1 Large array benchmark

The size of data that must be analyzed keeps increasing year after year and the prize for DRAM are not getting cheaper. NVDIMM offer a lot of storage at a cheaper prize. This opens the opportunity to save money by offloading some of the data to the NVDIMM where the data will be analyzed the same way as the data on the DRAM. The downside to this strategy is that NVDIMM is slower than DRAM so the question is how much data can be offloaded to NVDIMM. If the user offload too much data to NVDIMM then the threads working on analyzing the data on DRAM will be idle while waiting for NVDIMM threads to complete.

The goal is to find a formula that can easily calculate how much data can be offloaded to the NVDIMM from DRAM. The time taken to perform calculation on NVDIMM must be equal to the amount of time it takes to run calculation on the remaining data on DRAM.

In order to use the formula one must measure the NVDIMM and DRAM speed using a benchmark made in a previous chapter where speed was measured when data was transferred from DRAM-DRAM and NVDIMM-NVDIMM simultaneously with different amount threads allocated to the different processes. By using using the speed from the benchmark in the formula below along with the size of the data that will be used in the calculation the user can easily calculate how much data can be transferred to NVDIMM without losing time. The formula only decide how much data can be allocated to NVDIMM with a certain amount of threads. This means that the user must probably use the formula several times where the number of NVDIMM threads varies from one to five in order to find the best combination of threads and data allocated to the NVDIMM process.

Formula

$$\frac{Total_data - nvdimm_data}{dram_speed} = \frac{nvdimm_data}{nvdimm_speed}$$

$$nvdimm_data = \frac{nvdimm_speed * Total_data}{nvdimm_speed + dram_speed}$$

Calculation

This program have an two dimensional array filled with data. The program start at element (1,1) of the array where it sum ups all of its eight neighbors and then takes the average. The result is stored in the same position in another two dimensional array. The program does this for

every element between (1,1) and (m-2,n-2). The programs repeats this process ten times and after each time the programs will swap both the DRAM arrays and NVDIMM array. The time is measured at the beginning of the process and at the end, this time is called total_time in the code. Each thread will also measure the time they takes to complete their own tasks, in the code this is called individual_time.

1.1 First version

There are two groups of threads that works in parallel in this program. The first group of threads works on the part of the data that is stored on DRAM and the other works on the data stored on NVDIMM. One thread in each group works on data that borders with the other group. In the DRAM group that is the thread with the highest thread_id. Each of the elements in the last row of data will have three neighbors that exist on the NVDIMM side. This means that the thread must access the NVDIMM in order to get the data. The NVDIMM thread with the lowest thread_id also have elements in the first row of data that have three neighbours that exist in DRAM that must be accessed by the thread directly.

Explaination of code:
The code below only shows the calculation process, it does not the rest of the code. Allocation of memory have been done by all the threads, as a result the data have been spread across all the memory channels. The data is a 2d array where the rows of data on DRAM will be divided equally between the DRAM threads, the rows of data on NVDIMM will also be divided equally between the NVDIMM threads. The variable slice_start hold the index of the row where the tread must start at and slice_end holds the index of the row the thread must stop at. Array A and B are DRAM array and array C and D are NVDIMM arrays. The average found by adding together eight neighbors in A will be placed in same position in B. The same is true for C and D.

The process are repeated K_length amount of time, usually ten times in my tests. One way of knowing if the test result are correct is to run the test several time and look for consistency. The code measures the time taken to complete one iteration of calculation, this is done in the beginning of the code at line 5 and at the end at line 84 by a single thread. All the threads then get divided into the DRAM and NVDIMM at line 8. If the thread_id of a thread is less than the dram_threads is it will do calculation on the data in DRAM, the rest will fail the if test

and move on to the else bracket at line 42. Dram_threads is the total amount of threads that will be working on data in DRAM.

At line 11 the thread with the highest thread_id will pass the if test and the rest will move on to line 30. The thread with highest thread_id will then measure time at line 12 and end the measurement in line 29, this is the start and the end of the bracket. The thread will then enter a double for-loop at line 13-20 that will go through elements from position (slice_start,1) until (slice_end-1,n-1), this leaves out the last row assigned to the tread, that row will be dealt with later. At each element the for-loop it will add all of its eight neighbors together at line 15-17 and divide by eight at line 18. The thread will then enter a new for-loop at line 23, this for-loop will calculate average of the last row on DRAM. Elements of this row have three neighbors that exist in NVDIMM. The thread will access the NVDIMM directly when adding the eight neighbors at line 24-26. Data on NVDIMM are accessed by the thread at line 26, the thread is using a library developed for this purpose.

For all the other DRAM threads that jumped to line 30 will start by taking time measurement at the beginning and at the end of the bracket at line 31 and 40. The code from line 32-39 is identical to line 13-20 describe before.

The group of NVDIMM enters the else bracket at line 42 where the thread with the lowest thread_id will pass the if-sentence at line 44, the rest will move on to the else bracket at line 62. The thread will then measure time at line 45 and end the measurement in line 61. It will then enter a for-loop at line 47 and will begin calculating the average of the neighbors of the elements in the first row. The first row have three of its eight neighbors in the row above and they exist in the DRAM. Once done the thread will move on to a new for-loop at line 53. This for-loop will go through the rest of the portion of data the thread have been given and calculate the average of each elements neighbors.

The rest of the NVDIMM threads will move into the else bracket at line 62. The code here is very similar to the code at 31-40 that has been described at a previous paragraph. The only difference is that the code at line 66-68 where the code reads from NVDIMM instead DRAM.

All the threads will wait a barrier at line 75 until all threads are done. After that on thread will enter a single bracket where array A and B will swap places, array C and D will also swap places. The time it took for this one iteration will be registered at line 84. After this the code will move back to line 1.

Listing 1: First version

```
while(k<K_length){
  #pragma omp barrier
  #pragma omp single
  {
    total_time[k] = mysecond();
  }
  //Divides threads into DRAM threads and NVDIMM threads.
  if( thread_id < dram_threads ){

    //for the thread bordering on NVDIMM thread.
    if( thread_id==(dram_threads-1) ){
      individual_time[k][thread_id] = mysecond();
      for( i=slice_start; i<slice_end-1; i++){
        for( j=1; j<nMinusOne; j++){
          temp = A[i-1][j-1] + A[i-1][j] + A[i-1][j+1]+
               A[i][j-1]    +      A[i][j+1]+
                A[i+1][j-1] + A[i+1][j] + A[i+1][j+1];
          B[i][j] = temp*inverseEigth;
        }
      }

      i = slice_end-1;
      for( j=1; j<nMinusOne; j++){
        temp = A[i-1][j-1] + A[i-1][j] + A[i-1][j+1]+
             A[i][j-1]    +      A[i][j+1]+
             D_RO(C)[i*n+j] + D_RO(C)[i*n+j] +
                D_RO(C)[i*n+j];
        B[i][j] = temp*inverseEigth;
        }
      individual_time[k][thread_id] = mysecond() -
         individual_time[k][thread_id];
    }else{
      individual_time[k][thread_id] = mysecond();
      for( i=slice_start; i<slice_end; i++){
        for( j=1; j<nMinusOne; j++){
          temp = A[i-1][j-1] + A[i-1][j] + A[i-1][j+1]+
               A[i][j-1]    +      A[i][j+1]+
               A[i+1][j-1] + A[i+1][j] + A[i+1][j+1];
          B[i][j] = temp*inverseEigth;
        }
      }
      individual_time[k][thread_id] = mysecond() -
```

```
            individual_time[k][thread_id];
41        }
42      }else{
43        //for the thread bordering on DRAM thread.
44        if( thread_id==dram_threads ){
45          individual_time[k][thread_id] = mysecond();
46          i=0;
47          for( j=1; j<nMinusOne; j++){
48            temp =
                 A[dram_part-1][j-1]+A[dram_part-1][j]+A[dram_part-1][j+1]+
49                D_RO(C)[i*n+(j-1)]     +
                     D_RO(C)[i*n+(j+1)]+
50                D_RO(C)[(i+1)*n+(j-1)] + D_RO(C)[(i+1)*n+j]
                     + D_RO(C)[(i+1)*n+(j+1)];
51            D_RW(D)[i*n+j] = temp*inverseEigth;
52          }
53          for( i=slice_start+1; i<slice_end-1; i++){
54            for( j=1; j<nMinusOne; j++){
55              temp = D_RO(C)[(i-1)*n+(j-1)] +
                    D_RO(C)[(i-1)*n+j] + D_RO(C)[(i-1)*n+(j+1)]+
56                  D_RO(C)[i*n+(j-1)]     +
                        D_RO(C)[i*n+(j+1)]+
57                  D_RO(C)[(i+1)*n+(j+1)] +
                        D_RO(C)[(i+1)*n+j] +
                        D_RO(C)[(i+1)*n+(j+1)];
58              D_RW(D)[i*n+j] = temp*inverseEigth;
59            }
60          }
61          individual_time[k][thread_id] = mysecond() -
               individual_time[k][thread_id];
62        }else{
63          individual_time[k][thread_id] = mysecond();
64          for( i=slice_start; i<slice_end; i++){
65            for( j=1; j<nMinusOne; j++){
66              temp = D_RO(C)[(i-1)*n+(j-1)] +
                    D_RO(C)[(i-1)*n+j] + D_RO(C)[(i-1)*n+(j+1)]+
67                  D_RO(C)[i*n+(j-1)]     +
                        D_RO(C)[i*n+(j+1)]+
68                  D_RO(C)[(i+1)*n+(j-1)] +
                        D_RO(C)[(i+1)*n+j] +
                        D_RO(C)[(i+1)*n+(j+1)];
69                 D_RW(D)[i*n+j] = temp*inverseEigth;
70            }
```

```
71          }
72          individual_time[k][thread_id] = mysecond() -
               individual_time[k][thread_id];
73        }
74      }
75      #pragma omp barrier
76      #pragma omp single
77      {
78        tempArray = B;
79          B=A;
80          A=tempArray;
81        temp_nvdimm = C;
82        C = D;
83        D = temp_nvdimm;
84        total_time[k] = mysecond() - total_time[k];
85        k++;
86      }
87      #pragma omp barrier
88  }//End of while
```

m	2,000			
n	500,000			
total M	8,000			
speed				
Nvm-th	dram	nvm	nvmpar	rows
1	64,447	3,248	383.84	48
2	61,872	6,500	760.55	95
3	58,423	9,979	1167.10	146
4	55,367	13,416	1560.39	195
5	51,955	16,933	1966.44	246
6	48,656	20,438	2366.40	296

Table 1: First version, distribution

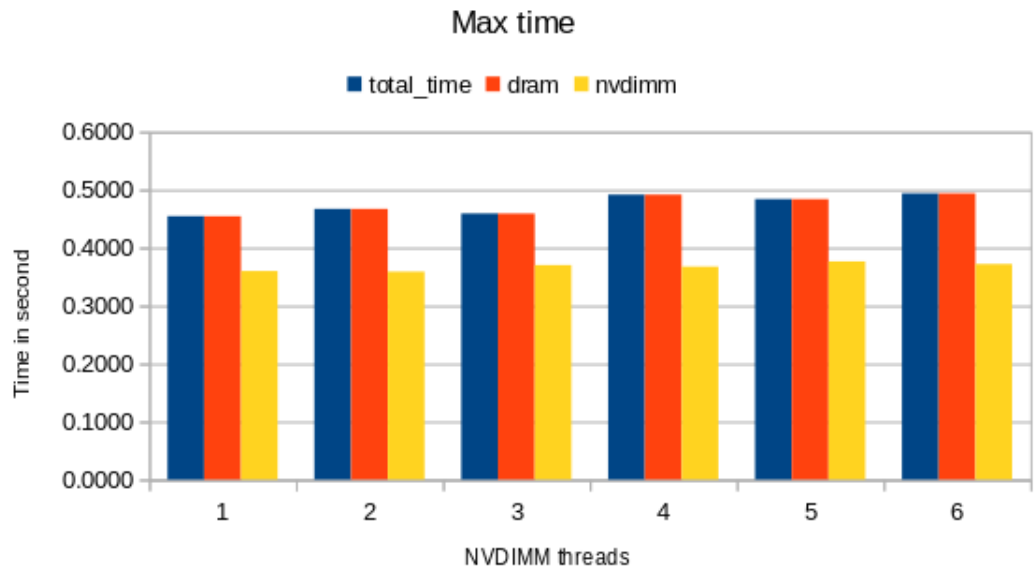

Figure 1: First version, max time

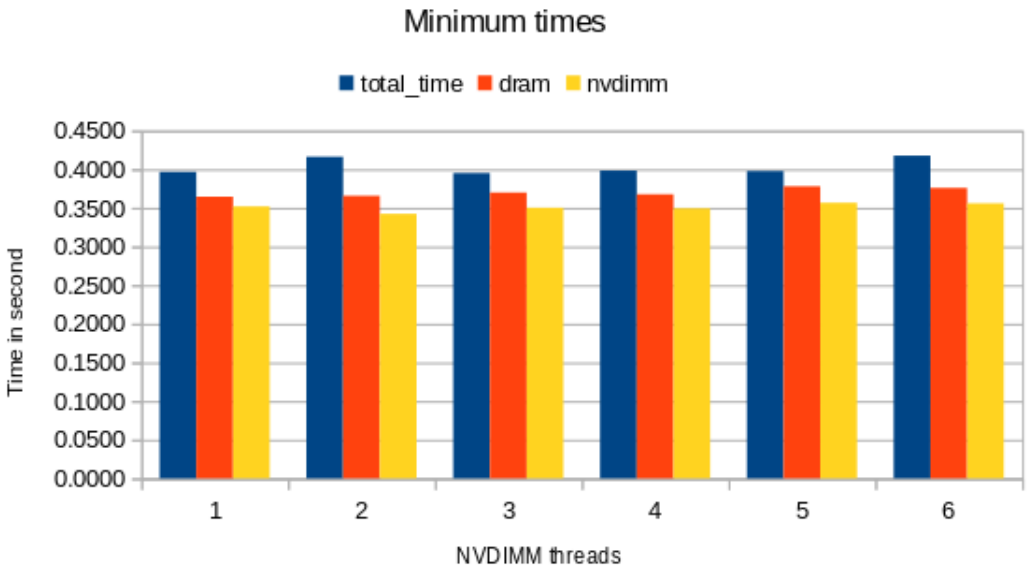

Figure 2: First version, minimum time

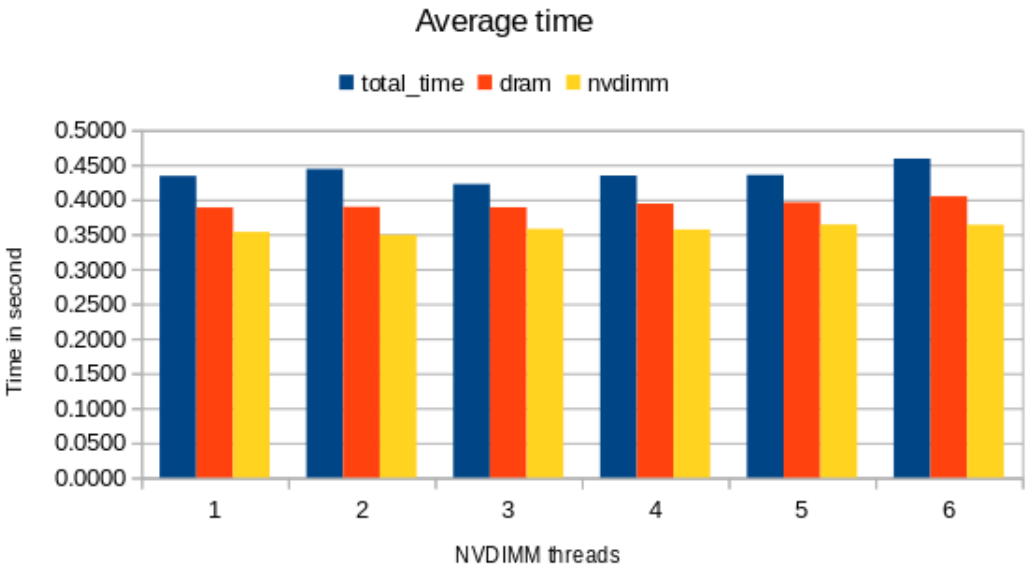

Figure 3: First version, average time

1.1.1 From previous weeks

		nvdimm	dram	nvdimm	dram	dram	dram	nvdimm	nvdimm	nvdimm	total	total	total
m	n	length	threads	threads	average	min	max	average	min	max	average	min	max
2,000	500,000	48	15	1	0.3885	0.3645	0.4543	0.3533	0.3519	0.3597	0.4340	0.3967	0.4543
2,000	500,000	95	14	2	0.3894	0.3657	0.4669	0.3491	0.3424	0.3587	0.4439	0.4163	0.4669
2,000	500,000	146	13	3	0.3888	0.3699	0.4589	0.3577	0.3502	0.3700	0.4221	0.3953	0.4590
2,000	500,000	195	12	4	0.3940	0.3676	0.4916	0.3568	0.3494	0.3673	0.4344	0.3984	0.4916
2,000	500,000	249	11	5	0.3958	0.3780	0.4837	0.3640	0.3566	0.3763	0.4353	0.3978	0.4838
2,000	500,000	296	10	6	0.4046	0.3759	0.4938	0.3636	0.3559	0.3718	0.4588	0.4176	0.4938

Table 2: First version, distribution

		nvdimm	dram	nvdimm	dram	dram	dram	nvdimm	nvdimm	nvdimm	total	total	total		
m	n	length	threads	threads	average	min	max	average	min	max	average	min	max		
2000	500000	48	15	1	0.3885	0.3645	0.4543	0.3533	0.3519	0.3597	0.4340	0.3967	0.4543		
0.3912	0.3925	0.3939	0.3952	0.3897	0.3878	0.3896	0.3927	0.3930	0.3936	0.3913	0.3928	0.3930	0.3929	0.3934	0.3525
0.4034	0.3877	0.3892	0.3905	0.3843	0.3832	0.3865	0.3895	0.3922	0.3933	0.3887	0.3891	0.3906	0.3924	0.4057	0.3524
0.4130	0.3893	0.3907	0.3922	0.3865	0.3844	0.3863	0.3895	0.3899	0.3905	0.3877	0.3898	0.3900	0.3898	0.3896	0.3546
0.3895	0.3902	0.3914	0.3928	0.3868	0.3857	0.3890	0.3918	0.3944	0.3954	0.3910	0.3914	0.3966	0.3947	0.3951	0.3525
0.3779	0.3791	0.3805	0.3863	0.3761	0.3742	0.3763	0.3793	0.3796	0.3850	0.3774	0.3794	0.4028	0.4475	0.4543	0.3524
0.3672	0.3693	0.3707	0.3720	0.3659	0.3645	0.3681	0.3712	0.3740	0.3752	0.3974	0.4315	0.4428	0.4240	0.4046	0.3597
0.3678	0.3694	0.3705	0.3768	0.3658	0.3701	0.3661	0.3695	0.4070	0.4477	0.4397	0.4198	0.3837	0.3698	0.3699	0.3519
0.3673	0.3746	0.3760	0.3728	0.3660	0.3646	0.4088	0.4433	0.4333	0.4163	0.3801	0.3708	0.3729	0.3749	0.3751	0.3522
0.3673	0.3688	0.3704	0.3720	0.4135	0.4508	0.4356	0.4121	0.3784	0.3755	0.3668	0.3692	0.3695	0.3695	0.3696	0.3521
0.3672	0.3772	0.4225	0.4514	0.4256	0.4023	0.3682	0.3720	0.3752	0.3763	0.3710	0.3774	0.3790	0.3755	0.3755	0.3522
		1	2	3	4	5	6	7	8	9	10				
Total Time		0.3952	0.4057	0.4130	0.3967	0.4543	0.4428	0.4477	0.4433	0.4508	0.4514				
		nvdimm	dram	nvdimm	dram	dram	dram	nvdimm	nvdimm	nvdimm	total	total	total		
m	n	length	threads	threads	average	min	max	average	min	max	average	min	max		
2000	500000	95	14	2	0.3894	0.3657	0.4669	0.3491	0.3424	0.3587	0.4439	0.4163	0.4669		
0.3918	0.3917	0.3917	0.3902	0.3911	0.3916	0.3918	0.3867	0.3907	0.3897	0.3921	0.3928	0.3906	0.4184	0.3520	0.3429
0.3868	0.3910	0.3909	0.3895	0.3878	0.3876	0.3881	0.3871	0.3905	0.3890	0.3891	0.3893	0.3911	0.4163	0.3534	0.3430
0.3855	0.3903	0.3902	0.3887	0.3895	0.3901	0.3902	0.3855	0.3893	0.3883	0.3907	0.3915	0.4205	0.4016	0.3585	0.3430
0.3697	0.3737	0.3737	0.3723	0.3706	0.3705	0.3711	0.3695	0.3735	0.3722	0.3941	0.4305	0.4536	0.4355	0.3518	0.3428
0.3699	0.3743	0.3743	0.3729	0.3737	0.3744	0.3743	0.3694	0.3966	0.4263	0.4489	0.4329	0.3867	0.3720	0.3579	0.3487
0.3657	0.3705	0.3703	0.3686	0.3668	0.3667	0.4032	0.4447	0.4458	0.4266	0.3871	0.3728	0.3707	0.3743	0.3515	0.3424
0.3726	0.3772	0.3769	0.3712	0.4089	0.4394	0.4318	0.4115	0.3865	0.3757	0.3733	0.3743	0.3767	0.3700	0.3516	0.3425
0.3920	0.3685	0.4053	0.4493	0.4410	0.4157	0.3810	0.3690	0.3679	0.3663	0.3661	0.3714	0.3687	0.3725	0.3587	0.3424
0.4344	0.4545	0.4447	0.4036	0.3795	0.3718	0.3760	0.3666	0.3706	0.3695	0.3720	0.3729	0.3705	0.3692	0.3516	0.3494
0.4669	0.4094	0.3828	0.3814	0.3797	0.3794	0.3800	0.3786	0.3824	0.3812	0.3810	0.3815	0.3830	0.3868	0.3519	0.3427
		1	2	3	4	5	6	7	8	9	10				
Total Time		0.4184	0.4163	0.4205	0.4536	0.4489	0.4458	0.4394	0.4493	0.4545	0.4669				

Table 3: First version part 1

		nvdimm	dram	nvdimm	dram	dram	dram	nvdimm	nvdimm	nvdimm	total	total	total		
m	n	length	threads	threads	average	min	max	average	min	max	average	min	max		
2000	500000	146	13	3	0.3888	0.3699	0.4589	0.3577	0.3502	0.3700	0.4221	0.3953	0.4590		
0.3889	0.3857	0.4451	0.3845	0.3876	0.3901	0.3878	0.3848	0.3806	0.3821	0.3798	0.3807	0.3828	0.3616	0.3580	0.3502
0.3880	0.4019	0.3909	0.3890	0.3893	0.3923	0.3921	0.3939	0.3865	0.3877	0.3853	0.3865	0.3883	0.3616	0.3671	0.3505
0.4303	0.4589	0.4298	0.3747	0.3780	0.3805	0.3781	0.3750	0.3709	0.3723	0.3699	0.3709	0.3731	0.3700	0.3579	0.3584
0.3971	0.4157	0.3864	0.3848	0.3852	0.3880	0.3882	0.3899	0.3822	0.3834	0.3803	0.3819	0.3839	0.3613	0.3585	0.3505
0.3889	0.3915	0.3915	0.3899	0.3926	0.3953	0.3931	0.3903	0.3862	0.3877	0.3849	0.3863	0.3883	0.3615	0.3581	0.3504
0.4231	0.3859	0.3917	0.3841	0.3846	0.3873	0.3875	0.3894	0.3815	0.3828	0.3801	0.3811	0.3832	0.3616	0.3592	0.3505
0.4006	0.3868	0.3873	0.3853	0.3886	0.3947	0.3888	0.3860	0.3817	0.3830	0.3803	0.3818	0.4215	0.3615	0.3581	0.3502
0.3789	0.3857	0.3822	0.3800	0.3806	0.3835	0.3837	0.3854	0.3817	0.3784	0.3754	0.4199	0.4330	0.3630	0.3580	0.3503
0.3795	0.3820	0.3824	0.3802	0.3837	0.3865	0.3880	0.3853	0.3761	0.3778	0.4067	0.4231	0.3976	0.3614	0.3583	0.3502
0.3774	0.3800	0.3804	0.3782	0.3791	0.3859	0.3822	0.3839	0.3752	0.4043	0.4265	0.4062	0.3768	0.3614	0.3579	0.3503
		1	2	3	4	5	6	7	8	9	10				
Total Time		0.4451	0.4019	0.4590	0.4158	0.3953	0.4231	0.4215	0.4330	0.4232	0.4265				
		nvdimm	dram	nvdimm	dram	dram	dram	nvdimm	nvdimm	nvdimm	total	total	total		
m	n	length	threads	threads	average	min	max	average	min	max	average	min	max		
2000	500000	195	12	4	0.3940	0.3676	0.4916	0.3568	0.3494	0.3673	0.4344	0.3984	0.4916		
0.3872	0.3868	0.3872	0.3893	0.3872	0.3894	0.4412	0.3909	0.3868	0.3812	0.3883	0.3935	0.3610	0.3568	0.3570	0.3497
0.3875	0.3875	0.3879	0.3894	0.3882	0.4464	0.3956	0.3937	0.3925	0.3849	0.3864	0.3992	0.3608	0.3570	0.3571	0.3502
0.3740	0.3735	0.3868	0.4345	0.4916	0.4548	0.3763	0.3776	0.3739	0.3680	0.3750	0.3804	0.3673	0.3641	0.3645	0.3496
0.3703	0.4364	0.4566	0.4436	0.3955	0.3708	0.3742	0.3725	0.3813	0.3676	0.3752	0.3783	0.3604	0.3565	0.3567	0.3498
0.4774	0.4403	0.4076	0.3818	0.3740	0.3764	0.3756	0.3781	0.3739	0.3679	0.3753	0.3806	0.3599	0.3566	0.3567	0.3494
0.3949	0.3917	0.3927	0.3938	0.3904	0.3926	0.3951	0.3938	0.3972	0.3894	0.3911	0.3993	0.3608	0.3569	0.3572	0.3497
0.3928	0.3923	0.3929	0.3969	0.3925	0.3947	0.3936	0.3960	0.3925	0.3864	0.3936	0.3984	0.3606	0.3570	0.3635	0.3498
0.4121	0.3897	0.3904	0.3917	0.3881	0.3904	0.3928	0.3915	0.3948	0.3876	0.3889	0.3967	0.3609	0.3569	0.3572	0.3497
0.3939	0.3924	0.3931	0.3949	0.3928	0.3948	0.3940	0.3964	0.3923	0.3867	0.3939	0.3986	0.3606	0.3569	0.3569	0.3500
0.3903	0.3900	0.3906	0.3918	0.3884	0.3907	0.3934	0.3917	0.3951	0.3877	0.3893	0.4295	0.3607	0.3571	0.3572	0.3499
		1	2	3	4	5	6	7	8	9	10				
Total Time		0.4413	0.4464	0.4916	0.4566	0.4774	0.3993	0.3984	0.4122	0.3986	0.4295				

Table 4: First version part 2

		nvdimm	dram	nvdimm	dram	dram	dram	nvdimm	nvdimm	nvdimm	total	total	total		
m	n	length	threads	threads	average	min	max	averag	min	max	averag	min	max		
2000	500000	249	11	5	0.3958	0.3780	0.4837	0.3640	0.3566	0.3763	0.4353	0.3978	0.4838		
0.3933	0.4028	0.4028	0.3949	0.3975	0.3980	0.3908	0.3948	0.3971	0.3903	0.3906	0.3687	0.3642	0.3640	0.3641	0.3568
0.4526	0.4837	0.3859	0.3833	0.3843	0.3831	0.3780	0.3817	0.3909	0.3802	0.3863	0.3683	0.3640	0.3639	0.3639	0.3570
0.3931	0.4026	0.3975	0.3950	0.3974	0.3982	0.3908	0.3949	0.3972	0.3902	0.3905	0.3686	0.3642	0.3640	0.3642	0.3568
0.3937	0.3973	0.3978	0.3957	0.3967	0.3957	0.3906	0.3943	0.3975	0.3932	0.3921	0.3687	0.3644	0.3641	0.3641	0.3569
0.4338	0.3926	0.3934	0.3906	0.3931	0.3939	0.3865	0.3907	0.3928	0.3860	0.3859	0.3763	0.3641	0.3663	0.3639	0.3571
0.4147	0.3912	0.3924	0.3900	0.3942	0.3895	0.3845	0.3883	0.3919	0.3868	0.4391	0.3684	0.3643	0.3641	0.3640	0.3567
0.3882	0.3907	0.3918	0.3888	0.3915	0.3958	0.3842	0.3888	0.3911	0.4121	0.4316	0.3686	0.3642	0.3641	0.3640	0.3570
0.3840	0.3878	0.3888	0.3902	0.3872	0.3859	0.3809	0.3845	0.3967	0.4386	0.4173	0.3698	0.3642	0.3640	0.3639	0.3567
0.3851	0.3922	0.3896	0.3869	0.3892	0.3936	0.3823	0.3867	0.4401	0.4237	0.3822	0.3684	0.3640	0.3639	0.3639	0.3569
0.3825	0.3866	0.3874	0.3848	0.3859	0.3847	0.3796	0.4454	0.4502	0.3817	0.3814	0.3737	0.3642	0.3694	0.3640	0.3566
		1	2	3	4	5	6	7	8	9	10				
Total Time		0.4029	0.4838	0.4027	0.3978	0.4339	0.4391	0.4316	0.4387	0.4401	0.4502				
		nvdimm	dram	nvdimm	dram	dram	dram	nvdimm	nvdimm	nvdimm	total	total	total		
m	n	length	threads	threads	average	min	max	averag	min	max	averag	min	max		
2000	500000	296	10	6	0.4046	0.3759	0.4938	0.3636	0.3559	0.3718	0.4588	0.4176	0.4938		
0.3955	0.3975	0.3966	0.3952	0.3950	0.3925	0.3888	0.3954	0.4560	0.4029	0.3663	0.3643	0.3636	0.3636	0.3637	0.3563
0.3972	0.4042	0.3982	0.4010	0.3952	0.3976	0.3936	0.4387	0.4020	0.4072	0.3664	0.3645	0.3639	0.3638	0.3637	0.3564
0.3902	0.3880	0.3866	0.3853	0.3851	0.3823	0.4310	0.4938	0.4322	0.3932	0.3663	0.3640	0.3635	0.3635	0.3635	0.3560
0.4035	0.4008	0.3987	0.4020	0.4015	0.3982	0.4024	0.4176	0.4029	0.4031	0.3666	0.3657	0.3651	0.3662	0.3645	0.3571
0.3899	0.3861	0.3849	0.3879	0.4284	0.4597	0.4791	0.3838	0.3861	0.3908	0.3663	0.3645	0.3635	0.3635	0.3634	0.3560
0.3851	0.3865	0.4013	0.4532	0.4722	0.4464	0.3759	0.3840	0.3846	0.3848	0.3718	0.3638	0.3635	0.3634	0.3634	0.3559
0.3903	0.3925	0.4086	0.4614	0.3996	0.3872	0.3836	0.3900	0.3921	0.3974	0.3689	0.3650	0.3633	0.3637	0.3660	0.3560
0.3911	0.4367	0.4468	0.3947	0.3888	0.3962	0.3874	0.3949	0.3998	0.3959	0.3665	0.3641	0.3637	0.3637	0.3705	0.3562
0.4742	0.4694	0.4422	0.3812	0.3807	0.3786	0.3812	0.3814	0.3835	0.3886	0.3662	0.3642	0.3634	0.3634	0.3635	0.3628
0.4453	0.4128	0.3897	0.3926	0.3865	0.3894	0.3852	0.3928	0.3935	0.4432	0.3660	0.3640	0.3636	0.3636	0.3636	0.3609
		1	2	3	4	5	6	7	8	9	10				
Total Time		0.4560	0.4387	0.4938	0.4176	0.4792	0.4723	0.4614	0.4468	0.4742	0.4453				

Table 5: First version part 3

		dram	dram	dram	dram	total	total	total							
m	n	threads	average	min	max	average	min	max							
2000	500000	16	0.3936	0.3809	0.4436	0.4255	0.4005	0.4436							
0.3978	0.3983	0.3987	0.3967	0.3966	0.3943	0.3956	0.3961	0.3946	0.3989	0.3980	0.3934	0.3957	0.3999	0.4001	0.3949
0.3969	0.3979	0.3983	0.3964	0.3961	0.3947	0.4004	0.3960	0.3944	0.3968	0.3965	0.3935	0.3955	0.3997	0.3993	0.3932
0.4262	0.3933	0.3936	0.3915	0.3913	0.3890	0.3906	0.3909	0.3893	0.3938	0.3929	0.3881	0.3905	0.3949	0.3950	0.3897
0.3943	0.3986	0.3959	0.3940	0.3935	0.3919	0.3941	0.3935	0.3919	0.3946	0.3938	0.3905	0.3930	0.3973	0.3963	0.4255
0.3976	0.3992	0.3961	0.3939	0.3937	0.3913	0.3929	0.3935	0.3915	0.3967	0.3953	0.3907	0.3927	0.3971	0.3990	0.4093
0.3873	0.3875	0.3884	0.3857	0.3858	0.3842	0.3864	0.3858	0.3837	0.3869	0.3900	0.3830	0.3853	0.4007	0.4436	0.4211
0.3868	0.3876	0.3883	0.3860	0.3895	0.3831	0.3847	0.3848	0.3879	0.3884	0.3869	0.3822	0.4012	0.4353	0.4240	0.3842
0.3846	0.3859	0.3864	0.3846	0.3840	0.3824	0.3883	0.3839	0.3819	0.3850	0.3845	0.4074	0.4318	0.4244	0.3876	0.3809
0.3869	0.3877	0.3880	0.3858	0.3856	0.3830	0.3839	0.3845	0.3826	0.3887	0.4105	0.4239	0.4100	0.3893	0.3935	0.3887
0.3849	0.3905	0.3870	0.3851	0.3849	0.3832	0.3856	0.3843	0.3829	0.4121	0.4335	0.4059	0.3882	0.3889	0.3881	0.3825
Total time		0.4001	0.4005	0.4262	0.4255	0.4093	0.4436	0.4353	0.4318	0.4240	0.4335				

Table 6: First version, dram only

1.2 Second version

Same as the first version there are two groups of threads that works in parallel in this program. The first group of threads works on the part of the data that is stored on DRAM and the other works on the data stored on NVDIMM. In this version the two threads that has a row of elements with neighbours in the other type of memory will not directly access this data. Instead the two arrays will have their own ghost array on their memory that they will access instead of fetching data from the other side.

Listing 2: Second version

```
while(k<K_length){
  #pragma omp barrier
  #pragma omp single
    {
    total_time[k] = mysecond();
  }
  if( thread_id < dram_threads ){
    individual_time[k][thread_id] = mysecond();
    for( i=slice_start; i<slice_end; i++){
      for( j=1; j<nMinusOne; j++){
        temp = A[i-1][j-1] + A[i-1][j] + A[i-1][j+1]+
             A[i][j-1]   +     A[i][j+1]+
             A[i+1][j-1] + A[i+1][j] + A[i+1][j+1];
        B[i][j] = temp*inverseEigth;
      }
    }
    individual_time[k][thread_id] = mysecond() -
       individual_time[k][thread_id];
  }else{
    individual_time[k][thread_id] = mysecond();
    for( i=slice_start; i<slice_end; i++){
      for( j=1; j<nMinusOne; j++){
        temp = D_RO(C)[(i-1)*n+(j-1)] +
           D_RO(C)[(i-1)*n+j] + D_RO(C)[(i-1)*n+(j+1)]+
              D_RO(C)[i*n+(j-1)]     +
                 D_RO(C)[i*n+(j+1)]+
             D_RO(C)[(i+1)*n+(j-1)] + D_RO(C)[(i+1)*n+j]
                + D_RO(C)[(i+1)*n+(j+1)];
        D_RW(D)[i*n+j] = temp*inverseEigth;
      }
    }
```

```
28        individual_time[k][thread_id] = mysecond() -
              individual_time[k][thread_id];
29      }
30      total_time[k] = mysecond() - total_time[k];
31      #pragma omp barrier
32      #pragma omp single
33      {
34        tempArray = B;
35        B=A;
36        A=tempArray;
37        total_time[k] = mysecond() - total_time[k];
38        temp_nvdimm = C;
39        C = D;
40        D = temp_nvdimm;
41        k++;
42      }
43      #pragma omp barrier
44  }//End of while
```

m	2,000			
n	500,000			
total M	8,000			
speed				
Nvm-th	dram	nvm	nvmpar	rows
1	64,447	3,248	383.84	48
2	61,872	6,500	760.55	95
3	58,423	9,979	1167.10	146
4	55,367	13,416	1560.39	195
5	51,955	16,933	1966.44	246
6	48,656	20,438	2366.40	296

Table 7: First version, distribution

		nvdimm	dram	nvdimm	dram	dram	dram	nvdimm	nvdimm	nvdimm	total	total	total		
m	n	length	threads	threads	average	min	max	average	min	max	average	min	max		
2000	500000	48	15	1	0.3912	0.3664	0.4737	0.3752	0.3746	0.3777	0.4105	0.3795	0.4513		
0.3898	0.3949	0.3940	0.3943	0.3967	0.3970	0.3972	0.3900	0.3955	0.3957	0.3942	0.3918	0.3925	0.3928	0.3924	0.3762
0.4004	0.3938	0.3926	0.3925	0.3938	0.3924	0.3932	0.3874	0.3916	0.3950	0.3935	0.3947	0.3955	0.3959	0.3958	0.3777
0.4274	0.3900	0.3893	0.3893	0.3918	0.3918	0.3922	0.3846	0.3907	0.3907	0.3893	0.3865	0.3877	0.3879	0.3876	0.3751
0.3881	0.3943	0.3975	0.3931	0.3944	0.3934	0.3939	0.3885	0.3924	0.3956	0.3943	0.3955	0.3962	0.3965	0.3974	0.3753
0.3822	0.3879	0.3826	0.3826	0.3852	0.3896	0.3858	0.3778	0.3882	0.3840	0.3826	0.3796	0.3825	0.4412	0.4703	0.3749
0.3676	0.3775	0.3720	0.3718	0.3727	0.3768	0.3725	0.3664	0.3758	0.3744	0.3876	0.4354	0.4737	0.4256	0.4041	0.3747
0.3667	0.3726	0.3716	0.3768	0.3791	0.3747	0.3753	0.3669	0.3966	0.4519	0.4643	0.4176	0.3806	0.3755	0.3693	0.3747
0.3683	0.3799	0.3736	0.3732	0.3749	0.3789	0.4014	0.4407	0.4521	0.4170	0.3759	0.3766	0.3772	0.3777	0.3771	0.3747
0.3688	0.3739	0.3732	0.3732	0.4077	0.4609	0.4603	0.4089	0.3745	0.3789	0.3731	0.3704	0.3715	0.3720	0.3713	0.3746
0.3683	0.3744	0.4100	0.4600	0.4436	0.4035	0.3737	0.3679	0.3721	0.3759	0.3741	0.3757	0.3765	0.3822	0.3764	0.3747
		1	2	3	4	5	6	7	8	9	10				
Total Time		0.3786	0.3843	0.3808	0.3795	0.4310	0.4008	0.4231	0.4159	0.4513	0.4277				
		nvdimm	dram	nvdimm	dram	dram	dram	nvdimm	nvdimm	nvdimm	total	total	total		
m	n	length	threads	threads	average	min	max	average	min	max	average	min	max		
2000	500000	95	14	2	0.3915	0.3656	0.4667	0.3724	0.3664	0.3812	0.3921	0.3760	0.4177		
0.3912	0.3885	0.3874	0.3871	0.4204	0.3922	0.3921	0.3915	0.3885	0.3912	0.3932	0.3924	0.3918	0.3925	0.3759	0.3667
0.3859	0.3900	0.3889	0.4066	0.4126	0.3897	0.3915	0.3900	0.3904	0.3891	0.3909	0.3899	0.3941	0.3900	0.3775	0.3670
0.3744	0.3988	0.4403	0.4660	0.3823	0.3818	0.3863	0.3812	0.3778	0.3808	0.3876	0.3864	0.3816	0.3824	0.3747	0.3667
0.4342	0.4650	0.4326	0.3793	0.3747	0.3739	0.3759	0.3746	0.3747	0.3730	0.3751	0.3739	0.3738	0.3742	0.3745	0.3735
0.4264	0.3902	0.3850	0.3837	0.3904	0.3905	0.3903	0.3900	0.3863	0.3897	0.3918	0.3907	0.3903	0.3910	0.3747	0.3668
0.3898	0.3934	0.3923	0.3903	0.3938	0.3932	0.3951	0.3937	0.3938	0.3926	0.3944	0.3935	0.3931	0.4074	0.3748	0.3743
0.3802	0.3787	0.3773	0.3754	0.3820	0.3820	0.3864	0.3813	0.3786	0.3809	0.3879	0.4026	0.4373	0.4667	0.3747	0.3669
0.3716	0.3740	0.3728	0.3706	0.3748	0.3786	0.3759	0.3792	0.3750	0.3935	0.4215	0.4566	0.4304	0.3871	0.3745	0.3737
0.3656	0.3692	0.3680	0.3661	0.3729	0.3726	0.3774	0.3979	0.4285	0.4576	0.4393	0.3856	0.3773	0.3731	0.3812	0.3664
0.3704	0.3742	0.3775	0.3705	0.3747	0.3970	0.4297	0.4426	0.4307	0.3913	0.3795	0.3741	0.3735	0.3739	0.3746	0.3665
		1	2	3	4	5	6	7	8	9	10				
Total Time		0.3833	0.3895	0.4177	0.3791	0.3786	0.3930	0.4071	0.3893	0.3987	0.3760				

Table 8: First version part 1

		nvdimm	dram	nvdimm	dram	dram	dram	nvdimm	nvdimm	nvdimm	total	total	total		
m	n	length	threads	threads	average	min	max	average	min	max	average	min	max		
2000	500000	146	13	3	0.3905	0.3612	0.4555	0.3802	0.3737	0.3893	0.4088	0.3805	0.4319		
0.3891	0.3870	0.3869	0.3859	0.3906	0.3882	0.3887	0.3887	0.4345	0.3871	0.3861	0.3854	0.3801	0.3837	0.3821	0.3741
0.3857	0.3881	0.3886	0.3871	0.3921	0.3905	0.3915	0.4144	0.3964	0.3939	0.3928	0.3911	0.3832	0.3848	0.3823	0.3742
0.3770	0.3793	0.3793	0.3784	0.3870	0.3908	0.4339	0.4423	0.4091	0.3834	0.3785	0.3780	0.3733	0.3820	0.3823	0.3740
0.3642	0.3669	0.3671	0.3656	0.4193	0.4446	0.4477	0.4163	0.3753	0.3730	0.3718	0.3699	0.3612	0.3819	0.3819	0.3739
0.3692	0.3710	0.4167	0.4468	0.4423	0.4154	0.3781	0.3730	0.3704	0.3713	0.3703	0.3698	0.3646	0.3817	0.3817	0.3877
0.4038	0.4555	0.4417	0.4106	0.3781	0.3703	0.3719	0.3719	0.3728	0.3788	0.3731	0.3712	0.3676	0.3819	0.3817	0.3737
0.3868	0.4170	0.3890	0.3881	0.3925	0.3903	0.3907	0.3908	0.3880	0.3889	0.3883	0.3878	0.3831	0.3823	0.3822	0.3741
0.3876	0.3908	0.3904	0.3888	0.3943	0.3925	0.3935	0.3935	0.3946	0.3958	0.3948	0.3932	0.3852	0.3822	0.3821	0.3741
0.4279	0.3837	0.3838	0.3828	0.3872	0.3849	0.3898	0.3899	0.3827	0.3838	0.3830	0.3823	0.4202	0.3893	0.3821	0.3742
0.4017	0.3710	0.3713	0.3695	0.3758	0.3785	0.3751	0.3747	0.3759	0.3818	0.4072	0.4449	0.4469	0.3818	0.3817	0.3738
		1	2	3	4	5	6	7	8	9	10				
Total Time		0.3806	0.3825	0.4099	0.4319	0.4242	0.4293	0.3805	0.3811	0.4084	0.4316				
		nvdimm	dram	nvdimm	dram	dram	dram	nvdimm	nvdimm	nvdimm	total	total	total		
m	n	length	threads	threads	average	min	max	average	min	max	average	min	max		
2000	500000	195	12	4	0.3935	0.3649	0.4712	0.3810	0.3733	0.3886	0.4195	0.3831	0.4450		
0.3931	0.3950	0.3945	0.3977	0.3977	0.3975	0.3952	0.3927	0.3868	0.3861	0.3895	0.3949	0.3828	0.3816	0.3817	0.3739
0.3832	0.3858	0.3850	0.3876	0.3875	0.3852	0.3894	0.3922	0.3777	0.3777	0.4209	0.4407	0.3842	0.3873	0.3816	0.3798
0.3752	0.3775	0.3768	0.3842	0.3802	0.3799	0.3778	0.3748	0.4025	0.4481	0.4622	0.4075	0.3814	0.3814	0.3817	0.3734
0.3687	0.3719	0.3709	0.3779	0.3735	0.3709	0.4157	0.4712	0.4554	0.4164	0.3714	0.3725	0.3813	0.3812	0.3814	0.3792
0.3736	0.3753	0.3746	0.3825	0.4165	0.4539	0.4561	0.4085	0.3706	0.3653	0.3748	0.3753	0.3816	0.3814	0.3814	0.3792
0.3688	0.3714	0.4143	0.4642	0.4575	0.4245	0.3751	0.3739	0.3689	0.3681	0.3660	0.3722	0.3813	0.3876	0.3813	0.3733
0.3990	0.4542	0.4523	0.4161	0.3864	0.3772	0.3747	0.3718	0.3654	0.3649	0.3685	0.3787	0.3879	0.3813	0.3879	0.3734
0.4287	0.4312	0.3856	0.3865	0.3865	0.3837	0.3883	0.3874	0.3769	0.3764	0.3797	0.3855	0.3818	0.3816	0.3818	0.3736
0.3933	0.3949	0.3942	0.3975	0.3974	0.3971	0.3951	0.3925	0.3864	0.3862	0.3895	0.3948	0.3818	0.3817	0.3819	0.3738
0.4034	0.3891	0.3930	0.3908	0.3952	0.3882	0.3928	0.3914	0.3812	0.3811	0.3843	0.4331	0.3817	0.3816	0.3886	0.3737
		1	2	3	4	5	6	7	8	9	10				
Total Time		0.3812	0.4136	0.4370	0.4450	0.4343	0.4315	0.4234	0.4198	0.3831	0.3875				

Table 9: First version part 2

		nvdimm	dram	nvdimm	dram	dram	dram	nvdimm	nvdimm	nvdimm	total	total	total		
m	n	length	threads	threads	average	min	max	average	min	max	average	min	max		
2000	500000	249	11	5	0.3970	0.3809	0.4542	0.3881	0.3813	0.3950	0.4074	0.3864	0.4319		
0.4362	0.4061	0.3946	0.3900	0.3927	0.3948	0.3943	0.3912	0.3968	0.3988	0.3929	0.3905	0.3897	0.3894	0.3895	0.3816
0.3948	0.3992	0.3976	0.3934	0.3943	0.3985	0.3980	0.3928	0.3957	0.3975	0.4004	0.3920	0.3896	0.3895	0.3894	0.3816
0.3951	0.3993	0.3977	0.3931	0.3959	0.3981	0.3976	0.3943	0.3999	0.4019	0.3960	0.3895	0.3897	0.3893	0.3894	0.3816
0.4186	0.4012	0.3981	0.3898	0.3906	0.3952	0.3946	0.3892	0.3921	0.3942	0.3971	0.3895	0.3896	0.3894	0.3894	0.3817
0.4542	0.3888	0.3874	0.3822	0.3848	0.3912	0.3870	0.3833	0.3896	0.3916	0.4358	0.3895	0.3894	0.3891	0.3892	0.3813
0.3867	0.3912	0.3897	0.3851	0.3866	0.3907	0.3940	0.3844	0.3879	0.4200	0.4443	0.3893	0.3893	0.3892	0.3892	0.3815
0.3868	0.3911	0.3901	0.3850	0.3875	0.3902	0.3894	0.3860	0.3987	0.4424	0.4184	0.3893	0.3894	0.3893	0.3893	0.3813
0.3827	0.3916	0.3859	0.3809	0.3824	0.3870	0.3864	0.4064	0.4510	0.4353	0.3885	0.3893	0.3894	0.3945	0.3893	0.3837
0.3814	0.3861	0.3845	0.3839	0.3818	0.3848	0.4062	0.4530	0.4451	0.3885	0.3825	0.3894	0.3893	0.3892	0.3892	0.3814
0.3853	0.3902	0.3887	0.3837	0.3850	0.3897	0.4432	0.4232	0.3868	0.3888	0.3914	0.3950	0.3895	0.3892	0.3891	0.3814
		1	2	3	4	5	6	7	8	9	10				
Total Time		0.3924	0.3881	0.3864	0.3892	0.4319	0.4106	0.4044	0.4166	0.4249	0.4139				
		nvdimm	dram	nvdimm	dram	dram	dram	nvdimm	nvdimm	nvdimm	total	total	total		
m	n	length	threads	threads	average	min	max	average	min	max	average	min	max		
2000	500000	296	10	6	0.4015	0.3822	0.4758	0.3882	0.3811	0.3918	0.4100	0.3906	0.4451		
0.4560	0.4074	0.4008	0.3978	0.4002	0.3994	0.3924	0.3929	0.3939	0.3942	0.3904	0.3894	0.3892	0.3893	0.3894	0.3814
0.4021	0.4124	0.4026	0.4001	0.4008	0.3999	0.3958	0.3957	0.3967	0.3970	0.3918	0.3896	0.3893	0.3892	0.3894	0.3815
0.4036	0.4052	0.4037	0.4008	0.4032	0.4026	0.3956	0.3958	0.3967	0.3971	0.3894	0.3897	0.3894	0.3893	0.3894	0.3815
0.4190	0.4024	0.4008	0.3982	0.4030	0.4032	0.3939	0.3940	0.3950	0.3956	0.3894	0.3895	0.3893	0.3893	0.3894	0.3815
0.4687	0.3973	0.3923	0.3893	0.3919	0.3912	0.3838	0.3841	0.3850	0.4330	0.3892	0.3893	0.3892	0.3892	0.3892	0.3861
0.3930	0.3950	0.3933	0.3907	0.3913	0.3908	0.3857	0.3864	0.4278	0.4611	0.3891	0.3892	0.3891	0.3890	0.3892	0.3864
0.3924	0.3943	0.3966	0.3893	0.3920	0.3915	0.3832	0.4220	0.4591	0.4082	0.3890	0.3893	0.3890	0.3891	0.3891	0.3811
0.3933	0.3958	0.3940	0.3911	0.3916	0.3914	0.4021	0.4487	0.4150	0.3877	0.3891	0.3892	0.3891	0.3891	0.3892	0.3865
0.3951	0.4009	0.3957	0.3922	0.3949	0.3943	0.4441	0.4265	0.3872	0.3885	0.3891	0.3893	0.3892	0.3893	0.3891	0.3813
0.3888	0.3948	0.3895	0.3866	0.3980	0.4758	0.4524	0.3822	0.3832	0.3837	0.3890	0.3893	0.3890	0.3890	0.3891	0.3811
		1	2	3	4	5	6	7	8	9	10				
Total Time		0.3955	0.3906	0.3928	0.3914	0.4258	0.4210	0.4058	0.4049	0.4124	0.4451				

Table 10: First version part 3

1.3 From previous weeks

		dram	dram	dram	dram	total	total	total							
m	n	threads	average	min	max	average	min	max							
2000	500000	16	0.3957	0.3727	0.4556	0.3583	0.3727	0.4556							
0.3980	0.4009	0.4019	0.4002	0.4008	0.3996	0.3996	0.3985	0.4017	0.4021	0.4001	0.4004	0.3998	0.4007	0.4016	0.4011
0.3960	0.3989	0.4044	0.3982	0.4168	0.3974	0.3977	0.3967	0.3996	0.3998	0.3981	0.3981	0.3976	0.3987	0.3995	0.3990
0.3767	0.3798	0.4116	0.4453	0.4556	0.4198	0.3775	0.3837	0.3803	0.3806	0.3845	0.3794	0.3782	0.3846	0.3860	0.3796
0.4200	0.4542	0.4555	0.4154	0.3878	0.3796	0.3740	0.3727	0.3759	0.3768	0.3806	0.3745	0.3738	0.3811	0.3755	0.3756
0.4421	0.4166	0.3869	0.3878	0.3856	0.3838	0.3844	0.3831	0.3862	0.3870	0.3849	0.3853	0.3846	0.3856	0.3861	0.4287
0.3941	0.3960	0.4019	0.3955	0.3969	0.3991	0.3952	0.3947	0.3973	0.3978	0.3961	0.3962	0.3957	0.3967	0.4188	0.4104
0.3819	0.3893	0.3863	0.3882	0.3887	0.3828	0.3828	0.3819	0.3853	0.3858	0.3839	0.3844	0.3960	0.4323	0.4407	0.4164
0.3832	0.3855	0.3878	0.3900	0.3861	0.3897	0.3841	0.3838	0.3873	0.3878	0.3901	0.4097	0.4364	0.4274	0.3977	0.3861
0.3915	0.3885	0.3906	0.3883	0.3893	0.3877	0.3876	0.3868	0.3902	0.3906	0.4187	0.4331	0.4146	0.3888	0.3900	0.3892
0.3942	0.3974	0.3991	0.3971	0.3980	0.3959	0.3964	0.3956	0.3985	0.4031	0.3973	0.4151	0.3966	0.3978	0.3985	0.3978
0.3980	0.4009	0.4020	0.4002	0.4008	0.3996	0.3996	0.3985	0.4017	0.4021	0.4001	0.4004	0.3998	0.4007	0.4016	0.4011
0.3960	0.3989	0.4044	0.3982	0.4168	0.3974	0.3977	0.3967	0.3996	0.3998	0.3981	0.3981	0.3976	0.3987	0.3995	0.3990
0.3767	0.3798	0.4116	0.4453	0.4556	0.4198	0.3775	0.3837	0.3803	0.3806	0.3845	0.3794	0.3782	0.3846	0.3860	0.3796
0.4200	0.4542	0.4555	0.4154	0.3878	0.3796	0.3740	0.3727	0.3759	0.3768	0.3806	0.3745	0.3738	0.3811	0.3755	0.3756
0.4421	0.4166	0.3869	0.3878	0.3856	0.3838	0.3844	0.3831	0.3862	0.3870	0.3849	0.3853	0.3846	0.3856	0.3861	0.4287
0.3941	0.3960	0.4019	0.3955	0.3969	0.3991	0.3952	0.3947	0.3973	0.3978	0.3961	0.3962	0.3957	0.3967	0.4188	0.4104
0.3819	0.3893	0.3863	0.3882	0.3887	0.3828	0.3828	0.3819	0.3853	0.3858	0.3839	0.3844	0.3960	0.4323	0.4407	0.4164
0.3832	0.3855	0.3878	0.3900	0.3861	0.3897	0.3841	0.3838	0.3873	0.3878	0.3901	0.4097	0.4364	0.4274	0.3977	0.3861
0.3915	0.3885	0.3906	0.3883	0.3893	0.3877	0.3876	0.3868	0.3902	0.3906	0.4187	0.4331	0.4146	0.3888	0.3900	0.3892
0.3942	0.3974	0.3991	0.3971	0.3980	0.3959	0.3964	0.3956	0.3985	0.4031	0.3973	0.4151	0.3966	0.3978	0.3985	0.3978

Table 11: First version, dram only

m:1000	n:1000000	nvdimm_size:48													
		nvdimm	dram	nvdimm	dram	dram	dram	nvdimm	nvdimm	nvdimm	total	total	total		
m	n	length	threads	threads	average	min	max	average	min	max	average	min	max		
1000	1000000	296	10	6	0.4122	0.3445	0.4545	0.9137	0.7143	0.7568	0.9138	0.7143	0.7568		
0.3078	0.3090	0.2965	0.3148	0.3173	0.3173	0.3156	0.3147	0.3150	0.3357	2.4630	2.6225	2.6307	2.6286	2.6321	2.6078
0.4292	0.3480	0.2647	0.2862	0.3140	0.4524	0.4440	0.4467	0.4473	0.4545	0.6976	0.7568	0.7558	0.7556	0.7562	0.7427
0.3301	0.3310	0.3202	0.3402	0.3397	0.3406	0.3370	0.3380	0.3381	0.3445	0.6661	0.7234	0.7196	0.7233	0.7192	0.7076
0.3165	0.3172	0.3275	0.4126	0.4360	0.3275	0.3235	0.3247	0.3249	0.3311	0.6576	0.7152	0.7162	0.7164	0.7204	0.7038
0.4152	0.4485	0.4224	0.3657	0.3132	0.3192	0.3103	0.3113	0.3115	0.3174	0.6613	0.7180	0.7155	0.7159	0.7160	0.7050
0.3587	0.3255	0.3145	0.3352	0.3348	0.3357	0.3320	0.3329	0.3331	0.3855	0.6565	0.7139	0.7114	0.7119	0.7144	0.6988
0.3159	0.3166	0.3056	0.3262	0.3256	0.3262	0.3224	0.3545	0.4240	0.4040	0.6634	0.7230	0.7179	0.7175	0.7185	0.7098
0.3163	0.3169	0.3062	0.3264	0.3257	0.3270	0.3953	0.4165	0.3479	0.3305	0.6561	0.7117	0.7143	0.7141	0.7124	0.7011
0.3146	0.3153	0.3044	0.3364	0.3870	0.4390	0.3747	0.3222	0.3250	0.3286	0.6592	0.7148	0.7169	0.7169	0.7154	0.7019
0.3120	0.3239	0.3759	0.4376	0.3846	0.3344	0.3197	0.3204	0.3209	0.3270	0.6585	0.7147	0.7129	0.7131	0.7182	0.7028
		nvdimm	dram	nvdimm	dram	dram	dram	nvdimm	nvdimm	nvdimm	total	total	total		
m	n	length	threads	threads	average	min	max	average	min	max	average	min	max		
1000	1000000	246	11	5	0.4045	0.3475	0.4516	0.8973	0.7128	0.7561	0.8973	0.7128	0.7561		
0.3190	0.3236	0.3247	0.3218	0.3171	0.3235	0.3191	0.3139	0.3149	0.3148	0.3351	2.3276	2.4411	2.4358	2.4330	2.4191
0.4494	0.4509	0.4516	0.3960	0.2946	0.3014	0.2966	0.2911	0.2919	0.3382	0.4341	0.6935	0.7507	0.7508	0.7527	0.7389
0.3420	0.3433	0.3475	0.3438	0.3393	0.3452	0.3413	0.3363	0.3373	0.3369	0.3421	0.6751	0.7314	0.7325	0.7332	0.7210
0.3335	0.3349	0.3394	0.3355	0.3304	0.3368	0.3329	0.3269	0.3671	0.3858	0.3329	0.6550	0.7122	0.7092	0.7162	0.6999
0.3223	0.3238	0.3286	0.3243	0.3188	0.3443	0.3794	0.4109	0.3938	0.3297	0.3306	0.6576	0.7105	0.7102	0.7128	0.6981
0.3183	0.3198	0.3245	0.3524	0.4056	0.4203	0.3745	0.3351	0.3129	0.3123	0.3180	0.6584	0.7103	0.7116	0.7150	0.7035
0.3249	0.3553	0.4027	0.4080	0.3487	0.3284	0.3288	0.3187	0.3199	0.3195	0.3251	0.6584	0.7166	0.7114	0.7113	0.6982
0.4309	0.4103	0.3677	0.3209	0.3164	0.3226	0.3182	0.3130	0.3142	0.3137	0.3617	0.6597	0.7561	0.7141	0.7161	0.7026
0.3276	0.3267	0.3273	0.3234	0.3176	0.3247	0.3202	0.3278	0.3757	0.4246	0.4096	0.6602	0.7141	0.7123	0.7086	0.6972
0.3174	0.3190	0.3239	0.3196	0.3186	0.3579	0.3982	0.4300	0.3807	0.3300	0.3160	0.6578	0.7113	0.7149	0.7129	0.6977
		nvdimm	dram	nvdimm	dram	dram	dram	nvdimm	nvdimm	nvdimm	total	total	total		
m	n	length	threads	threads	average	min	max	average	min	max	average	min	max		
1000	1000000	195	12	4	0.4194	0.3610	0.4609	0.8003	0.6938	0.7376	0.8003	0.6938	0.7376		
0.3339	0.3425	0.3327	0.3383	0.3440	0.3444	0.3423	0.3390	0.3386	0.3393	0.3393	0.3510	1.5855	1.6687	1.6728	1.6619
0.4408	0.4505	0.3848	0.3175	0.3247	0.3249	0.3223	0.3189	0.3182	0.3190	0.4399	0.4609	0.6780	0.7376	0.7374	0.7247
0.3505	0.3593	0.3498	0.3551	0.3607	0.3610	0.3587	0.3556	0.3554	0.3559	0.3560	0.3582	0.6424	0.6976	0.6991	0.6834
0.3319	0.3408	0.3305	0.3361	0.3426	0.3429	0.3403	0.3855	0.4219	0.4545	0.3533	0.3399	0.6414	0.7010	0.7011	0.6891
0.3199	0.3287	0.3183	0.3239	0.3864	0.4370	0.4536	0.4050	0.3639	0.3253	0.3250	0.3280	0.6411	0.7030	0.7038	0.6879
0.3340	0.3909	0.4350	0.4574	0.4080	0.3506	0.3294	0.3259	0.3255	0.3263	0.3262	0.3284	0.6421	0.7035	0.7026	0.6897
0.4529	0.4074	0.3426	0.3353	0.3416	0.3419	0.3395	0.3362	0.3357	0.3364	0.3362	0.3890	0.6393	0.6938	0.6938	0.6814
0.3506	0.3591	0.3494	0.3549	0.3607	0.3610	0.3586	0.3556	0.3552	0.3558	0.3557	0.3581	0.6421	0.6952	0.6962	0.6845
0.3416	0.3503	0.3400	0.3462	0.3521	0.3524	0.3498	0.3468	0.3463	0.3470	0.3989	0.4004	0.6394	0.6946	0.6980	0.6814
0.3326	0.3416	0.3311	0.3369	0.3434	0.3437	0.3413	0.3433	0.3897	0.4417	0.3980	0.3499	0.6483	0.6974	0.6950	0.6823

Table 12: First version, more detailed 1

		nvdimm	dram	nvdimm	dram	dram	dram	nvdimm	nvdimm	nvdimm	total	total	total		
m	n	length	threads	threads	average	min	max	average	min	max	average	min	max		
1000	1000000	146	13	3	0.4255	0.4131	0.4619	0.7816	0.6928	0.7811	0.7816	0.6928	0.7811		
0.3501	0.3519	0.3500	0.3504	0.3500	0.3506	0.3512	0.3487	0.3498	0.3488	0.3497	0.3478	0.3600	1.3751	1.4686	1.4489
0.3158	0.3696	0.4255	0.4501	0.4500	0.4503	0.4236	0.3141	0.3149	0.3142	0.3151	0.3137	0.3251	0.7087	0.7811	0.7682
0.4619	0.4170	0.3588	0.3396	0.3412	0.3400	0.3407	0.3380	0.3390	0.3378	0.3387	0.3372	0.3793	0.6535	0.7060	0.6919
0.3443	0.3465	0.3444	0.3448	0.3447	0.3452	0.3458	0.3430	0.3466	0.3430	0.3867	0.4325	0.4108	0.6426	0.6948	0.6811
0.3460	0.3502	0.3457	0.3463	0.3461	0.3465	0.3472	0.3444	0.3792	0.4135	0.4033	0.3580	0.3486	0.6430	0.6945	0.6855
0.3462	0.3483	0.3463	0.3467	0.3463	0.3470	0.3477	0.3983	0.4137	0.3779	0.3454	0.3441	0.3492	0.6434	0.6928	0.6871
0.3438	0.3482	0.3439	0.3441	0.3507	0.4008	0.4463	0.3891	0.3435	0.3422	0.3433	0.3417	0.3468	0.6430	0.6947	0.6854
0.3471	0.3490	0.3471	0.3829	0.4342	0.3900	0.3484	0.3456	0.3467	0.3455	0.3463	0.3450	0.3501	0.6420	0.6931	0.6864
0.3474	0.3675	0.4131	0.4088	0.3547	0.3479	0.3486	0.3462	0.3471	0.3460	0.3469	0.3453	0.3505	0.6427	0.6955	0.6845
0.4163	0.4296	0.3793	0.3465	0.3470	0.3436	0.3443	0.3415	0.3427	0.3418	0.3422	0.3410	0.3575	0.6423	0.6950	0.6825

		nvdimm	dram	nvdimm	dram	dram	dram	nvdimm	nvdimm	nvdimm	total	total	total		
m	n	length	threads	threads	average	min	max	average	min	max	average	min	max		
1000	1000000	95	14	2	0.4314	0.3890	0.4787	0.7298	0.6581	0.7028	0.7298	0.6581	0.7028		
0.3621	0.3699	0.3672	0.3706	0.3715	0.3663	0.3618	0.3581	0.3588	0.3578	0.3587	0.3593	0.3708	0.3880	1.2456	1.3069
0.4731	0.4787	0.4398	0.3529	0.3537	0.3480	0.3431	0.3395	0.3401	0.3391	0.3398	0.3405	0.3529	0.3651	0.6633	0.7028
0.3696	0.3774	0.3747	0.3778	0.3788	0.3740	0.3693	0.3659	0.3666	0.3656	0.3664	0.3668	0.3782	0.3890	0.6427	0.6620
0.3611	0.3690	0.3678	0.3696	0.3704	0.3676	0.3606	0.3573	0.3581	0.3570	0.3578	0.3584	0.4079	0.4649	0.6263	0.6631
0.3503	0.3591	0.3561	0.3596	0.3608	0.3602	0.3496	0.3458	0.3467	0.3454	0.3970	0.4437	0.4180	0.3853	0.6250	0.6626
0.3539	0.3639	0.3608	0.3644	0.3654	0.3594	0.3532	0.3618	0.3974	0.4310	0.4022	0.3613	0.3645	0.3766	0.6269	0.6606
0.3485	0.3585	0.3553	0.3592	0.3602	0.3758	0.4030	0.4197	0.4023	0.3800	0.3443	0.3446	0.3594	0.3713	0.6258	0.6581
0.3471	0.3609	0.3531	0.3872	0.4349	0.4314	0.3936	0.3632	0.3435	0.3422	0.3432	0.3438	0.3567	0.3683	0.6273	0.6616
0.3509	0.3995	0.4423	0.4271	0.3839	0.3551	0.3501	0.3497	0.3471	0.3463	0.3471	0.3505	0.3598	0.3713	0.6277	0.6601
0.4029	0.4221	0.3778	0.3667	0.3677	0.3671	0.3570	0.3535	0.3540	0.3535	0.3540	0.3545	0.3668	0.3779	0.6303	0.6601

		nvdimm	dram	nvdimm	dram	dram	dram	nvdimm	nvdimm	nvdimm	total	total	total		
m	n	length	threads	threads	average	min	max	average	min	max	average	min	max		
1000	1000000	48	15	1	0.4496	0.4140	0.4759	0.6884	0.6252	0.6792	0.6884	0.6252	0.6792		
0.3785	0.3860	0.3854	0.3887	0.3863	0.3880	0.3793	0.3758	0.3740	0.3748	0.3755	0.3811	0.3803	0.3793	0.3827	1.1083
0.3553	0.3670	0.3637	0.3676	0.3649	0.3667	0.4085	0.4368	0.4598	0.4620	0.3785	0.3584	0.3572	0.3559	0.3527	0.6792
0.3600	0.3680	0.3695	0.4079	0.4318	0.4759	0.4100	0.3823	0.3547	0.3556	0.3564	0.3630	0.3618	0.3608	0.3582	0.6642
0.3969	0.4410	0.4579	0.4286	0.4240	0.3661	0.3564	0.3503	0.3487	0.3495	0.3500	0.3566	0.3552	0.3568	0.3522	0.6265
0.4140	0.4016	0.3820	0.3852	0.3829	0.3847	0.3755	0.3720	0.3703	0.3709	0.3717	0.3775	0.3767	0.3758	0.3731	0.6252
0.3827	0.3831	0.3813	0.3872	0.3797	0.3815	0.3716	0.3681	0.3665	0.3672	0.3679	0.3741	0.3733	0.4107	0.4442	0.6310
0.3559	0.3625	0.3619	0.3700	0.3632	0.3690	0.3540	0.3498	0.3481	0.3487	0.3907	0.4322	0.4588	0.4232	0.3849	0.6328
0.3519	0.3609	0.3644	0.3642	0.3615	0.3633	0.3519	0.3859	0.4213	0.4580	0.4261	0.3957	0.3602	0.3522	0.3487	0.6417
0.3509	0.3635	0.3582	0.3622	0.4074	0.4513	0.4617	0.4244	0.3853	0.3457	0.3464	0.3534	0.3523	0.3512	0.3484	0.6401
0.3706	0.4205	0.4451	0.4747	0.4305	0.3814	0.3527	0.3482	0.3467	0.3541	0.3548	0.3548	0.3540	0.3529	0.3500	0.6350

Table 13: First version, more detailed 2.

		nvdi	dram	nvdi	dram	dram	dram	nvdimm	nvdimm	nvdimm	total	total	total
m	n	leng	threa	thre	averag	min	max	average	min	max	average	min	max
1,000	1,000,000	100	10	6	0.4823	0.4213	0.5350	0.3320	0.2711	0.8619	0.5260	0.4213	0.8619
1,000	1,000,000	100	11	5	0.4628	0.3977	0.5020	0.4063	0.3391	0.9953	0.5226	0.4040	0.9953
1,000	1,000,000	100	12	4	0.4450	0.4045	0.4901	0.4728	0.4195	0.9261	0.4986	0.4218	0.9261
1,000	1,000,000	100	13	3	0.4452	0.3841	0.5099	0.5823	0.5246	1.0428	0.5823	0.5246	1.0428
1,000	1,000,000	100	14	2	0.4440	0.3814	0.4807	0.8134	0.7380	1.3800	0.8134	0.7381	1.3801
1,000	1,000,000	100	15	1	0.4367	0.3729	0.4590	1.2964	1.1864	2.2079	1.2964	1.1864	2.2080

		nvdi	dram	nvdi	dram	dram	dram	nvdimm	nvdimm	nvdimm	total	total	total
m	n	leng	threa	thre	averag	min	max	average	min	max	average	min	max
1,000	1,000,000	200	10	6	0.4293	0.3801	0.5221	0.6604	0.5321	1.7671	0.6604	0.5321	1.7671
1,000	1,000,000	200	11	5	0.4225	0.3513	0.4817	0.7697	0.6238	2.0151	0.7698	0.6238	2.0151
1,000	1,000,000	200	12	4	0.4146	0.3415	0.4519	0.8611	0.7571	1.7370	0.8611	0.7571	1.7370
1,000	1,000,000	200	13	3	0.3970	0.3359	0.4278	1.0750	0.9597	1.9889	1.0750	0.9597	1.9889
1,000	1,000,000	200	14	2	0.3902	0.3389	0.4095	1.5548	1.3768	2.8569	1.5548	1.3769	2.8570
1,000	1,000,000	200	15	1	0.3812	0.3273	0.3937	2.4958	2.2860	4.2250	2.4958	2.2860	4.2250

		nvdi	dram	nvdi	dram	dram	dram	nvdimm	nvdimm	nvdimm	total	total	total
m	n	leng	threa	thre	averag	min	max	average	min	max	average	min	max
1,000	1,000,000	300	10	6	0.4187	0.3337	0.4504	0.9607	0.7672	2.5984	0.9607	0.7672	2.5984
1,000	1,000,000	300	11	5	0.3860	0.3149	0.4189	1.1095	0.8941	2.9522	1.1095	0.8941	2.9522
1,000	1,000,000	300	12	4	0.3716	0.3147	0.4021	1.2554	1.0973	2.5936	1.2555	1.0973	2.5936
1,000	1,000,000	300	13	3	0.3553	0.2994	0.3754	1.5950	1.4262	2.9722	1.5950	1.4262	2.9722
1,000	1,000,000	300	14	2	0.3586	0.2939	0.4467	2.2757	2.0535	4.0482	2.2757	2.0536	4.0482
1,000	1,000,000	300	15	1	0.3440	0.2899	0.4570	3.6785	3.3726	5.9822	3.6785	3.3726	5.9823

		nvdi	dram	nvdi	dram	dram	dram	nvdimm	nvdimm	nvdimm	total	total	total
m	n	leng	threa	thre	averag	min	max	average	min	max	average	min	max
1,000	1,000,000	400	10	6	0.3859	0.3285	0.4935	1.2587	0.9947	1.0591	1.2587	0.9947	1.0591
1,000	1,000,000	400	11	5	0.3522	0.3021	0.4969	1.4667	1.1868	1.2097	1.4667	1.1868	1.2097
1,000	1,000,000	400	12	4	0.3175	0.2716	0.4268	1.6739	1.4492	1.5125	1.6739	1.4492	1.5126
1,000	1,000,000	400	13	3	0.3242	0.2898	0.4059	2.1027	1.8852	1.9380	2.1028	1.8852	1.9380
1,000	1,000,000	400	14	2	0.2966	0.2831	0.4023	3.0072	2.7257	2.8082	3.0072	2.7257	2.8083
1,000	1,000,000	400	15	1	0.2930	0.2775	0.3902	4.9659	4.5704	5.0607	4.9659	4.5704	5.0607

Table 14: First version.

		nvdi	dram	nvdi	dram	dram	dram	nvdimm	nvdimm	nvdimm	total	total	total
m	n	leng	threa	thre	averag	min	max	average	min	max	average	min	max
1,000	1,000,000	100	10	6	0.5031	0.4696	0.5522	0.3221	0.2608	0.2654	0.5421	0.4696	0.5522
1,000	1,000,000	100	11	5	0.4612	0.4093	0.4975	0.3968	0.3246	0.3328	0.5246	0.4093	0.4975
1,000	1,000,000	100	12	4	0.4513	0.4098	0.4884	0.4552	0.4048	0.4098	0.5014	0.4098	0.4884
1,000	1,000,000	100	13	3	0.4422	0.3912	0.4799	0.5642	0.5084	0.5379	0.5642	0.5084	0.5379
1,000	1,000,000	100	14	2	0.4334	0.3799	0.4681	0.8098	0.7294	0.8177	0.8098	0.7295	0.8177
1,000	1,000,000	100	15	1	0.4367	0.4298	0.4616	1.4619	1.3356	1.4728	1.4619	1.3356	1.4728
		nvdi	dram	nvdi	dram	dram	dram	nvdimm	nvdimm	nvdimm	total	total	total
m	n	leng	threa	thre	averag	min	max	average	min	max	average	min	max
1,000	1,000,000	200	10	6	0.4462	0.4150	0.5193	0.6424	0.5142	0.5365	0.6424	0.5142	0.5365
1,000	1,000,000	200	11	5	0.4145	0.3720	0.4703	0.7537	0.6025	0.6358	0.7537	0.6025	0.6358
1,000	1,000,000	200	12	4	0.4130	0.3786	0.4469	0.8285	0.7306	0.7617	0.8285	0.7306	0.7617
1,000	1,000,000	200	13	3	0.4032	0.3466	0.4310	1.0511	0.9367	1.0338	1.0511	0.9367	1.0338
1,000	1,000,000	200	14	2	0.3898	0.3712	0.4123	1.4831	1.3442	1.3693	1.4831	1.3442	1.3694
1,000	1,000,000	200	15	1	0.3867	0.3754	0.4716	2.8308	2.5865	2.6867	2.8309	2.5866	2.6867
		nvdi	dram	nvdi	dram	dram	dram	nvdimm	nvdimm	nvdimm	total	total	total
m	n	leng	threa	thre	averag	min	max	average	min	max	average	min	max
1,000	1,000,000	300	10	6	0.3999	0.3447	0.4524	0.9276	0.7416	0.7500	0.9276	0.7416	0.7500
1,000	1,000,000	300	11	5	0.3932	0.3244	0.4249	1.0898	0.8660	0.9322	1.0898	0.8660	0.9322
1,000	1,000,000	300	12	4	0.3749	0.3143	0.4042	1.2065	1.0654	1.0783	1.2065	1.0654	1.0783
1,000	1,000,000	300	13	3	0.3481	0.3203	0.3696	1.5408	1.3923	1.4199	1.5408	1.3923	1.4199
1,000	1,000,000	300	14	2	0.3501	0.3459	0.3733	2.1808	2.0092	2.0432	2.1808	2.0092	2.0432
1,000	1,000,000	300	15	1	0.3404	0.3264	0.4569	4.1787	3.8467	3.9795	4.1788	3.8468	3.9795
		nvdi	dram	nvdi	dram	dram	dram	nvdimm	nvdimm	nvdimm	total	total	total
m	n	leng	threa	thre	averag	min	max	average	min	max	average	min	max
1,000	1,000,000	400	10	6	0.3710	0.2957	0.5086	1.2246	0.9551	1.0135	1.2246	0.9551	1.0135
1,000	1,000,000	400	11	5	0.3437	0.2816	0.4704	1.4251	1.1364	1.2231	1.4251	1.1364	1.2231
1,000	1,000,000	400	12	4	0.3336	0.2733	0.4385	1.5954	1.3988	1.4362	1.5954	1.3988	1.4363
1,000	1,000,000	400	13	3	0.3182	0.2837	0.4174	2.0210	1.8115	1.8356	2.0210	1.8115	1.8356
1,000	1,000,000	400	14	2	0.3018	0.2896	0.4058	2.9019	2.6311	2.7827	2.9019	2.6312	2.7827
1,000	1,000,000	400	15	1	0.2974	0.2847	0.4018	5.4534	5.0678	5.1469	5.4535	5.0679	5.1469

Table 15: Second version.

		nvdimm	dram	nvdimm	dram	dram	dram	nvdimm	nvdimm	nvdimm
m	n	length	threads	threads	average	min	max	average	min	max
1,000	1,000,000	200	1	15	2.4969	2.3980	2.6683	0.2652	0.1845	0.5940
1,000	1,000,000	200	2	14	1.4481	1.2292	1.7017	0.2503	0.1988	0.6042
1,000	1,000,000	200	3	13	1.0203	0.8528	1.2142	0.2675	0.2131	0.6043
1,000	1,000,000	200	4	12	1.0637	0.6941	1.2707	0.4761	0.2276	0.6246
1,000	1,000,000	200	5	11	0.7014	0.5716	0.8123	0.3013	0.2567	0.6231
1,000	1,000,000	200	6	10	0.5767	0.5035	0.6715	0.3755	0.2848	0.8516
1,000	1,000,000	200	7	9	0.5649	0.4562	0.6394	0.3539	0.3151	0.6364
1,000	1,000,000	200	8	8	0.4774	0.4289	0.5666	0.4176	0.3599	0.6759
1,000	1,000,000	200	9	7	0.4865	0.4106	0.5245	0.4371	0.4061	0.7098
1,000	1,000,000	200	10	6	0.4713	0.3851	0.5153	0.5126	0.4728	0.8159
1,000	1,000,000	200	11	5	0.4563	0.3681	0.4958	0.6027	0.5551	0.9569
1,000	1,000,000	200	12	4	0.3926	0.3576	0.4642	0.7724	0.6760	1.1671
1,000	1,000,000	200	13	3	0.3822	0.3459	0.4368	0.9688	0.8599	1.5051
1,000	1,000,000	200	14	2	0.3931	0.3430	0.4605	1.5638	1.2419	2.4540
1,000	1,000,000	200	15	1	0.3820	0.3332	0.4844	2.7315	2.3613	4.0120

Table 16: First version. OLD

		nvdimm	dram	nvdimm	dram	dram	dram	nvdimm	nvdimm	nvdimm
m	n	length	threads	threads	average	min	max	average	min	max
1000	1000000	400	1	15	1.9421	1.7041	2.5587	0.5400	0.3737	1.1992
1000	1000000	400	2	14	1.6456	1.3045	2.1652	0.9189	0.7172	1.4330
1000	1000000	400	3	13	0.7794	0.6837	0.9609	0.5340	0.4342	1.1997
1000	1000000	400	4	12	0.7031	0.5605	0.9786	0.7232	0.4821	1.2280
1000	1000000	400	5	11	0.5446	0.4239	0.6813	0.6175	0.5254	1.2250
1000	1000000	400	6	10	0.4830	0.3795	0.6112	0.6968	0.5731	1.2296
1000	1000000	400	7	9	0.4217	0.3497	0.5369	0.7117	0.6213	1.2246
1000	1000000	400	8	8	0.4217	0.3202	0.6186	0.9400	0.6843	1.3209
1000	1000000	400	9	7	0.3489	0.3263	0.4202	0.8846	0.7568	1.4615
1000	1000000	400	10	6	0.3534	0.2994	0.4695	1.2051	0.9452	1.6556
1000	1000000	400	11	5	0.3400	0.3112	0.4017	1.1752	1.0287	1.8976
1000	1000000	400	12	4	0.3907	0.2700	0.5614	2.4105	1.5335	2.8562
1000	1000000	400	13	3	0.2984	0.2701	0.3220	1.8764	1.6555	2.8262
1000	1000000	400	14	2	0.2894	0.2565	0.3947	2.7862	2.4556	3.9577
1000	1000000	400	15	1	0.3067	0.2609	0.3710	5.4896	4.7125	7.1350

Table 17: First version. OLD

m	n	nvdimm length	dram threads	nvdimm threads	dram average	dram min	dram max	nvdimm average	nvdimm min	nvdimm max
1,000	1,000,000	200	1	15	4.3506	3.0851	5.4226	12.5578	12.0879	13.9106
1,000	1,000,000	200	2	14	2.4177	1.6629	3.3427	12.5061	11.9543	13.8187
1,000	1,000,000	200	3	13	1.6175	1.1164	2.1824	12.0978	11.6232	13.2806
1,000	1,000,000	200	4	12	1.2294	0.8984	1.6496	11.8080	11.4248	12.8516
1,000	1,000,000	200	5	11	0.9603	0.5595	1.3311	11.2715	10.9282	12.2981
1,000	1,000,000	200	6	10	0.8311	0.4913	1.1458	11.2827	11.0103	11.8192
1,000	1,000,000	200	7	9	0.7681	0.4157	1.2062	11.0349	10.3212	12.9057
1,000	1,000,000	200	8	8	0.6855	0.4458	0.9048	10.7173	10.1667	12.3145
1,000	1,000,000	200	9	7	0.6231	0.3692	1.0769	10.5659	9.9144	12.4387
1,000	1,000,000	200	10	6	0.5536	0.3801	0.7129	10.2459	9.4983	12.5660
1,000	1,000,000	200	11	5	0.4918	0.3547	0.6574	9.5222	9.1636	10.7587
1,000	1,000,000	200	12	4	0.4674	0.3504	0.6201	8.6057	8.3691	9.3879
1,000	1,000,000	200	13	3	0.4439	0.3312	0.5859	7.9526	7.5966	8.5104
1,000	1,000,000	200	14	2	0.4377	0.3325	0.6917	5.6382	5.1366	6.2976
1,000	1,000,000	200	15	1	0.3979	0.3336	0.5328	2.7644	2.4067	3.7062

Table 18: Second version. OLD

m	n	nvdimm threads	nvdimm average	nvdimm min	nvdimm max
200	1,000,000	1	2.9744	2.5180	3.9372
200	1,000,000	2	4.9422	4.6678	5.4835
200	1,000,000	3	5.0508	4.8935	5.6034
200	1,000,000	4	5.5549	5.3542	6.7077
200	1,000,000	5	5.2473	4.9133	6.5496
200	1,000,000	6	5.3491	5.0966	6.7279
200	1,000,000	7	5.6929	5.4649	6.3630
200	1,000,000	8	5.8173	5.3828	6.8326
200	1,000,000	9	5.3901	5.2969	5.9944
200	1,000,000	10	5.5692	5.2874	6.2419
200	1,000,000	11	5.4967	5.2975	6.0858
200	1,000,000	12	5.8591	5.6733	7.0265
200	1,000,000	13	6.0996	5.8470	7.0950
200	1,000,000	14	5.7147	5.5264	6.6942
200	1,000,000	15	5.7758	5.5657	6.6912
200	1,000,000	16	5.8444	5.6211	6.4624

Table 19: NVDIMM only of second version. OLD

				predicted	
m	n	threads	time	time	bandwidth
1,000	1,000,000	1	1.7719	0.4233	18,898.7
1,000	1,000,000	2	1.0333	0.2800	28,571.4
1,000	1,000,000	3	1.0121	0.2744	29,158.2
1,000	1,000,000	4	0.9899	0.2736	29,235.5
1,000	1,000,000	5	0.6998	0.2011	39,789.2
1,000	1,000,000	6	0.6439	0.1792	44,646.4
1,000	1,000,000	7	0.5595	0.1565	51,121.6
1,000	1,000,000	8	0.5318	0.1486	53,839.6
1,000	1,000,000	9	0.4858	0.1357	58,964.7
1,000	1,000,000	10	0.4578	0.1263	63,321.0
1,000	1,000,000	11	0.4300	0.1198	66,792.3
1,000	1,000,000	12	0.3985	0.1139	70,227.7
1,000	1,000,000	13	0.3873	0.1083	73,838.5
1,000	1,000,000	14	0.3694	0.1041	76,823.2
1,000	1,000,000	15	0.3594	0.1004	79,680.9
1000	1000000	16	0.3394	0.0972	82,326.0
	Formula for	prediction			
	(m*n*8*0.000001)/bandwidth				

Table 20: DRAM only on n50. OLD