



**HAL**  
open science

# Interferences between Communications and Computations in Distributed HPC Systems

Philippe Swartvagher

► **To cite this version:**

Philippe Swartvagher. Interferences between Communications and Computations in Distributed HPC Systems. Journée de l'École Doctorale Mathématiques et Informatique, May 2021, Bordeaux, France. hal-03292004

**HAL Id: hal-03292004**

**<https://hal.inria.fr/hal-03292004>**

Submitted on 20 Jul 2021

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

# Interferences between Communications and Computations in Distributed HPC Systems

Philippe SWARTVAGHER - Alexandre DENIS, Emmanuel JEANNOT  
TADaam - INRIA, LaBRI, France



## 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 ?

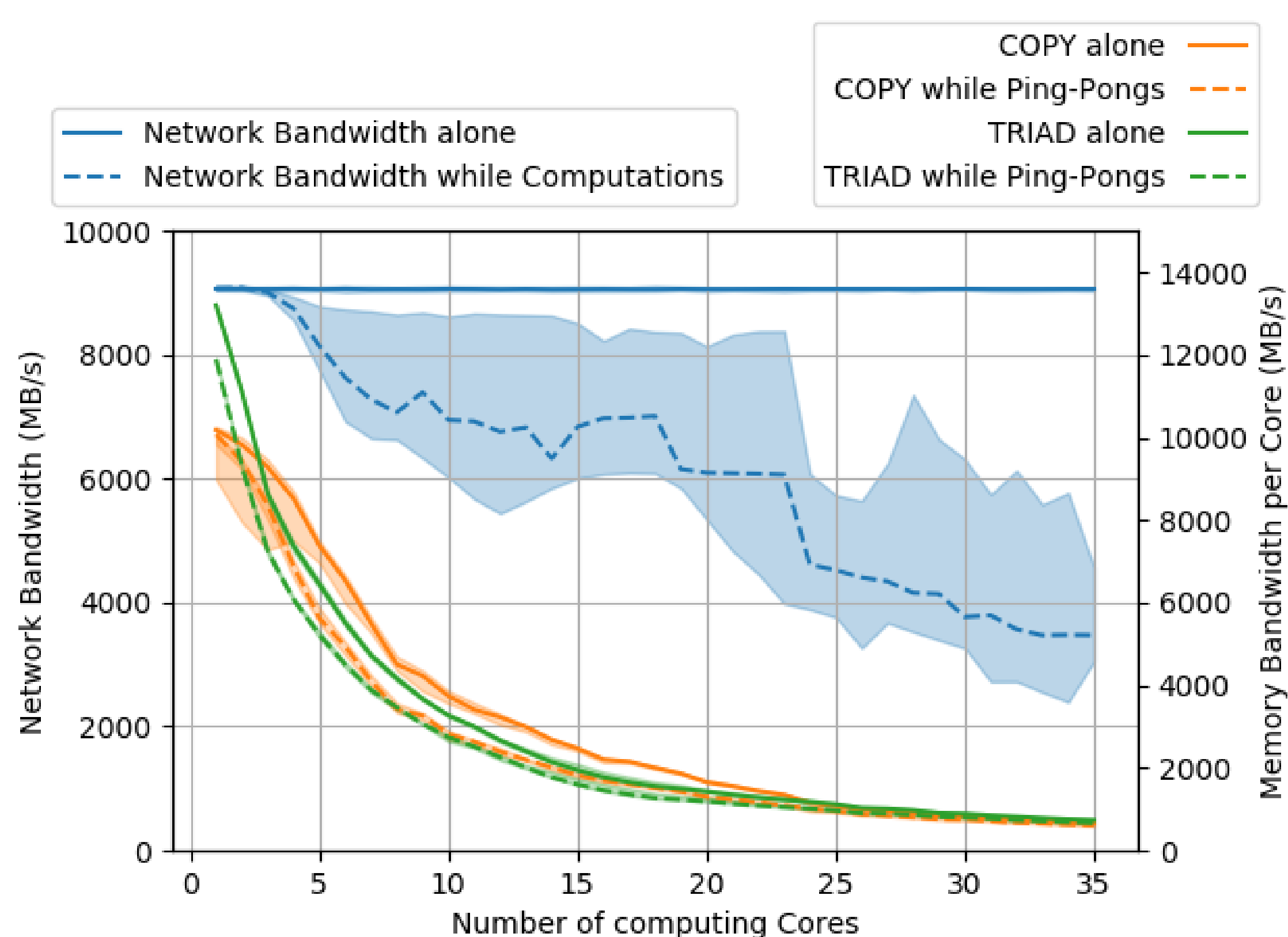
## Methodology

- ▶ 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

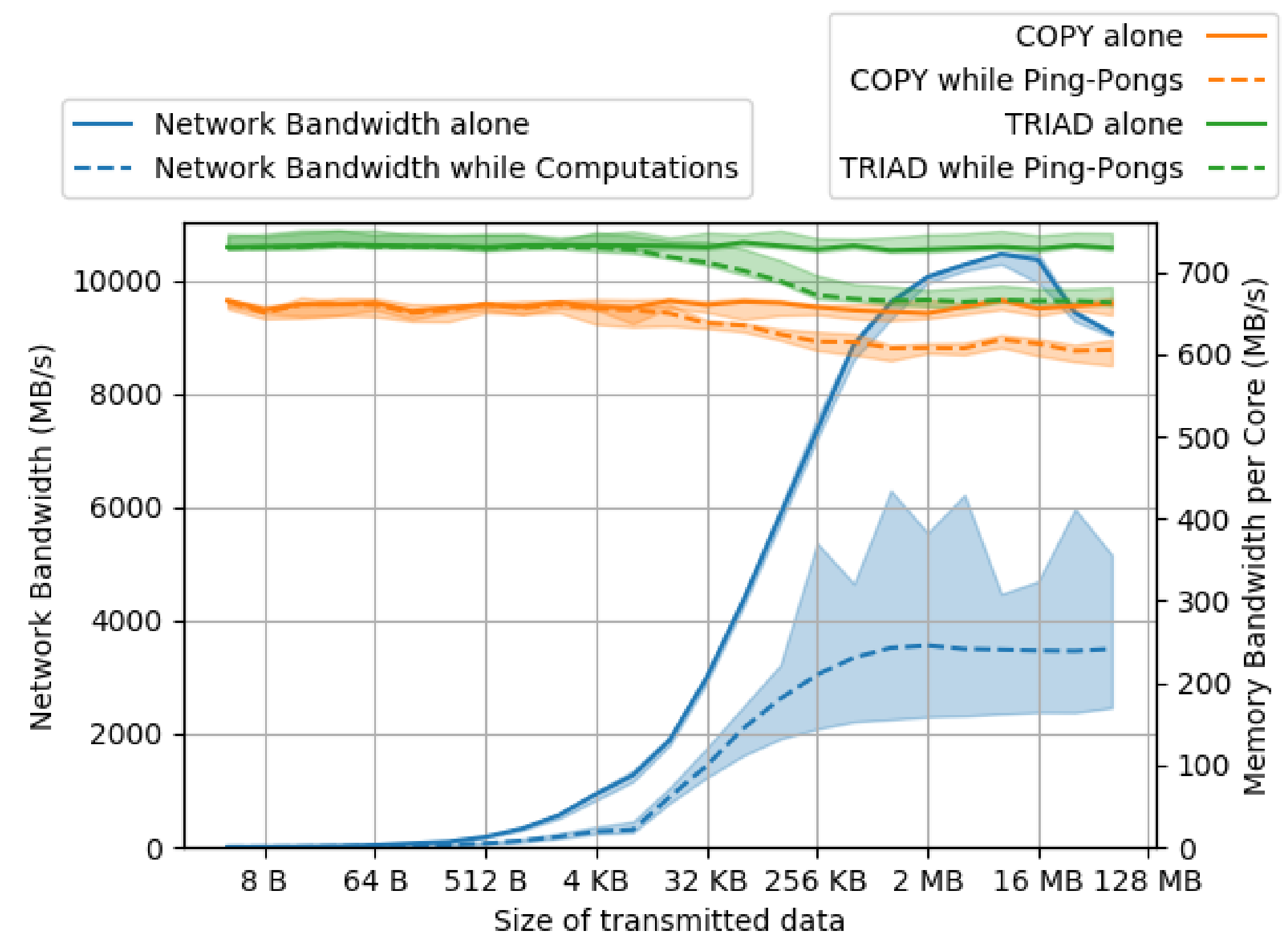


- ▶ The higher the number of computing cores, the higher the memory contention and the more communication performances lower

## 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

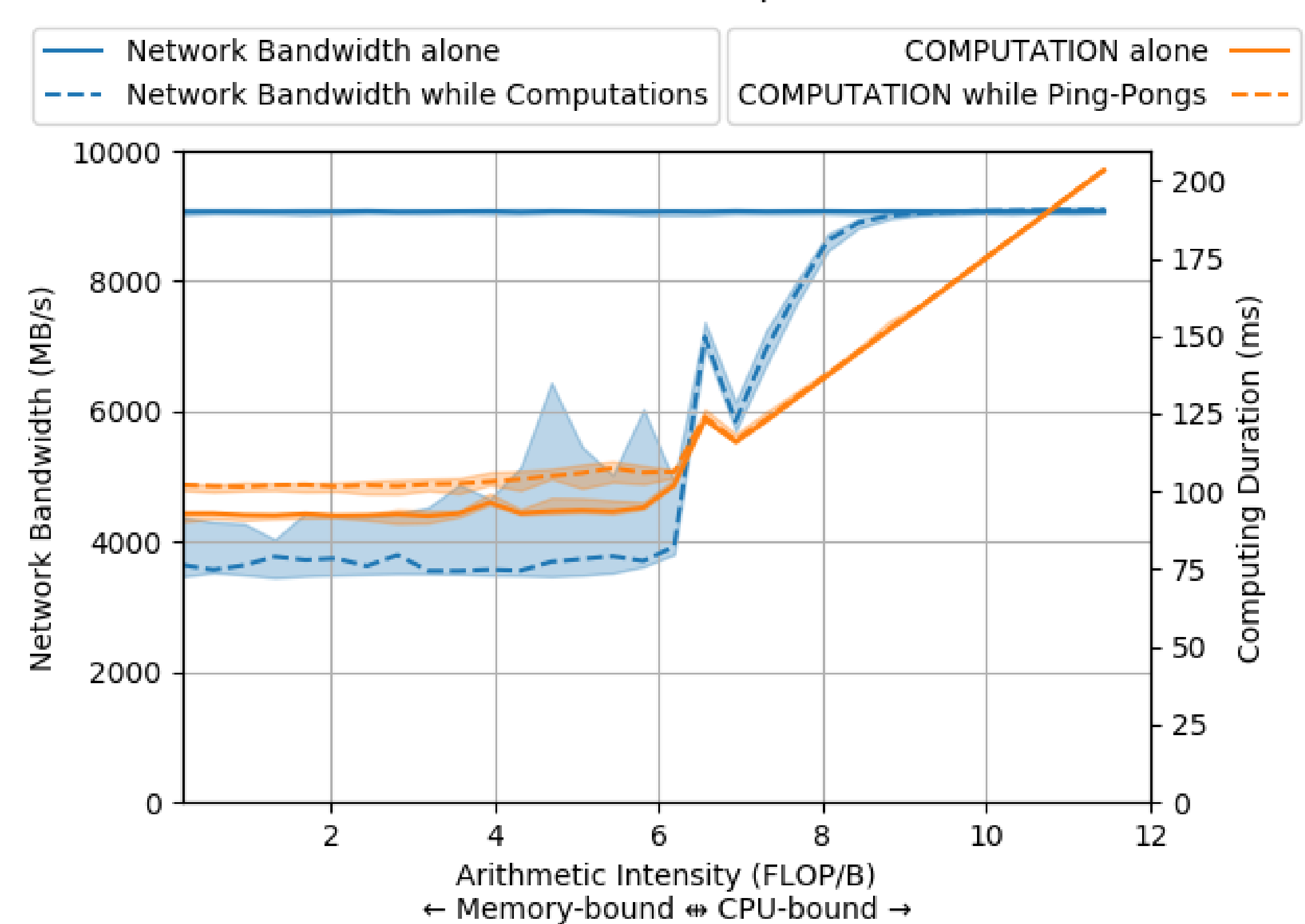


- ▶ The bigger the communicated data, the more it disturbs computations, and the more communications are disturbed by computations

## 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