

Multi-GPU расчёты с помощью технологии CUDA на примере плоской задачи линейной теории упругости

27 апреля 2023 г.

Общий вид программы

```
1  for (int iter = 0; iter < niter; iter++) {
2      for (int i = 0; i < device_count; i++) {
3          cudaSetDevice(device[i]);
4          compute<<<grid, block, shared_mem, stream[i]>>>(...);
5      }
6
7      for (int i = 0; i < device_count; i++)
8          cudaStreamSynchronize(stream[i]);
9
10     for (int i = 1; i < device_count; i++)
11         cudaMemcpyPeerAsync(..., stream[i]);
12     for (int i = 0; i < device_count - 1; i++)
13         cudaMemcpyPeerAsync(..., stream[i]);
14
15     for (int i = 0; i < device_count; i++)
16         cudaStreamSynchronize(stream[i]);
17 }
```

Общий вид программы

```
1  for (int iter = 0; iter < niter; iter++) {
2      for (int i = 0; i < device_count; i++) {
3          cudaSetDevice(device[i]);
4          compute<<<..., stream_halo[i]>>>(...);    // compute halos
5          compute<<<..., stream_halo[i]>>>(...);
6          compute<<<..., stream_internal[i]>>>(...); // compute internal data
7      }
8
9      for (int i = 1; i < device_count; i++)          // exchange halos
10         cudaMemcpyPeerAsync(..., stream_halo[i]);
11     for (int i = 0; i < device_count - 1; i++)
12         cudaMemcpyPeerAsync(..., stream_halo[i]);
13
14     for (int i = 0; i < device_count; i++) {          // sync before next step
15         cudaSetDevice(device[i]);
16         cudaDeviceSynchronize();
17     }
18 }
```

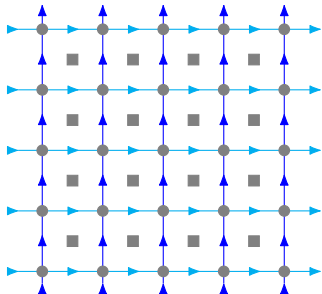
Пример

● p, τ_{xx}, τ_{yy}

■ τ_{xy}

▶ v_x, u_x

▶ v_y, u_y



$$\operatorname{div} v_{i,j}^n = \frac{v_{x,i+\frac{1}{2},j}^n - v_{x,i-\frac{1}{2},j}^n}{dx} + \frac{v_{y,i,j+\frac{1}{2}}^n - v_{y,i,j-\frac{1}{2}}^n}{dy}$$

$$p_{i,j}^{n+1} = p_{i,j}^n - K \operatorname{div} v_{i,j}^n \, dt$$

$$\tau_{xx,i,j}^{n+1} = \tau_{xx,i,j}^n + 2G \left(\frac{v_{x,i+\frac{1}{2},j}^n - v_{x,i-\frac{1}{2},j}^n}{dx} - \frac{\operatorname{div} v_{i,j}^n}{3} \right) dt$$

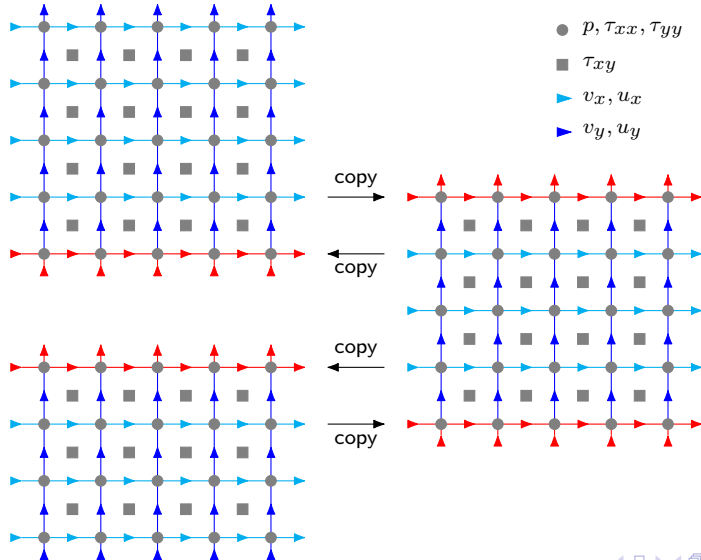
$$\tau_{yy,i,j}^{n+1} = \tau_{yy,i,j}^n + 2G \left(\frac{v_{y,i,j+\frac{1}{2}}^n - v_{y,i,j-\frac{1}{2}}^n}{dy} - \frac{\operatorname{div} v_{i,j}^n}{3} \right) dt$$

$$\tau_{xy,i,j}^{n+1} = \tau_{xy,i+\frac{1}{2},j+\frac{1}{2}}^n + G \left(\frac{v_{x,i+\frac{1}{2},j+1}^n - v_{x,i+\frac{1}{2},j}^n}{dy} + \frac{v_{y,i+1,j+\frac{1}{2}}^n - v_{y,i,j+\frac{1}{2}}^n}{dx} \right) dt$$

$$v_{x,i+\frac{1}{2},j}^{n+1} = (1 - d_{dmp} \, dt) v_{x,i+\frac{1}{2},j}^n + \frac{1}{\rho} \left(\frac{-p_{i+1,j}^{n+1} + p_{i,j}^{n+1} + \tau_{xx,i+1,j}^{n+1} - \tau_{xx,i,j}^{n+1}}{dx} + \frac{\tau_{xy,i+\frac{1}{2},j+\frac{1}{2}}^{n+1} - \tau_{xy,i+\frac{1}{2},j-\frac{1}{2}}^{n+1}}{dy} \right)$$

$$v_{y,i,j+\frac{1}{2}}^{n+1} = (1 - d_{dmp} \, dt) v_{y,i,j+\frac{1}{2}}^n + \frac{1}{\rho} \left(\frac{-p_{i,j+1}^{n+1} + p_{i,j}^{n+1} + \tau_{yy,i,j+1}^{n+1} - \tau_{yy,i,j}^{n+1}}{dy} + \frac{\tau_{xy,i-\frac{1}{2},j+\frac{1}{2}}^{n+1} - \tau_{xy,i+\frac{1}{2},j+\frac{1}{2}}^{n+1}}{dx} \right)$$

Разбиение сетки



Разбиение сетки

