Leveraging HPCaaS to optimise preventive maintenance processes
Today, it’s still rare for a highly regulated company such as France’s power distribution operator Réseau de Transport d’Électricité (RTE) to rely on cloud based High Performance Computing (HPC) digital engineering solutions to perform large-scale projects. But as this case study demonstrates, participants from many regulated industries can attain a number of similar benefits.

While our document focuses on the area of predictive and preventive maintenance, organizations from various fields and industries can use HPC to perform ambitious tasks with success. Examples range from manufacturing, finance, logistics and automotive sectors, as well as universities and research centers.

With on-demand access to compute resources in the cloud, firms become more agile, bring their products to market faster and deliver superior quality at lower cost because they pay only for the resources they use.

This case study tracks how RTE succeeded in using atNorth’s HPC as a Service platform, HPCFLOW and docker-based UberCloud HPC application containers to save critical time and resources on preventive maintenance of its overhead power lines.

It all started in 2012 when RTE decided to optimize its preventive maintenance process, the cost of which was expected to reach hundreds of millions of Euros in the coming years.

To do this, the network needed to know more about the fatigue damage of the power lines’ conductors, caused by the vortex-induced vibrations that result from the wind. RTE’s team ran an internal simulation to obtain insights using an HPC cluster with 240 cores for the initial phase of the project. Relying on a four-node, 80-core HPC cluster, the team was collecting 500,000 data samples from sensors and field operations every 10 seconds.

At this rate, the simulation project would have taken RTE six months to complete.

This is why the team decided to turn to atNorth HPCFLOW AI & HPC/Infrastructure-as-a-Service platform, which provided a 32-node HPC cluster to run a simulation on its 1,000 cores.
The role of HPC resources made it possible for RTE to analyze and predict vortex-induced vibrations that generate stress and eventual fatigue failure of the wire strands inside the power lines.

Since the experiment called for a flexible and scalable application environment, RTE decided on ADC and UberCloud. The containerized simulation environment was deployed on ADC’s Hewlett Packard Enterprise’s (HPE) 32-node compute cluster.

As a result of HPC resources, RTE was able to predict the vibrations – necessary for estimating the lifespan of the strands – while saving time and reducing cost. The project time was reduced to 18 days from an earlier projection of six months, resulting in a 10-fold decrease of the total amount of time.

**Challenge: RTE needs data about overhead conductors to curb preventive maintenance costs**

RTE, a subsidiary of the French electricity utility company Électricité de France, operates a high-voltage electricity transmission network in France. As the largest network in Europe, RTE invests substantial amounts in the preventive maintenance of its physical assets that deteriorate over time. In order for RTE to provide uninterrupted services and reduce outages, the company must replace overhead conductors each year, the cost of which is expected to reach hundreds of millions of Euros in the coming years.

**RTE couldn’t extract insights about overhead conductors using internal resources**

All network power lines experience fatigue damage due to vortex-induced vibrations caused by wind blowing at lower speeds. For this reason, RTE needed to gain better insights into the impact of the vibrations and accurately estimate the lifespan of the conductors. Fikri Hafid, RTE’s Head of Research and Development, and his consortium of university students, ran internal simulations to obtain these insights but the effort was too costly and took too long to complete.

Running the project on these resources, RTE was looking at a span of six months to complete the simulation.

Specifically, RTE was working on an in-house, four-node, 80-core HPC cluster to collect 500,000 data samples from sensors and field operations every 10 seconds. This cluster provided 240 cores for the initial phase of the project which wasn’t enough to reach a comprehensive outcome.
The 55,000 computational timesteps correspond to a physical time of 55 seconds.

During these 55 seconds, the vibrations became stable, in other words the vibration magnitude became constant.

Approach: atNorth’s HPC resources estimated lifespan of conductors and reduced maintenance costs

RTE turned to atNorth’s HPCFLOW HPC-as-a-Service platform, and UberCloud HPC application containers, which provided a 32-node HPC cluster to run a simulation on its 1,000 cores. As result of these HPC resources, project time was reduced to 18 days from an estimated six months. On balance, the project time was reduced by a factor of 10.

atNorth’s HPC resources help estimate power lines’ lifespan

HPC resources enable teams to study and predict vortex-induced vibrations of overhead power lines that transmit and distribute energy across large distances. Predicting the vibrations is essential to accurately estimate the lifespan of the strands. Wind induces vortex shedding downstream of the overhead line, creating alternating lift and drag force which causes line vibrations and generates cyclic stresses leading to fatigue failure of wire strands.

The simulation process evaluates each section of the cable, or a group of conductors, as well as the interaction between them to simulate the impact. This is achieved by assigning each cable section to an individual CPU core and applying a Computational Fluid Dynamics (CFD) to simulate the airflow around the overhead lines. A Finite Element Method (FEM) was used to capture an in-house solid solver, while the code coupling was used to determine the interaction between the wind and the power line.

Performing this simulation required a large number of computational sections which, in turn, required a large number of cores to properly evaluate the impact on the cable. This is why atNorth’s HPC cluster of 1,000 cores was indispensable.
How RTE performed CFD and FEM simulations in the cloud

As a reminder, CFD simulations were set up in a way that each cable of the multicore cable was distributed to one processor core. In total, 10,000 timesteps were simulated this way. After each CFD step was simulated, one FEM step was performed. The test configuration consisted of 60 cores, which was then increased to 240, 480, 720 and, finally, 1,000 cable cores (on 1,000 CPU cores). In detail, the CPU time for one timestep for 60 cores was 1.1s; for 240 cores 4.5s; for 480 cores 10s; for 720 cores 14s; and for 1,000-cores 17.6s. We can observe a linear correlation between the number of cores and the execution time for one timestep.

Following 10,000 timesteps, which correspond to the build-up phase of the electric cable vibration, the cable vibrations were still weak. The flow field was almost the same as the flow past a fixed cable, with a weak vortex shedding phenomenon of flow around each cylinder.

Since these results weren’t particularly exciting, RTE decided to increase further the number of timesteps for the 1,000-core case. They used a cluster of 32 compute nodes for 1,000 compute cores on atNorth HPCFLOW. RTE discovered that 10,000 iterations took 78.4 hours to complete, while for reaching near-steady vibrations following about 55,000 timesteps, the simulation took 431 hours, or 18 days.

Tools used: The role of CAE software in the study

Accessing and running Computer-Aided Engineering (CAE) applications in HPC clusters required a flexible and scalable application environment. RTE used docker-based UberCloud HPC application containers managed by Atrio’s Composable Cloud management platform. This containerized simulation environment was deployed on atNorth’s Hewlett Packard Enterprise’s (HPE) 32-node compute cluster. The CAE software, containerized by UberCloud, included Code_Saturne, Salome, Salome-Meca, ParaView and Gnuplot.

atNorth HPCFLOW AI & HPC/Infrastructure-as-a-Service platform, together with UberCloud, provided the HPC resources and a flexible environment for use and ease of access. atNorth cluster was built on HPE’s Apollo platform with Intel® Xeon® Scalable Processors and Intel® Omni-Path high speed interconnect. UberCloud provided the software layer through a CentOS Docker container with Code_Saturne CFD, Salome-Meca, and Paraview installation, including additional technical support during the project.
Impact and results: atNorth’s HPCFLOW reduced project time by tenfold

This case study demonstrates the importance of HPC and big data analytics for applications related to predictive and preventive maintenance. These resources play a crucial role in assessing the lifespan of overhead power lines, which is critical to the operations of any large network such as RTE.

This case study also proves that all enterprises in digital manufacturing – small, medium and large, including publicly owned enterprises – can strongly benefit from HPC-as-a-Service platforms such as HPCFLOW. By getting on-demand access from their desktop workstations and additional compute resources in the private, hybrid and public cloud, they gain the following benefits: agility, shorter product design and development cycles, superior quality and reduced costs because they pay only for the resources used.

The benefits make HPC, and especially HPCaaS, very attractive. We closely monitored RTE’s challenges and progress. This is why we were able to extract detailed hts into their roadblocks. They included:

- Security, privacy and trust
- Traditional software licensing models
- Slow data transfer
- Uncertain cost & ROI
- Availability of appropriate resources
- Standardization, transparency and cloud expertise

As a result, we now know how RTE tackled the roadblocks and how they can be reduced or fully resolved.
Conclusion

atNorth worked closely with HPE to ensure that our HPCaaS offering would meet all of our HPC customers’ requirements. As a result, our HPC Cloud HPC FLOW has a highly flexible range of offerings including dedicated, scalable and customizable HPC clusters that can be tailored to specific company needs. This flexibility was vital in meeting the requirements of RTE whose experiment called for a flexible and scalable application environment.

We were able to help RTE set up atNorth’s HPC FLOW in hours, prove its value and get the massive simulation up and running almost immediately. This was a landmark moment for RTE, considering that the company was trying to find the right HPC solution for months prior to partnering with us.

As the results were outstanding and quickly achieved, RTE decided to start a much more detailed and complex simulation which would have been virtually impossible on their fixed environment. It would have taken RTE several weeks at best and months at worst to complete. Now, they were able to launch a more sophisticated simulation and expect to finalize it 10 times faster.

Although HPC-as-a-Service continues to be rarely used in highly regulated sectors and academia, our partnership with RTE has demonstrated that it can be applied across different industries with impressive results.