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Final Year B. Tech., Sem VII 2021-22

High Performance Computing Lab

Assignment submission

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Batch: B3

Assignment: 3

Title of assignment: Study and Implementation of schedule, nowait, reduction, ordered and collapse clauses

1. Analyse and implement a Parallel code for below program using openMP

```
// C Program to find the minimum scalar product of two vectors (dot
product)
#include<stdio.h>
int sort(int arr[], int n)
{
    int i, j;
    for (i = 0; i < n-1; i++)
        for (j = 0; j < n-i-1; j++)
            if (arr[j] > arr[j+1])
        {
            int temp = arr[j];
            arr[j] = arr[j+1];
            arr[j+1] = temp;
        }
}
```

```
}
}
int sort_des(int arr[], int n)
{
       int i,j;
       for (i = 0; i < n; ++i)
       {
              for (j = i + 1; j < n; ++j)
                      if (arr[i] < arr[j])</pre>
                      {
                             int a = arr[i];
                             arr[i] = arr[j];
                             arr[j] = a;
                      }
              }
       }
}
int main()
{
       //fill the code;
       int n;
       scanf("%d",&n);
       int arr1[n], arr2[n];
       int i;
       for(i = 0; i < n; i++)
       {
              scanf("%d",&arr1[i]);
       for(i = 0; i < n; i++)
              scanf("%d",&arr2[i]);
       }
```

```
sort(arr1, n);
sort_des(arr2, n);
int sum = 0;
for(i = 0; i < n; i++)
{
        sum = sum + (arr1[i] * arr2[i]);
}
printf("%d",sum);
return 0;
}</pre>
```

Ans:

```
// C Program to find the minimum scalar product of two vectors (dot
product)
#include<bits/stdc++.h>
#include <omp.h>
using namespace std;
int sort(int arr[], int n)
{
      int i, j;
      #pragma omp parallel shared(arr) private(j)
      #pragma omp for schedule(dynamic)
      for (i = 0; i < n-1; i++)
             for (j = 0; j < n-i-1; j++)
                   if (arr[j] > arr[j+1])
                   {
                          int temp = arr[j];
                          arr[j] = arr[j+1];
                          arr[j+1] = temp;
                    }
```

```
}
int sort_des(int arr[], int n)
       int i,j;
       #pragma omp parallel shared(arr) private(j)
       #pragma omp for schedule(dynamic)
       for (i = 0; i < n; ++i)
       {
              for (j = i + 1; j < n; ++j)
              {
                     if (arr[i] < arr[j])</pre>
                     {
                            int a = arr[i];
                            arr[i] = arr[j];
                            arr[j] = a;
                     }
              }
       }
}
int main()
{
       //fill the code;
       int i,tid,n,psum;
       int threads = 4;
       cout<<"Enter Size of Array: ";</pre>
       cin>>n;
       int arr1[n], arr2[n];
       cout<<"Enter Elements of First Array:\n";
       for(i = 0; i < n; i++)
       {
              cin>>arr1[i];
       cout<<"Enter Elements of Second Array:\n";</pre>
```

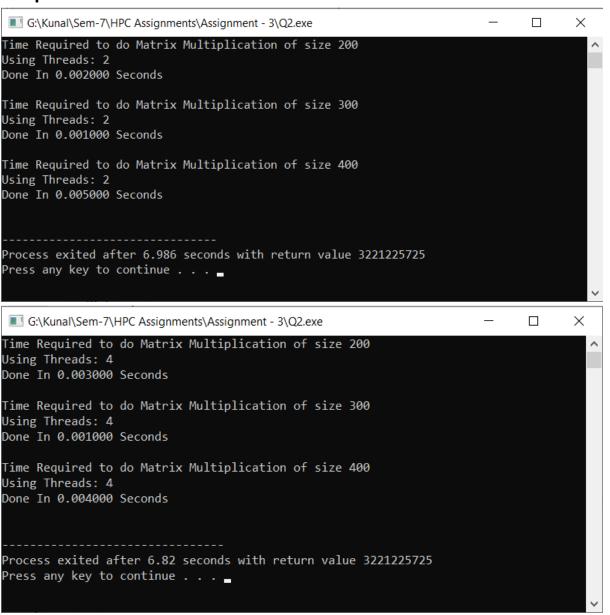
```
for(i = 0; i < n; i++)
      {
            cin>>arr2[i];
      }
      sort(arr1, n);
      sort_des(arr2, n);
      int sum = 0;
      #pragma omp parallel private(i,tid,psum) num_threads(threads)
      {
            psum=0;
            tid = omp_get_thread_num();
            #pragma omp for reduction(+:sum)
            for(int i=0; i<n; i++)
            {
                  sum += arr1[i] * arr2[i];
                  psum+=sum;
            printf("Thread %d partial sum = %d\n",tid,psum);
      }
      cout<<"Sum: "<<sum<<endl;
      return 0;
}
```

- 2. Write OpenMP code for two 2D Matrix addition, vary the size of your matrices from 250, 500, 750, 1000, and 2000 and measure the runtime with one thread (Use functions in C in calculate the execution time or use GPROF)
 - i. For each matrix size, change the number of threads from 2,4,8., and plot the speedup versus the number of threads.
 - ii. Explain whether or not the scaling behaviour is as expected.

Ans:

```
#include <bits/stdc++.h>
#include <omp.h>
using namespace std;
int main()
{
      int tid, nthreads , i, j;
      int n=100;
      while(1){
             if(n==500)
                    break;
             else
                    n+=100;
             nthreads=4;
             int a[n][n], b[n][n], c[n][n];
             int index = 0;
             for (i = 0; i < n; i++)
                    for (j = 0; j < n; j++)
```

```
{
                          a[i][j] = b[i][j] = (i+j);
                    }
             }
             printf("Time Required to do Matrix Multiplication of size
%d\nUsing Threads: %d",n,nthreads);
             double time = omp_get_wtime();
             #pragma omp parallel shared(a, b, c, nthreads) private(tid, i,
j) num_threads(nthreads)
             {
                    # pragma omp parallel for
                   for (int i = 0; i < n; i++)
                    {
                          for (int j = 0; j < n; j++)
                          {
                                 c[i][j] = a[i][j] + b[i][j];
                          }
                    }
             }
             printf("\nDone In %f Seconds\n\n", omp_get_wtime() -
time);
      }
      return 0;
}
```



- 3. For 1D Vector (size=200) and scalar addition, Write a OpenMP code with the following:
 - Use STATIC schedule and set the loop iteration chunk size to various sizes when changing the size of your matrix. Analyze the speedup.
 - ii. Use DYNAMIC schedule and set the loop iteration chunk size to various sizes when changing the size of your matrix. Analyze the speedup.
 - iii. Demonstrate the use of nowait clause

Ans:

Use of Static Schedule

```
#include <omp.h>
#include <stdio.h>
#include <stdlib.h>
#include <time.h>

int main(){
    int n = 200, i ,j=99;
    int arr1[n], answer[n];
        for(i = 0; i < n; i++){
        arr1[i] = rand()%100;
    }

    double time = omp_get_wtime();
    #pragma omp parallel for schedule(static,20) shared(arr1, answer,j)
private(i)

    for(i = 0; i < n; i++)
{</pre>
```

```
answer[i] = arr1[i] + j;
}

printf("\nDone In %f Seconds\n\n", omp_get_wtime() - time);

printf("\nArray 1: \n");
for(i = 0; i < n; i++){
    printf("\t %d", arr1[i]);
}

printf("\nAnswer: \n");
for(i = 0; i < n; i++){
    printf("\t %d", answer[i]);
}
return 0;
}</pre>
```

```
□ G:\Kunal\Sem-7\HPC Assignments\Assignment - 3\Q3A.exe

Cone In 0.015000 Seconds

Array 1:

41 67 34 0 69 24 78 58 62 64 5 45 81 27
61 91 95 42 27 36 91 4 2 53 92 82 21 16 18
95 47 26 71 38 69 12 67 99 35 94 3 11 22 33
73 64 41 11 53 68 47 44 62 57 37 59 23 41 29
78 16 35 90 42 88 6 40 42 64 48 46 5 90 29
78 16 35 90 42 88 6 40 42 64 48 46 5 90 29
70 50 6 1 93 48 29 23 84 54 56 40 66 76 31
8 44 39 26 23 37 38 18 82 29 41 33 15 39 58
4 30 77 6 73 86 21 45 24 72 70 29 77 73 97
12 86 90 61 36 55 67 55 74 31 52 50 50 41 24
66 30 7 91 7 73 757 87 53 83 45 9 9 58 21
48 83 95 41 2 50 91 36 74 20 96 21 48 99 68
84 81 34 53 99 18 38 0 88 27 67 28 93 48 83
7 21 10 17 13 14
```

nswer	:														
	140	166	133	99	168	123	177	157	161	163	104	144	180	126	
L60	190	194	141	126	135	190	103	101	152	191	181	120	115	117	
94	146	125	170	137	168	111	166	198	134	193	102	110	121	132	
72	163	140	110	152	167	146	143	161	156	136	158	122	140	128	
77	115	134	189	141	187	105	139	141	163	147	145	104	189	128	
69	149	105	100	192	147	128	122	183	153	155	139	165	175	130	
07	143	138	125	122	136	137	117	181	128	140	132	114	138	157	
3 3	129	176	105	172	185	120	144	123	171	169	128	176	172	196	
11	185	189	160	135	154	166	154	173	130	151	149	149	140	123	
55	129	106	190	106	136	156	186	152	182	144	108	108	157	120	
37	121	145	105	129	112	167	99	190	161	154	109	158	123	136	
17	182	194	140	101	149	190	135	173	119	195	120	147	198	167	
33	180	133	152	198	117	137	99	187	126	166	127	192	147	182	
36	120	109	116	112	113										

Use of Dynamic Schedule

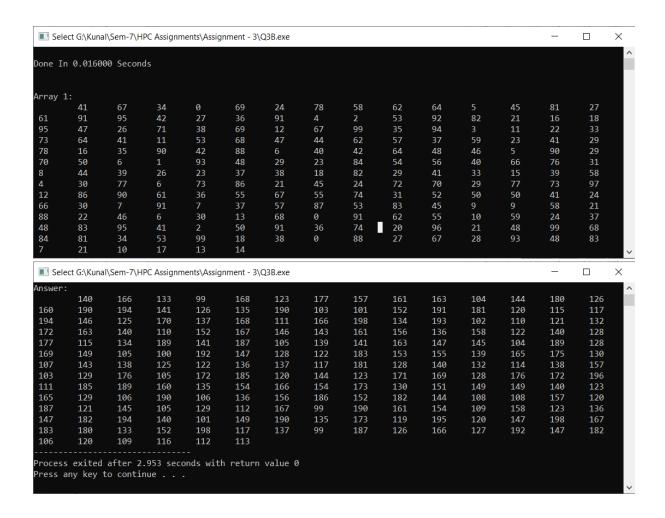
```
#include <omp.h>
#include <stdio.h>
#include <stdlib.h>
#include <time.h>

int main(){
   int n = 200, i ,j=99;

        int arr1[n], answer[n];

        for(i = 0; i < n; i++)
        {
        arr1[i] = rand()%100;
    }</pre>
```

```
double time = omp_get_wtime();
      #pragma omp parallel for schedule(dynamic,20) shared(arr1,
answer,j) private(i)
  for(i = 0; i < n; i++)
  {
    answer[i] = arr1[i] + j;
  }
  printf("\nDone In %f Seconds\n\n", omp_get_wtime() - time);
      printf("\nArray 1: \n");
  for(i = 0; i < n; i++)
      {
    printf("\t %d", arr1[i]);
  }
      printf("\nAnswer: \n");
  for(i = 0; i < n; i++)
      {
    printf("\t %d", answer[i]);
  }
  return 0;
}
```



Use of Nowait Clause

Code:

#include <omp.h>
#include <stdio.h>
#include <stdlib.h>
#include <time.h>

int main()

```
{
  int n = 200, i ,j=99;
  int arr1[n], answer[n];
      for(i = 0; i < n; i++)
    arr1[i] = rand()%100;
  }
  double time = omp_get_wtime();
      #pragma omp parallel
  {
         #pragma omp for nowait
         for(i = 0; i < n; i++)
           answer[i] = arr1[i] + j;
         }
  }
  printf("\nDone In %f Seconds\n\n", omp_get_wtime() - time);
  printf("\nArray 1: \n");
  for(i = 0; i < n; i++){
     printf("\t %d", arr1[i]);
  }
  printf("\nAnswer: \n");
  for(i = 0; i < n; i++){
    printf("\t %d", answer[i]);
  }
  return 0;
}
```

ne n	11 0.0000	00 Secon	us												
ray :	1:														
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1	91	95	42	27	36	91	4	2	53	92	82	21	16	18	
5	47	26	71	38	69	12	67	99	35	94	3	11	22	33	
3	64	41	11	53	68	47	44	62	57	37	59	23	41	29	
3	16	35	90	42	88	6	40	42	64	48	46	5	90	29	
3	50	6	1	93	48	29	23	84	54	56	40	66	76	31	
	44	39	26	23	37	38	18	82	29	41	33	15	39	58	
	30	77	6	73	86	21	45	24	72	70	29	77	73	97	
2	86	90	61	36	55	67	55	74	31	52	50	50	41	24	
5	30	7	91	7	37	57	87	53	83	45	9	9	58	21	
_		46	6	30	13	68	0	91	62	55	10	59	24	37	
	22					91	36	74	20	96	21	48	99	68	
8	83	95	41	2	50										
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3 4	83						0	88	27	67	28	93	48	83	
3 1	83 81 21	34 10	53 17	99	18 14	38	0	88	27	67	28	93	48	83	
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