Programming OpenMP

OpenMP and MPI

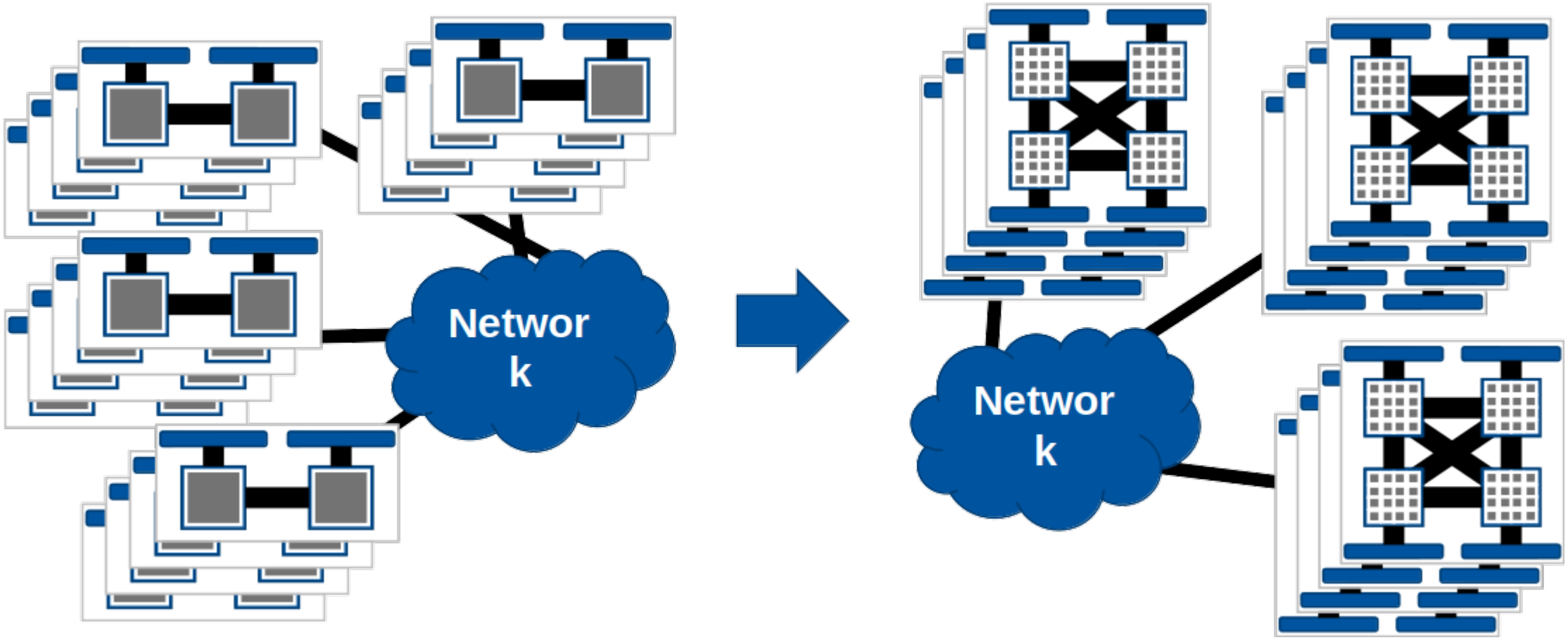
Christian Terboven

RWTH AACHEN UNIVERSITY

Motivation

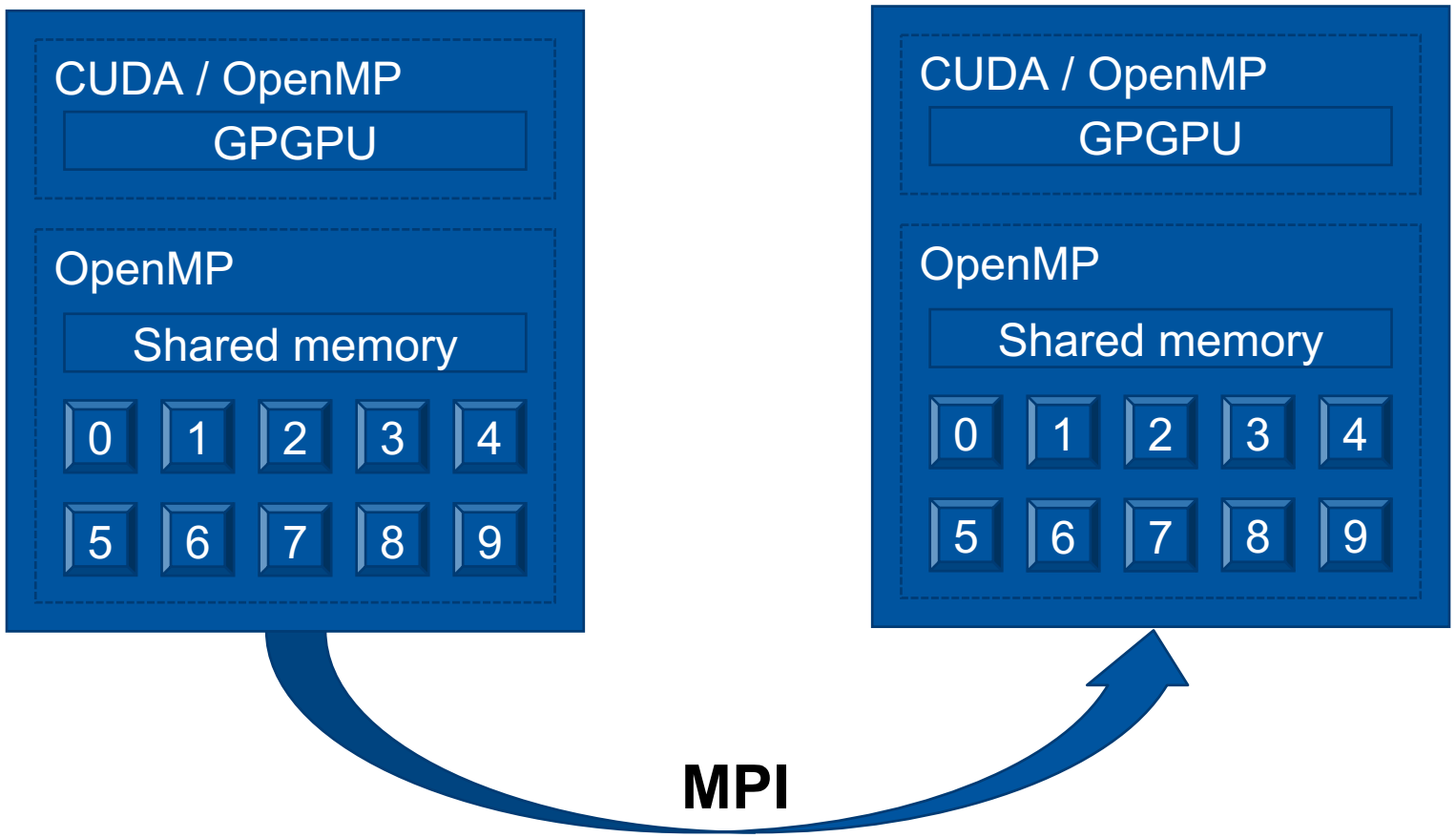
Motivation for hybrid programming

- Increasing number of cores per node



Hybrid programming

- (Hierarchical) mixing of different programming paradigms



MPI and OpenMP

MPI – threads interaction

- MPI needs special initialization in a threaded environment
  - Use `MPI_Init_thread` to communicate thread support level

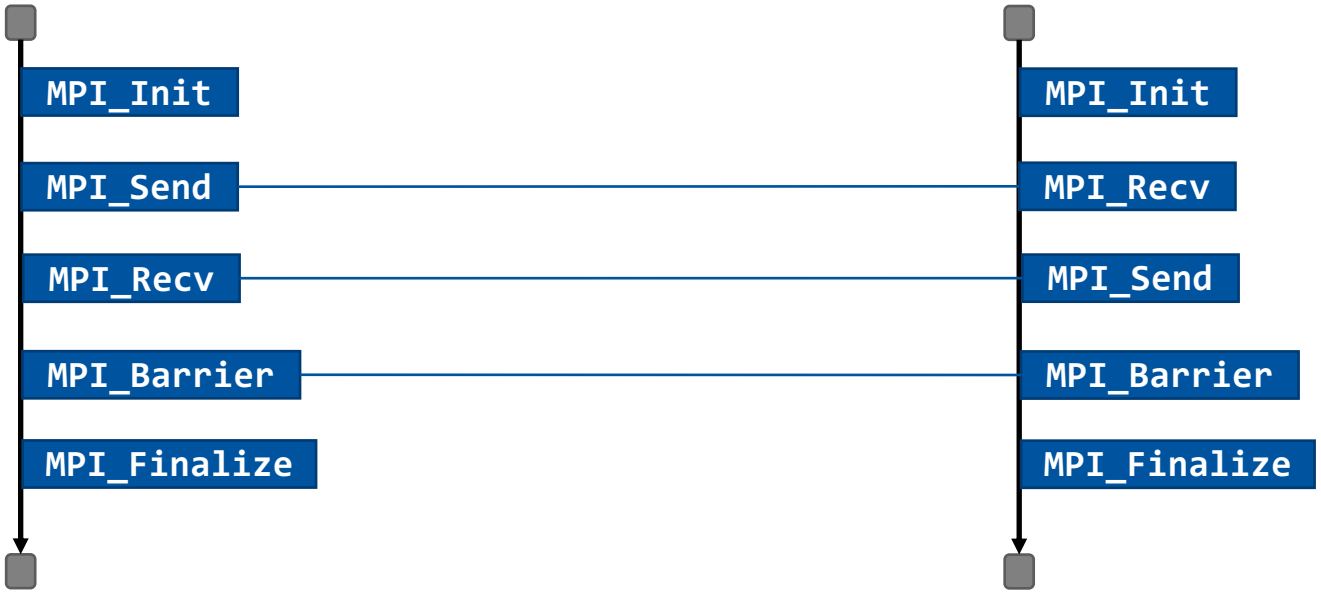
- Four levels of threading support

Level identifier	Description
`MPI_THREAD_SINGLE`	Only one thread may execute
`MPI_THREAD_FUNNELED`	Only the main thread may make MPI calls
`MPI_THREAD_SERIALIZED`	Any one thread may make MPI calls at a time
`MPI_THREAD_MULTIPLE`	Multiple threads may call MPI concurrently with no restrictions

- `MPI_THREAD_MULTIPLE` may incur significant overhead inside an MPI implementation

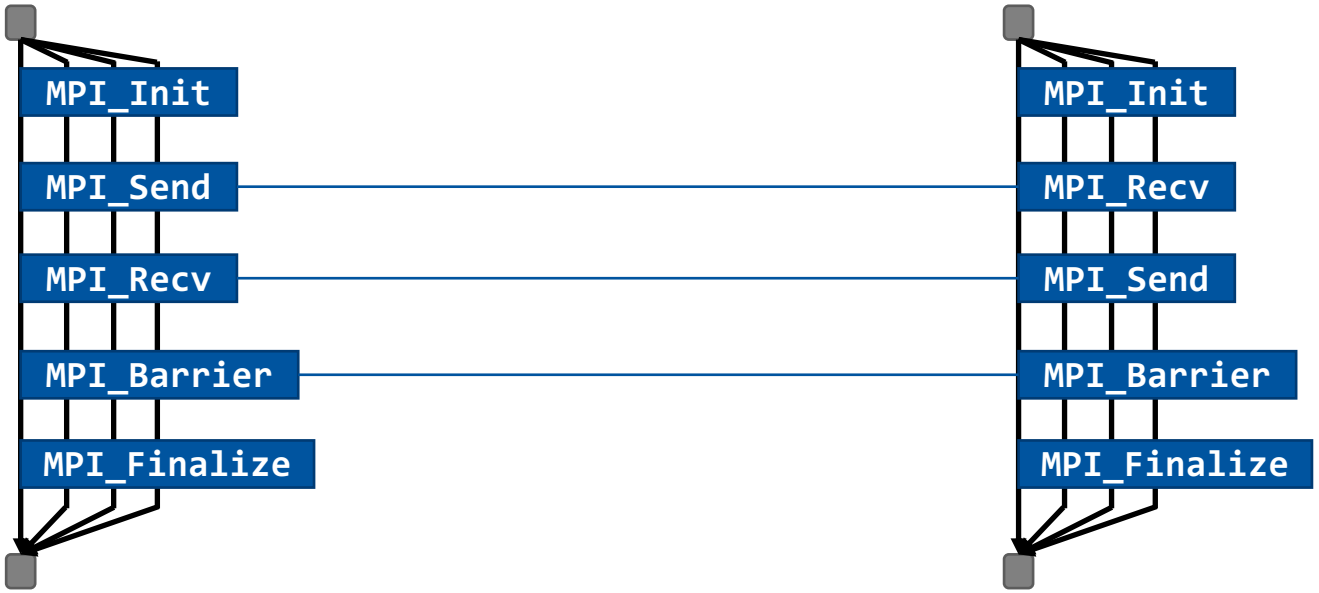
MPI – Threading support levels

- MPI_THREAD_SINGLE
  - Only one thread per MPI rank



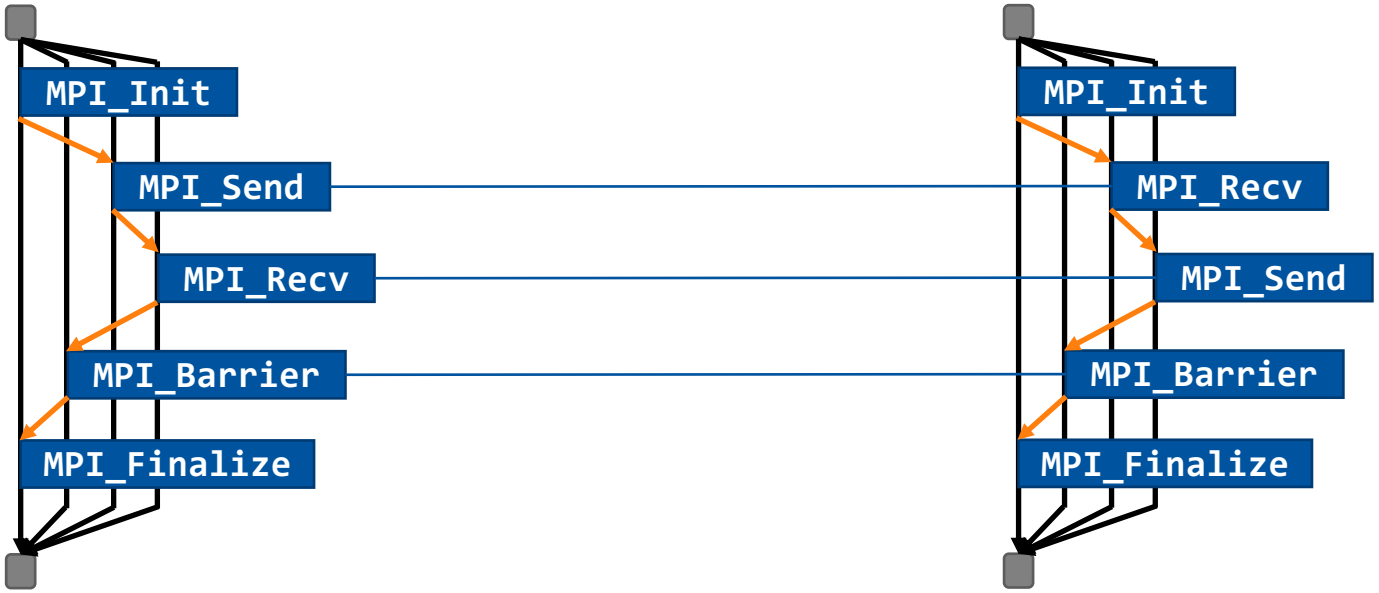
MPI – Threading support levels

- MPI_THREAD_FUNNELED
  - Only one thread communicates



MPI – Threading support levels

- MPI_THREAD_SERIALIZED
  - Only one thread communicates at a time



MPI – Threading support levels

- MPI_THREAD_MULTIPLE
  - All threads communicate concurrently without synchronizatio

MPI Communication
Thread Synchronization