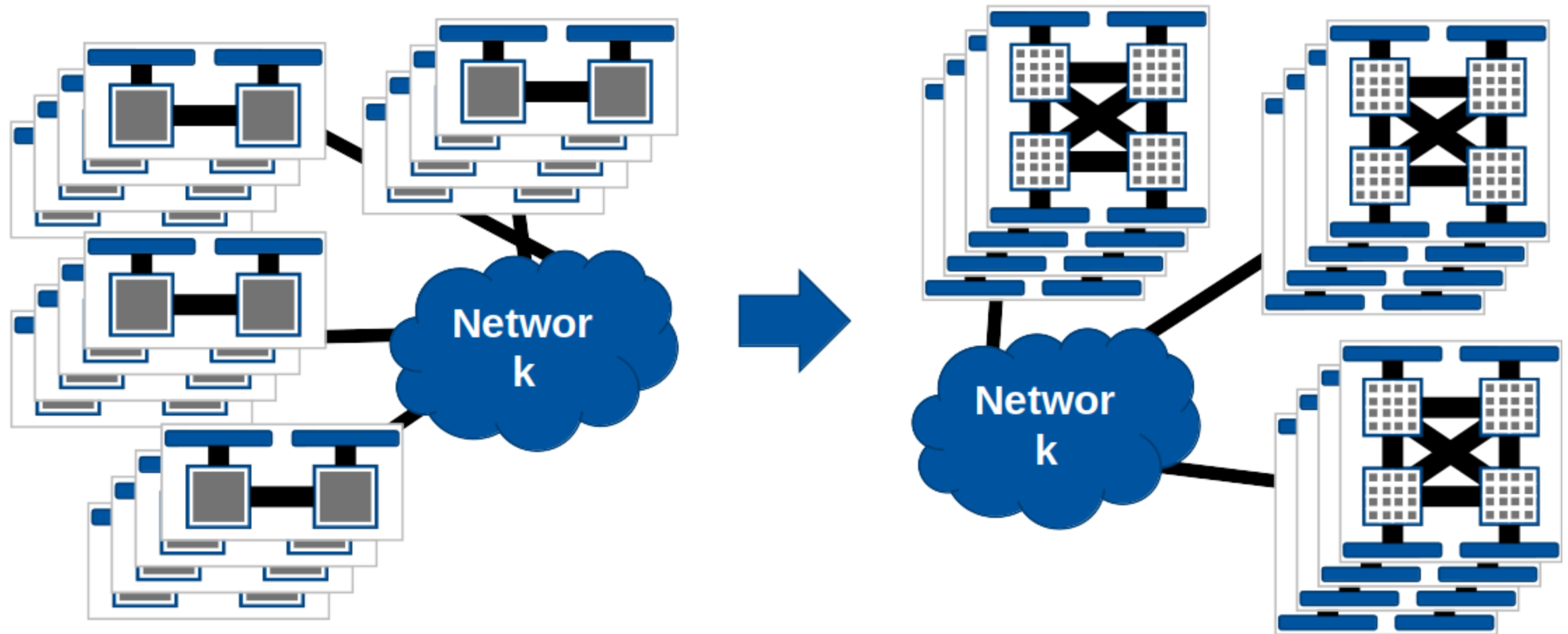# Programming OpenMP

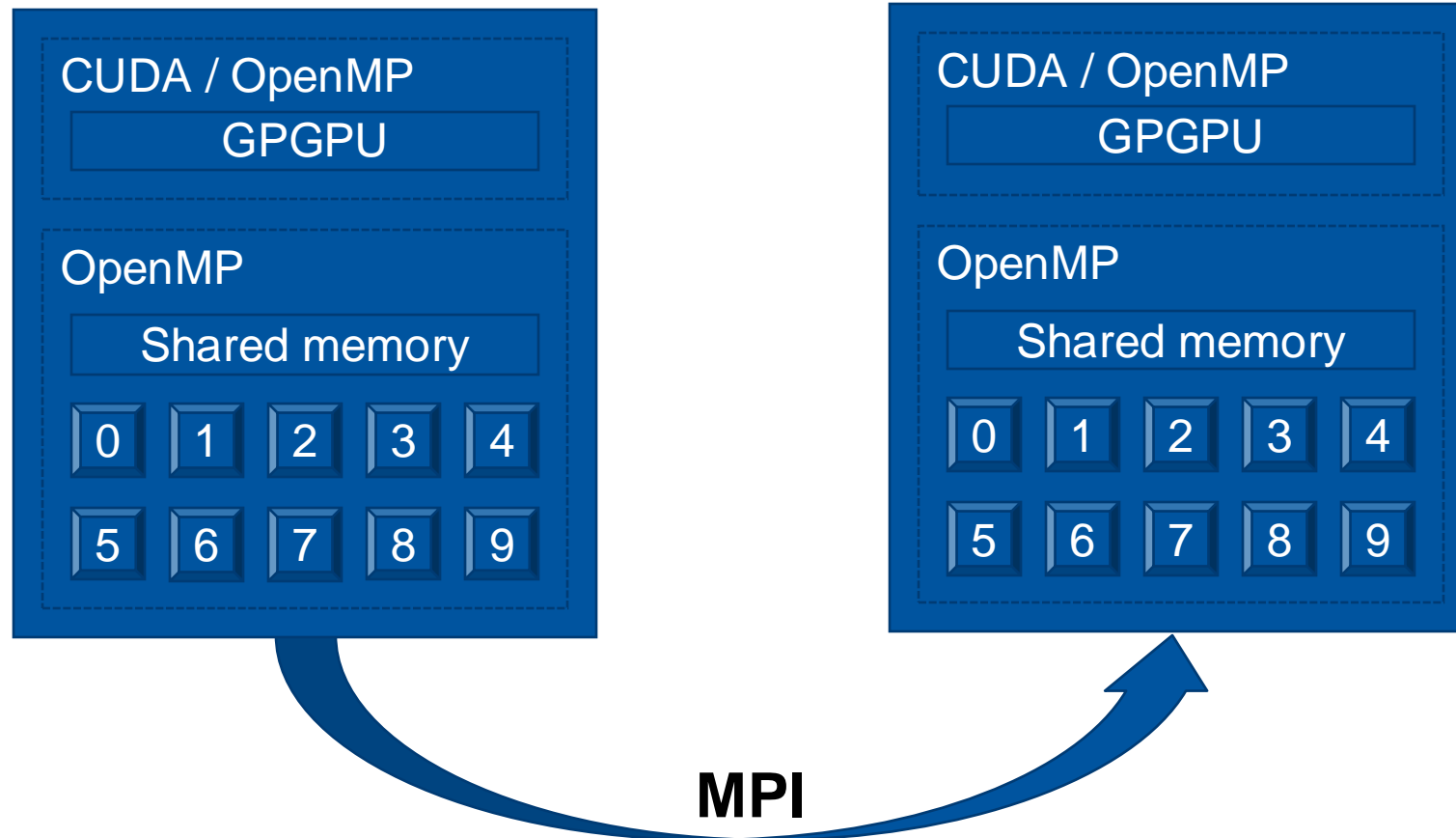## *OpenMP and MPI*

Christian Terboven

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
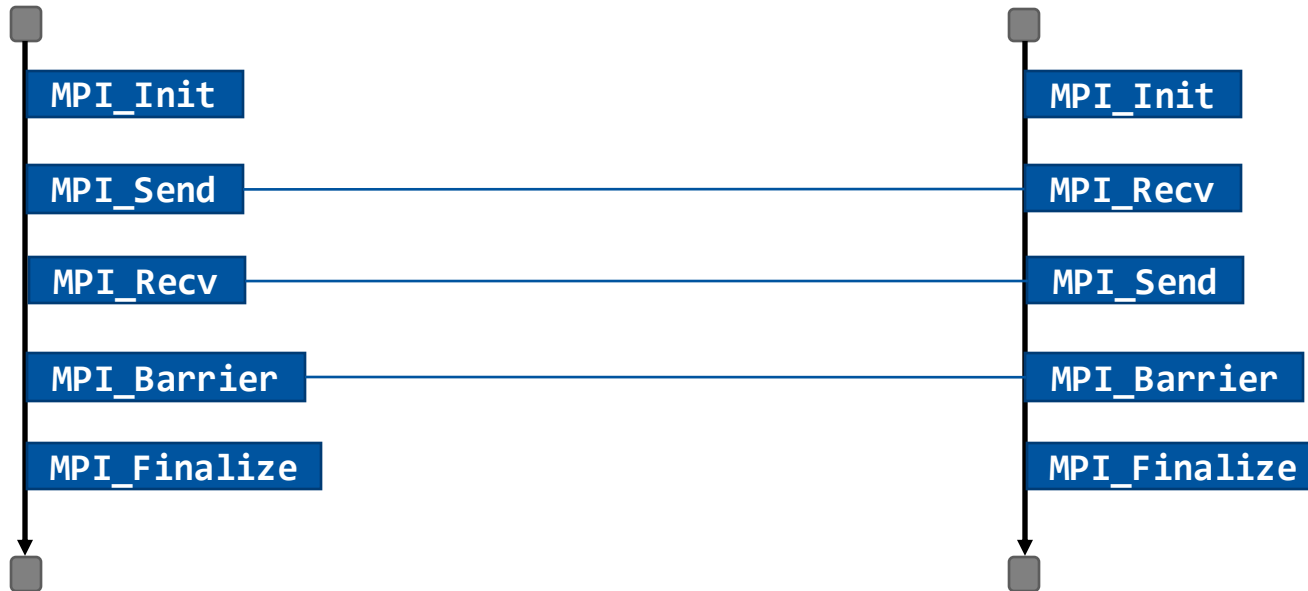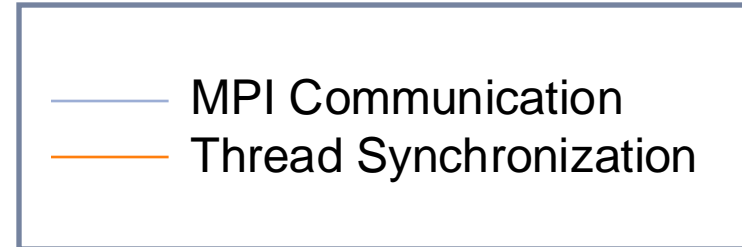
- Four levels of threading support

Higher levels ↓

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
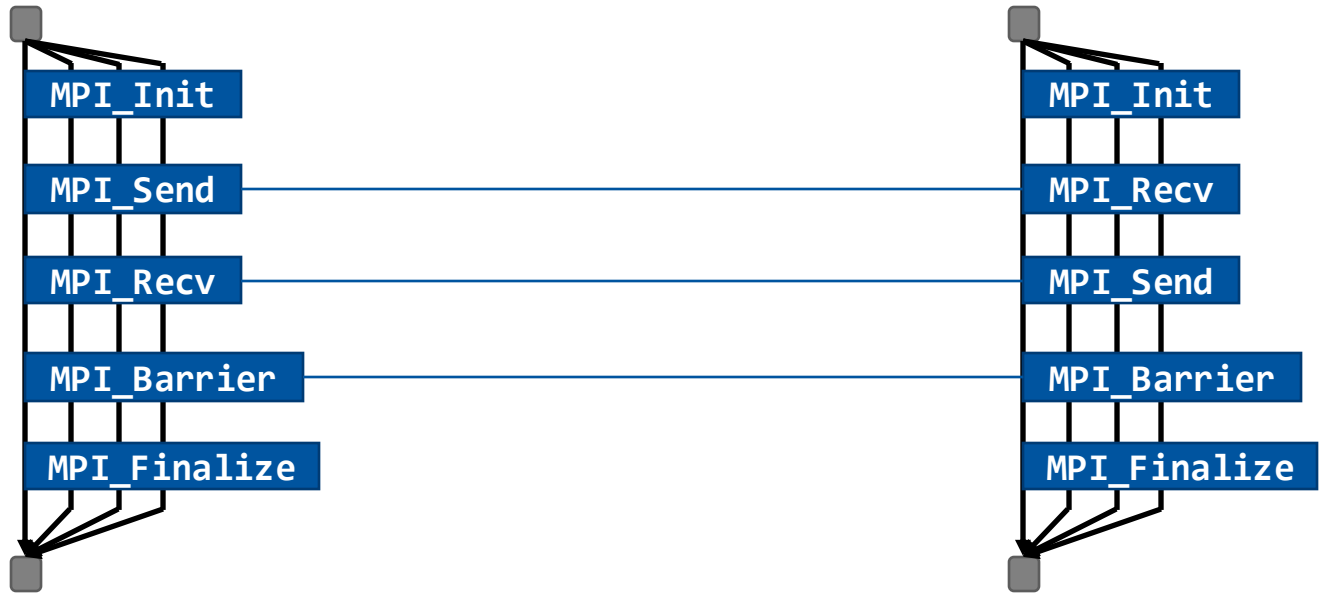
MPI – Threading support levels

- MPI_THREAD_SINGLE
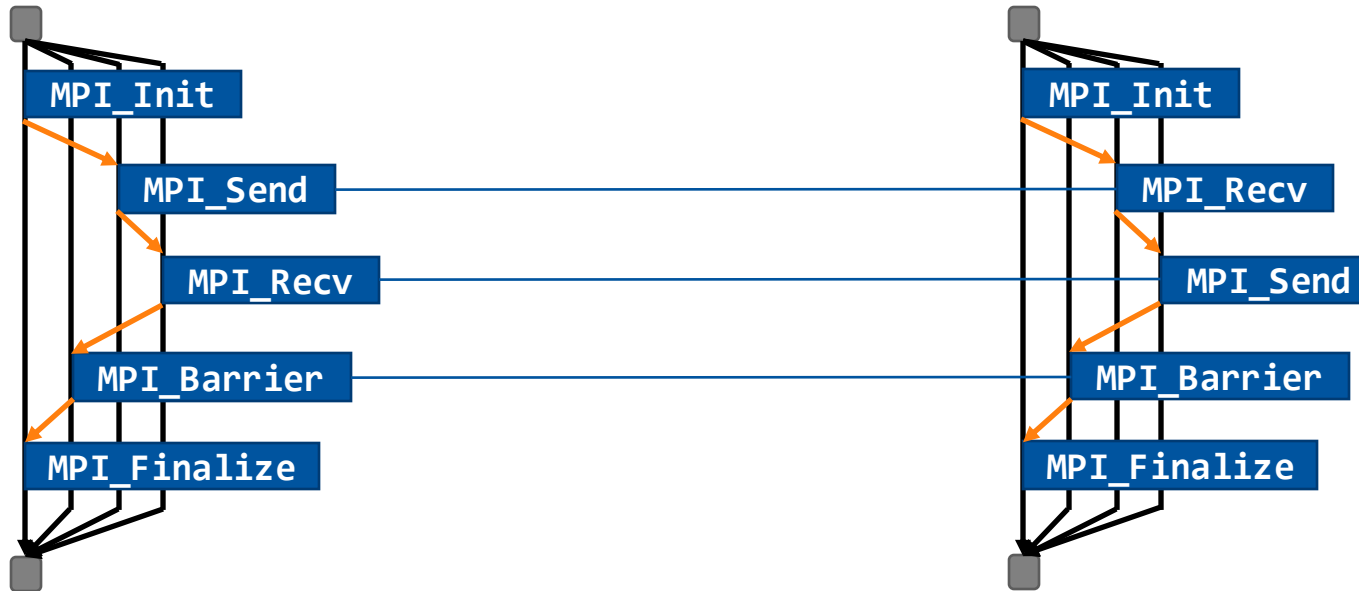 - Only one thread per MPI rank

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

Programming in OpenMP
Christian Terboven & Members of the OpenMP Language Committee

MPI – Threading support levels

- MPI_THREAD_MULTIPLE
  - All threads communicate concurrently without synchronization

MPI Communication
Thread Synchronization