UK Research and Innovation

Porting and Optimising TELEMAC–MASCARET for the OpenPOWER Ecosystem

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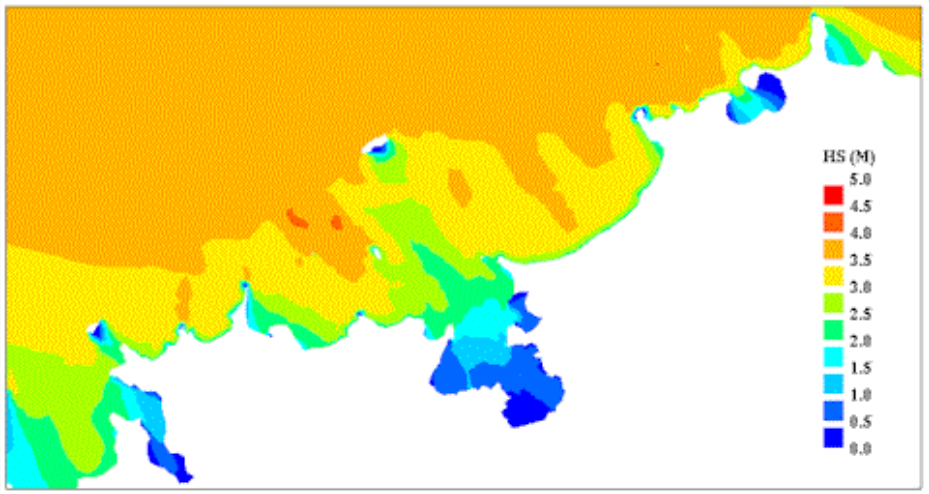
What is TELEMAC–MASCARET?

TELEMAC–MASCARET is an open-source suite of hydrodynamic solvers for free-surface flow modelling.

It was originally developed by Électricité de France (EDF) in the 1990s and is now developed through the TELEMAC–MASCARET consortium:

- Artelia
- BAW
- CEREMA
- CERFACS
- UKRI–STFC, Daresbury Laboratory
- EDF
- HR Wallingford



Courtesy of the official TELEMAC–MASCARET website.

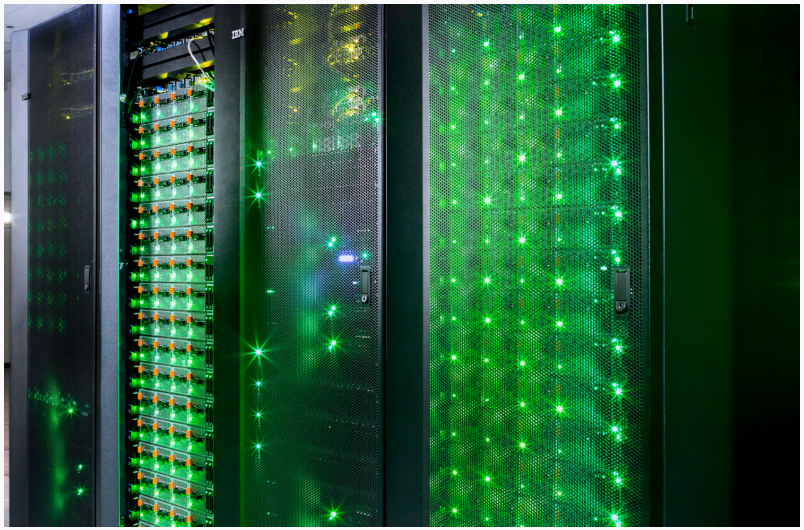
What is TELEMAC–MASCARET?

- TELEMAC–MASCARET is only parallelized with MPI
- Which is usefull when HPC clusters are made of single core processor
- But HPC clusters have more and more core per processor
- The compute nodes also have more and more GPUs
- Then in order to let TELEMAC–MASCARET use the full computing power of tommorrow's cluster, it is needed to search for new way of adding parallelism

Computing used

OpenPOWER archtecture in a nutshell:

- IBM POWER processors
- NVIDIA GPUs
- NVIDIA NVLink



The machine used for this work, Paragon

In our case, each node of the machine used consists of:

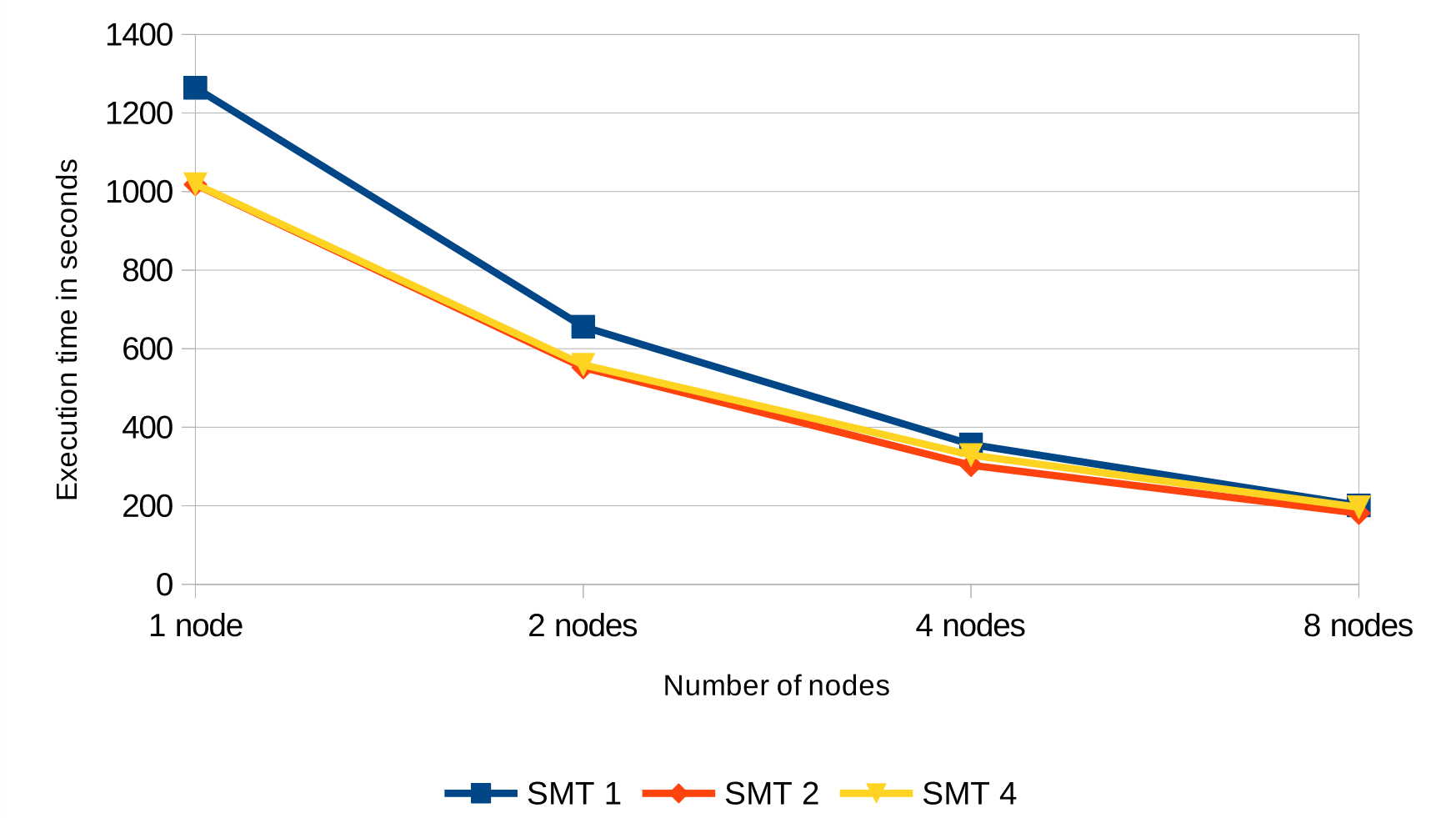
- Two IBM POWER 8 processors, with 8 cores each
- Each core has simultaneous multithreading (SMT) capability
- In this case the cores are able to run either 1 threads (SMT1), 2 threads (SMT2), 4 threads (SMT4) or 8 threads (SMT8) at the same time
- Four NVIDIA P100 GPUs
- NVIDIA NVLink for GPU–GPU and GPU–CPU interconnections

The test case

Test case used: tomawac/fetch_limited/tom_test6.cas

- This is a limited test with a small mesh: 18k elements, 9.6k points.
- It spends all of its time in a single fortran function: qnlin3.f
- This function was reported to be a bottleneck by some users during the annual TELEMAC User Conference (2018).

Original execution time with MPI (IBM compiler)

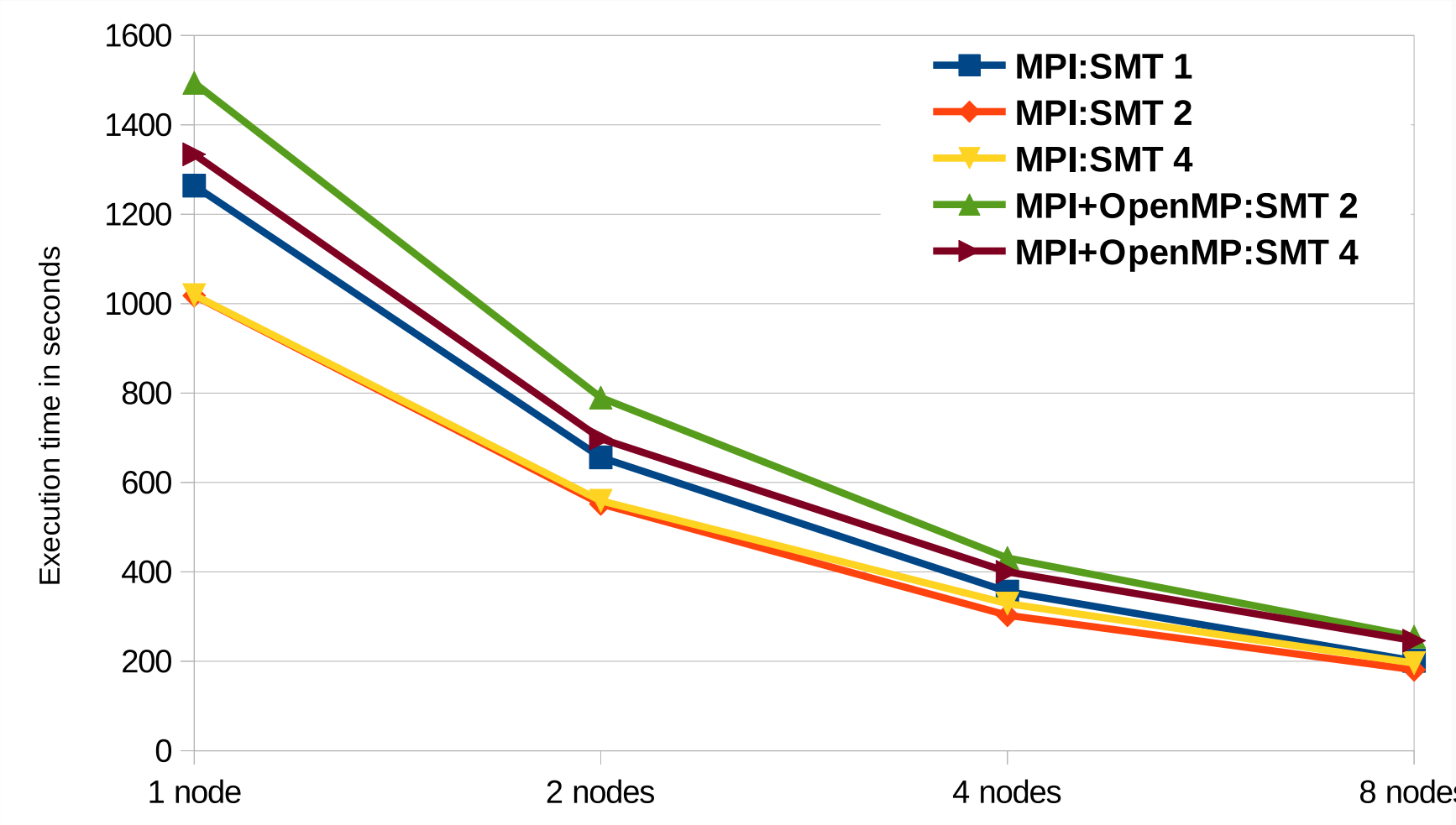


MPI+OpenMP (IBM compiler) on CPU

We can already use the simultaneous multithreading for MPI parallelization.
But would it be better to use it for OpenMP parallelization?

- create and initialise array for reduction
- !$omp parallel do reduction(+:tmp_array)
- do loop
- do loop
- do loop
- do loop
- tmp_array(x,y,z) = tmp_array(x,y,z) + k
- ...
- !$omp end parallel do
- array = array + tmp_array

MPI+OpenMP (IBM compiler)



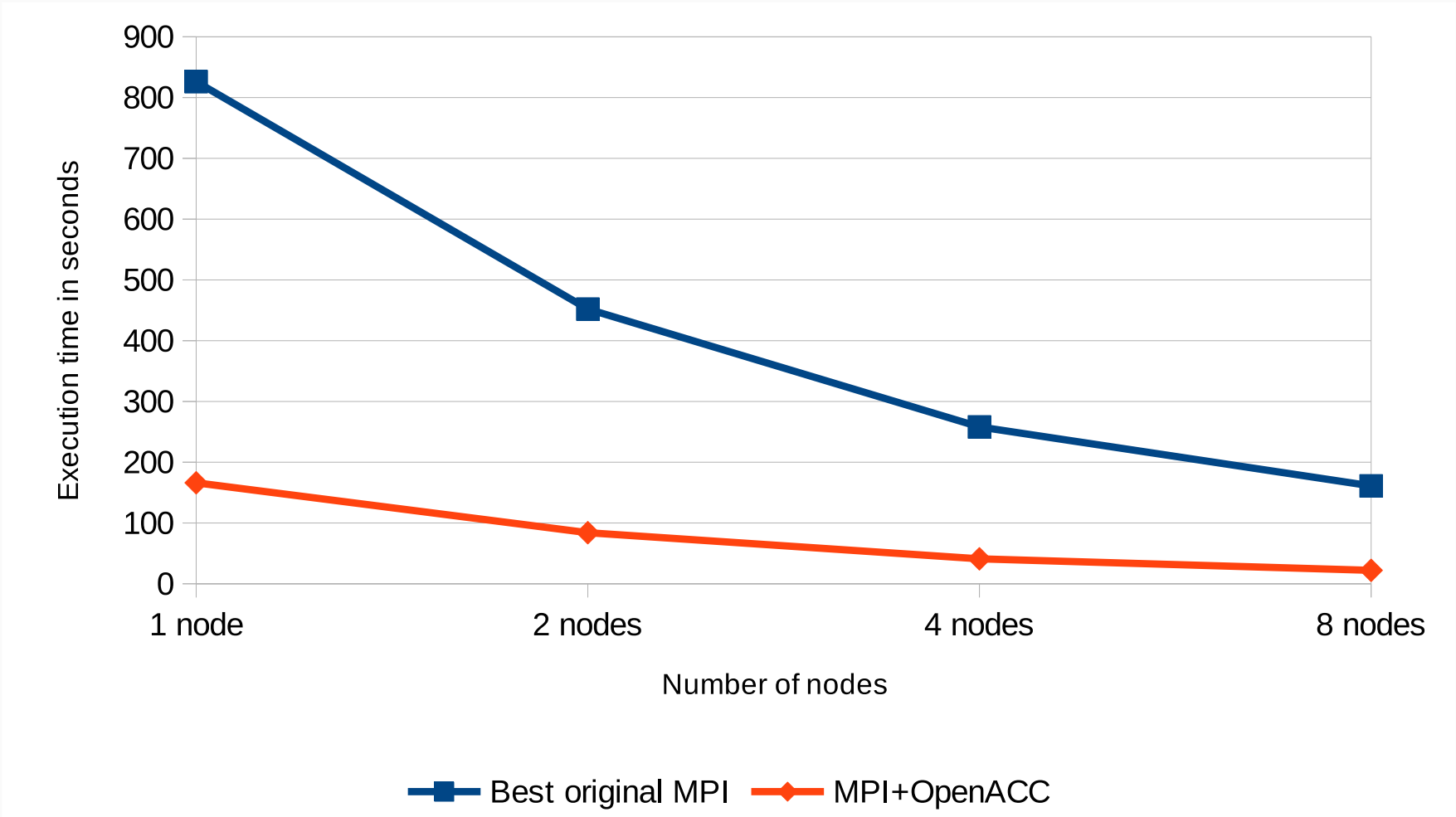
MPI+OpenACC (PGI compiler) on GPU

Move data to GPU and execute the loop on it.

- !$acc data copy(array)
- !$acc parallel loop collapse(4)
- do loop
- do loop
- do loop
- !$acc atomic
- array(x,y,z) = array(x,y,z) + k
- ...
- !$acc end data

Elsewhere during the initialisation of the code, we have linked each MPI task to a specific GPU.

MPI+OpenACC (PGI compiler) on GPU



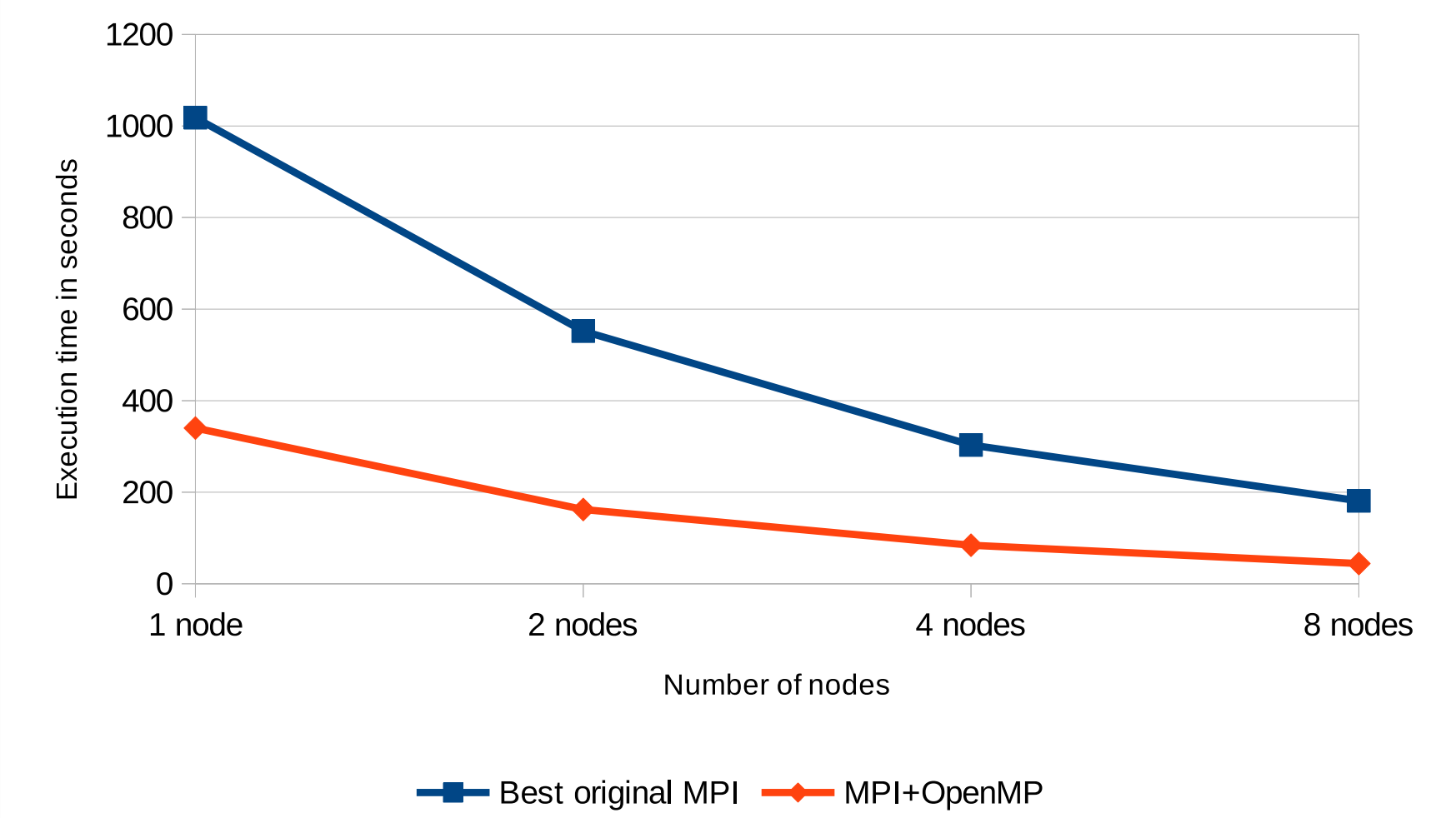
MPI+OpenMP (IBM compiler) on GPU

Move data to GPU and execute the loop on it.

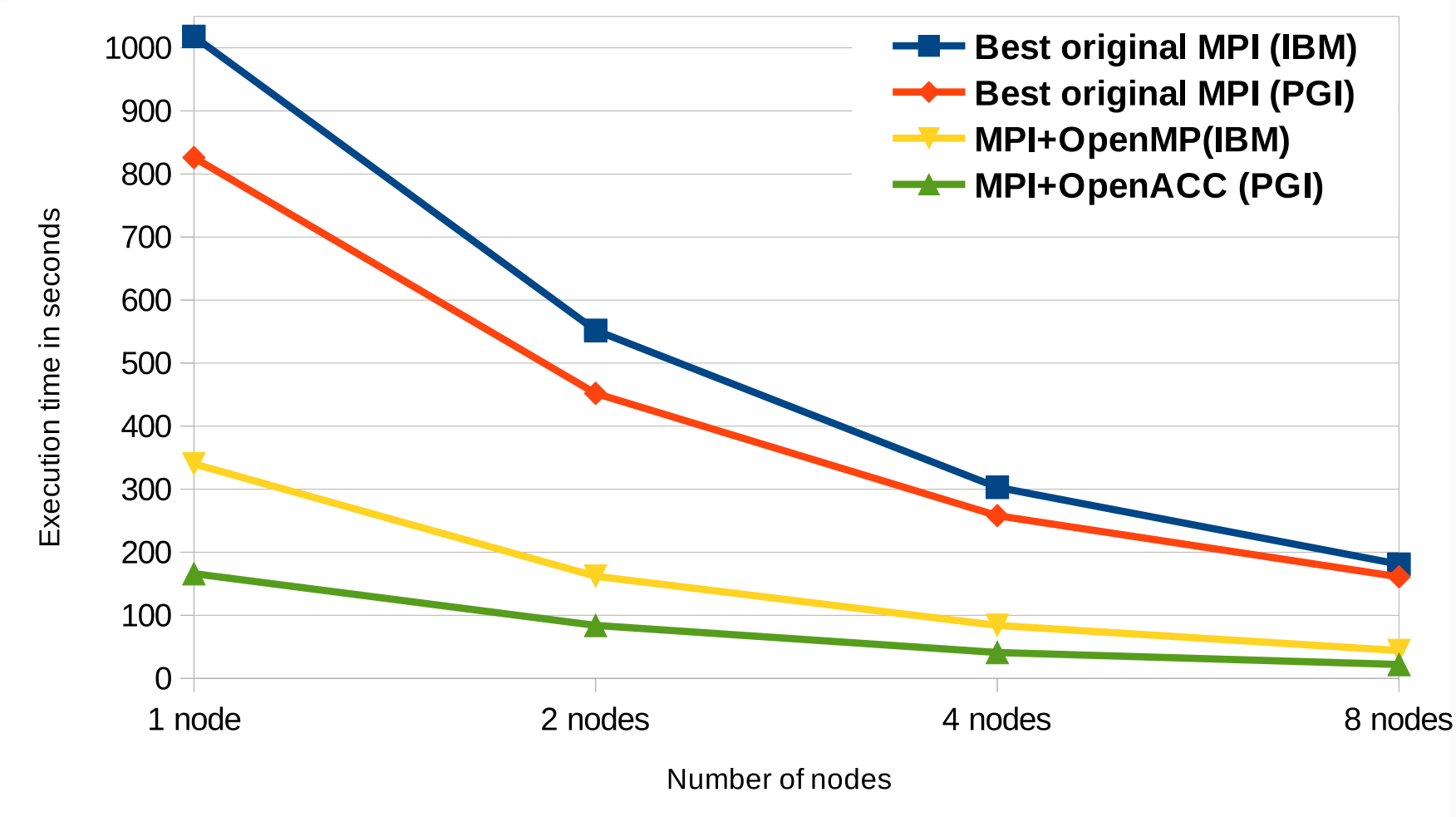
- !$omp target data map(array)
- !$omp target teams distribute parallel do collapse(4)
- do loop
- do loop
- do loop
- !$omp atomic
- array(x,y,z) = array(x,y,z) + k
- ...
- !$omp end target data

Elsewhere during the initialisation of the code, we have linked each MPI task to a specific GPU.

MPI+OpenMP (IBM compiler) on GPU



MPI+OpenMP (IBM compiler) VS MPI+OpenACC (PGI compiler)



Conclusion

Results achieved:

- No improvement when using SMT with OpenMP
- Good improvement when using GPU
- Between 4.8 and 7.3 speedup with OpenACC
- Between 3 and 4.1 speedup with OpenMP

Technical advices:

- PGI compiler is helpful and gives informative messages about how the compiler translates the OpenACC directives
- The nvprof profiler is able to profile the OpenACC code, which lets you efficiently visualize when data transfers occur
- We have been unable to use it with OpenMP code

Future work

- Offloading more parts of TELEMAC–MASCARET to GPU
- Keeping track of the enhancements of OpenACC and OpenMP implementations across different compilers
- Producing increasingly large simulation meshes and proving better convergence, provided by higher resolutions, enabled by faster processing

Acknowledgements

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