

# StarPU Handbook - StarPU Applications

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for StarPU 1.4.0

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	<b>1</b>
<b>1 Introduction of StarPU Applications</b>	<b>3</b>
1.1 Organization . . . . .	3
<b>2 A Stencil Application</b>	<b>5</b>
2.1 The Original Application . . . . .	5
2.2 The StarPU Application . . . . .	5
2.3 The StarPU MPI Application . . . . .	7
<b>I Appendix</b>	<b>9</b>
<b>3 The GNU Free Documentation License</b>	<b>11</b>
3.1 ADDENDUM: How to use this License for your documents . . . . .	15

This manual documents the usage of StarPU version 1.4.0. Its contents was last updated on 2023-03-28.

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# Chapter 1

## Introduction of StarPU Applications

### 1.1 Organization

This part presents how to write a StarPU application from an existing application.

The application presented in the following chapter and some others are available in the git repository <https://gitlab.inria.fr/starpu/starpu-applications>



## Chapter 2

# A Stencil Application

We show in this chapter how to easily convert an existing application to use StarPU.

### 2.1 The Original Application

```
void stencil5_cpu(double *xy, double *xmly, double *xply, double *xym1, double *xyp1)
{
    *xy = (*xy + *xmly + *xply + *xym1 + *xyp1) / 5;
}

int main(int argc, char **argv)
{
    int niter, n;
    int x, y, loop;
    read_params(argc, argv, &n, &niter);
    double *A = calloc(n*n, sizeof(*A));
    fill(A, n, n);
    for(loop=0 ; loop<niter; loop++)
    {
        for (x = 0; x < n; x++)
        {
            for (y = 0; y < n; y++)
            {
                int xml = (x==0) ? n-1 : x-1;
                int xpl = (x==n-1) ? 0 : x+1;
                int yml = (y==0) ? n-1 : y-1;
                int ypl = (y==n-1) ? 0 : y+1;
                stencil5_cpu(&A[_(x,y,n)],
                           &A[_(xml,y,n)], &A[_(xpl,y,n)],
                           &A[_(x,yml,n)], &A[_(x,ypl,n)]);
            }
        }
    }
    return 0;
}
```

### 2.2 The StarPU Application

The computation function must be defined through a codelet.

```
void stencil5_cpu(void *descr[], void *_args)
{
    (void)_args;
    double *xy = (double *)STARPU_VARIABLE_GET_PTR(descr[0]);
    double *xmly = (double *)STARPU_VARIABLE_GET_PTR(descr[1]);
    double *xply = (double *)STARPU_VARIABLE_GET_PTR(descr[2]);
    double *xym1 = (double *)STARPU_VARIABLE_GET_PTR(descr[3]);
    double *xyp1 = (double *)STARPU_VARIABLE_GET_PTR(descr[4]);
    *xy = (*xy + *xmly + *xply + *xym1 + *xyp1) / 5;
}

struct starpu_codelet stencil5_cl =
{
    .cpu_funcs = {stencil5_cpu},
    .nbuffers = 5,
    .modes = {STARPU_RW, STARPU_R, STARPU_R, STARPU_R, STARPU_R},
    .model = &starpu_perfmodel_nop,
};
```

Data must be registered to StarPU.

```
data_handles = malloc(n*n*sizeof(*data_handles));
for(x = 0; x < n; x++)
{
    for (y = 0; y < n; y++)
```

```

    {
        starpu_variable_data_register(&data_handles[_(x,y,n)],
                                     STARPU_MAIN_RAM,
                                     (uintptr_t) &A[_(x,y,n)], sizeof(double));
    }
}

```

Instead of directly calling the function, a StarPU task must be created.

```

    int xml = (x==0) ? n-1 : x-1;
    int xpl = (x==n-1) ? 0 : x+1;
    int yml = (y==0) ? n-1 : y-1;
    int ypl = (y==n-1) ? 0 : y+1;
    starpu_task_insert(&stencil5_cl,
                      STARPU_RW, data_handles[_(x,y,n)],
                      STARPU_R, data_handles[_(xml,y,n)],
                      STARPU_R, data_handles[_(xpl,y,n)],
                      STARPU_R, data_handles[_(x,yml,n)],
                      STARPU_R, data_handles[_(x,ypl,n)],
                      0);

```

And finally data must be released from StarPU.

```

    for(x = 0; x < n; x++)
    {
        for (y = 0; y < n; y++)
        {
            starpu_data_unregister(data_handles[_(x,y,n)]);
        }
    }

```

The whole StarPU application looks as follows.

```

void stencil5_cpu(void *descr[], void *_args)
{
    (void)_args;
    double *xy = (double *)STARPU_VARIABLE_GET_PTR(descr[0]);
    double *xmly = (double *)STARPU_VARIABLE_GET_PTR(descr[1]);
    double *xply = (double *)STARPU_VARIABLE_GET_PTR(descr[2]);
    double *xymly = (double *)STARPU_VARIABLE_GET_PTR(descr[3]);
    double *xypl = (double *)STARPU_VARIABLE_GET_PTR(descr[4]);
    *xy = (*xy + *xmly + *xply + *xymly + *xypl) / 5;
}

struct starpu_codelet stencil5_cl =
{
    .cpu_funcs = {stencil5_cpu},
    .nbuffers = 5,
    .modes = {STARPU_RW, STARPU_R, STARPU_R, STARPU_R, STARPU_R},
    .model = &starpu_perfmodel_nop,
};

int main(int argc, char **argv)
{
    starpu_data_handle_t *data_handles;
    int ret;
    int niter, n;
    int x, y, loop;
    ret = starpu_init(NULL);
    STARPU_CHECK_RETURN_VALUE(ret, "starpu_init");
    read_params(argc, argv, &verbose, &n, &niter);
    double *A = calloc(n*n, sizeof(*A));
    fill(A, n, n);
    data_handles = malloc(n*n*sizeof(*data_handles));
    for(x = 0; x < n; x++)
    {
        for (y = 0; y < n; y++)
        {
            starpu_variable_data_register(&data_handles[_(x,y,n)],
                                         STARPU_MAIN_RAM,
                                         (uintptr_t) &A[_(x,y,n)], sizeof(double));
        }
    }
    for(loop=0 ; loop<niter; loop++)
    {
        for (x = 0; x < n; x++)
        {
            for (y = 0; y < n; y++)
            {
                int xml = (x==0) ? n-1 : x-1;
                int xpl = (x==n-1) ? 0 : x+1;
                int yml = (y==0) ? n-1 : y-1;
                int ypl = (y==n-1) ? 0 : y+1;
                starpu_task_insert(&stencil5_cl,
                                STARPU_RW, data_handles[_(x,y,n)],
                                STARPU_R, data_handles[_(xml,y,n)],
                                STARPU_R, data_handles[_(xpl,y,n)],
                                STARPU_R, data_handles[_(x,yml,n)],
                                STARPU_R, data_handles[_(x,ypl,n)],
                                0);
            }
        }
    }
    starpu_task_wait_for_all();
}

```

```

for(x = 0; x < n; x++)
{
    for (y = 0; y < n; y++)
    {
        starpu_data_unregister(data_handles[_(x,y,n)]);
    }
}
starpu_shutdown();
return 0;
}

```

## 2.3 The StarPU MPI Application

The initialisation for StarPU-MPI is as follows.

```

int ret = starpu_mpi_init_conf(&argc, &argv, 1, MPI_COMM_WORLD, NULL);
STARPU_CHECK_RETURN_VALUE(ret, "starpu_mpi_init_conf");
starpu_mpi_comm_rank(MPI_COMM_WORLD, &my_rank);
starpu_mpi_comm_size(MPI_COMM_WORLD, &size);

```

An additional call to `starpu_mpi_data_register()` is necessary.

```

starpu_variable_data_register(&data_handles[_(x,y,n)],
                             STARPU_MAIN_RAM,
                             (uintptr_t)&(A[_(x,y,n)]), sizeof(double));
int mpi_rank = my_distrib(x, y, size);
starpu_mpi_data_register(data_handles[_(x,y,n)], (y*n)+x, mpi_rank);

```

And to insert a task, the function `starpu_mpi_task_insert()` must be used.

```

starpu_mpi_task_insert(MPI_COMM_WORLD, &stencil5_cl,
                      STARPU_RW, data_handles[_(x,y,n)],
                      STARPU_R, data_handles[_(x+1,y,n)],
                      STARPU_R, data_handles[_(x-1,y,n)],
                      STARPU_R, data_handles[_(x,y+1,n)],
                      STARPU_R, data_handles[_(x,y-1,n)],
                      0);

```

The whole StarPU-MPI application looks as follows.

```

void stencil5_cpu(void *descr[], void *_args); // Same as in sequential StarPU
struct starpu_codelet stencil5_cl; // Same as in sequential StarPU
/* Returns the MPI node number where data indexes index is */
int my_distrib(int x, int y, int nb_nodes)
{
    return ((int)(x / sqrt(nb_nodes) + (y / sqrt(nb_nodes)) * sqrt(nb_nodes))) % nb_nodes;
}
int main(int argc, char **argv)
{
    starpu_data_handle_t *data_handles;
    int niter, n;
    int my_rank, size, x, y, loop;
    int ret = starpu_mpi_init_conf(&argc, &argv, 1, MPI_COMM_WORLD, NULL);
    STARPU_CHECK_RETURN_VALUE(ret, "starpu_mpi_init_conf");
    starpu_mpi_comm_rank(MPI_COMM_WORLD, &my_rank);
    starpu_mpi_comm_size(MPI_COMM_WORLD, &size);
    read_params(argc, argv, &n, &niter);
    double *A = calloc(n*n, sizeof(*A));
    fill(A, n, n);
    data_handles = malloc(n*n*sizeof(*data_handles));
    for(x = 0; x < n; x++)
    {
        for (y = 0; y < n; y++)
        {
            starpu_variable_data_register(&data_handles[_(x,y,n)],
                                         STARPU_MAIN_RAM,
                                         (uintptr_t)&(A[_(x,y,n)]), sizeof(double));
            int mpi_rank = my_distrib(x, y, size);
            starpu_mpi_data_register(data_handles[_(x,y,n)], (y*n)+x, mpi_rank);
        }
    }
    for(loop=0 ; loop<niter; loop++)
    {
        for (x = 0; x < n; x++)
        {
            for (y = 0; y < n; y++)
            {
                int xml = (x==0) ? n-1 : x-1;
                int xpl = (x==n-1) ? 0 : x+1;
                int yml = (y==0) ? n-1 : y-1;
                int ypl = (y==n-1) ? 0 : y+1;
                starpu_mpi_task_insert(MPI_COMM_WORLD, &stencil5_cl,
                                      STARPU_RW, data_handles[_(x,y,n)],
                                      STARPU_R, data_handles[_(x+1,y,n)],
                                      STARPU_R, data_handles[_(x-1,y,n)],
                                      STARPU_R, data_handles[_(x,y+1,n)],
                                      STARPU_R, data_handles[_(x,y-1,n)],
                                      0);
            }
        }
    }
}

```



```
    }
    starpu_task_wait_for_all();
    /* bring data back to node 0 and unregister it */
    for (x = 0; x < n; x++)
    {
        for (y = 0; y < n; y++)
        {
            starpu_mpi_data_migrate(MPI_COMM_WORLD, data_handles[_(x,y,n)], 0);
            starpu_data_unregister(data_handles[_(x,y,n)]);
        }
    }
    starpu_mpi_shutdown();
    return 0;
}
```

## Part I

# Appendix



## Chapter 3

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