MPI 3.0 Neighbourhood Collectives

Advanced Parallel Programming

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- Review of topologies in MPI

- MPI 3.0 includes new neighbourhood collective operations:
  - MPI_Neighbor_allgather[v]
  - MPI_Neighbor_alltoall[v|w]
- Example usage:
  - Halo-exchange can be done with a single MPI communication call

- Practical tomorrow:
  - Replace all point-to-point halo-exchange communication with a single neighbourhood collective in your MPP coursework code

Topology communicators (review 1)

- Regular n-dimensional grid or torus topology
  - MPI_CART_CREATE
- General graph topology
  - MPI_GRAPH_CREATE
    - All processes specify all edges in the graph (not scalable)
- General graph topology (distributed version)
  - MPI_DIST_GRAPH_CREATE_ADJACENT
    - All processes specify their incoming and outgoing neighbours
  - MPI_DIST_GRAPH_CREATE
    - Any process can specify any edge in the graph (too general?)

Topology communicators (review 2)

- Testing the topology type associated with a communicator
  - MPI_TOPO_TEST
- Finding the neighbours for a process
  - MPI_CART_SHIFT

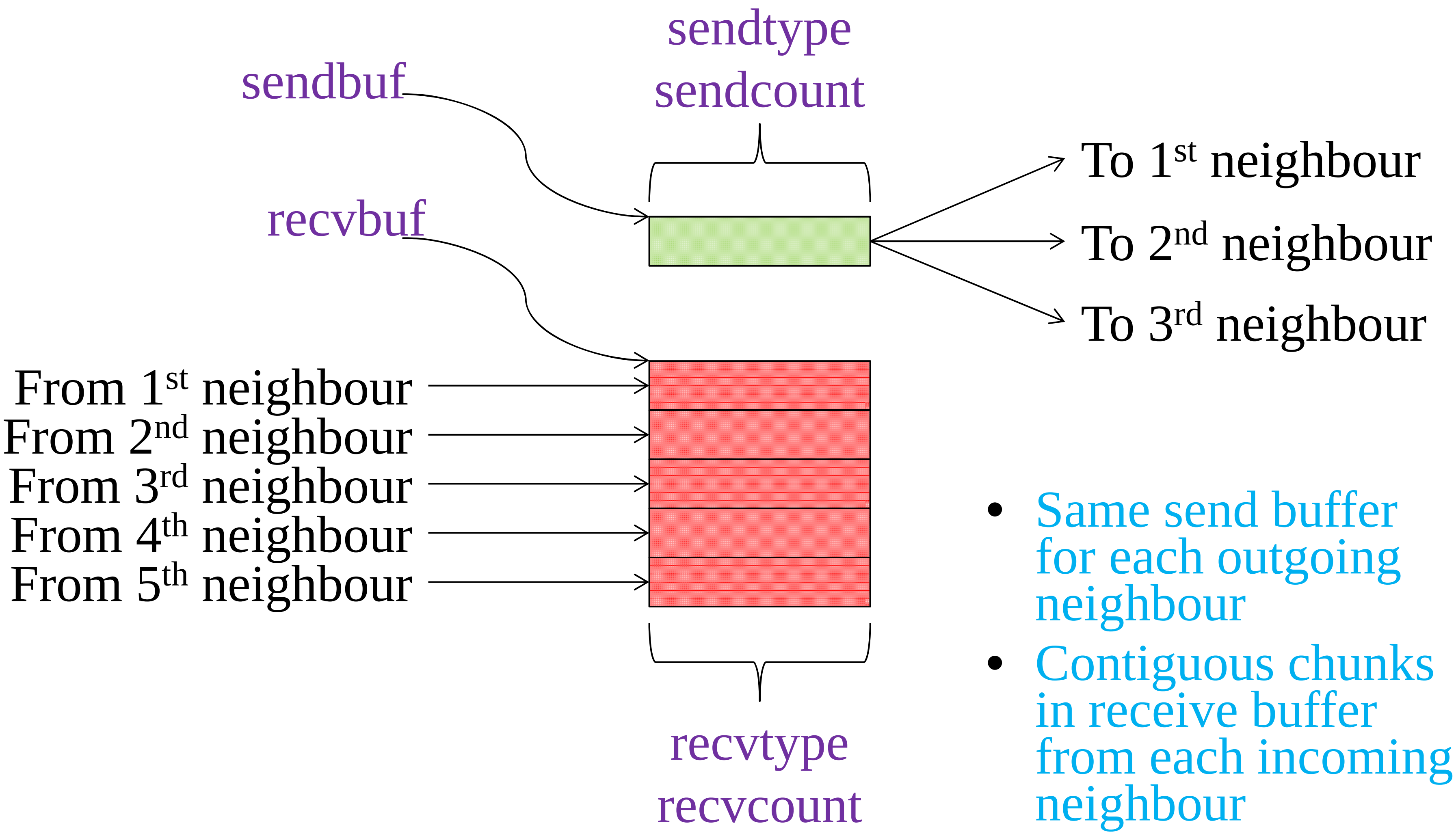
  - Find out how many neighbours there are:
    - MPI_GRAPH_NEIGHBORS_COUNT
  - Get the ranks of all neighbours:
    - MPI_GRAPH_NEIGHBORS

  - Find out how many neighbours there are:
    - MPI_DIST_GRAPH_NEIGHBORS_COUNT
  - Get the ranks of all neighbours:
    - MPI_DIST_GRAPH_NEIGHBORS

Neighbourhood collective operations

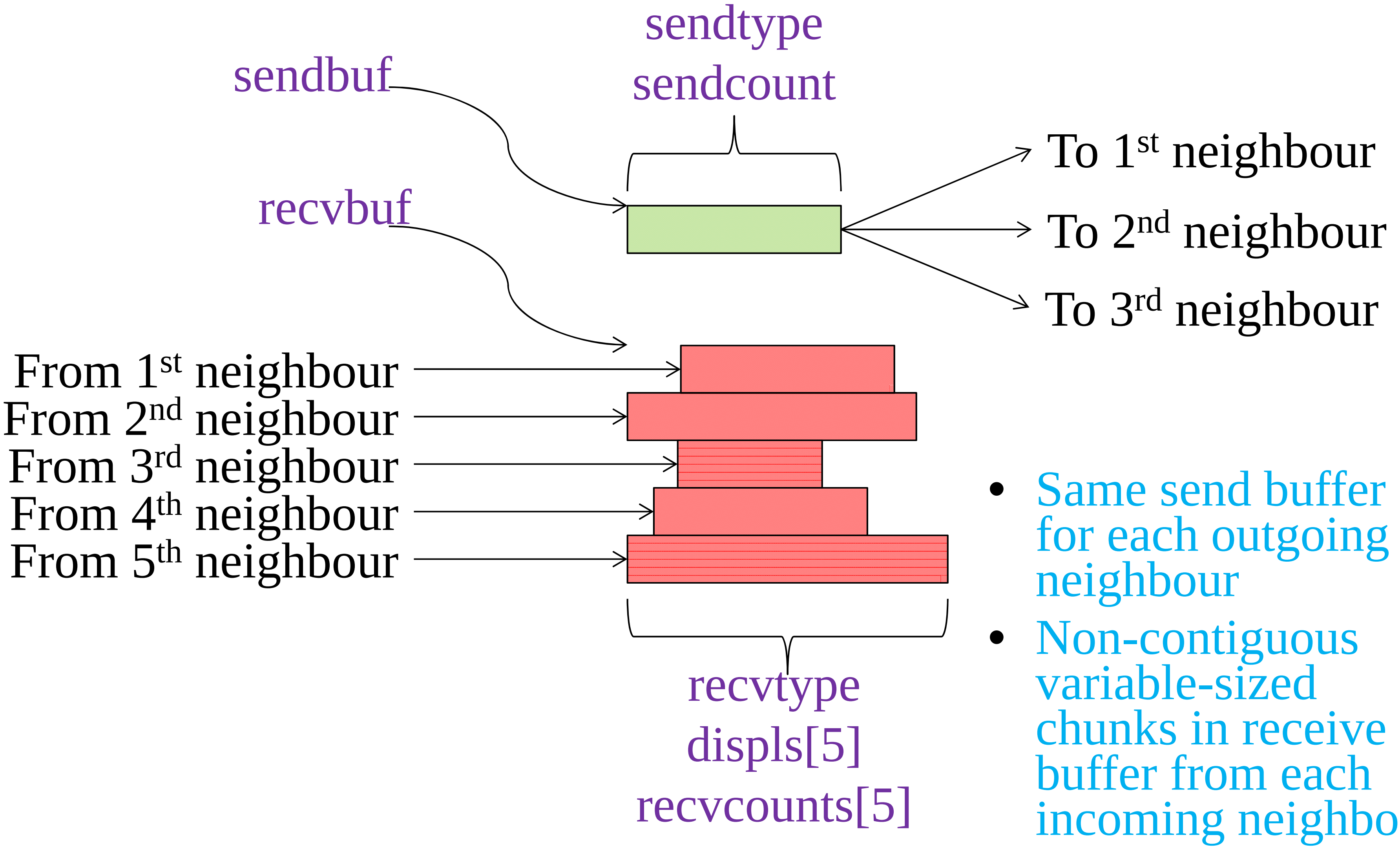
- See section 7.6 in MPI 3.0 for blocking functions
  - See section 7.7 in MPI 3.0 for non-blocking functions
  - See section 7.8 in MPI 3.0 for an example application
    - But beware of the mistake(s) in the example code!
- MPI_[N|In]eighbor_allgather[v]
  - Send one piece of data to all neighbours
  - Gather one piece of data from each neighbour
- MPI_[N|In]eighbor_alltoall[v|w]
  - Send different data to each neighbour
  - Receive different data from each neighbour
- Use-case: regular or irregular domain decomposition codes
  - Where the decomposition is static or changes infrequently
  - Because creating a topology communicator takes time

MPI_Neighbor_allgather



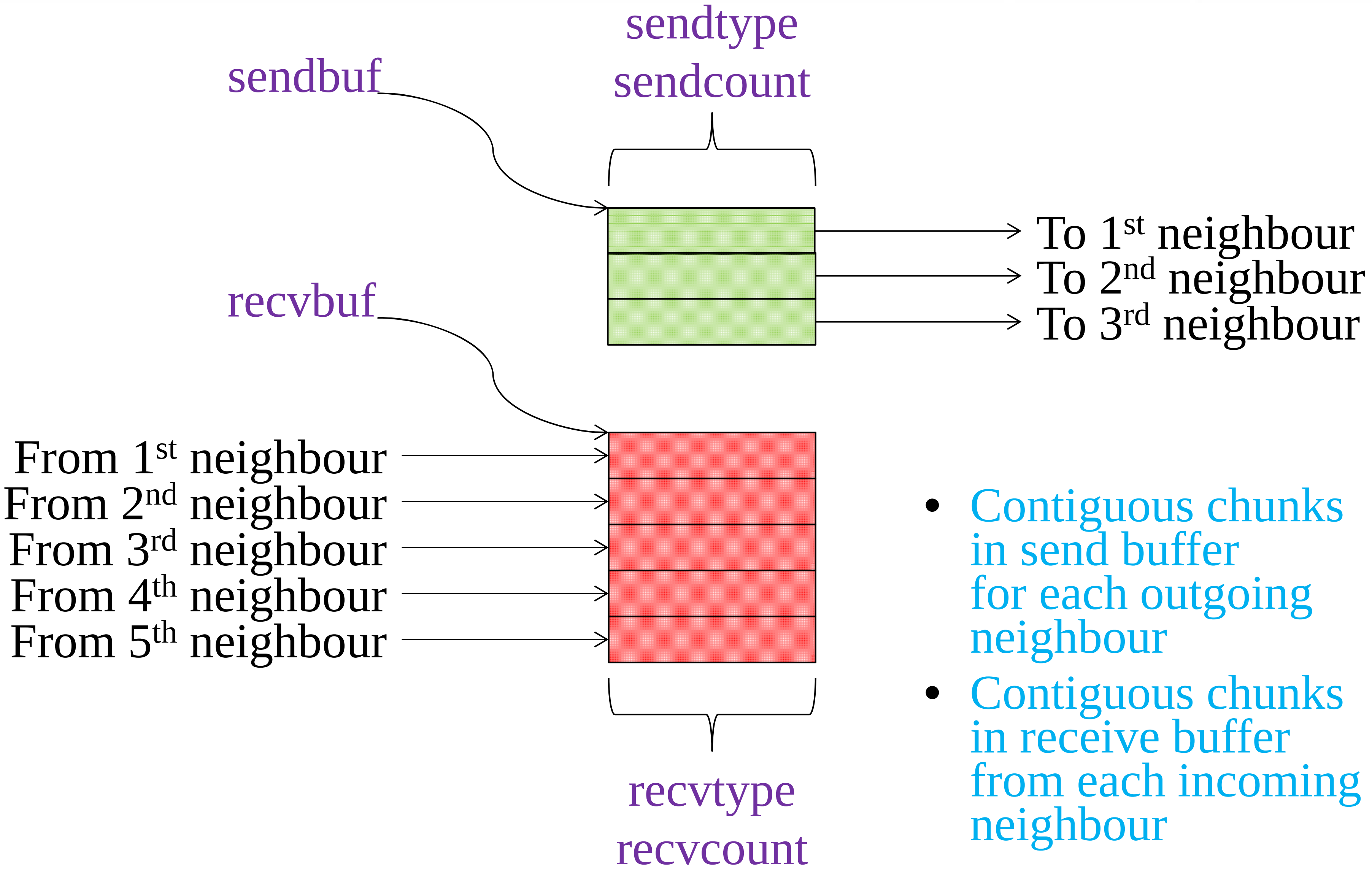
- Same send buffer for each outgoing neighbour
- Contiguous chunks in receive buffer from each incoming neighbour

MPI_Neighbor_allgatherv



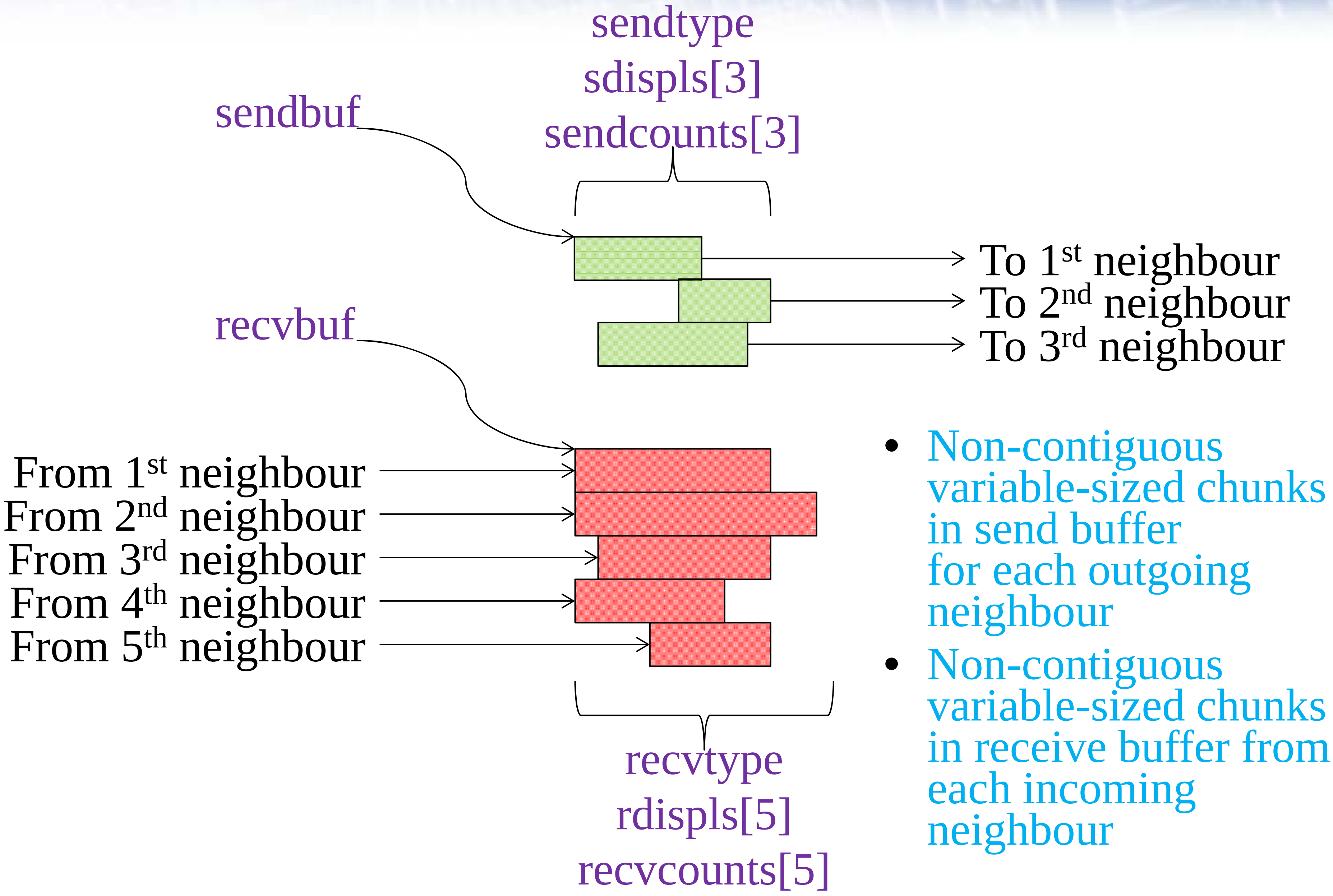
- Same send buffer for each outgoing neighbour
- Non-contiguous variable-sized chunks in receive buffer from each incoming neighbour

MPI_Neighbor_alltoall



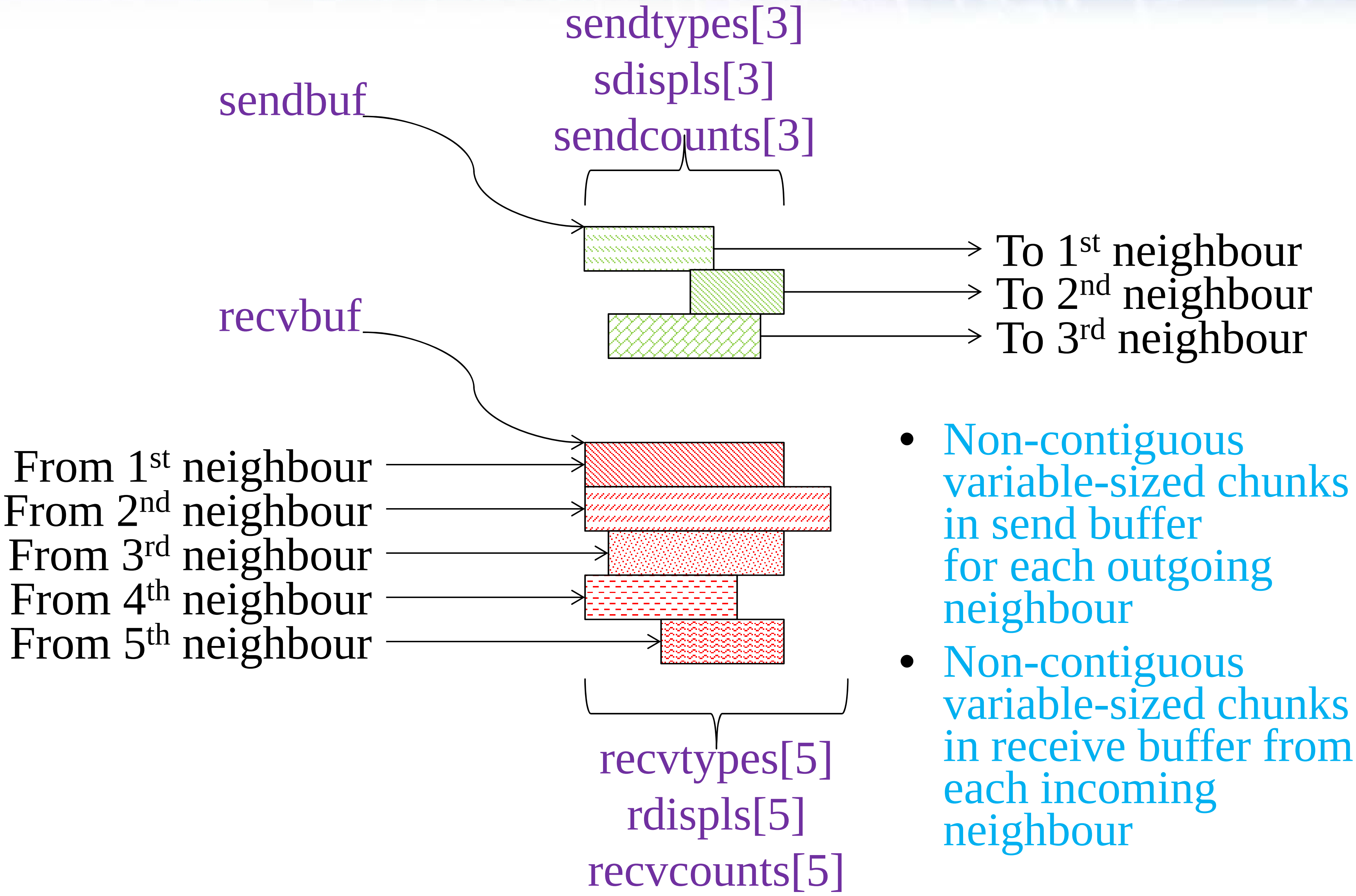
- Contiguous chunks in send buffer for each outgoing neighbour
- Contiguous chunks in receive buffer from each incoming neighbour

MPI_Neighbor_alltoallv



- Non-contiguous variable-sized chunks in send buffer for each outgoing neighbour
- Non-contiguous variable-sized chunks in receive buffer from each incoming neighbour

MPI_Neighbor_alltoallw



- Non-contiguous variable-sized chunks in send buffer for each outgoing neighbour
- Non-contiguous variable-sized chunks in receive buffer from each incoming neighbour

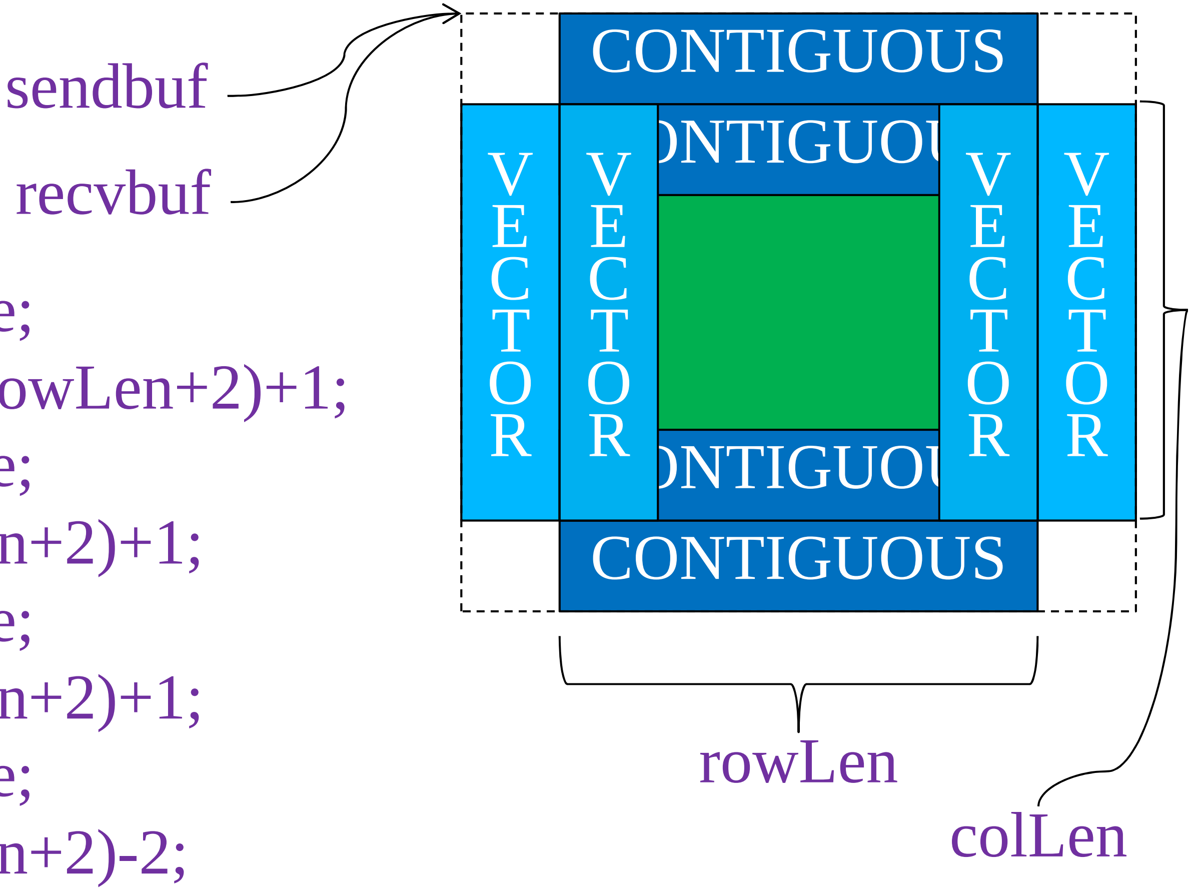
MPI_Neighbor_alltoallw

```
for (int i=0;i<4;++i) {
    sendcounts[i] = 1;
    recvcounts[i]=1; }

sendtypes[0] = contigType;
senddispls[0] = colLen*(rowLen+2)+1;
sendtypes[1] = contigType;
senddispls[1] = 1*(rowLen+2)+1;
sendtypes[2] = vectorType;
senddispls[2] = 1*(rowLen+2)+1;
sendtypes[3] = vectorType;
senddispls[3] = 2*(rowLen+2)-2;

// similarly for recvtypes and recvdispls

MPI_Neighbor_alltoallw(sendbuf, sendcounts, senddispls, sendtypes,
                       recvbuf, recvcounts, recvdsipls, recvtypes,
                       comm);
```



Summary

- Regular or irregular domain decomposition codes
  - Where the decomposition is static or changes infrequently
- Should investigate replacing point-to-point communication
  - E.g. halo-exchange communication
- With neighbourhood collective communication
  - Probably MPI_Ineighbor_alltoallw
- So that MPI can optimise the whole pattern of messages
  - Rather than trying to optimise each message individually
- And so your application code is simpler and easier to read

Exercise

- Extend MPP coursework to use neighbourhood collectives
- Procedure
  - define a cartesian topology (if not already done)
  - replace explict halo swapping with neighbourhood collectives
  - first use MPI_neighbor_alltoall
    - declare new buffers large enough to contain 4 halos (send + recv)
    - copy boundaries (in correct order) from main array to send buffer
    - call MPI_neighbor_alltoallv
    - unpack contents from receive buffer to halos of main array
  - now use MPI_neighbor_alltoallw to avoid copies
    - see example in slides
    - can now read / write from / to main array directly by defining appropriate derive types and displacements
    - be careful about what you call "up" and "down" halos!