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

21 апреля 2023 г.

Общий вид программы

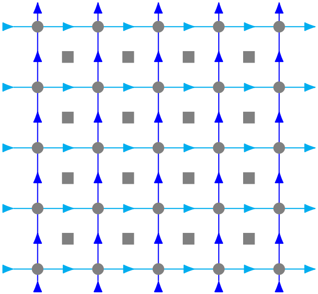
```
for (int iter = 0; iter < niter; iter++) {
    for (int i = 0; i < device_count; i++) {
        cudaSetDevice(device[i]);
        compute<<<..., stream_halo[i]>(...);       // compute halos
        compute<<<..., stream_halo[i]>(...);
        compute<<<..., stream_internal[i]>(...);  // compute internal data
    }

    for (int i = 1; i < device_count; i++)         // exchange halos
        cudaMemcpyPeerAsync(..., stream_halo[i]);
    for (int i = 0; i < device_count - 1; i++)
        cudaMemcpyPeerAsync(..., stream_halo[i]);

    for (int i = 0; i < device_count; i++) {       // sync before next step
        cudaSetDevice(device[i]);
        cudaDeviceSynchronize();
    }
}
```

Пример

- p, τ_{xx}, τ_{yy}
- τ_{xy}
- v_x, u_x
- v_y, u_y



$$p^{n+1}_{i,j} = p^{n}_{i,j} - K \operatorname{div} v^{n}_{i,j}\, \mathrm{d}t$$

$$\tau_{xx}{}^{n+1}_{i,j} = \tau_{xx}{}^{n}_{i,j} + 2G \left(\frac{v_x{}^{n}_{i+\frac{1}{2},j} - v_x{}^{n}_{i-\frac{1}{2},j}}{\mathrm{d}x} - \frac{\operatorname{div} v^{n}_{i,j}}{3} \right) \mathrm{d}t$$

$$\tau_{yy}{}^{n+1}_{i,j} = \tau_{yy}{}^{n}_{i,j} + 2G \left(\frac{v_y{}^{n}_{i,j+\frac{1}{2}} - v_y{}^{n}_{i,j-\frac{1}{2}}}{\mathrm{d}y} - \frac{\operatorname{div} v^{n}_{i,j}}{3} \right) \mathrm{d}t$$

$$\tau_{xy}{}^{n+1}_{i,j} = \tau_{xy}{}^{n}_{i+\frac{1}{2},j+\frac{1}{2}} + G \left(\frac{v_x{}^{n}_{i+\frac{1}{2},j+1} - v_x{}^{n}_{i+\frac{1}{2},j}}{\mathrm{d}y} + \frac{v_y{}^{n}_{i+1,j+\frac{1}{2}} - v_y{}^{n}_{i,j+\frac{1}{2}}}{\mathrm{d}x} \right) \mathrm{d}t$$

$$v_x{}^{n+1}_{i+\frac{1}{2},j} = (1 - d_{dmp}\, \mathrm{d}t) v_x{}^{n}_{i+\frac{1}{2},j} + \frac{1}{\rho} \left(\frac{-p^{n+1}_{i+1,j} + p^{n+1}_{i,j} + \tau_{xx}{}^{n+1}_{i+1,j} - \tau_{xx}{}^{n+1}_{i,j}}{\mathrm{d}x} + \right.$$
$$\left. + \frac{\tau_{xy}{}^{n+1}_{i+\frac{1}{2},j+\frac{1}{2}} - \tau_{xy}{}^{n+1}_{i+\frac{1}{2},j-\frac{1}{2}}}{\mathrm{d}y} \right)$$

$$\operatorname{div} v^{n}_{i,j} = \frac{v_x{}^{n}_{i+\frac{1}{2},j} - v_x{}^{n}_{i-\frac{1}{2},j}}{\mathrm{d}x} + \frac{v_y{}^{n}_{i,j+\frac{1}{2}} - v_y{}^{n}_{i,j-\frac{1}{2}}}{\mathrm{d}y}$$

$$v_y{}^{n+1}_{i,j+\frac{1}{2}} = (1 - d_{dmp}\, \mathrm{d}t) v_y{}^{n}_{i,j+\frac{1}{2}} + \frac{1}{\rho} \left(\frac{-p^{n+1}_{i,j+1} + p^{n+1}_{i,j} + \tau_{yy}{}^{n+1}_{i,j+1} - \tau_{yy}{}^{n+1}_{i,j}}{\mathrm{d}y} + \right.$$
$$\left. + \frac{\tau_{xy}{}^{n+1}_{i-\frac{1}{2},j+\frac{1}{2}} - \tau_{xy}{}^{n+1}_{i+\frac{1}{2},j+\frac{1}{2}}}{\mathrm{d}x} \right)$$

Разбиение сетки