Numerical computing performance comparison of AMD and Intel for COMSOL Multiphysics 5.X

We are looking for an upgrade of our current COMSOL 5.X [1, •] workstations, so as there are much different possible configurations we tested several cases on the available and planned hardware. All the prepared benchmarks are mostly suitable for single-processor use. Let's leave aside all the details regarding the implementation of distributed computing and cluster swapping (https://www.comsol.com/support/knowledgebase/1001) and discuss only the shared-memory case. Our main goal is to find suitable processor for our phase-field and hydrodynamics simulations (let's say for highly nonlinear computations). This benchmark data will be useful for other software utilizing MUMPS and PARDISO solvers as soon as we test some of the tasks on both solvers. In addition we also provide some tests on GMRES solver.

Testing

We discard saving and initialization times to look only on a solution time.
All equations are in a weak form with periodic boundary conditions and simple geometries.
-blas -mkl refers to the optimized mkl libraries which replace comsol defaults.
-np X refers to the cores available for solver.
Windows and Linux versions of comsol were tested both on Intel Core i7 but we got almost no difference in results, except a little more memory consumption, so here it did not presented.

Hardware setup:

Intel i7-9700KF Setup		AMD TR-2970wx Setup
Intel Core i7-9700KF RAM 4x16 Gb DDR4 2666MHZ MB Tomahawk Z390		AMD Threadripper 2970wx RAM 3x32 Gb DDR4 3200 MHz MB Gigabyte TRX40
Intel i5-3550 Setup	Xeon X5650	Intel Notebook
Intel i7-2630 QM (2 GHz) RAM 2x8 Gb DDR3 1600 MHz	Intel Xeon X5650 x2 RAM 16x16 Gb 1333 Mhz MB SuperMicro	Intel Core i5-3550 (3.3 GHz) RAM 2x4 Gb DDR3 1333 MHz

Let's compare our most powerful competitors by its properties

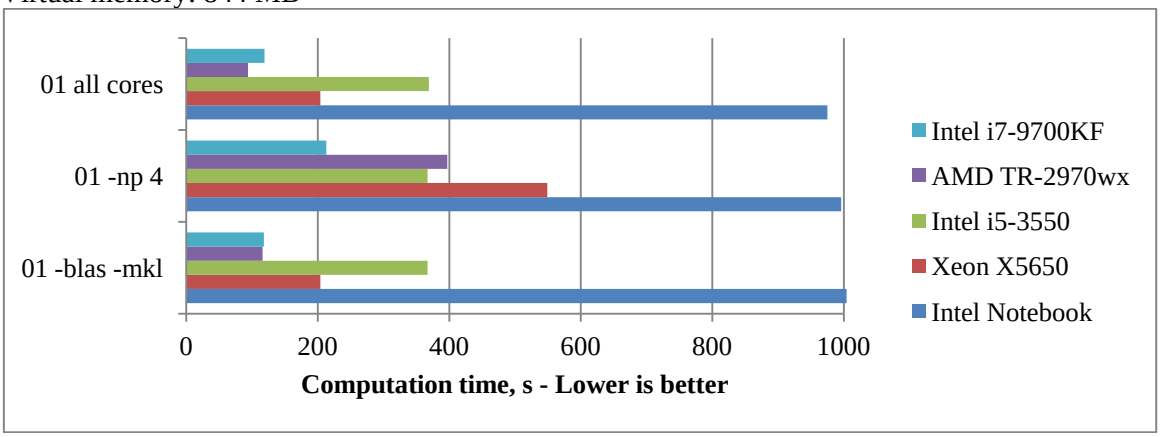
Processor	AMD Ryzen Threadripper 2970WX	Intel Core i7-9700KF
Family	Zen+	Coffee Lake
Release date	Q4 2018	Q1 2019
Lithography	12 nm	14 nm++
Cores	24	8
Threads	48	8
Base frequency	3.0 GHz	3.6 GHz
Turbo frequency	4.2 GHz	4.9 GHz
Cache memory	64 MB	12 MB
Max memory capacity	1 TB	128 GB
Memory types	DDR4-2933	DDR4-2666
Max PCIe lanes	60	16
TDP	250 W	95 W
GPU integrated graphics	None	None
Socket	TR4, LGA-4094	LGA 1151
(Windows 64-bit) **Geekbench 4 single core**	4,435	6,197

(Windows 64-bit) **Geekbench 4 multi-core**	32,802	30,080
(SGEMM) **GFLOPS performance**	346 GFLOPS	441.5 GFLOPS
(Multi-core / price performance) **Performance / price ratio**	30 pts / €	81 pts / €
(Average) **New price on Amazon**	1,080 €	370 €

COMSOL benchmarks and intermediate results

01 Diffusion Equation with convolution-integral source term

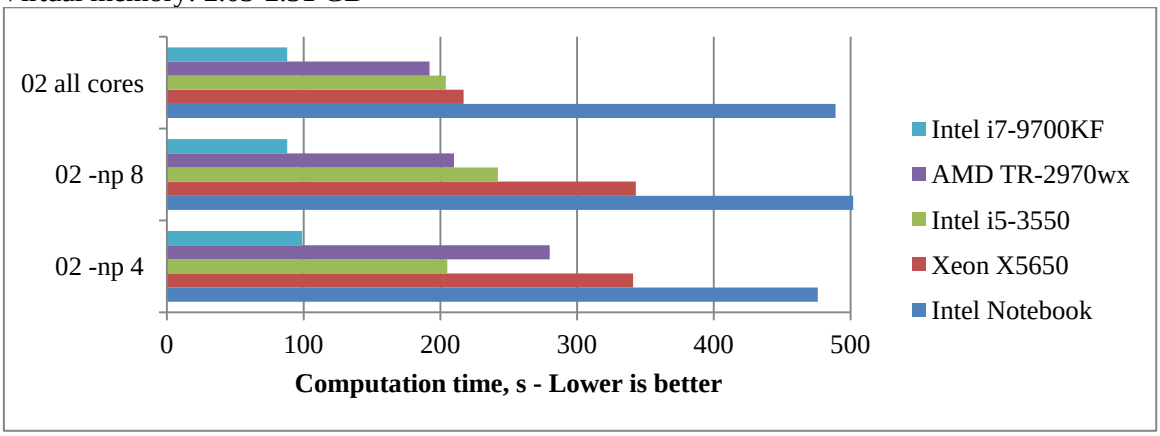
The source term in 2D diffusion equation includes integral term with convolution over the whole domain; Jacobian got from the previous time step.
DOFs: 7545
Virtual memory: 844 MB



We may return here the leading of Threadripper for a good enough paralleling task. Low clock brakes TR down for the case of limited cores. Replacement of mkl libraries do mostly nothing just a little slow down.

02 Phase Field with Hydrodynamics MUMPS

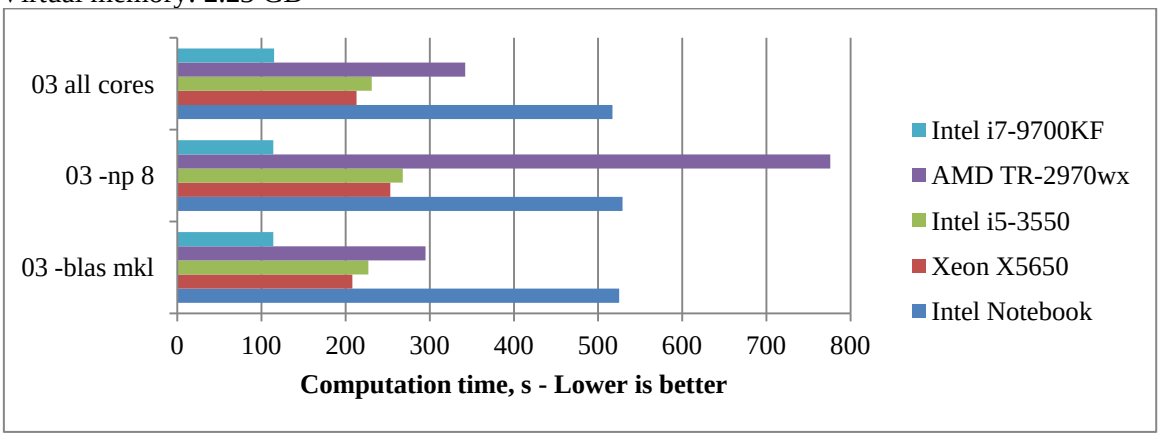
Phase-field equation in 3D with high-order spatial derivatives. MUMPS solver.
DOFs: 52746
Virtual memory: 2.03-2.31 GB



Intel is faster than Threadripper due to the possible bottleneck in poor-paralleling tasks. Maybe only for a MUMPS?

03 Phase Field with Hydrodynamics PARDISO

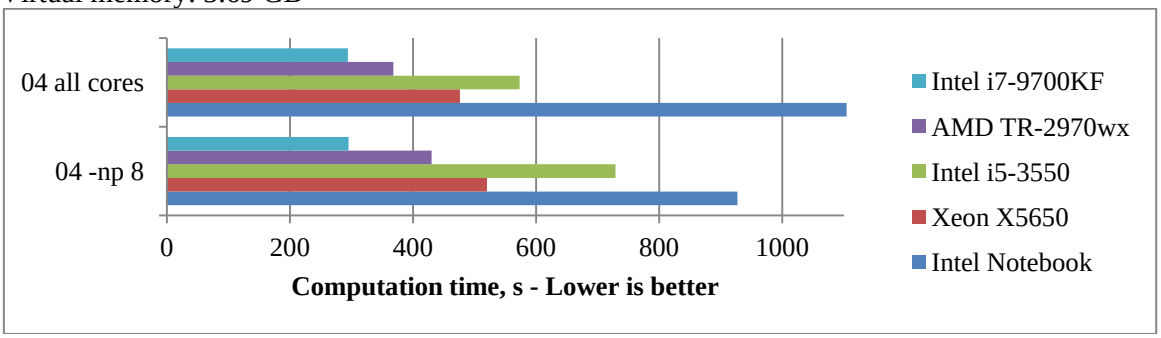
Phase-field equation in 3D with high-order spatial derivatives. PARDISO solver, same task as 02.
DOFs: 52746
Virtual memory: 2.23 GB



-no, Intel again is fasterFor our case the PARDISO solver is less optimized than MUMPS. By the way it's not a case for Intel. Possible bug in a results for TR for 8 cores. Mkl again does no influence on our results.

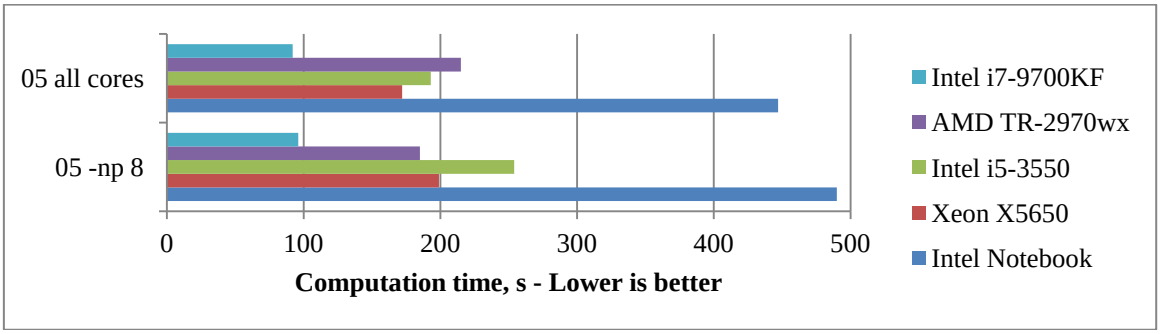
04 Laminar Hydrodynamics

Laminar flow hydrodynamics coupled with diffusion term; Iterative GMRES solver.
DOFs : 747197
Virtual memory: 3.69 GB



05 Phase-field capillary flow

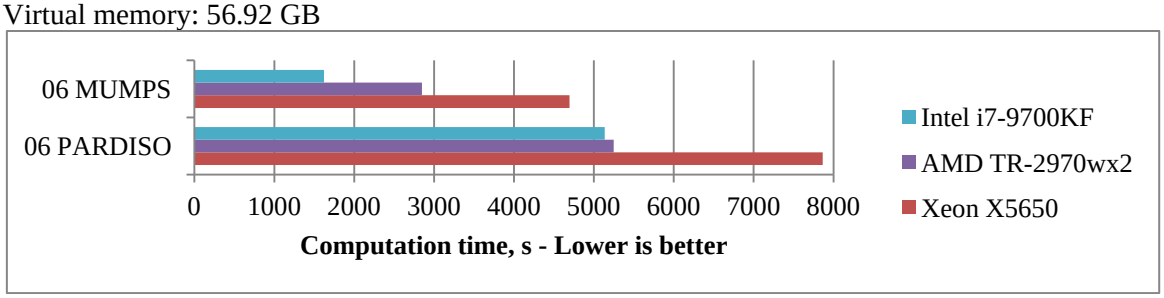
Phase field coupled with laminar hydrodynamics equation; PRADISO solver.
DOFs: 41600
Virtual memory: 1.54 GB



06 Phase-field with Hydrodynamics

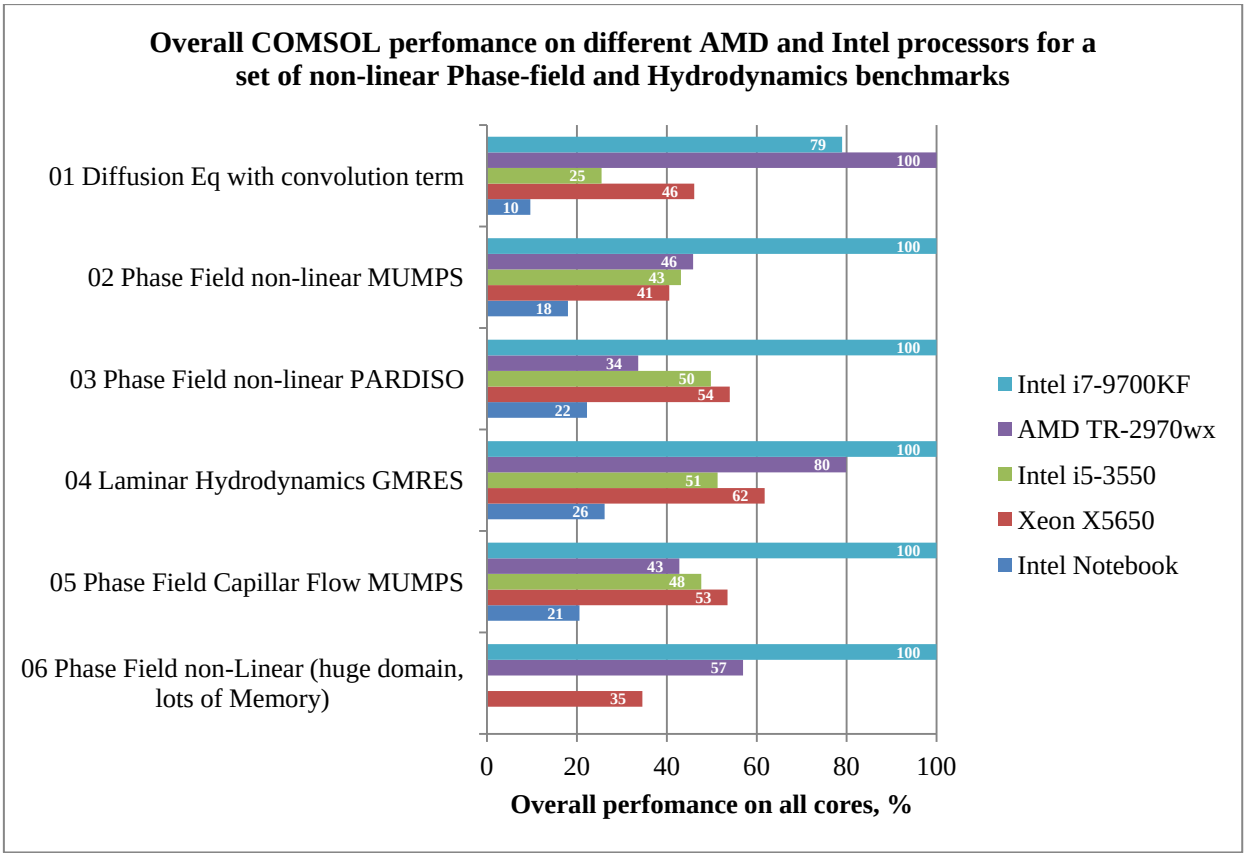
Phase-field equation in 3D with high-order spatial derivatives same as 02 and 03. MUMPS and PARDISO solver. Huge domain, many DOFs. Tested only systems with enough memory.
DOFs: 1112130

Virtual memory: 56.92 GB



Results

Overall performance X normalized to the fastest one t_fastest in a group as X=t_i/t_fastest*100, where t_i is a computation time of a presented earlier benchmark on all cores for given benchmark set. The MUMPS solution is presented for Task 06.



CONCLUSIONS

Presented summary graph shows the limitations of TR followed from it's clock frequency and possible excellence only on nicely-parallelized taks. There is mostly no sense to change default mkl lib for comsol and careful optimization of solver for each task is needed. Higher frequencies and memory bandwidths are preferable for Phase-field and Hydrodynamics tasks. Setup of number of cores more than presence with "-np" key leads to some allocation problems. Also it's well known but should be added – such software is not capable to carry hyperthreading (HT) features or Simultaneous Multi-Threading (SMT) for AMD.

REFERENCES

1. www.comsol.com.nl

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