# Използване на OpenMP. Част 2. for, barrier, section, master, single

*Курс „Паралелно програмиране“*

[redacted]

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## План

## Задача

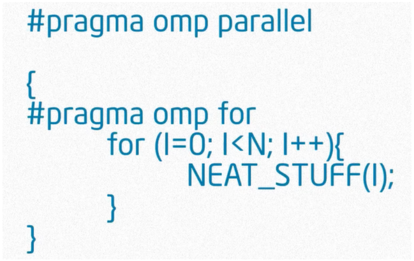
$$\int_0^1 \frac{4}{1+x^2}dx = \pi$$

## SPMD <-> Worksharing

Loop
Section
Single
Task

## Loop

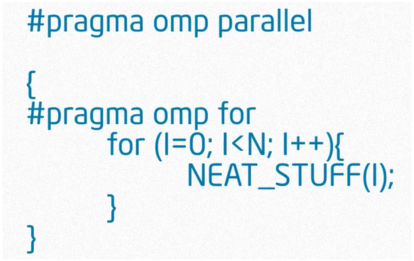
Нишките изпълняват итерации с различен номер.



```
#pragma omp parallel

{
#pragma omp for
        for (I=0; I<N; I++){
                NEAT_STUFF(I);
        }
}
```

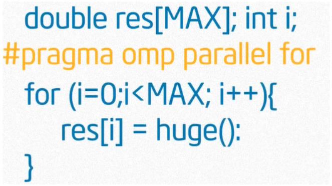
## Loop

Нишките изпълняват итерации с различен номер.



```
#pragma omp parallel

{
#pragma omp for
        for (I=0; I<N; I++){
                NEAT_STUFF(I);
        }
}
```

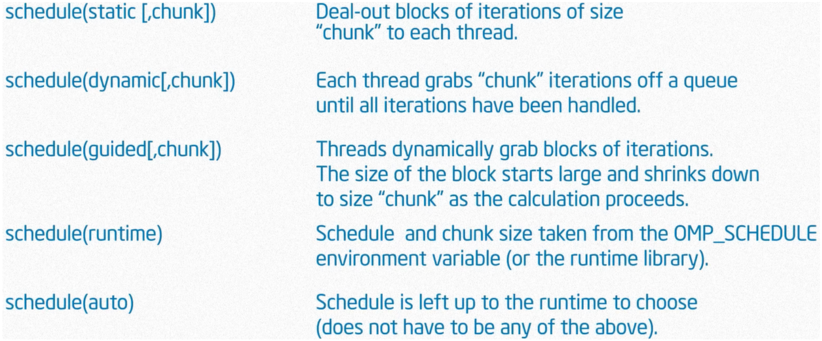
Съкратен запис:



```
  double res[MAX]; int i;
#pragma omp parallel for
  for (i=0;i<MAX; i++){
      res[i] = huge():
  }
```

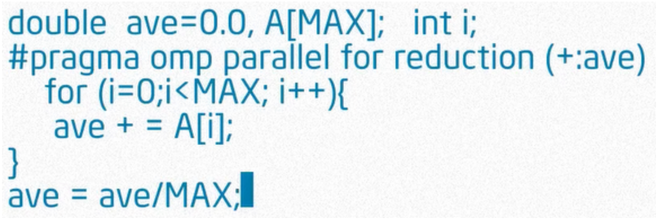
```
int i = 0;
omp_set_num_threads(4);

printf("Total number of threads allocated in the
    serial section %d \n", omp_get_num_threads() );
#pragma omp parallel
{
  #pragma omp for
  for( i = 0; i < omp_get_num_threads(); i++) {
    printf("This is run by thread %d, Total threads
        in the parallel section %d\n",
        omp_get_thread_num(), omp_get_num_threads());
  }
}
```

## Schedule



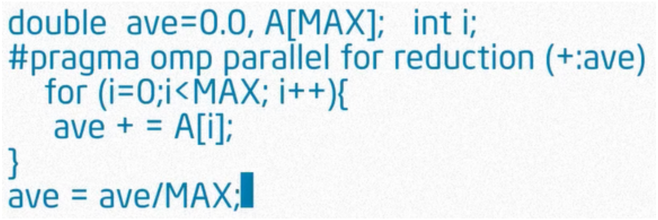
| | |
|---|---|
| schedule(static [,chunk]) | Deal-out blocks of iterations of size "chunk" to each thread. |
| schedule(dynamic[,chunk]) | Each thread grabs "chunk" iterations off a queue until all iterations have been handled. |
| schedule(guided[,chunk]) | Threads dynamically grab blocks of iterations. The size of the block starts large and shrinks down to size "chunk" as the calculation proceeds. |
| schedule(runtime) | Schedule  and chunk size taken from the OMP_SCHEDULE environment variable (or the runtime library). |
| schedule(auto) | Schedule is left up to the runtime to choose (does not have to be any of the above). |

## Reduction

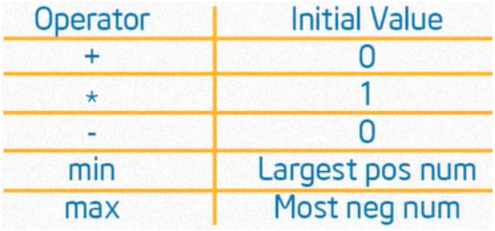


```
double  ave=0.0, A[MAX];   int i;
#pragma omp parallel for reduction (+:ave)
   for (i=0;i<MAX; i++){
    ave + = A[i];
}
ave = ave/MAX;
```

## Reduction

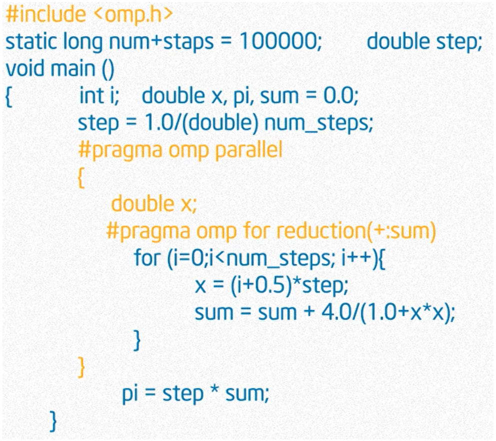


```
double  ave=0.0, A[MAX];   int i;
#pragma omp parallel for reduction (+:ave)
   for (i=0;i<MAX; i++){
    ave + = A[i];
}
ave = ave/MAX;
```



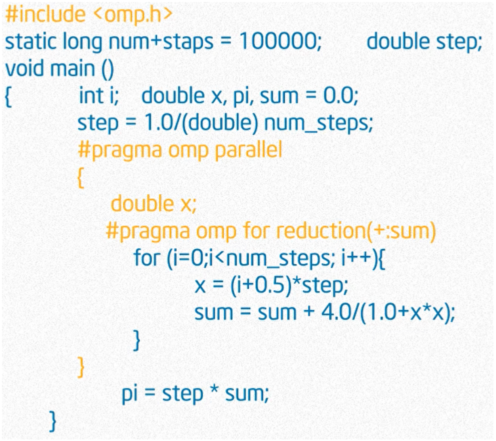
| Operator | Initial Value |
|---|---|
| + | 0 |
| * | 1 |
| - | 0 |
| min | Largest pos num |
| max | Most neg num |

## Integral

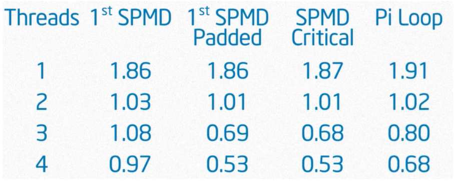


```
#include <omp.h>
static long num+staps = 100000;       double step;
void main ()
{          int i;    double x, pi, sum = 0.0;
           step = 1.0/(double) num_steps;
           #pragma omp parallel
           {
                double x;
               #pragma omp for reduction(+:sum)
                   for (i=0;i<num_steps; i++){
                            x = (i+0.5)*step;
                            sum = sum + 4.0/(1.0+x*x);
                   }
           }
                 pi = step * sum;
       }
```

## Integral

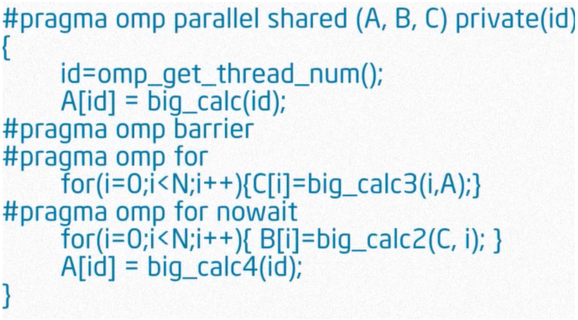


```
#include <omp.h>
static long num+staps = 100000;       double step;
void main ()
{          int i;    double x, pi, sum = 0.0;
           step = 1.0/(double) num_steps;
           #pragma omp parallel
           {
                double x;
               #pragma omp for reduction(+:sum)
                   for (i=0;i<num_steps; i++){
                            x = (i+0.5)*step;
                            sum = sum + 4.0/(1.0+x*x);
                   }
           }
                 pi = step * sum;
    }
```



| Threads | 1st SPMD | 1st SPMD Padded | SPMD Critical | Pi Loop |
|---|---|---|---|---|
| 1 | 1.86 | 1.86 | 1.87 | 1.91 |
| 2 | 1.03 | 1.01 | 1.01 | 1.02 |
| 3 | 1.08 | 0.69 | 0.68 | 0.80 |
| 4 | 0.97 | 0.53 | 0.53 | 0.68 |

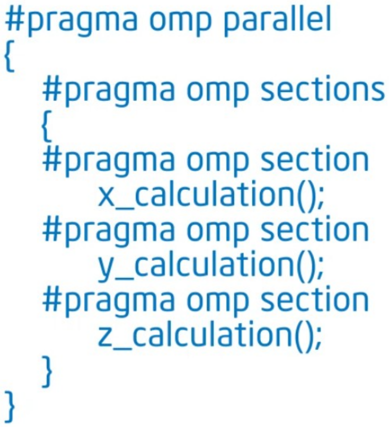
## Barrier



```
#pragma omp parallel shared (A, B, C) private(id)
{
        id=omp_get_thread_num();
        A[id] = big_calc(id);
#pragma omp barrier
#pragma omp for
        for(i=0;i<N;i++){C[i]=big_calc3(i,A);}
#pragma omp for nowait
        for(i=0;i<N;i++){ B[i]=big_calc2(C, i); }
        A[id] = big_calc4(id);
}
```

## Section

Нишките изпълняват код от различни `section`



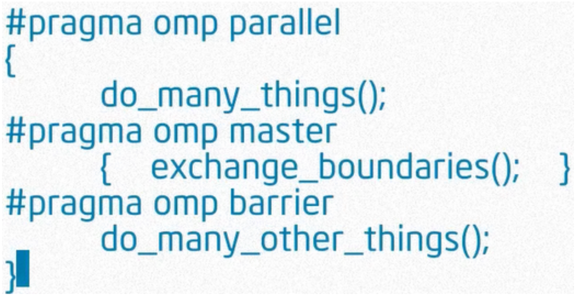
```
#pragma omp parallel
{
    #pragma omp sections
    {
    #pragma omp section
        x_calculation();
    #pragma omp section
        y_calculation();
    #pragma omp section
        z_calculation();
    }
}
```

## Section

```c
int a = 6;
int b = 3;
omp_set_num_threads(4);
#pragma omp parallel
{
  #pragma omp sections
  {
    #pragma omp section
    {
      printf("Sum = %d on thread %d \n", a + b,
           omp_get_thread_num());
    }
    #pragma omp section
    {
      printf("Difference = %d on thread %d \n", a - b,
           omp_get_thread_num());
    }
  }
}
```

## Master

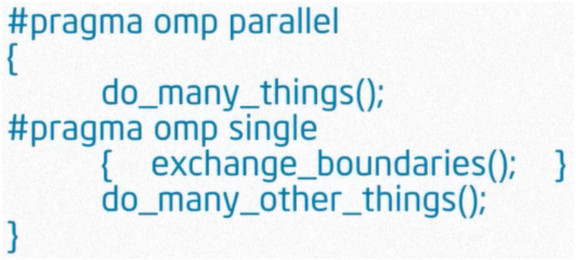
Когато искаме някоя част от кода да се изпълни само от една нишка използваме `master` или `single`. При `signle` нишката, която първа достигне до кода, го изпълнява, докото при `master` точно нишката с `id=0` изпълнява кода (, а останалите - не). Няма скрит `barrier` след `master`, но има скрит `barrier` след `single`.



```
#pragma omp parallel
{
        do_many_things();
#pragma omp master
        {   exchange_boundaries();   }
#pragma omp barrier
        do_many_other_things();
}
```

```
int i = 0, N = 8;
omp_set_num_threads(N);
int *a, *b, *c;
#pragma omp parallel
{
  #pragma omp master
  {
    a = malloc(N * sizeof(int));
    b = malloc(N * sizeof(int));
    c = malloc(N * sizeof(int));
    srand(time(NULL));
  }
  #pragma omp for
  for( i  = 0; i < N; i++) {
    a[i] = rand() % 10;
    b[i] = rand() % 10;
  }
  #pragma omp for
  for( i  = 0; i < N; i++) {
      c[i] = a[i] * b[i];
  }
  #pragma omp for
  for( i = 0; i < N ; i++) {
    printf("A[%d] * B[%d] = %d \n", i, i, c[i]);
  }
```

## Single



```
#pragma omp parallel
{
        do_many_things();
#pragma omp single
        {   exchange_boundaries();   }
        do_many_other_things();
}
```

```
int i = 0, N = 8;
omp_set_num_threads(N);
int *a, *b, *c;
#pragma omp parallel
{
  #pragma omp single
  {
    a = malloc(N * sizeof(int));
    b = malloc(N * sizeof(int));
    c = malloc(N * sizeof(int));
    srand(time(NULL));
  }
  #pragma omp for
  for( i  = 0; i < N; i++) {
    a[i] = rand() % 10;
    b[i] = rand() % 10;
  }
  #pragma omp for
  for( i  = 0; i < N; i++) {
      c[i] = a[i] * b[i];
  }
  #pragma omp for
  for( i = 0; i < N ; i++) {
    printf("A[%d] * B[%d] = %d \n", i, i, c[i]);
```

## Домашна работа

`https://www.youtube.com/watch?list=`
`PLLbPZJxtMs4ZHSamRRYCtvowRS0qIwC-I`
От "Introduction to OpenMP 08 Discussion 3 "
до "Introduction to OpenMP 11 part 1 Module 6".