

# Programming OpenMP

## *OpenMP and MPI*

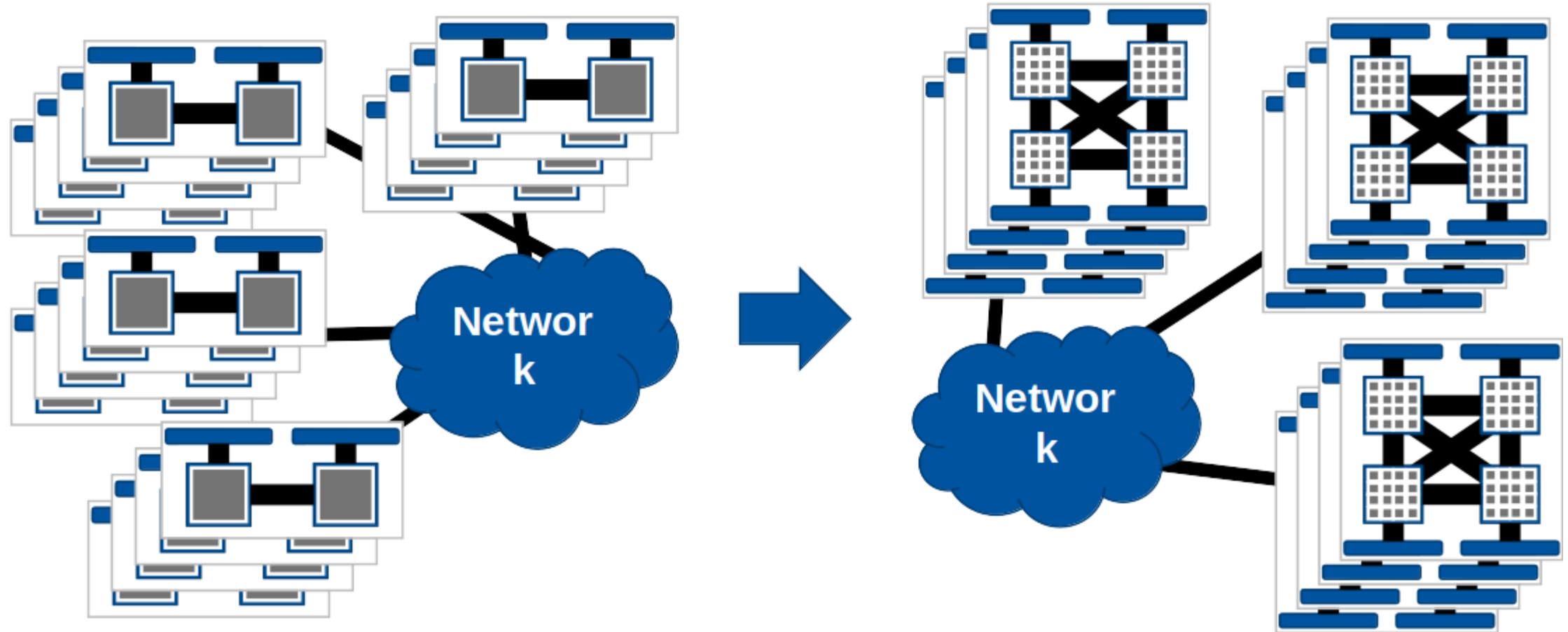
**Christian Terboven**



# Motivation

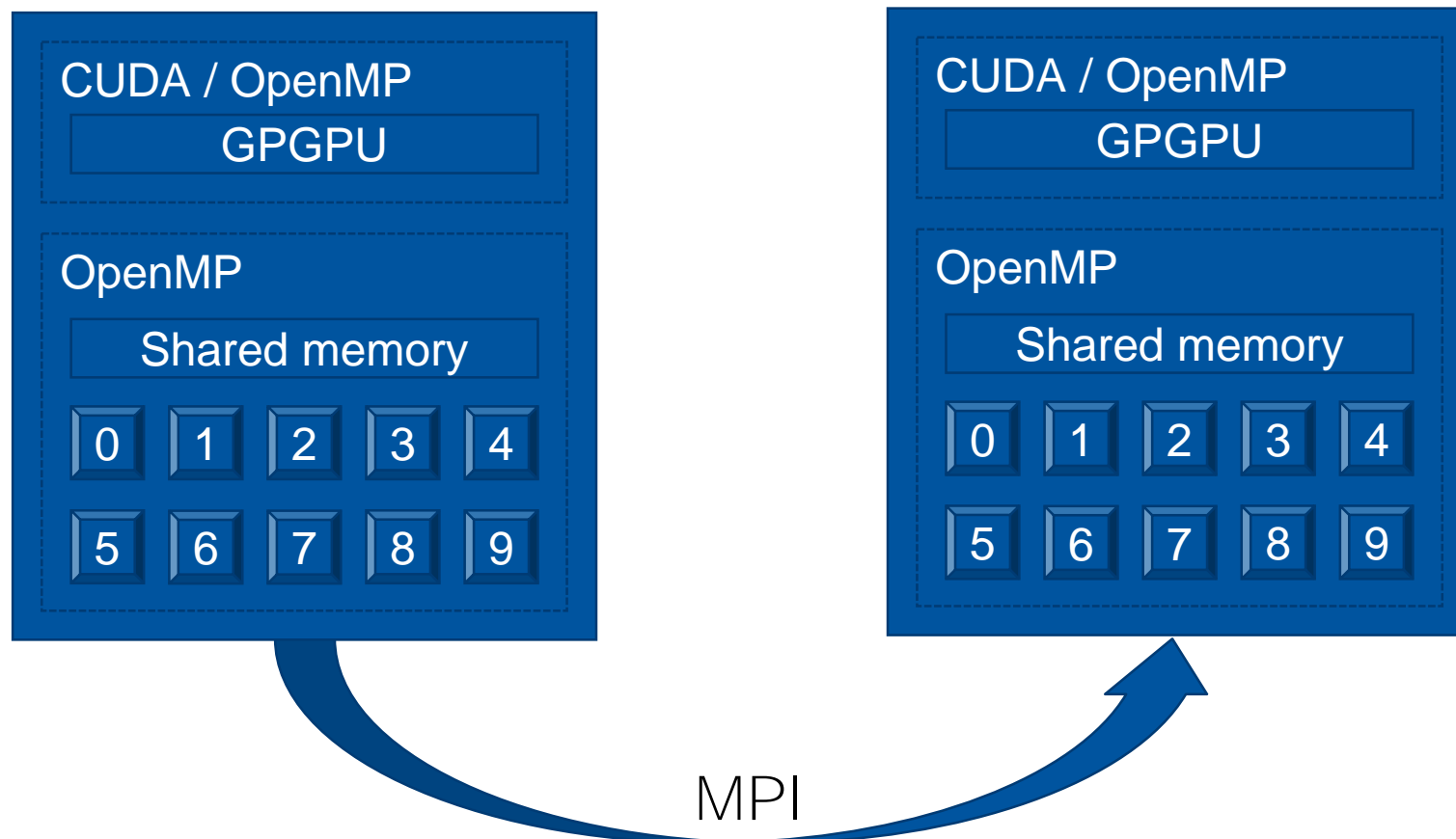
# Motivation for hybrid programming

- 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

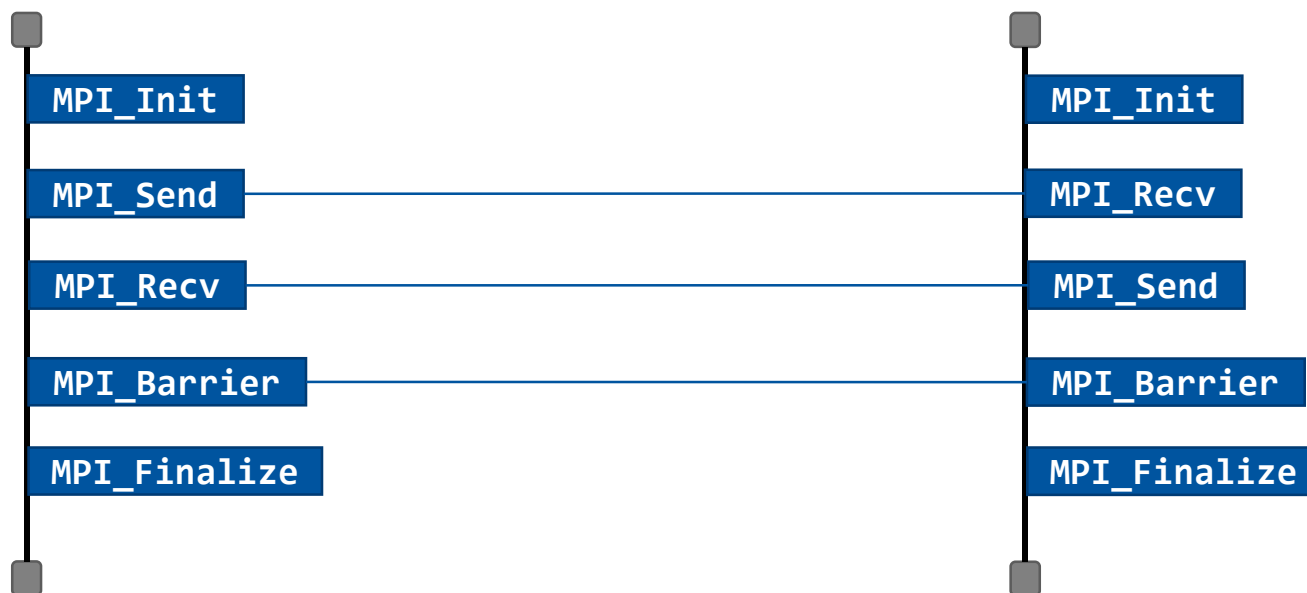
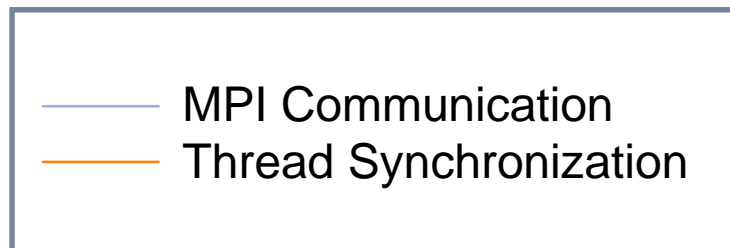


Level identifier	Description
<code>MPI_THREAD_SINGLE</code>	Only one thread may execute
<code>MPI_THREAD_FUNNELED</code>	Only the main thread may make MPI calls
<code>MPI_THREAD_SERIALIZED</code>	Any one thread may make MPI calls at a time
<code>MPI_THREAD_MULTIPLE</code>	Multiple threads may call MPI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

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

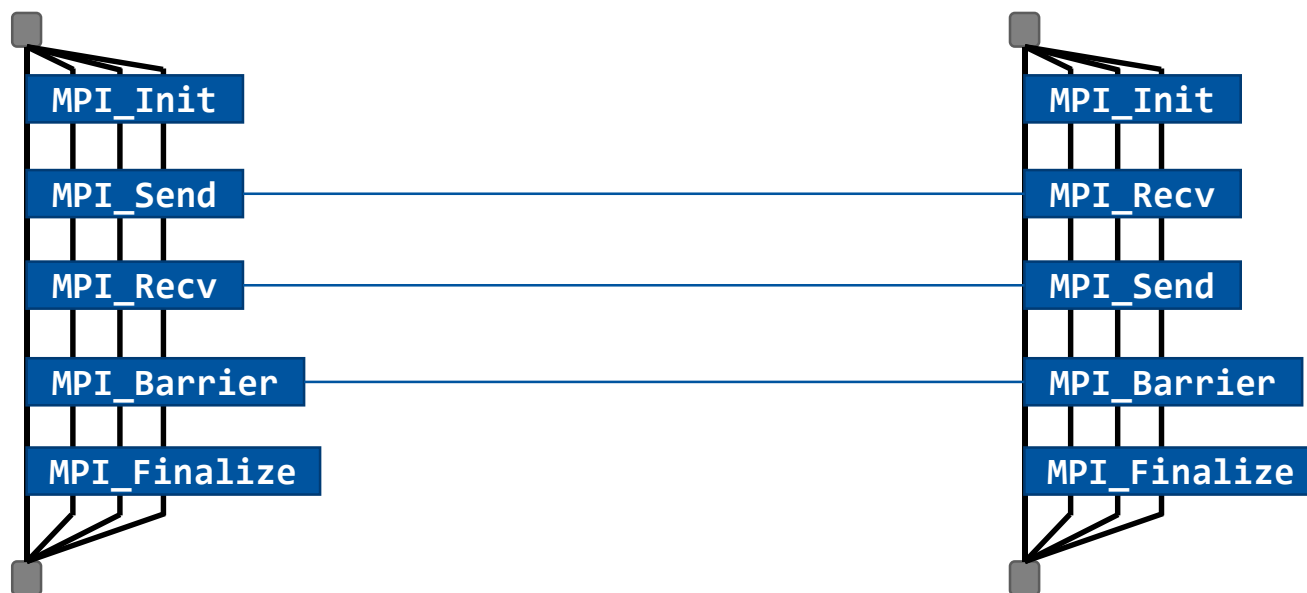
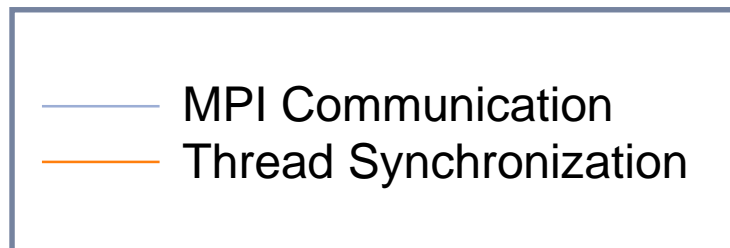
# MPI – Threading support levels

- **MPI\_THREAD\_SINGLE**
  - Only one thread per MPI rank



# MPI – Threading support levels

- **MPI\_THREAD\_FUNNELED**
  - Only one thread communicates

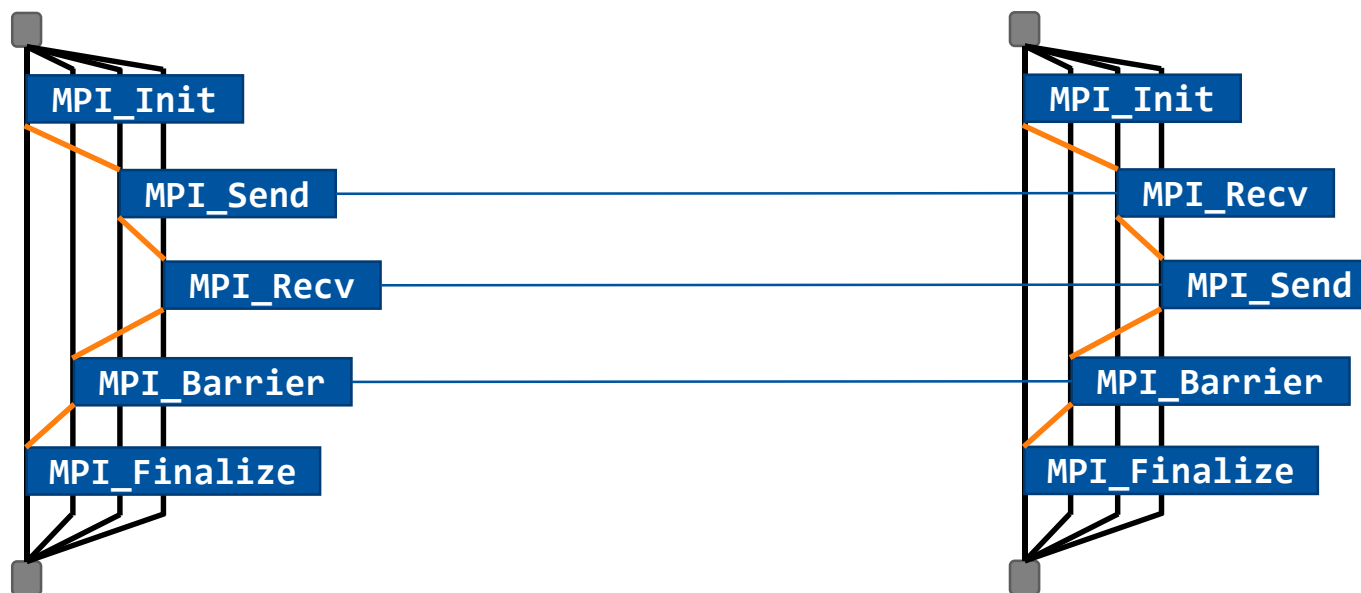




# MPI – Threading support levels

- **MPI\_THREAD\_SERIALIZED**
  - Only one thread communicates at a time

— MPI Communication  
— Thread Synchronization



# MPI – Threading support levels

- **MPI\_THREAD\_MULTIPLE**
  - All threads communicate concurrently without synchronization

— MPI Communication  
— Thread Synchronization

