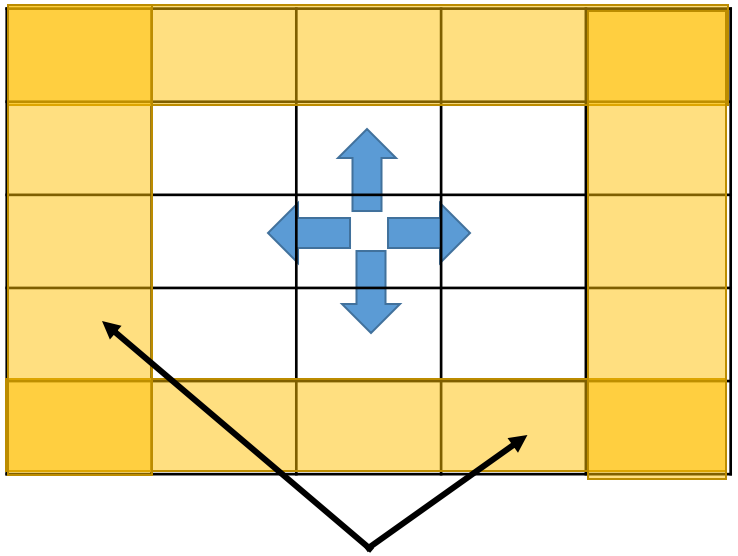
Advanced MPI – RMA example

Jacobi Solver

- The Jacobi method is an iterative algorithm for solving a system of linear equations.
- In the 2D model an approximation can be made by taking the average of the 4 neighbouring values (4 point stencil).




```
REAL A(0:n+1,0:n+1), B(1:n,1:n)
...
!Main Loop
DO WHILE(.NOT.converged)
   ! perform 4 point stencil
   DO j=1, n
      DO i=1, n
         B(i,j)=0.25*(A(i-1,j)+A(i+1,j)+A(i,j-
1)+A(i,j+1))
      END DO
   END DO

   ! copy result back into array A
   DO j=1, n
      DO i=1, n
         A(i,j) = B(i,j)
      END DO
   END DO
...
! convergence test
END DO
```

Jacobi in Parallel

- For simplicity, can use 1D domain decomposition, dividing rows or columns of the grid among the MPI ranks.
- Since each rank will need data from neighbouring domains need to set up halo regions.
- For efficiency, exchange columns with Fortran and rows with C.
- As a first version, can use MPI_Send and MPI_Recv to exchange the data.

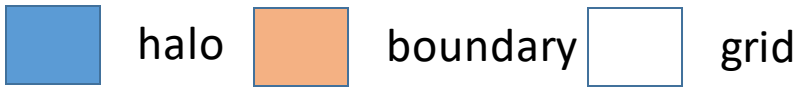
Halo exchange -Fortran Version

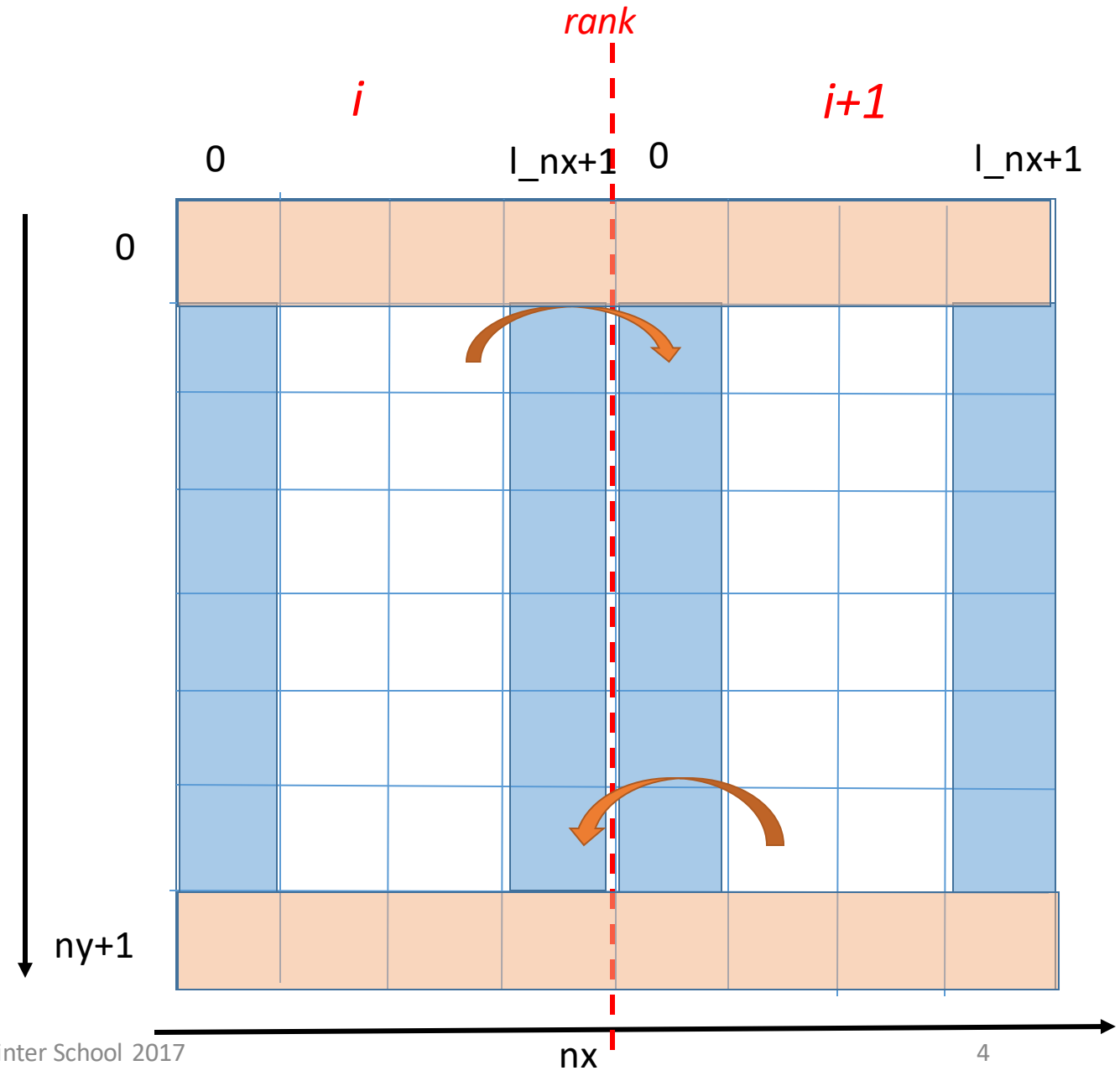
We start with a data grid(ny,nx) which becomes grid(0:ny+1,0:nx+1) when we include the boundaries.

Each local domain is (1..ny,1..l_{nx}) but with a halo region + boundaries we have

(0..ny+1,0..l_{nx}+1).

Ranks 0 and size-1 need only 1 halo region, since they must store the left and right border conditions.



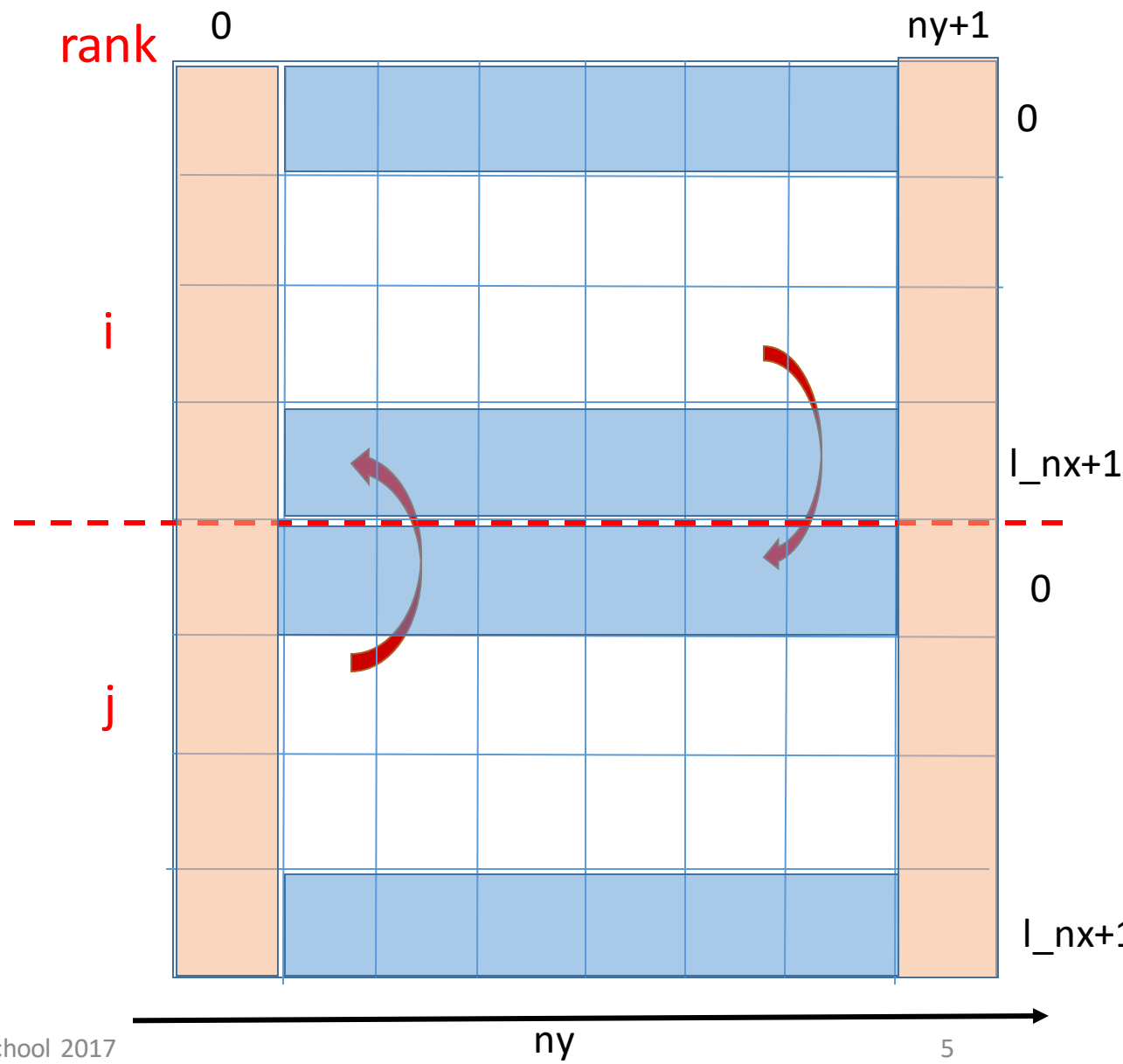


Halo exchange C Version

For C we exchange rows instead of columns, such that the rows are divided among the MPI ranks.

MPI ranks 0 and size-1 need only 1 halo region (and only 2 transfers) because they contain the top and bottom boundary conditions.

Note we have inverted the nx and ny axes with respect to the FORTRAN version.



halo boundary grid

Practical

1. Download the MPI C or Fortran source code:
   - git clone https://gitlab.hpc.cineca.it/training/advanced-school.git
2. Try first the serial code, for various grid sizes.
3. Look at the MPI version, compile, run and see how long it takes for various numbers of tasks:

   mpicc –o jacobi jacobi.c OR mpiifort –o jacobi jacobi.f90

   mpirun –n 4 ./jacobi 10 10
4. Replace the blocking send/recv with non-blocking send/recv and re-run. (optional: mpi_sendrecv).
5. Replace the non-blocking send/recv with mpi_rma.
6. Instead of fence synchronization you could try:
   1. PSCW (Post Start Complete Wait)
   2. Use lock and unlock.

Inspired by the example at http://www.archer.ac.uk/training/course-material/2016/09/160929_AdvMPI_EPCC/index.php