Migrating Engineering Workloads to the Azure Cloud

An FLSmidth Case Study

With Support From:

UberCloud Case Study 217

http://www.TheUberCloud.com

August 06, 2019

Welcome!

The UberCloud* Experiment started in July 2012, with a discussion about cloud adoption in technical computing and a list of technical and cloud computing challenges and potential solutions. We decided to explore these challenges further, hands-on, and the idea of the UberCloud Experiment was born, then also due to the excellent support from INTEL generously sponsoring these experiments since the early days!

We found that especially small and medium enterprises in digital manufacturing would strongly benefit from technical computing in HPC centers and in the cloud. By gaining access on demand from their desktop workstations to additional and more powerful compute resources in the cloud, their major benefits became clear: the **agility** gained by shortening product design cycles through shorter simulation times; the superior **quality** achieved by simulating more sophisticated geometries and physics and by running many more iterations to look for the best product design; and the **cost** benefit by only paying for what is really used. These are benefits that obviously increase a company's innovation and competitiveness.

Tangible benefits like these make computing - and more specifically technical computing as a service in the cloud - very attractive. But how far are we from an ideal cloud model for engineers and scientists? At first, we didn't know. We were facing challenges like security, privacy, and trust; traditional software licensing models; slow data transfer; uncertain cost & ROI; lack of standardization, transparency, cloud expertise. However, in the course of this experiment, as we followed each of the 197 teams closely and monitored their challenges and progress, we've got an excellent insight into these roadblocks, how our teams have tackled them, and how we are now able to reduce or even fully resolve them.

This UberCloud Experiment #217 is about "Migrating Engineering Workloads to the Azure Cloud – An FLSmidth Case Study". In September 2018, FLSmidth approached UberCloud to perform an extensive Proof of Concept to evaluate whether the timing was right to consider moving their engineering simulation workload to the Cloud. During this half-year project, FLSmidth A/S and UberCloud implemented some of the engineering simulations on Microsoft Azure. The UberCloud project team worked with FLSmidth's IT Group and subject matter experts to design and configure FLSmidth's Azure cloud environment for running ANSYS software in an HPC configuration, to benchmark FLSmidth applications, and to understand engineering simulation usage of Cloud HPC resources and related workflows.

Now, enjoy reading!

Wolfgang Gentzsch and Burak Yenier

**) UberCloud is the online community & marketplace where engineers and scientists discover, try, and buy Computing Power as a Service, on demand. Engineers and scientists can explore and discuss how to use this computing power to solve their demanding problems, and to identify the roadblocks and solutions, with a crowd-sourcing approach, jointly with our engineering and scientific community. Learn more about the UberCloud at: http://www.TheUberCloud.com.*

Team 217

Migrating Engineering Workloads to the Azure Cloud – An FLSmidth Case Study

> *"From all the cloud service providers we have worked with so far, your team at UberCloud is the most professional and the most pleasant one to work with."*

MEET THE TEAM

Customer – Sam Zakrzewski, Fluid Dynamic Specialist and Janaina Hyldvang, IT Infrastructure Architect at FLSmidth A/S, Copenhagen, Denmark.
Engineering Software Providers – Wim Slagter, Director, HPC & Cloud Alliances at ANSYS, Inc. and Clovis Maliska Jr., President, and Marcus Reis, VP Sales, Support, Services at ESSS / Rocky.
Cloud Resource Provider – Microsoft Azure.
HPC Cloud Experts –Ozden Akinci, Ronald Zilkovski, and Ender Guler at the UberCloud Inc.
Project Manager – Reha Senturk and Alexander Gatzemeier at the UberCloud Inc.

FLSMIDTH

FLSmidth is the leading supplier of engineering, equipment and service solutions to customers in mining and cement industries. With more than 135 years of experience and with activities in more than 100 countries worldwide, FLSmidth is productivity provider no. 1 to its customers. Sharing customers' ambitions, FLSmidth brings better solutions to light by improving their safety standards and enhancing their performance.

FLSmidth's 11.000+ employees use their unique process knowledge about projects, products and services to meet their customers' needs for technical innovations, digitalization and sustainable life-cycle management. Together with their customers, they challenge conventions, explore opportunities and drive success through sustainable productivity enhancement.

USE CASE

In September 2018, Sam Zakrzewski from FLSmidth approached UberCloud to perform an extensive Proof of Concept to evaluate whether the timing was right to consider moving their engineering simulation workload to the Cloud. During this half-year project, FLSmidth A/S and UberCloud implemented some of the engineering simulations on Microsoft Azure. The UberCloud project team worked with FLSmidth's IT Group and subject matter experts to design and configure FLSmidth's Azure cloud environment for running ANSYS software in an HPC configuration, to benchmark FLSmidth applications, and to understand engineering simulation usage of Cloud HPC resources and related workflows.

The FLSmidth engineering team, which is distributed between locations in Copenhagen, India, South Africa, and Brazil, drafted a list of their actual requirements with a two-year roadmap of moving different simulation scenarios using ANSYS CFX and ESSS Rocky to Azure. FLSmidth currently has its own on-premises Haswell-based HPE cluster with 512 cores and Infiniband FDR for its 20 habitual users. In the next step, it wishes to increase its user base and upgrade the on-premises environment with cloud bursting for mission-critical applications in CFD (multi-phase, combustion) using ANSYS CFX and Fluent, STAR CCM+, and ANSYS Mechanical (static, thermal, modal, fatigue). In addition, the company is applying the discrete element method (DEM) to simulate granular and discontinuous materials with ESSS Rocky.

FLSmidth HPC Cluster in Azure

FLSmidth's IT Team created the pilot cluster in FLSmidth's Azure subscription, and established access for the UberCloud team. The pilot cluster has IP based firewall security to allow proper access and testing. The HPC cluster will be moved to FLSmidth's subnet when it is rolled out to production.

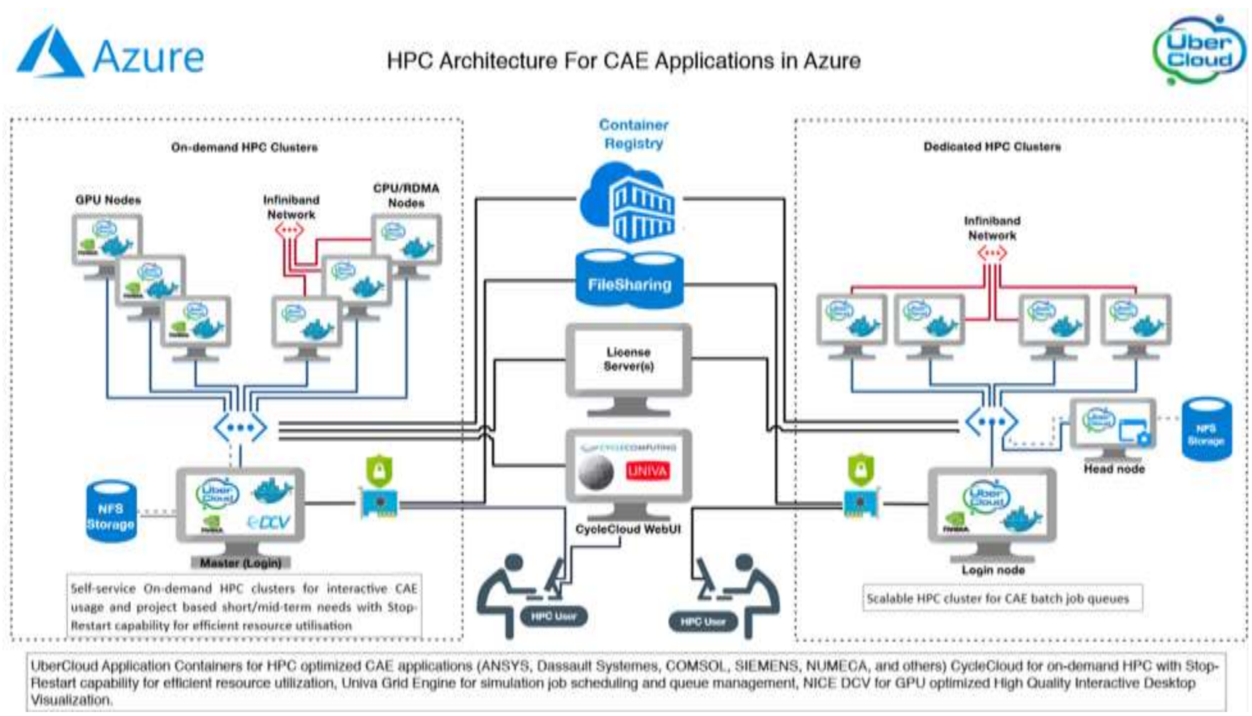

Figure 1: HPC architecture for CAE applications in Azure, with UberCloud CAE containers, CycleCloud, Univa Grid Engine, and NICE DCV.

Based on FLSmidth project team's decision, West Europe and Central India datacenters were identified as POC sites. The Azure West Europe Data Center is the main site for FLSmidth's datacenter migration. India was chosen as the second site to provide regional HPC resources to eliminate their latency issues.

Based on FLSmidth IT requirements and engineering usage needs, UberCloud created a flexible global HPC Cluster Architecture (Figure 1). FLSmidth IT naming standards were used to properly identify the resources. UberCloud created a Cloud HPC Architecture which is able to handle different workloads and easily expands to other sites providing maximum flexibility and cost efficiency. The main site in West Europe was created with two cluster types; one dedicated 256 core cluster for batch jobs managed by Univa Grid Engine based on queues with different priorities, and on-demand HPC clusters are used for all extra workloads and additional simulations that require powerful compute resources. Azure's CycleCloud provides self-service cluster provisioning and management capability directly to engineers without adding any overhead to IT. UberCloud created custom web interfaces in CycleCloud to provide these on-demand resources to engineers based on FLSmidth's consumption rules built into the system. Resource groups were created, 1 TB centralized storage account was created for storing test cases and shared files, nodes were created as head node, compute nodes, visualization nodes, container registry was created as resource group, and a license server was created. Finally, resources in the India cluster were created.

Application: FLSmidth JETFLEX® Kiln Burners

One of FLSmidth's major applications is the simulation of the JETFLEX® kiln burner which offers maximal flexibility for solid pulverized and alternative fuel firing, with a unique design utilizing fixed or rotatable rectangular jet air nozzles, see Figure 2. Fast and easy shipping keeps initial costs low, while a common solid fuel channel reduces usage of cold fuel-conveying air.

The JETFLEX® burner is a highly flexible kiln burner, designed to produce the best flame shape at lowest NOx emissions for various fuel types and operating conditions. It fires rotary kilns ('ovens') with pulverised coal or coke, oil, natural gas, or any mixture of these fuels. Alternative fuel firing of plastic chips, wood chips and sewage sludge can also occur through the same common fuel channel. The JETFLEX® burner is available for any fuel combination and maximum capacity ranging from 10 to 250 MW, catering for even the largest of rotary kilns. The primary air supply to the kiln burner enables a flame momentum of 7 N/MW up to 11 N/MW.

FLSmidth offers two kiln burner models: The standard JETFLEX® burner and the JETFLEX® PLUS burner. The **standard JETFLEX® burner** has no moving parts, offering easy operation and reliability as fewer parts are exposed to wear. The kiln burner flame shape or momentum is easily controlled by simple regulation of the primary air pressure and flow. If you find a series of optimum kiln burner settings work for you, these can be easily repeated. This improves plant production by enabling smooth transition between production qualities or fuels. For optimum combustion flexibility, **JETFLEX® PLUS burner** offers superior combustion of cost-effective grade fuels, complete flame-forming control and increased fuel retention time. The two design features that characterise the JETFLEX® PLUS burner model are rotatable jet air nozzles and a retractable centre pipe for alternative fuel firing. The concentric placement of the rotatable jet air nozzles enables high suspension of the fuel inside the flame. The swirler is the main mechanism for shaping the flame during start-up and daily operation.

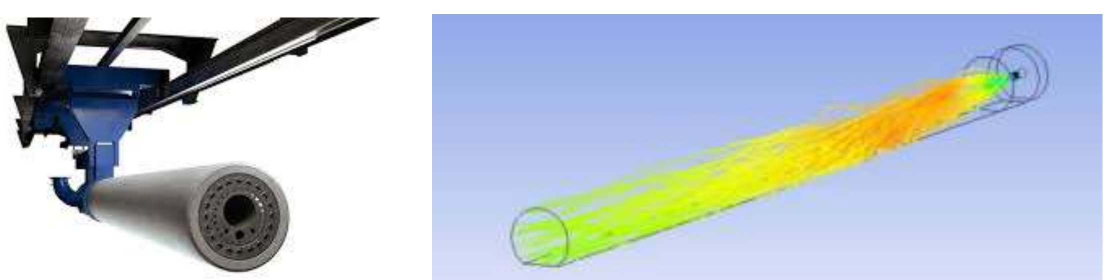

Figure 2: JETFLEX® kiln burner. The simulation shows a multi-phase Lagrangian CFD calculation, including solid fuel combustion.

APPLICATION AND TECHNOLOGY TESTING

A container registry was created in FLSmidth's Azure HPC environment, and UberCloud ANSYS Container images (ANSYS19, ANSYS19.2, and Rocky DEM 4.1 with CPU and GPU versions) were stored. Containers were deployed on the FLSmidth pilot cluster in Microsoft Azure West Europe datacenter. As a part of this project, enabling tools like Nice DCV for high-resolution remote visualization, CycleCloud for resource management, Univa Grid Engine for scheduling, GPU and Infiniband/RDMA were configured and successfully tested.

The test clusters were created for FLSmidth engineers to perform the benchmark tests using ANSYS Mechanical, Fluent, CFX, and Rocky DEM. UberCloud assisted FLSmidth engineers during the tests by setting up license servers, providing CLI and UI support, setting up RSM, troubleshooting computation errors, and resolving Azure resource issues. Benchmark tests were successfully run and results were reported.

Performance

ANSYS Fluent, CFX, and Mechanical benchmark tests were performed using H16 nodes in Azure which have the same CPUs as FLSmidth's on-premise HPC cluster. Single node runs brought very close results.

Multi-node runs showed good scalability when using many compute nodes for large simulations. Performance on Azure was 10-30% slower due to the difference of InfiniBand speed for interconnect (FLSmidth cluster has 56 Gb FDR vs H16's with 20 Gb FDR). The ability to scale up to large number of resources enabled FLSmidth to run multiple jobs simultaneously reducing multi-job duration and significantly increasing HPC throughput for engineers. Some of the benchmark results are shown in Figures 3 and 4, for FLSmidth's in-house Quasar cluster versus Azure (H16r and HC44 compute instances).

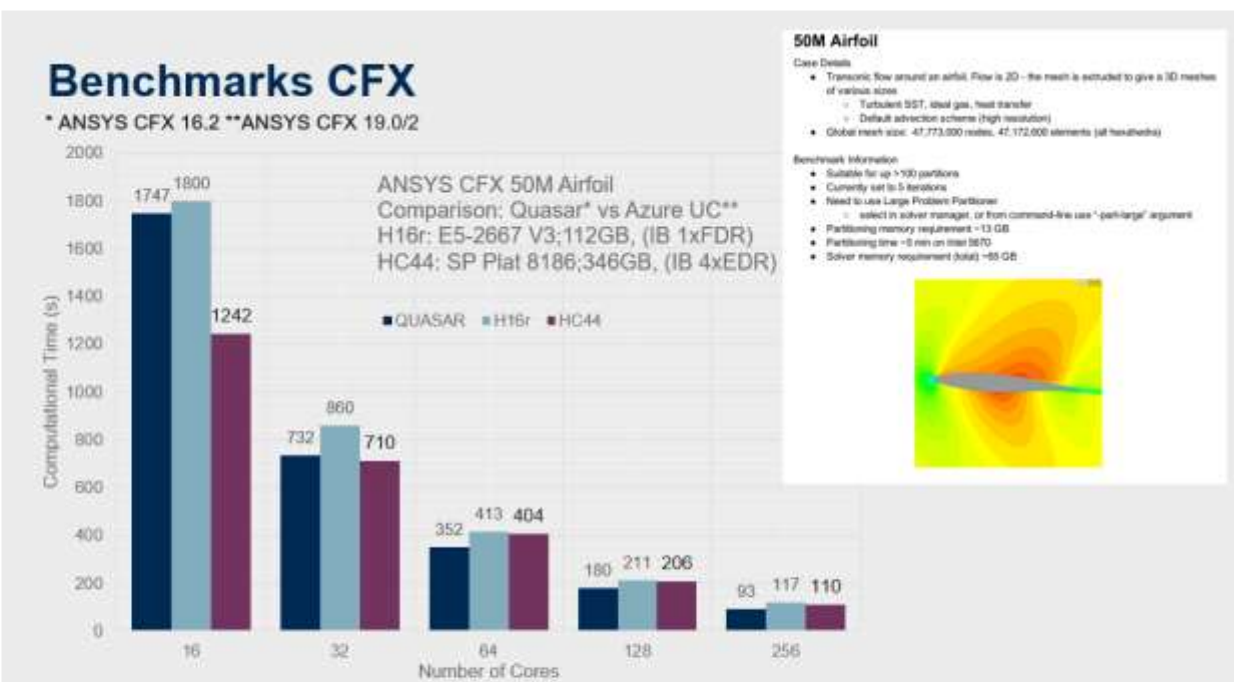

Figure 3: ANSYS CFX Benchmarks - External flow over an airfoil. approximately 48 million nodes (47 million hexahedral elements), solving compressible fluid flow with heat transfer using the SST turbulence model.

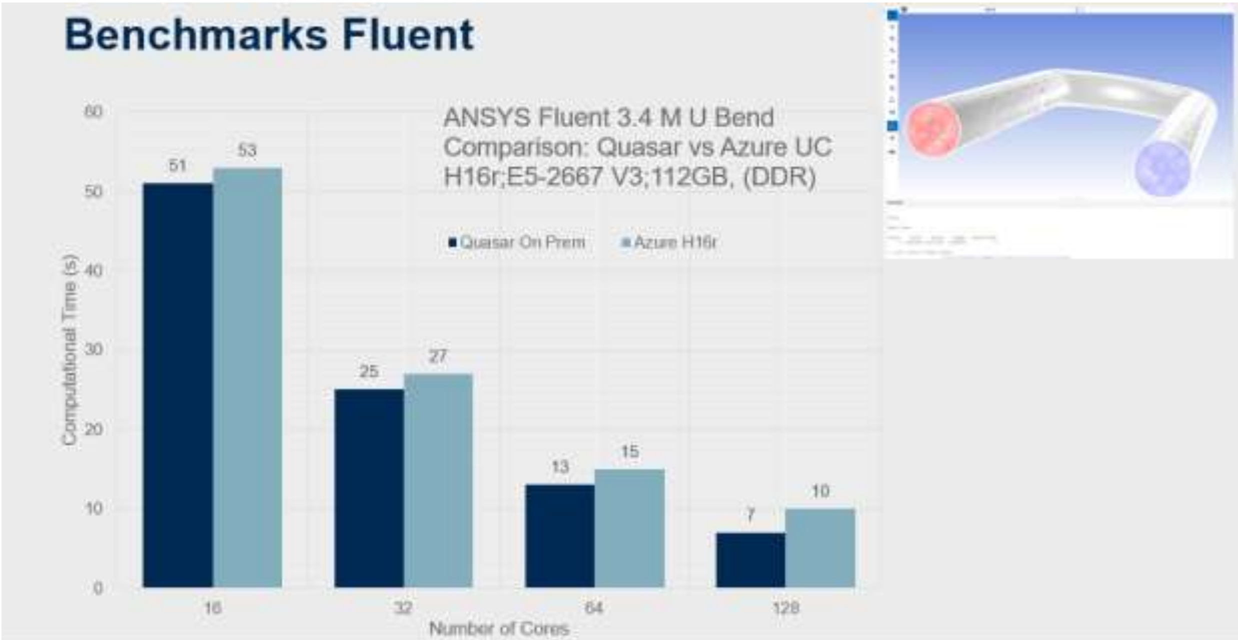

Figure 4: ANSYS Fluent Benchmarks – CFD analysis of flow through a U-Bend pipe.

CycleCloud and Univa Grid Engine (UGE)

Microsoft CycleCloud offers an easy to use, web-based cluster provisioning and management interface for engineers to create their own cloud computing resources on-demand. CycleCloud's policy-based templates allow administrators to set up the rules and usage limitations to control HPC utilization of different groups.

Univa Grid Engine provides a powerful multi-cloud workload management platform. Combined with CycleCloud, on-demand clusters can be created with built-in workload management capabilities. This combination delivers self-service HPC capability to engineers to create and control their own HPC resources which should reduce IT dependency of HPC resources.

Deliverables

- UberCloud ANSYS and Rocky Containers with FEA and CFD applications deployed to FLSmidth's Azure subscription.
- Benchmark results provided to FLSmidth engineers.
- FLSmidth Azure HPC Operations and Enterprise Roll-Out Map Document created.
- FLSmidth Cloud HPC Usage Projection for 2020 provided.
- A Document about "Using FLSmidth simulation applications with UberCloud software containers on Azure HPC environment" created and shared with FLSmidth project team.
- Engineers and FLSmidth's IT team trained on the use of the UberCloud containers.

CONCLUSION AND NEXT STEPS

During this project, FLSmidth's engineering applications (ANSYS Mechanical, Fluent, CFX, and Rocky DEM) were implemented in Azure HPC and tested in West Europe and Central India datacenters. FLSmidth's engineering and IT workflows were analyzed to provide the best cloud environment for the engineering processes which also reduces the IT management overheads. Cloud HPC will allow FLSmidth engineers to use simulation applications and vast resources on demand allowing faster results and turnaround time while providing complete control and management to IT. Moving the complete engineering simulations to Azure will provide scalable infrastructure and by keeping data in Azure's secure data centers will eliminate any delays of data transfer to local systems. Some of the outcomes are summarized below:

- Azure provides a variety of HPC compute resources for different application needs of FLSmidth engineers. New compute resources are regularly added, providing faster and cheaper resources for FLSmidth.
- Azure HPC resources are available in many datacenters around the world, providing low-latency regional access for FLSmidth sites.
- UberCloud provides complete engineering workflow capability in the cloud including full graphical user interface for pre- and post-processing, and batch.
- UberCloud HPC containers provide portability of FLSmidth's engineering applications, and allow multi-location and multi-cloud usability to application workloads.
- UberCloud HPC containers allow engineers to collaborate and increase productivity by working on the same simulation from any location.
- UberCloud HPC containers provide a standard HPC Application Management for all HPC applications including the ability to containerize other simulation applications including in-house codes.
- Cloud access allows worldwide usage of FLSmidth's applications from all sites.
- Cloud HPC providing almost unlimited number of resources enables FLSmidth engineers the freedom to innovate. They can use the resources to speed-up their simulations, run multiple iterations, models, physics, perform parametric sweeps and Design of Experiments (DoE).
- Cloud HPC allows global access to software licenses, reducing the number of local licenses or using them more efficiently (e.g. by more engineers).
- Cloud HPC eliminates the hardware bottlenecks during peak usage and fluctuating project loads.

Microsoft Azure with UberCloud CAE containers provides the modern Cloud HPC environment for FLSmidth. During this project, FLSmidth's IT and engineering workflows were evaluated and the following operational tasks were identified as critical processes to be developed before enterprise roll-out:

- **Engineering Workflow and Usage Optimizations:** Cloud HPC usage requires better planning of the simulations, results and data storage, job-based vs interactive usage and processing. UberCloud and FLSmidth teams started creating the list of "Engineering Best Practices in Cloud for FLSmidth Engineers" and documented in "FLSmidth Azure HPC Operations and Enterprise Roll-Out Map".
- **Consumption Monitoring and Billing:** User/Group based consumption should be monitored to ensure proper use of cloud resources and minimize idle resources.
- **Simulations generate large amount of data**. FLSmidth HPC Architecture is designed with regional storage and also replication for data that needs global access. Storage, archival and cleanup policy must be developed in alignment with FLSmidth Data Center Migration project.

As the result of this project, the HPC Cloud architecture was built and tested successfully. An Enterprise Roll-Out map was created identifying the steps necessary to establish steady-state operation. The next phase will focus on the Enterprise Roll-Out tasks and help FLSmidth complete its cloud migration of the HPC workloads.

Case Study Authors – Sam Zakrzewski and Reha Senturk

Join the UberCloud Experiment or Contact Us for Your Proof of Concept

If you, as an **end-user**, would like to participate in this Experiment to explore hands-on the end-to-end process of on-demand Technical Computing as a Service, in the Cloud, for your business then please register at: http://www.theubercloud.com/hpc-experiment/

If you, as a **service provider**, are interested in promoting your services through the UberCloud then please send us a message at https://www.theubercloud.com/help/

UberCloud Library of Case Study Compendiums at https://www.theubercloud.com/ubercloud-compendiums

HPCwire Readers Choice Award 2013: http://www.hpcwire.com/off-the-wire/ubercloud-receives-top-honors-2013-hpcwire-readers-choice-awards/
HPCwire Readers Choice Award 2014: https://www.theubercloud.com/ubercloud-receives-top-honors-2014-hpcwire-readers-choice-award/
Gartner Names The UberCloud a 2015 Cool Vendor in Oil & Gas: https://www.hpcwire.com/off-the-wire/gartner-names-ubercloud-a-cool-vendor-in-oil-gas/
HPCwire Editors' Choice Awards 2017 & 2018: https://www.hpcwire.com/2017-hpcwire-awards-readers-editors-choice/
IDC/Hyperion Innovation Excellence Awards 2017 & 2018: https://www.hpcwire.com/off-the-wire/hyperion-research-announces-hpc-innovation-excellence-award-winners-2/

If you wish to be informed about the latest developments in technical computing in the cloud, then please **subscribe to our monthly newsletter http://info.theubercloud.com/subscribe-to-newsletter**