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Interferences between Communications and Computations in Distributed HPC Systems

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Distributed HPC systems

- ▶ HPC: *High-Performance Computing*
- ▶ Distributed: many computers connected through a network
- ▶ Common usecases: scientific computations, simulations (physics, chemistry, weather, astronomy, ...)
- ▶ Goal: get the highest computing performance
- ▶ One HPC cluster is composed of:
 - ▷ Several nodes...
 - ▷ ... composed of several computing units (CPUs, GPUs, ...)
 - ▷ ... composed of many cores.

Computations and communications in parallel

- ▶ While many cores are computing, a core makes communications with other nodes
- ▶ A technic known for improving performances

Interferences between communications and computations ?

- ▶ Side-by-side communications and computations share common resources (memory bus)
- ▶ Impact of memory contention on computations already observed in the litterature
- ▶ **Can simultaneous communications and computations have a negative impact on each other ?**
 - ▷ Is there an impact on communications ?
 - ▷ Which factors change the impact of interferences ?

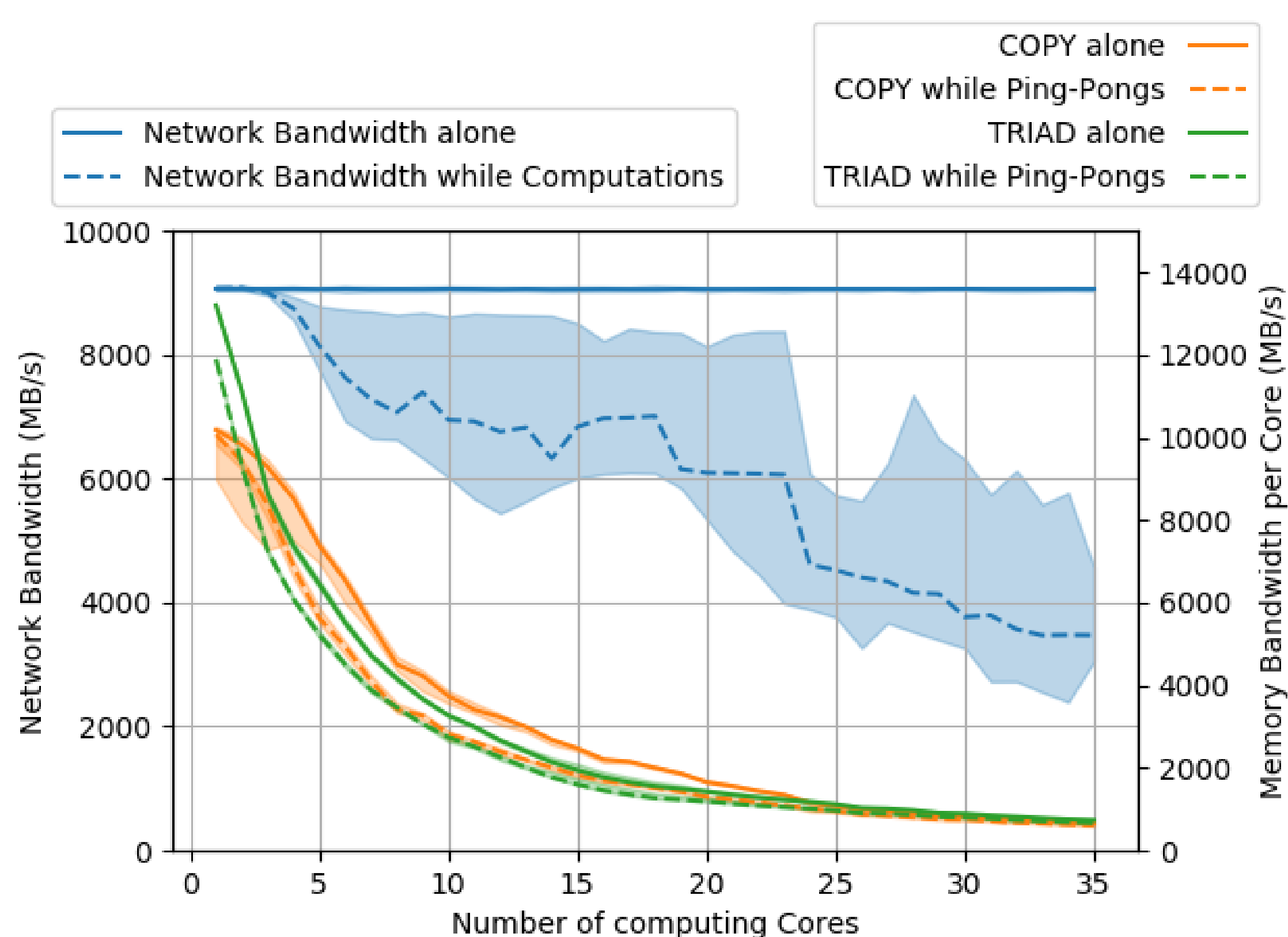
Methodology

- ▶ Goal: compare performances of communications and computations executed alone or simultaneously
- ▶ Own benchmark with the following steps:
 1. Computations alone
 2. Communications alone
 3. Computations with communications in parallel
- ▶ Parallelization with OpenMP, communications with MPI

Impact of memory contention

- ▶ Extreme case: computing cores executing memory-bound kernels

Network Bandwidth and STREAM Benchmark

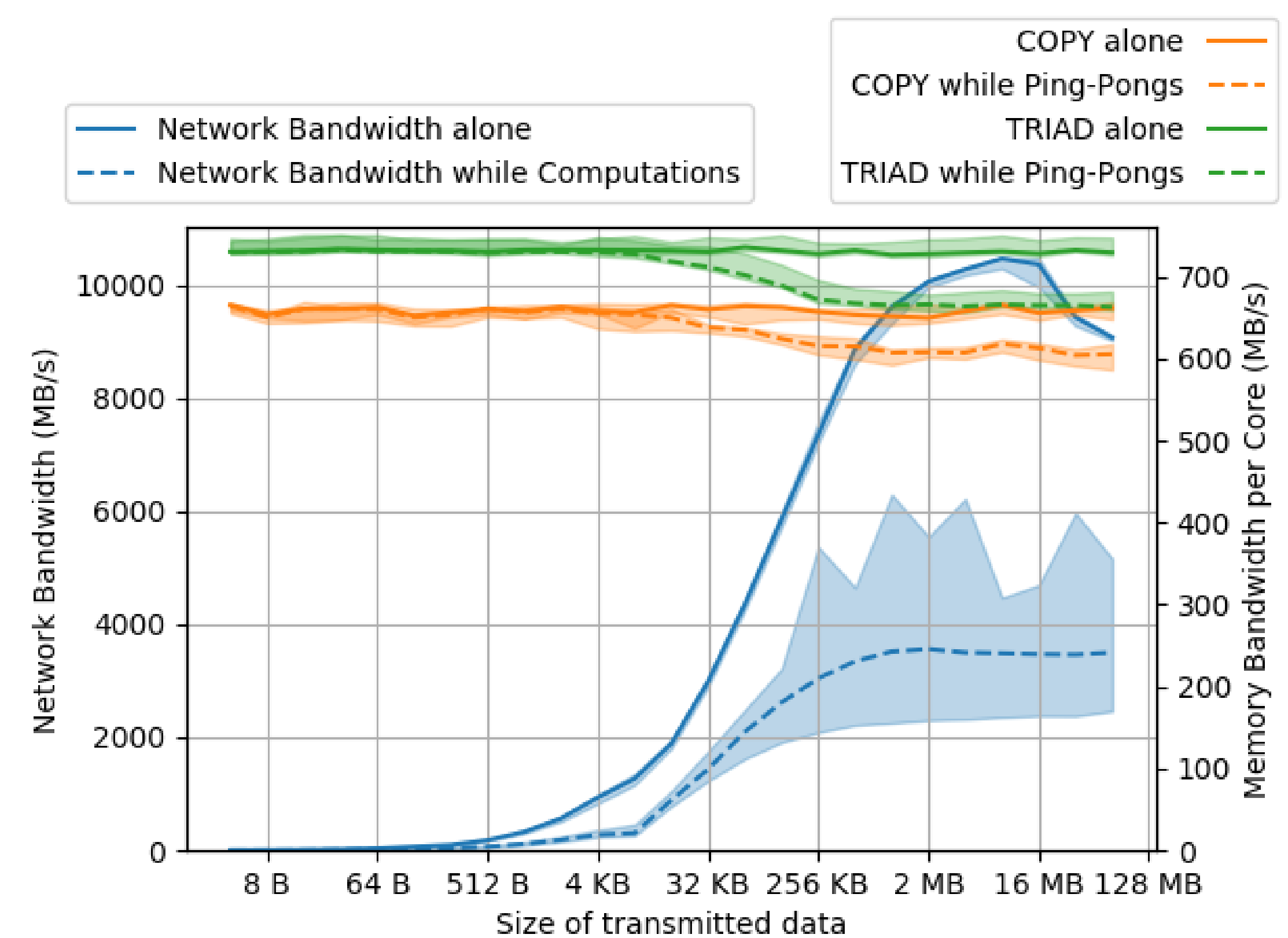


- ▶ The higher the number of computing cores, the higher the memory contention and the more communication performances lower

Impact of the size of transmitted data

- ▶ Does the size of transmitted data across the network affect the memory contention ?

Network Bandwidth and STREAM Benchmark

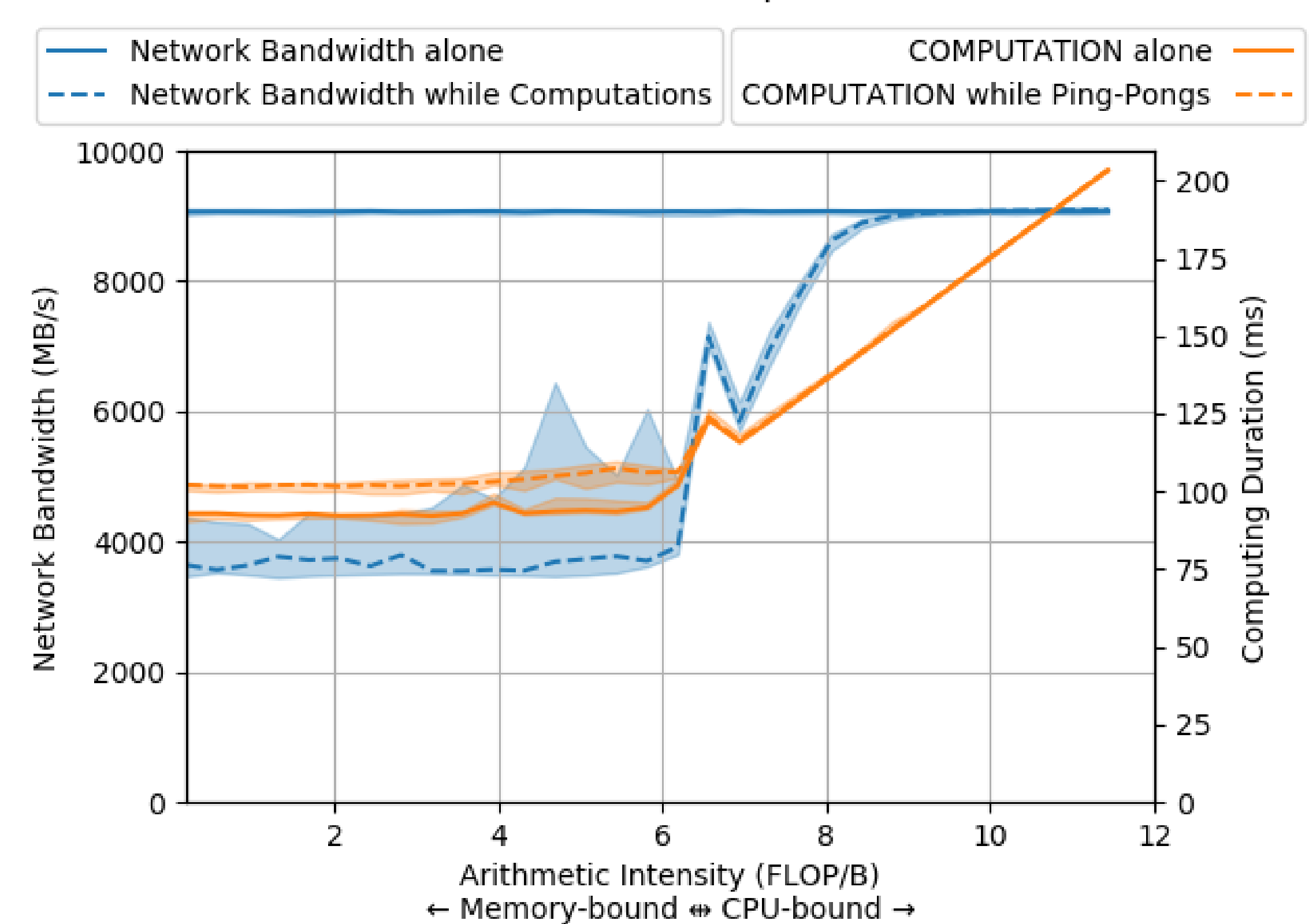


- ▶ The bigger the communicated data, the more it disturbs computations, and the more communications are disturbed by computations

Impact of arithmetic intensity

- ▶ Arithmetic intensity: number of arithmetic operations per accessed byte of memory
- ▶ Computing cores execute instructions with tunable arithmetic intensity

Network Bandwidth and Computation Benchmark



- ▶ Interferences disappear when computations become CPU-bound

Conclusion

- ▶ Computations can slow down communications
 - ▷ it depends on arithmetic intensity of computations
 - ▷ it depends on size of transmitted data
 - ▷ *vice-versa*, communications can impact computations too
- ▶ Future works:
 - ▷ Better understand origins of interferences to model and predict them
 - ▷ Consider data movements between main memory and GPUs
 - ▷ Take into account these interferences in scheduling made by runtime systems