00000
Free	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,67398	0,00000	0,00000	0,00000
20,57460	20,51340	20,59140	21,25110	21,09490	20,74080	20,78920	21,23860	20,87590	21,48040	21,36300	21,09240	20,95580
417,50100	418,74800	417,16200	404,21100	407,20400	414,15600	413,19100	404,44900	411,47600	399,89700	402,09400	407,25400	409,90600
5,01344	4,95606	5,00109	5,60102	5,48634	5,11811	5,08115	5,12074	5,24618	5,84317	5,67405	4,99728	5,40490
1,35117	1,34173	1,38746	1,32842	1,35267	1,37965	1,42566	1,34710	1,39933	1,35539	1,36691	1,37251	1,31389

14,18920	14,19540	14,18300	14,28330	14,23520	14,22380	14,21550	14,75050	14,21340	14,26110	14,29630	14,70270	14,21670
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,03059	0,00000	0,00000	0,00000	0,01494	0,01050	0,00000
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
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4096,00000	shared	Host										
time*	138,51100	129,23500	129,02200	129,04400	129,90200	129,66300	129,99000	131,20100	128,88900	128,92400	129,67100	130,17400
GFLOPS	496,13100	531,74000	532,61700	532,52700	529,01200	529,98700	528,65400	523,77400	533,16700	533,02300	529,95200	527,90600
Memcpy AB	21,13950	20,41250	20,32680	20,21560	21,59160	20,75210	21,82860	21,71210	20,29080	20,56920	21,22820	21,71400
Memcpy C	5,18314	5,25811	5,24861	5,24803	5,22938	5,19814	5,29168	5,27110	5,42182	5,23120	5,17242	5,32995
Kernel	112,16700	103,53200	103,42800	103,54800	103,06500	103,69000	102,84500	104,20000	103,13000	103,10000	103,24800	103,10900
Malloc	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
Sync	0,01331	0,01853	0,01069	0,01738	0,00000	0,01523	0,00000	0,01082	0,01542	0,01069	0,00944	0,01370
Free	0,83546	0,00000	0,00000	1,03520	1,13082	0,00000	0,00000	0,00000	0,00000	0,74054	0,00000	0,00000
128,73000	130,73500	129,47500	129,68700	128,92100	129,72200	130,12400	128,91500	129,14400	129,26700	128,85100	130,45200	129,76000
533,82800	525,64000	530,75500	529,88800	533,03600	529,74600	528,10800	533,06000	532,11600	531,60900	533,32600	526,78100	529,59000
20,58970	21,97940	21,46170	21,53870	20,58540	21,15890	21,65340	20,81430	20,50990	20,75200	20,32580	21,45410	21,29080
5,23488	5,26336	5,27181	5,26528	5,32019	5,23344	5,31440	5,23626	5,22755	5,15437	5,30291	5,26096	5,23744
102,87900	103,46500	102,71700	102,85900	102,98600	103,31000	103,12800	102,84000	103,38700	103,29800	103,20400	103,67000	103,21100
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
0,01318	0,01379	0,01562	0,01309	0,01680	0,01046	0,01331	0,01437	0,00000	0,02758	0,01014	0,02838	0,01274
0,00000	0,00000	0,75021	0,00000	1,15606	0,00000	0,00000	0,84563	0,00000	0,00000	0,00000	1,20374	0,00000
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8192,00000	shared	Host										
time*	964,91100	962,82800	957,38000	958,97300	960,24600	960,34500	964,11900	963,40100	960,60100	960,03400	961,94900	959,17700
GFLOPS	569,74800	570,98000	574,23000	573,27500	572,51600	572,45700	570,21500	570,64100	572,30400	572,64200	571,50200	573,15400
Memcpy AB	78,47110	80,00660	77,42030	79,12840	79,03150	79,29380	82,74750	82,51840	79,03110	78,95840	80,68770	78,10030
Memcpy C	20,50650	20,42660	20,54160	20,70830	20,53230	20,58080	20,55420	20,53270	20,43190	20,53210	20,50730	20,59510
Kernel	865,90500	862,37200	859,38800	859,09200	860,65400	860,43800	860,74300	860,31500	861,07700	860,47800	860,72200	860,44800
Malloc	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000

Sync	0,01171	0,01158	0,01155	0,03677	0,01504	0,01587	0,01315	0,01312	0,01379	0,01213	0,01626	0,01536
Free	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
964,61600	956,25300	964,21400	958,00600	961,82500	960,91700	958,49200	962,62200	959,92400	959,95100	959,56800	958,16600	962,23400
569,92200	574,90600	570,16000	573,85400	571,57600	572,11600	573,56400	571,10200	572,70700	572,69100	572,92000	573,75900	571,33300
83,79600	76,43010	83,50510	76,68530	79,46610	78,82700	76,80600	79,82170	78,20060	77,48230	76,54840	76,36880	79,25820
20,40990	20,53940	20,53290	20,52380	20,59510	20,56340	20,59800	20,53160	20,43540	20,50880	20,53490	20,50520	20,49820
860,32800	859,23700	860,15400	860,77400	861,73100	861,49300	861,05800	862,22000	861,26500	861,92700	862,40600	861,25800	862,44800
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
0,01632	0,03341	0,00000	0,01648	0,01648	0,01328	0,01773	0,03331	0,01210	0,01443	0,03594	0,01850	0,01565
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
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1024,00000	shared	Malloc										
time*	4,30262	4,27763	4,18976	4,18970	4,28022	4,19568	4,17085	4,80922	4,16442	4,55392	4,16944	4,71517
GFLOPS	249,55500	251,01300	256,27800	256,28200	250,86100	255,91600	257,44000	223,26800	257,83700	235,78400	257,52700	227,72100
Memcpy AB	1,33965	1,31162	1,24909	1,22246	1,27645	1,22704	1,22896	1,30384	1,22317	1,24832	1,22157	1,38358
Memcpy C	0,94502	0,92957	0,91290	0,93414	0,95635	0,95056	0,93331	0,96867	0,91648	1,01258	0,92666	1,22592
Kernel	1,99789	2,01456	2,00685	2,01069	2,02723	1,99814	1,98685	2,51520	2,00400	2,27040	2,00141	2,08496
Malloc	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
Sync	0,00000	0,01123	0,01094	0,00000	0,00000	0,01088	0,00000	0,01139	0,00000	0,01286	0,00000	0,00000
Free	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
4,40934	4,31178	4,15846	4,23875	4,87382	4,88282	4,19043	4,26362	4,21302	4,45478	4,15923	4,24099	4,20355
243,51500	249,02500	258,20600	253,31600	220,30800	219,90200	256,23700	251,83800	254,86200	241,03100	258,15900	253,18200	255,43700
1,26230	1,25149	1,22595	1,26906	1,39891	1,53648	1,22643	1,23114	1,27085	1,34819	1,20989	1,23245	1,25619
1,11290	0,94538	0,92365	0,93683	1,32522	0,94966	0,94614	1,02310	0,92970	1,00931	0,93568	1,01757	0,92938
2,01302	2,09235	1,98835	2,01184	2,10426	2,37654	1,99750	1,98864	1,99414	2,05238	1,99251	1,96950	1,99734
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
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2048,00000	shared	Malloc										

time*	23,05740	22,39890	22,71330	23,26850	22,82220	23,51410	22,89940	22,99760	23,38390	22,78550	23,69140	23,41930
GFLOPS	372,54600	383,49800	378,18900	369,16600	376,38400	365,31000	375,11600	373,51400	367,34400	376,99100	362,57600	366,78900
Memcpy AB	5,15901	4,97056	5,03811	5,74202	5,00518	5,16032	5,00877	5,26714	5,50794	5,36291	5,72656	5,49149
Memcpy C	3,68310	3,22483	3,47229	3,21715	3,27091	4,12915	3,38230	3,50778	3,29805	3,21514	3,70682	3,34269
Kernel	14,17370	14,18270	14,18400	14,28800	14,52620	14,20480	14,48780	14,20060	14,55520	14,18620	14,23080	14,56380
Malloc	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
Sync	0,03258	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,01075	0,00000	0,00000	0,01293	0,00000
Free	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
23,67970	23,19100	22,68680	22,38500	23,04180	23,37970	22,90930	22,97750	22,34430	22,48970	23,72170	22,37380	22,38440
362,75500	370,39900	378,63200	383,73600	372,79800	367,41000	374,95400	373,84100	384,43500	381,94900	362,11300	383,92800	383,74600
5,29184	5,49398	5,03677	5,01680	5,03341	5,46896	5,35171	5,23882	4,98502	5,08992	5,47872	4,99162	4,99907
3,95136	3,40224	3,19830	3,16442	3,46883	3,25930	3,22211	3,22560	3,15037	3,16813	3,96291	3,17296	3,17181
14,26970	14,25160	14,43360	14,18690	14,51500	14,63060	14,31390	14,49530	14,18650	14,21020	14,25640	14,18940	14,19230
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
0,03424	0,00000	0,00000	0,00000	0,01299	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
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4096,00000	shared	Malloc										
time*	145,39600	148,96700	135,60900	138,78800	135,87100	137,29200	135,71300	136,47000	137,61000	136,31700	136,47500	136,29600
GFLOPS	472,63600	461,30600	506,74700	495,14000	505,77000	500,53600	506,36000	503,54900	499,37800	504,11600	503,53000	504,19400
Memcpy AB	20,47630	20,77520	19,51590	22,29310	20,51760	21,88560	20,25400	19,97790	20,29640	20,02250	20,20000	20,30210
Memcpy C	12,67640	15,52090	12,26680	13,25480	12,49100	12,47300	12,16720	13,37630	13,59990	12,46710	12,54750	12,45880
Kernel	112,22400	112,64700	103,80700	103,21200	102,84000	102,91300	103,27100	103,07400	103,69300	103,80400	103,70800	103,51800
Malloc	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
Sync	0,00000	0,01651	0,01232	0,01312	0,01338	0,01334	0,01091	0,03552	0,01235	0,01037	0,01210	0,01043
Free	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	1,14576	0,00000
135,14800	136,77700	136,93400	137,05100	135,82400	135,21100	137,37300	136,18800	135,50700	136,94800	135,91000	136,17000	142,19900
508,47600	502,42000	501,84300	501,41600	505,94600	508,23900	500,24100	504,59100	507,12800	501,79400	505,62500	504,65800	483,26400
19,73190	21,21010	20,24720	20,90330	20,19460	19,51060	22,14370	20,62850	19,35430	21,34480	20,39170	20,57790	20,72880
12,45180	12,42050	13,74040	12,20050	12,34100	12,27760	12,41460	12,50680	12,71110	12,38970	12,25870	12,34650	13,30570

102,94400	103,12300	102,90000	103,92500	103,26900	103,40000	102,79300	103,03200	103,41700	103,19400	103,23400	103,22400	108,11900
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
0,01299	0,01395	0,03283	0,01069	0,01270	0,01213	0,01094	0,01181	0,01603	0,01146	0,01219	0,01146	0,03347
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,98842
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8192,00000	shared	Malloc										
time*	999,30100	989,72900	992,86600	988,90600	989,20800	994,39900	987,04000	993,78000	987,31000	1003,32000	995,88000	996,62600
GFLOPS	550,14100	555,46100	553,70600	555,92400	555,75300	552,85200	556,97400	553,19700	556,82200	547,93500	552,03000	551,61700
Memcpy AB	84,96690	77,64740	80,77590	77,30590	79,73650	76,81870	77,44260	77,39130	76,57480	80,62940	77,62710	80,14920
Memcpy C	50,35000	51,81250	52,26030	52,08860	49,15760	58,79650	50,85390	57,34470	51,87580	64,35240	58,36830	57,23300
Kernel	863,96000	860,22300	859,76100	859,49000	860,29400	858,76000	858,72400	859,02100	858,83800	858,29500	859,86100	859,19800
Malloc	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
Sync	0,01565	0,03882	0,03683	0,01318	0,01296	0,01616	0,01331	0,01440	0,01370	0,03709	0,01648	0,03843
Free	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
989,53300	986,19300	1000,44000	994,50900	1006,07000	991,62200	994,57800	1000,11000	1001,94000	988,92500	989,58900	1001,85000	992,61500
555,57100	557,45300	549,51500	552,79100	546,43800	554,40100	552,75300	549,69300	548,69100	555,91300	555,54000	548,74300	553,84600
78,46540	77,30920	80,74030	80,44050	85,74190	76,81280	81,16310	78,14420	77,75160	76,90690	76,97280	78,84640	76,84910
51,57820	49,90980	59,64570	53,13420	60,36940	53,88820	52,18800	61,30980	62,03390	50,08840	51,39910	61,88000	54,37630
859,46800	858,95100	860,03000	860,90700	859,93800	860,87700	861,20600	860,61700	862,13000	861,90800	861,17000	861,09700	861,34700
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
0,01418	0,01382	0,01443	0,02022	0,01347	0,03616	0,01286	0,03590	0,01642	0,01405	0,03942	0,01360	0,03523
0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
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