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Cloud Computing
Thermal Stress

Introduction

Finite element method calculations are often really complex. Therefore, if we want to solve them efficiently we need powerful computer. Unfortunately we are often limited by our own hardware. The solutions are the virtual machines and clusters available on Microsoft Azure, Amazon Web Services and such like.

In this case the Microsoft Azure virtual machine was used to compute exemplary Thermal Stress problem.

Creating Virtual Machine

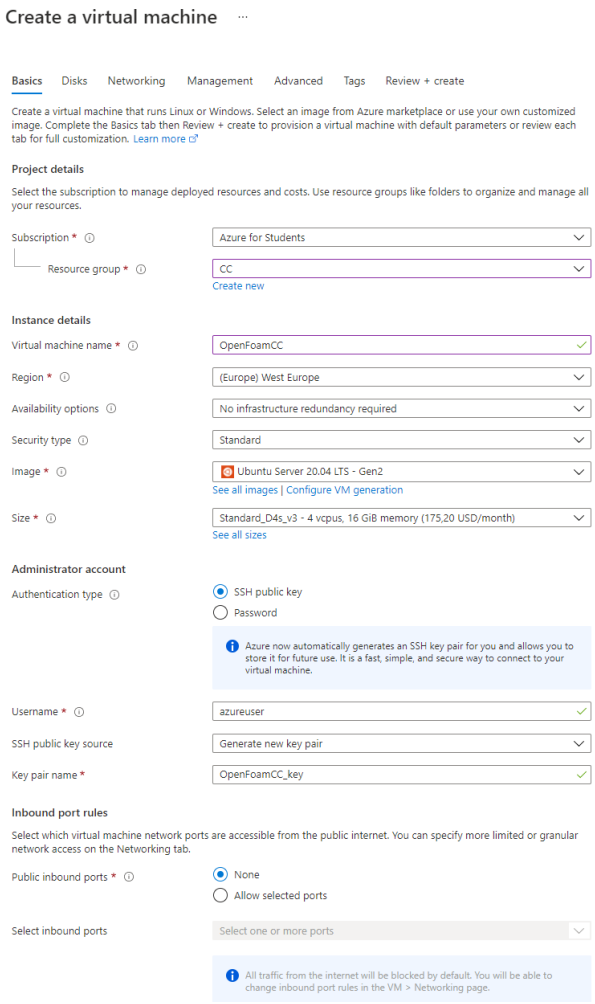
The virtual machine was created in Microsoft Azure using student account.

Due to student account quotas limitations the linux machine with 4 vCPUs and 16 Gb of memory was chosen.

The file with certificate was saved on the local computer.

All public inbounds ports were locked. When the machine was already operational, the inbound port rule was set for port 22. The connection from single IP address were allowed.

Using the saved certificate the SSH connection was established.



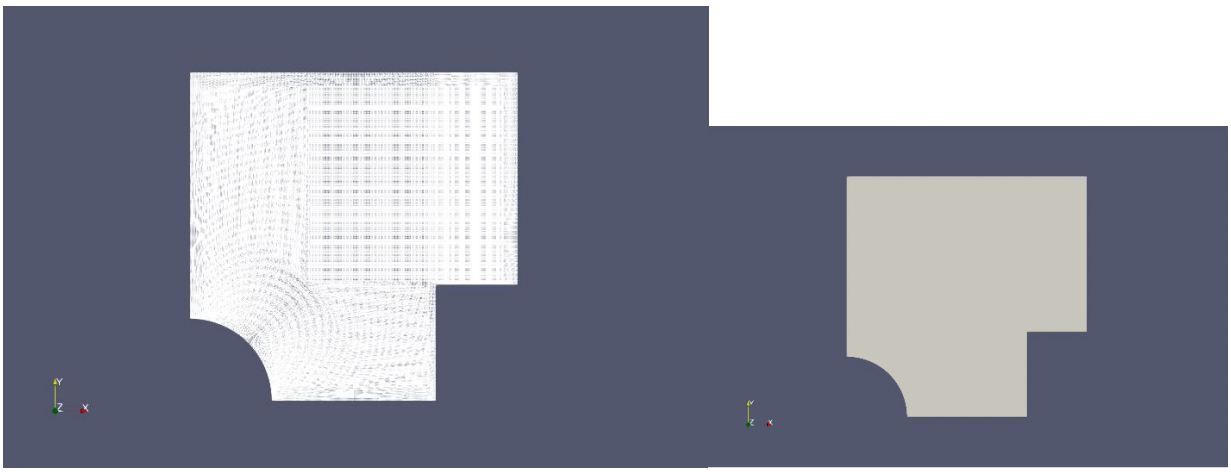
OpenFoam on Virtual Machine

Using SSH connection and following the instructions on OpenFoam page, the OpenFoam package was installed.

Preparing Thermal Stress case files

The files were prepared on the basis of OpenFoam tutorial available on: https://www.openfoam.com/documentation/tutorial-guide/5-stress-analysis/5.1-stress-analysis-of-a-plate-with-a-hole

The following mesh was created:



Following boundary conditions were applied:

- Upper and lower edge were fixed
- On the upper edge the temperature was set to 100°C
- On the lower edge the temperature was set to 0°C
- Rest of the edges were free to move

Two sets of files were prepared. One to be calculated using single core, and second to be calculated 4 cores.

Calculations

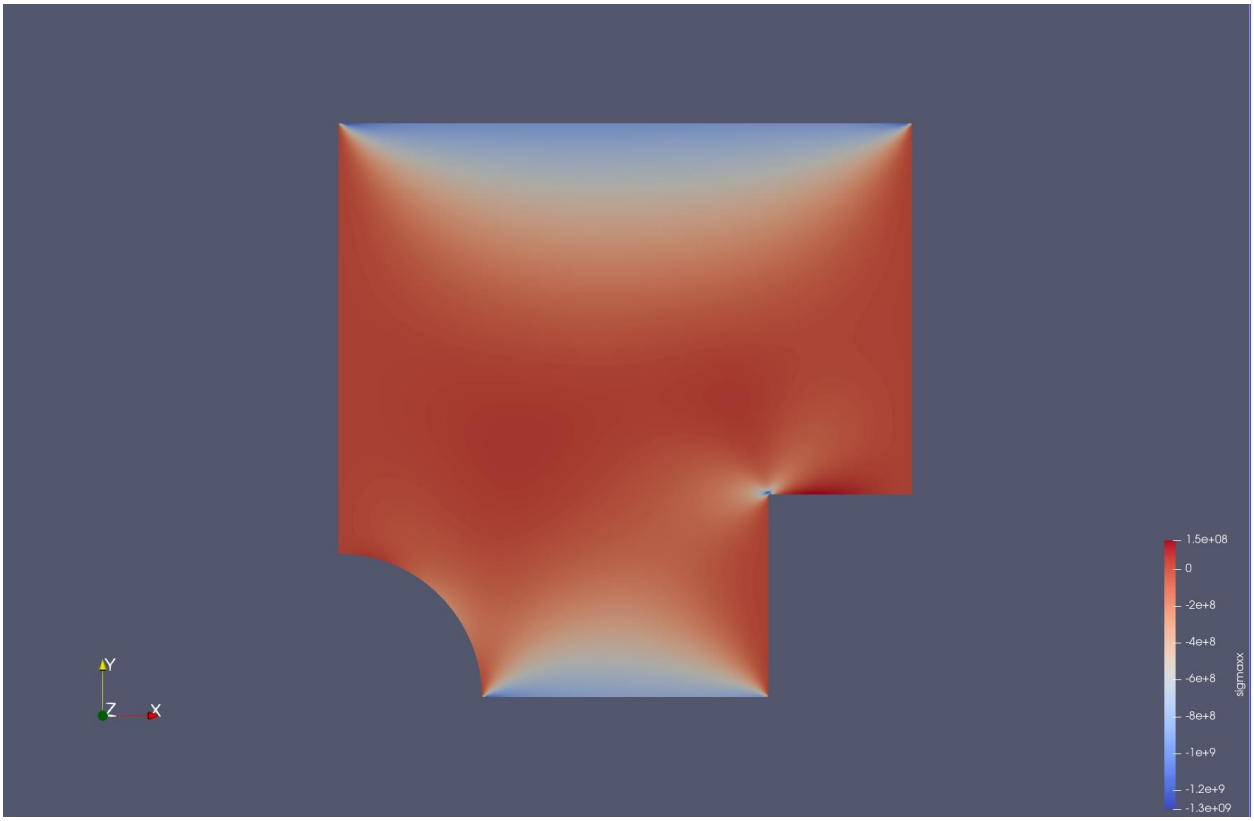
The calculations were performed using the script located in CC.sh file.

The calculation using single core took 658 seconds and parallel calculations on 4 cores took 479. It is clearly visible that there is great advantage to using parallel calculations. If the more powerful machine had been used, the calculation time would be even shorter. That is great option for advanced and complicated problems.

In both cases the result were identical and are presented below:


Y
Z
X
3.7e+02
360
350
340
330
320
310
300
290
280
2.7e+02
T


Y
Z
X
6.3e+09
6e+9
5.5e+9
5e+9
4.5e+9
4e+9
3.5e+9
3e+9
2.5e+9
2e+9
1.5e+9
1e+9
5.0e+08
sigmod Magnitude


Y
Z
X
1.5e+08
0
-2e+8
-4e+8
-6e+8
-8e+8
-1e+9
-1.2e+9
-1.3e+09
sigmaxx


Y
Z
X
9.9e+07
-1e+9
-2e+9
-3e+9
-4e+9
-5e+9
-6.0e+09
sigmayy