**Deploy HELYX® for HPC on a virtual machine**

This article describes the steps for running the CFD software [HELYX](https://engys.com/products/helyx) on a Virtual Machine (VM) and a HPC cluster that have been deployed on Azure Cloud Platform. It also presents the performance results of HELYX on Azure while running on single-node and multi-node VM configurations. HELYX version 3.5.0 was employed to complete all tests.

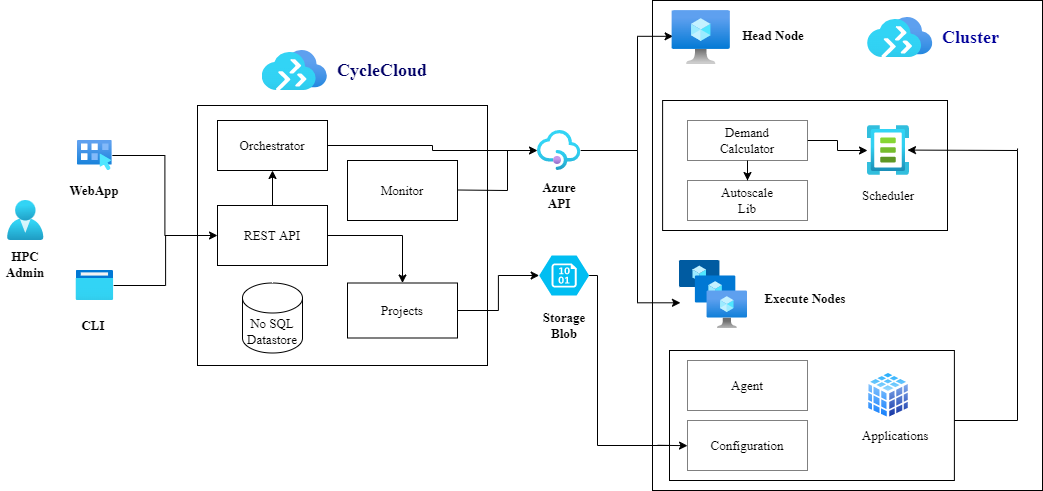
**About HELYX**

HELYX is a comprehensive, general purpose, computational fluid dynamics (CFD) software package for engineering analysis and design optimization developed by [ENGYS](https://engys.com/). HELYX features an open-source simulation engine with an advanced hex-dominant automatic mesh algorithm which can run in parallel, as well as a highly capable solver stack based on the finite-volume approach which covers a wide range of physical models: single- and multi-phase turbulent flows (RANS, URANS, DES, LES), thermal flows with natural/forced convection, thermal/solar radiation, incompressible and compressible flow solutions, etc.

The key benefits of HELYX include:

* Comprehensive CFD solution: capable of tackling the most complex flow problems using ENGYS’ advanced automatic meshing and a wide range of robust, accurate and fully-validated solvers.
* Cost-effective: pay only for the number of users that need the tool without any solver restrictions.
* Highly scalable: free yourself from HPC license restrictions and make the most of your hardware resources with open-source solvers.
* Cloud ready: with a unique client-server architecture to handle remote connections to in-house hardware resources, as well as on-demand HPC services.
* Best-in-class user support: to help tackle the most complex flow problems using HELYX to its maximum potential.
* Modular and extendable with HELYX ADD-ONS: for specialized solver applications and design optimization.

**Azure Architecture**



**Components**

* [Azure Virtual Machines](https://azure.microsoft.com/services/virtual-machines). Create Linux and Windows virtual machines in seconds.
* [Azure Virtual Network](https://azure.microsoft.com/services/virtual-network). Use Virtual Network to create your own private network infrastructure in the cloud.

**Install HELYX 3.5.0 on a VM and HPC Cluster**

The software HELYX must be purchased from ENGYS or one of their local authorized distributors/agents to get access to the installation files and technical support. Contact [ENGYS](https://engys.com/products/helyx) if you are interested in buying HELYX.

Before you install HELYX, you need to deploy and connect a VM or HPC Cluster.

For information about deploying the VM and installing the drivers, see one of these articles:

* [Run a Windows VM on Azure](https://docs.microsoft.com/en-us/azure/architecture/reference-architectures/n-tier/windows-vm)
* [Run a Linux VM on Azure](https://docs.microsoft.com/en-us/azure/architecture/reference-architectures/n-tier/linux-vm)

For information about deploying the Azure CycleCloud and HPC cluster, see below articles:

* [Install and configure Azure CycleCloud](https://docs.microsoft.com/en-us/learn/modules/azure-cyclecloud-high-performance-computing/4-exercise-install-configure/)
* [Create a HPC Cluster](https://docs.microsoft.com/en-us/learn/modules/azure-cyclecloud-high-performance-computing/5-exercise-create-cluster/)

**Test Models**

Three models were considered for testing the parallel scalability performance of HELYX version 3.5.0 on Azure, namely:

* A steady-state model of a city landscape, typical of wind comfort analysis.
* A steady-state model of a ventilator fan with moving blades approximated using a MRF approach with arbitrary mesh interface. Two mesh densities were compared.
* A transient model of a ship moving in calm water using a two-phase volume-of-fluid solver. Two mesh densities were compared.

All computational grids tested herein were created in parallel as part of the execution process using the hex-dominant meshing utility provided with HELYX.

The details of each test model are shown below:

**Model 1 – City\_landscape\_Niigata-NNE**

|  |  |  |
| --- | --- | --- |
| image showing model 3 -City_landscape_Niigata-NNE | **Model Details** | |
| **Mesh Size** | 26,500,000 cells |
| **Solver** | Single phase, turbulent flow |
| **Steady-state** | 1000 iterations |

**Model 2 – Turbomachine\_Ventilator-AFnq182**

|  |  |  |  |
| --- | --- | --- | --- |
| image showing model 4 -Turbomachine_Ventilator-AFnq182 | **Model Details** | **2a** | **2b** |
| **Mesh Size** | 3,100,000 cells | 11,800,000 cells |
| **Solver** | Single phase, turbulent flow with MRF (AMI) | |
| **Steady-state** | 1000 iterations | |

**Model 3 – Marine\_G2010-C2.2b-KCS-Fn026**

|  |  |  |  |
| --- | --- | --- | --- |
| image showing model 5 - Marine_G2010-C2.2b-KCS-Fn026 | **Model Details** | **3a** | **3b** |
| **Mesh Size** | 1,350,000 cells | 11,100,000 cells |
| **Solver** | Two-phase (VOF) with automatic mesh refinement | |
| **Transient** | CFL regulated for 20 s | |

**HELYX 3.5.0 Performance Results on Single-Node VM**

The performance results achieved running HELYX in parallel on single-node Azure [HBv3 AMD EPYC™ 7V73X](https://docs.microsoft.com/en-us/azure/virtual-machines/hbv3-series) (Milan-X) VMs are presented below as baseline for comparing with multi-node runs.

**Model 1 - City\_landscape\_Niigata-NNE**

| **Number of**  **cores** | **Total Solver time**  **in seconds** | **Relative Solver Speedup** |
| --- | --- | --- |
| 16 | 6176.48 | 1.00 |
| 32 | 4301.36 | 1.44 |
| 64 | 3783.12 | 1.63 |
| 120 | 3774.44 | 1.64 |

**Model 2a - Turbomachine\_Ventilator-AFnq182**

| **Number of**  **cores** | **Total Solver time**  **in seconds** | **Relative Solver Speedup** |
| --- | --- | --- |
| 16 | 1609.85 | 1.00 |
| 32 | 1081.2 | 1.49 |
| 64 | 850.98 | 1.89 |
| 120 | 715.07 | 2.25 |

**Model 3a - Marine\_G2010-C2.2b-KCS-Fn026**

| **Number of**  **cores** | **Total Solver time**  **in seconds** | **Relative Solver Speedup** |
| --- | --- | --- |
| 16 | 16608.29 | 1.00 |
| 32 | 13622.88 | 1.22 |
| 64 | 7979.05 | 2.08 |
| 120 | 8007.08 | 2.07 |

**Single-Node Tests Observations**

For all single-node tests we have taken the solver time on HB120-16rs\_v3 (16 cores) as the reference to calculate the relative speed up with respect to other similar VMs with more cores. The results presented above show that parallel performance improves as we increase from 16 to 64 cores, then at 120 cores some simulations show very limited improvement and others show a drop in performance. This is a common occurrence with CFD solvers and other memory intensive applications due to the saturation of the onboard memory available on each processor.

The AMD EPYC™ 7V73​-series (Milan-X) featured in the Azure HBv3 VMs tested here is a very capable processor with 768MB of total L3 cache. Our single-node tests confirm that this memory is sufficient to guarantee parallel scalability of the HELYX solvers when using half the cores available on each 7V73​-series chip.

**HELYX 3.5.0 Performance Results on Multi-Node (Cluster)**

The single-node tests carried out with HELYX confirmed that the solver exhibits proper parallel performance when using up to 64 cores with HBv3 VMs. Therefore, we employed only 64 cores to evaluate the performance of HELYX with [Standard\_HB120-64rs\_v3](https://learn.microsoft.com/en-us/azure/virtual-machines/hbv3-series) when testing multi-node (cluster) configurations. The results are shared below for each test case considered in this study:

**Model 1 - City\_landscape\_Niigata-NNE**

| **Number of Nodes** | **Number of Cores** | **Cells per Cores** | **Total Solver time**  **in seconds** | **Relative Solver Speedup** |
| --- | --- | --- | --- | --- |
| 1 | 64 | 414063 | 3741.59 | 1.00 |
| 2 | 128 | 207031 | 1528.34 | 2.45 |
| 4 | 256 | 103516 | 640.64 | 5.84 |
| 8 | 512 | 51758 | 398.73 | 9.38 |
| 16 | 1024 | 25879 | 193.72 | 19.31 |

**Model 2a - Turbomachine\_Ventilator-AFnq182**

| **Number of Nodes** | **Number of Cores** | **Cells per Core** | **Total Solver time**  **in seconds** | **Relative Solver Speedup** |
| --- | --- | --- | --- | --- |
| **1** | 64 | 48438 | 838.4 | 1.00 |
| **2** | 128 | 24219 | 567.48 | 1.48 |
| **4** | 256 | 12109 | 455.9 | 1.84 |
| **8** | 512 | 6055 | 372.82 | 2.25 |

**Model 2b - Turbomachine\_Ventilator-AFnq182\_large**

| **Number of Nodes** | **Number of Cores** | **Cells per Core** | **Total Solver time**  **in seconds** | **Relative Solver Speedup** |
| --- | --- | --- | --- | --- |
| 1 | 64 | 184375 | 2710.14 | 1.00 |
| 2 | 128 | 92188 | 1602.64 | 1.69 |
| 4 | 256 | 46094 | 1076.27 | 2.52 |
| 8 | 512 | 23047 | 756.73 | 3.58 |

**Model 3a - Marine\_G2010-C2.2b-KCS-Fn026**

| **Number of Nodes** | **Number of Cores** | **Cells per Core** | **Total Solver time**  **in seconds** | **Relative Solver Speedup** |
| --- | --- | --- | --- | --- |
| 1 | 64 | 21094 | 8028.75 | 1.00 |
| 2 | 128 | 10547 | 6354.25 | 1.26 |
| 4 | 256 | 5273 | 4320.72 | 1.86 |
| 8 | 512 | 2637 | 4518.09 | 1.78 |

**Model 3b - Marine\_G2010-C2.2b-KCS-Fn026\_large**

| **Number of Nodes** | **Number of Cores** | **Cells per Core** | **Total Solver time**  **in seconds** | **Relative Solver Speedup** |
| --- | --- | --- | --- | --- |
| 1 | 64 | 173438 | 66860.55 | 1.00 |
| 2 | 128 | 86719 | 41243.12 | 1.62 |
| 4 | 256 | 43359 | 25901.95 | 2.58 |
| 8 | 512 | 21680 | 16781.86 | 3.98 |

**Multi-Node Tests Observations**

We conclude from the multi-node tests that parallel scalability for Model 1 (steady-state, incompressible, turbulent flow) is above optimal. We also notice from the results obtained with Models 2 and 3 that parallel solver performance can be somewhat conditioned when using ancillary methods such as MRF/AMI or automatic mesh refinement.

The results also show that a minimum number of cells per core is required to reach optimal scalability across multiple nodes when using HELYX. This is evident when comparing the results from Model 2a to 2b and 3a to 3b. Solver performance is reduced when the number of cells per core falls below 20,000 due to excessive data communication between processor boundaries.

**Pricing**

Only solver time has been considered for the cost calculations. Meshing times, installation time and software costs have been ignored.

You can use the [Azure pricing calculator](https://azure.microsoft.com/pricing/calculator) to estimate VM costs for your configurations.

The following tables provide the solver times in hours. The Azure VM hourly rates are subject to change. To compute the cost, multiply the solver time by the number of nodes and the Azure VM hourly cost which you can find [here for Windows](https://azure.microsoft.com/pricing/details/virtual-machines/windows/#pricing)  and [here for Linux](https://azure.microsoft.com/pricing/details/virtual-machines/linux/#pricing).

**Model 1 - City\_landscape\_Niigata-NNE**

|  |  |
| --- | --- |
| **Number of Nodes** | **Solver time (Hr)** |
| 1 | 1.052 |
| 2 | 0.436 |
| 4 | 0.186 |
| 8 | 0.118 |
| 16 | 0.062 |

**Model 2a - Turbomachine\_Ventilator-AFnq182**

|  |  |
| --- | --- |
| **Number of Nodes** | **Solver time (Hr)** |
| 1 | 0.244 |
| 2 | 0.168 |
| 4 | 0.138 |
| 8 | 0.118 |

**Model 2b - Turbomachine\_Ventilator-AFnq182\_large**

|  |  |
| --- | --- |
| **Number of Nodes** | **Solver time (Hr)** |
| 1 | 0.801 |
| 2 | 0.483 |
| 4 | 0.337 |
| 8 | 0.247 |

**Model 3a - Marine\_G2010-C2.2b-KCS-Fn026**

|  |  |
| --- | --- |
| **Number of Nodes** | **Solver time (Hr)** |
| 1 | 2.291 |
| 2 | 1.823 |
| 4 | 1.264 |
| 8 | 1.336 |

**Model 3b - Marine\_G2010-C2.2b-KCS-Fn026\_large**

|  |  |
| --- | --- |
| **Number of Nodes** | **Solver time (Hr)** |
| 1 | 18.800 |
| 2 | 11.670 |
| 4 | 7.406 |
| 8 | 4.890 |

**Conclusions**

* HELYX 3.5.0 was successfully tested on Azure using HBv3 standalone Virtual Machines and Azure Cycle Cloud multi-node (cluster) setup.
* All models tested demonstrated good CPU acceleration when running in a multi-node configuration.
* The meshing, setup and solver applications in HELYX can all be run in parallel, thus making this CFD tool ideal for execution in multi-node configurations (no need for mesh decomposition/reconstruction).
* The simulation engine delivered with HELYX is open source, which means users can run as many simulations in as many processors as needed without incurring additional license costs.
* For better parallel performance we recommend using 64 cores per HBv3 node and a minimum of 20,000 cells per core.

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