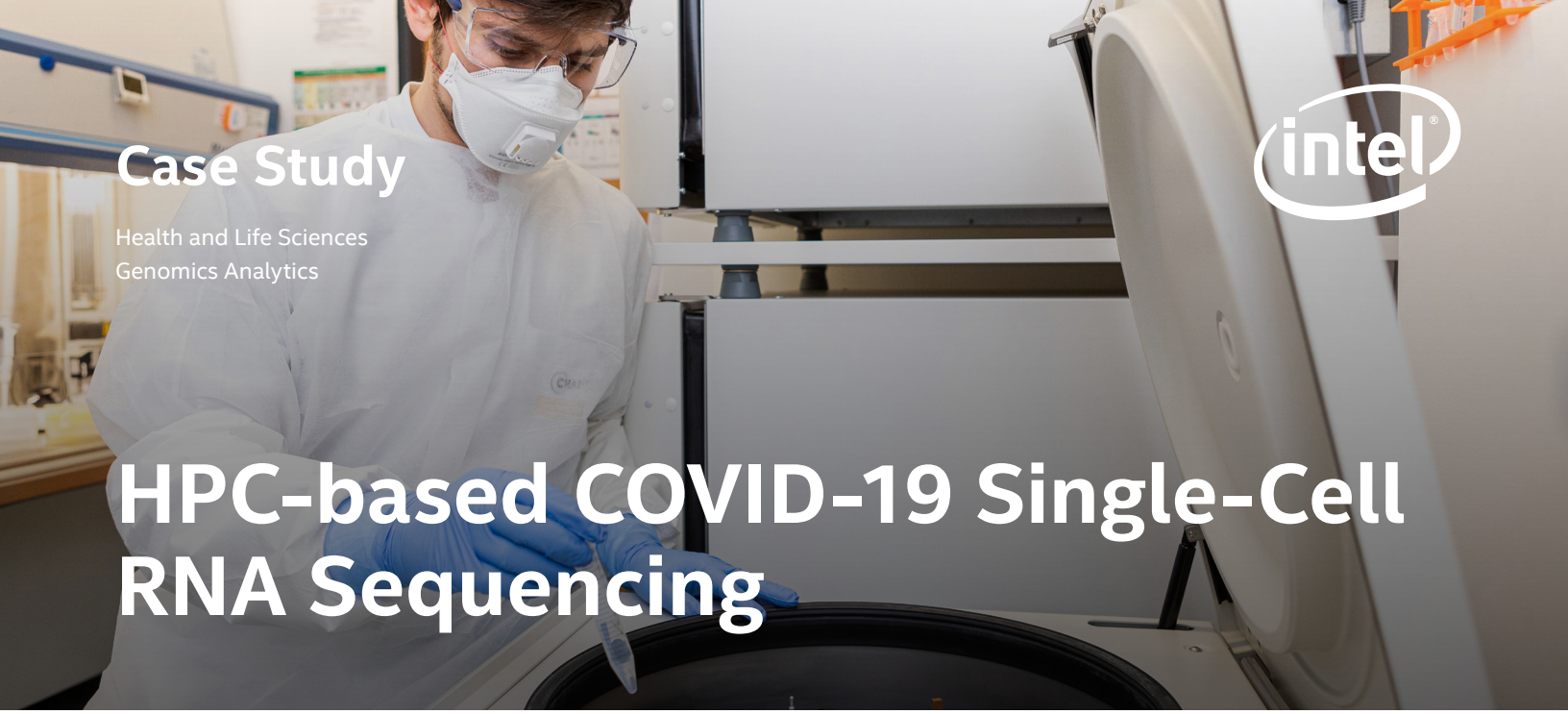


Case Study

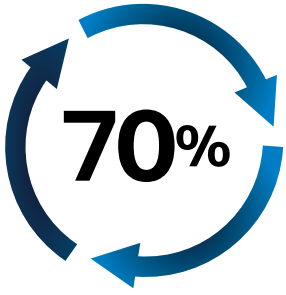
Health and Life Sciences
Genomics Analytics

HPC-based COVID-19 Single-Cell RNA Sequencing

Berlin Institute of Health (BIH) and Intel co-developed a high-performance computing (HPC) solution that can help determine what human cell types the virus attacks and how the cellular and transcriptional landscape changes upon virus infection.

At a Glance

- Researchers at Berlin Institute of Health (BIH) are on the front lines of understanding COVID-19
- Genomics analytics requires huge amounts of compute power, but cost efficiency is a concern
- BIH was able to increase the number of cells flowing through the analysis by 70 percent[1]
- Close collaboration between Intel, Dell, SVA and BIH resulted in efficient development, shipment and installation and enabled fast time-to-operation



more cells flowing through the analysis

Understanding how the novel corona virus (called SARS-CoV-2) responsible for the COVID-19 pandemic works is an important step in developing successful treatment. Charité and the Berlin Institute of Health (BIH) are using Intel's high-performance computing (HPC) architecture to successfully perform compute-intensive RNA sequencing on the single-cell level in a highly efficient manner. Intel is well positioned to assist in this effort through its deep IT knowledge, ecosystem scale and experience in the health and life sciences industry.

Challenge

BIH researchers seek to study thousands of cells using single-cell RNA sequencing to better understand how the novel corona virus works. But such sequencing requires immense amounts of compute power. The existing infrastructure at BIH was insufficient for this task, and its budget was tight. BIH needed to perform its sequencing tasks faster without breaking the bank.

Solution

BIH consulted with Intel, Dell and system integrator System Vertrieb Alexander GmbH (SVA) to develop a solution that was both technically and economically optimized. The solution takes advantage of Intel's expertise in genomics analytics and uses the Intel® Select Solution for Genomics Analytics hardware configuration.

Results

The BIH – Center for Digital Health has demonstrated that studying samples from precisely defined parts of the human respiratory system can provide new insights into host cell vulnerability and the cellular response upon SARS-CoV-2 infection. Working with Intel and Dell, BIH was able to cost-effectively increase the number of cells it could sequence by 70 percent. This was achieved by increasing the number of HPC nodes available and optimizing analysis workloads.[2]

Speeding up Research to Slow the Virus Down

As the world joins forces to counter the COVID-19 pandemic, molecular researchers are on the front lines. Every contribution towards this effort makes a difference. Charité and BIH believe their researchers can apply their deep research experience to explore the virus's infection strategies and how the disease progresses. Understanding what types of cells SARS-CoV-2 attacks can help identify high-risk patients and inform the design of targeted treatment therapies. But developing this level of understanding requires sequencing of the RNA of thousands of single cells individually, to uncover the cells most vulnerable to infection.

Sequencing the RNA of a single cell takes approximately one day, while the subsequent data analysis takes days to weeks and is highly compute-intensive. BIH's existing HPC resources were insufficient—it would simply take too long to perform the research. Therefore, BIH needed to make a significant investment in compute capabilities to accelerate the analysis workflows. Like many organizations, BIH's budget is highly constrained, meaning both the existing and additional HPC resources needed to be as efficient as possible. This includes optimizing the hardware configuration and workload performance.

> "In light of the global threat posed by the SARS-CoV-2 virus, we as researchers have a duty to marshal all of our scientific knowledge to understand the virus and its infection strategies as well as the disease progression of COVID-19 patients...[to] better identify high-risk patients and develop new therapies and vaccines. Every contribution towards this effort makes a difference."
>
> **— Professor Axel R. Pries**
> interim Chairman of the BIH Executive Board
> and Dean of Charité - Universitätsmedizin

Putting High-Performance Computing (HPC) to Work for the World

To achieve its goal of better understanding of how SARS-CoV-2 works, the BIH – Center for Digital Health set out to examine samples from the lower respiratory tract of 16 non-virus infected patients —resulting in nearly 58,000 cells. Their goal was to determine which kinds of cells in the lungs are vulnerable to infection—and why. In another study, the researchers investigated the cellular and transcriptional landscape in the respiratory tract of 19 COVID-19 patients in comparison to SARS-CoV-2 negative patients. This research helped them better understand the host response upon SARS-CoV-2 infection and the mechanisms that are associated with the severity of the disease. Working closely with Intel, Dell and system integrator SVA, BIH initially conducted a proof of concept using eight HPC nodes. Subsequently, BIH was able cost effectively increase the node count of its HPC cluster from 40 nodes to 68 nodes (a 70 percent increase).

Technical Components of Solution

- 8x Dell PowerEdge R740xd Rack Server
- Intel® Xeon® Gold 6252 processors
- Intel® SSD Data Center Family P4160 Series
- Intel® Ethernet Converged Network Adapter X710 Dual Port 10 GbE SFP+

The solution takes advantage of Intel's expertise and reference designs for genomics analytics—in particular, the Intel Select Solution for Genomics Analytics. Packaged in Dell's PowerEdge R740xd Rack Server, the solution is powered by Intel® Xeon® Gold 6252 processors (24 cores, 20.10 GHz), Intel® SSD Data Center Family P4160 Series and two 10 GbE Intel® Ethernet Converged Network Adapter X710.

Intel Supports Critical COVID-19 Research

Intel has a long-term and deep relationship with BIH, Charité and Dell—these three firms have collaborated on many projects in the past. The understanding and appreciation on all sides led to a quick decision to provide compute resources and accelerate BIH's research. SVA is familiar with data center infrastructure and provided guidelines and advice regarding system setup. SVA made recommendations regarding networking, power and cabling and allowed smooth integration in the existing data center environment. The close collaboration between Intel, Dell, SVA and BIH resulted in efficient development, shipment and installation. By working together, the team brought the new resources into operation quickly.

Intel is excited to put its expertise in HPC scalability, Intel® architecture-optimized genomics analytics frameworks, and experience in the health and life sciences sector directly to work for BIH. It is Intel's hope that working with BIH will enable researchers to uncover insights that will help defeat the COVID-19 pandemic. In addition to providing expert IT advice, Intel supports Charité and BIH activities with funding through Intel's Pandemic Response Technology Initiative.

One Step Closer to Understanding—and Defeating—SARS-CoV-2

The BIH - Center for Digital Health analyzed 52 samples originating from the upper and lower respiratory tract of 40 individuals, both COVID-19 patients or non-infected donors, resulting in a total of nearly 220,000 single cells. This research has revealed insights about which cells have the receptors and co-factors the virus needs to infect the cell and how the host cells respond to the virus infection. Although more research is necessary, especially with larger sample sizes, these insights can help lead to the identification of high-risk patients and to the development of targeted treatments. You can read more about BIH's research findings in the following scientific papers:

- "SARS -CoV-2 receptor ACE 2 and TMPRSS 2 are primarily expressed in bronchial transient secretory cells"
- "COVID-19 severity correlates with airway epithelium–immune cell interactions identified by single-cell analysis"

Spotlight on Charité and the Berlin Institute of Health (BIH)

Charité is one of the largest university hospitals in Europe with over four campuses and close to 100 different departments and institutes. Charité marked its 300-year anniversary in 2010. It is now one of the largest employers in Berlin, employing 14,576 staff (or 18,010 if including its subsidiaries). It has a total annual turnover of €1.8 billion. The Berlin Institute of Health (BIH) was founded in March 2013 by Charité and Max Delbrück Center for Molecular Medicine in the Helmholtz Association (MDC) as a unique biomedical research institute.

The BIH focuses on translational research and precision medicine. The BIH is dedicated to improving the prediction in progressive diseases and developing advanced therapies for unmet medical needs. The overarching goal is to improve patients' health and quality of life. The Institute is committed to providing research solutions and innovation enabling value-based, personalized healthcare. The BIH is 90 percent funded by the Federal Ministry of Education and Research (BMBF) and 10 percent by the State of Berlin. The two founding institutions, Charité and MDC, are independent member entities within the BIH.

> "There are many things we don't know about the corona virus. This research project and the next steps require enormous computing resources. That's exactly where our expertise can help."
>
> **— Hannes Schwaderer**
> country manager of Intel Germany

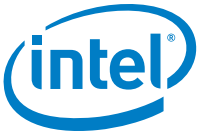
Behind the research, technology is indispensable in the fight against disease. The optimized HPC solution designed by Intel and Dell increased BIH's HPC cluster size by 70 percent. This has enabled BIH to cost-effectively accelerate sequencing so that it can perform more analyses per week. With future work, such as using Intel architecture-optimized frameworks like DeepVariant and GATK v2, BIH can expand its research efforts even further. Working together, Intel and the health and life sciences ecosystem help drive immediate solutions that make a difference in our world.

Learn More

You may find the following resources helpful:

- **Charité** home page
- **Berlin Institute of Health** home page
- **SARS -CoV-2 receptor ACE 2 and TMPRSS 2 are primarily expressed in bronchial transient secretory cells** article (EMBO Journal)
- **COVID-19 severity correlates with airway epithelium–immune cell interactions identified by single-cell analysis article** (Nature Biotechnology)
- **System Vertrieb Alexander GmbH** home page
- **Intel® Select Solution for Genomics Analytics** home page
- **Intel Select Solution for Genomics Analytics** solution brief
- **2nd Generation Intel® Xeon® Scalable processors**
- **Intel® Ethernet Converged Network Adapter X710**
- **Dell PowerEdge R740xd Rack Server**

Find the solution that is right for your organization. Contact your Intel representative or visit **https://intel.com/healthcare**.



[1] BIH increased the node count of its HPC cluster from 40 nodes to 68 nodes (a 70 percent increase). According to BIH internal observation, the amount of cell sequencing scales linearly with the number of nodes.

[2] See endnote 1.