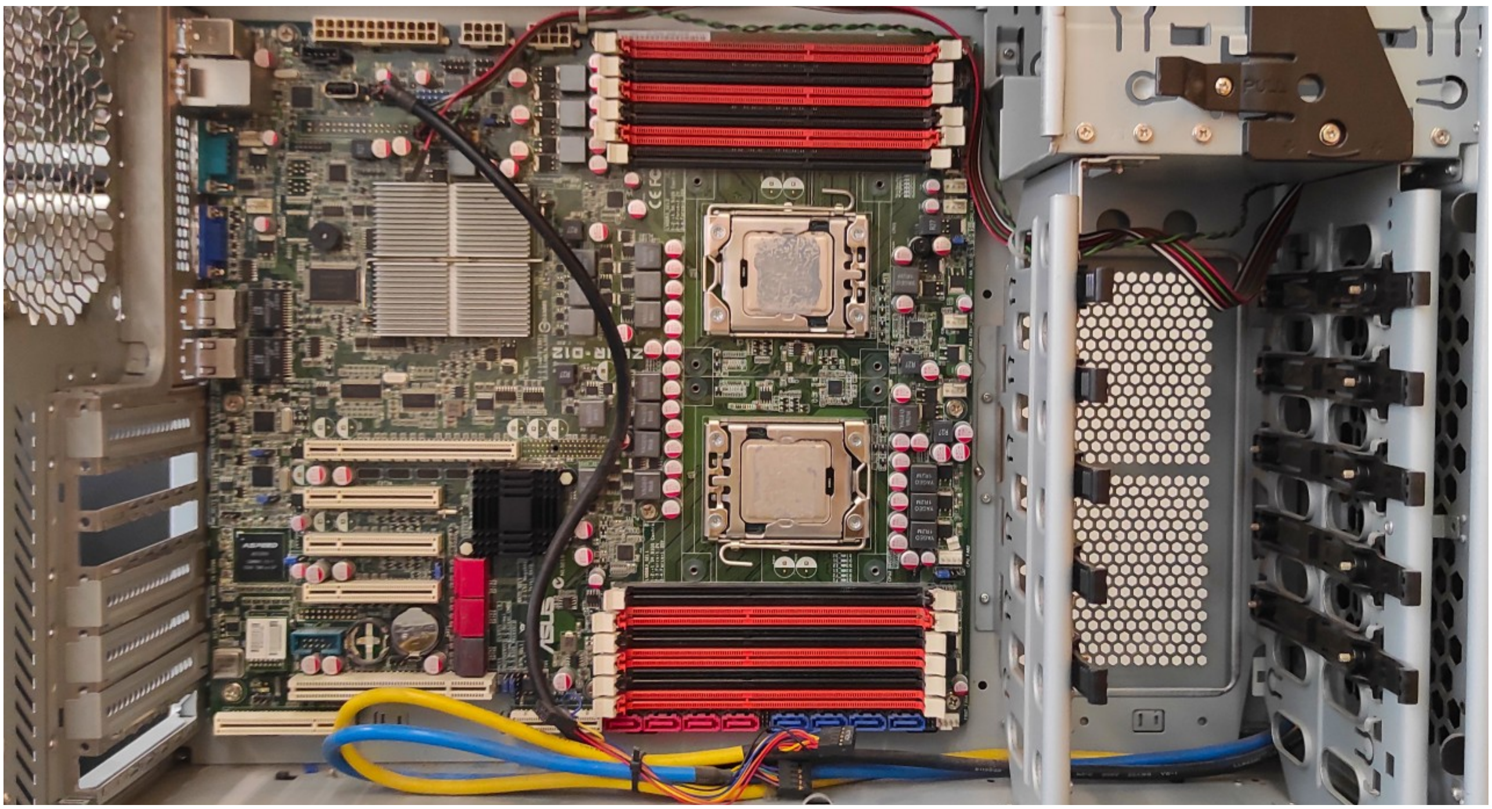

Hardware for CFD

Lubos Pirkl
Enabler, Storyteller at CFDSUPPORT, Indiana Jones in the Jungle of CAE

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website Hardware for CFD, in addition, I decided to write down a few general tips and proven strategies that work for us at CFDSUPPORT. They are based on the typical users' questions we keep receiving.

Minimal Requirements for CAE Simulations

First of all, please note that there are no specific minimum requirements for CFD simulations. You can successfully run your CAE (CFD and FEA) simulations anywhere on a personal computer, laptop, cluster, cloud, or even mobile device. However, in real practice, I wouldn't ever recommend anything less than a 64-bit system, 4GBRAM memory, 500GB hard drive, and 15" screen.

Know your simulation size. Know your core*hours!

Before going for any hardware, you should know how demanding your typical simulation is. At least the rough estimation of simulation size has to be known. For the simulation size, there is a commonly used measure counted in *core*hour* units. It basically says a theoretical value of how many CPU cores would be needed for a single simulation job to finish in one hour, or the other way around, how many hours would a single job need to finish on one CPU core. And all the related combinations work too. For instance, a simulation that requires 100 core*hours, can be run on one core for 100

These three are by far the most important factors in terms of the demands of any CFD simulation. These three factors have to be balanced with corresponding hardware or the project is in big trouble.

Mesh size - critical factor

The size of the mesh of your virtual model is the ultimate player. It has a major impact on the results accuracy, simulation time, convergence speed and stability, postprocessing, storage, ... wait, where do I stop? The mesh size is a super-critical factor. Perhaps factor number one. A larger mesh, compared to a smaller one brings two levels of complexity. First, larger mesh simulation takes more time to finish because more numerical operations have to be processed. Second, larger mesh simulations converge slower because of more degrees of freedom (more unknowns). Mesh size is absolutely a critical factor.

Time method - critical factor

Another critical factor related to the simulation size is the time treatment. Essentially, your simulation can be steady-state or transient. And if it is transient then it is very important how much physical time has to be simulated and what is the maximal time step.

Resulting Hardware Recommendations

That brings us to the hardware recommendations. As stated above, hardware and simulation size have to be well balanced or no party concerned will ever be happy. Sure, one can say that we can wait a little bit longer if the simulation is too big for our hardware. We were there too. But trust me, waiting too long for the results is killing productivity and too many opportunities are missed. Time is everything.

CPU Processor - critical hardware component

At the end of the day, it is the processor that does the work. Processor power (speed) is critical. When it comes to CPU power, more CPU power is always better than less CPU power. On the other hand, it’s reasonable to find a good power/cost ratio. For years, we‘ve had a good experience with this CPU Benchmark website which compares various processors available in the market. There you can find reliable information about the particular processor power. Please note that the prices listed on *cpubenchmark.net* are only a rough guess. The particular costs are best to check with your hardware supplier because prices may differ in time and space. Power and price give you the basic information on what to pick. Another very important factor is the processor's possibility to built the cluster (or if it is just a lonely wolf).

peripherals, it is picked to fit the processor after the processor is picked. You should only check it has enough ports compatible with other devices and components. The choice of the motherboard is not a very critical decision.

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Memory - not that critical hardware component

Regarding the computer memory, it's all primarily about the mesh size. There is a golden rule: count for each one million cells mesh a need for 2GB RAM. In any case, we recommend at least 4GB RAM memory per CPU core. BTW, it may easily happen that the mesh generation or advanced visual postprocessing will be more demanding on computer memory than the simulation run itself. The memory is relatively cheap and we recommend taking as much memory as possible.

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Monitors - surprisingly critical hardware component

There is only one rule. You need to see things! Get a display size you're comfortable with. But remember, the devil is always in the details. Over time we realized that large too) how much more large screens are effective compared to smaller displays. If you once get used to the luxury of two 4K monitors on your desk, there is no way back.

Graphic Card - not that critical factor

The choice of the graphic card goes hand in hand with the size of the display. First of all, all your actions in a graphical interface like zooming, scrolling, and rotating have to be smooth and enjoyable. No matter how complex the model is. Second, you may want to process many high-quality images for an animation and/or render complex multiple-layer semi-transparent images. If you want to see through the rendering process in a reasonable time you should definitely look for a high-end graphics card. Despite the fact that the graphic card isn't the most important component for CPU simulations, it surely deserves to be at a similar level to other computer components.

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Disks & Storage - not that critical factor

your work more enjoyable. All over again we realize it quickly pays off to invest a little bit more in better hardware and comfort. At the end of the day, it is your joy, efficiency, and good use of your valuable time that matters. And sure, we did our homework already, we regularly update our website *Hardware for CFD* where we publish the reliable hardware configurations we find best at power/cost ratio.

Simulation costs

The simulation costs can be evaluated as the cost per one core*hour multiplied by total simulation core*hours. The cost per one core*hour on a PC can be calculated from the total cost of ownership and estimated simulation time. One core*hour on a PC starts at about $0.002 but in real life, it's rather $0.005. Total simulation core*hours for a particular simulation case are impossible to calculate a priori because there are too many unknowns, especially the convergence speed. To get to know each particular simulation case core*hours, there is no other option but to test it.

The different CPU Speed Issue

The core*hour concept has two issues. The first one is scaling. The scaling topic is too large to discuss here in detail. Let's talk about scaling some time later. The second issue is the core*hour concept doesn't compare among different computers. It is not perfectly sight. There is an easy way to do it. You can try out the following example. Download vanilla OpenFOAM (you can do so on our website), run the basic tutorial *motorBike*, and measure the time to finish. Run it everywhere you can and measure the total simulation time. You'll be surprised how large differences you can find across the processors.

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You can make it even more profound and refine the mesh several times. You may need to change the configuration file *decomposeParDict* to for example *numberOfSubdomains 24; method scotch;* and in the file, *blockMeshDict* refine the basic background mesh blocks a couple of times. Don't forget to remove cell limits from *snappyHexMeshDict*. Run the corresponding simulations with otherwise default settings. Anyone can make an independent study.

You can be sure I did my homework too. Here's a little experiment as an example. I picked two not-too-bad processors from AMD and Intel and ran a couple of motorBike simulations.

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derive what hardware to get. Remember, the simulation size and used hardware have to be balanced.

For example, if you are a master's degree student and want to chase a stall point of an airfoil for your diploma thesis. Then your typical simulation may take up to 5 core*hours. Then you can easily make do it with a normal laptop.

If you are a designer or engineer and your typical simulation takes up to 500 core*hours then you may need just a good PC.

If you are a CFD professional whose typical simulation takes more than 500 core*hours, then you need a PC and also a simulation cluster. Preprocessing, case set-up, first tests, and postprocessing are typically done on PC while the productive simulations are run on a cluster.

All in all, PC is a golden standard. And you still need s station to sit for preprocessing and postprocessing after all. As you know, at CFDSUPPORT, we do believe that any successful project is a result of focus, skills, experience, patience, and dedication. And especially, if you are aiming high with your results' accuracy, it definitely makes sense to spend your effort in a pleasant environment and in an effective way.

Eric Zoppellari 6mo

Eric Zoppellari

A point which is important is also the power consumption of the workstation.
A good means of comparison is, depending on its use, to take into account the purchase price / computing power / consumption criteria.
Personally, I have my own benchmarks under OpenFoam and they are quite similar to the results obtained with Cinebench or Passmark (a good way to compare CPU power very quickly). Knowing that a calculation can take several days on a cluster of bi-Xeon workstations, consumption becomes an important criterion.
Buying a second-hand workstation makes it possible to obtain a very high power at a low purchase cost but, in the long term, the performances obtained by less consuming and more recent machines must be taken into account ...
A 3rd column including the TDP (or even the consumption of the motherboard / CPU pair) would suitably complete the CPU benchmark provided.

Like Reply | 1 Like

Lubos Pirkl 6mo

Lubos Pirkl

This is a good one. Thanks, Eric Zoppellari

Like Reply | 1 Like

Christopher Sarkizi Shams Hajian 6mo

Christopher Sarkizi Shams Hajian

Great post! I'm sure Wim Audenaert will find this quite helpful.

Like Reply | 2 Likes

Wim Audenaert 6mo

Wim Audenaert

Thanks for tagging Chris. Might be worth checking for Usman Rehman and Simon Duchi

Like Reply | 2 Likes

Like Reply | 1 Like

Anant Diwakar 6mo

Based on my experience, I may say that people often neglect the importance of higher cache memory and clock speed, and simply go for large number of cores. Size of cache memory becomes very important while handling large data structures. I have seen systems with lesser number of cores but higher cache, giving much better performance than a larger number of cores cluster with lower cache memory per processor.

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Anant Diwakar 6mo

Julio Mendez Right. SU2 being a vertex centered solver, requires lesser memory allocation than a cell centered CFD solvers. So, as you said, it was built with the objective of high efficiency and performance.

Like Reply

Julio Mendez 6mo

Anant Diwakar SU2 is great and extremely efficient.. OF too, but I feel that SU2 was developed with a different mindset and with the objective of high performance in mind.

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