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Project Outcomes Report

Project Outcomes Report Help

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Award Title: CC*DNI DIBBs: Data Analysis and Management Building Blocks for Multi-Campus Cyberinfrastructure through Cloud Federation
Federal Award ID: 1541215
Report Submission Period: 10/01/2020 to 09/30/2021

The Aristotle Cloud Federation project (https://federatedcloud.org/) built a scalable multi-institutional cloud federation that provides data analysis building blocks to support researchers requiring flexible workflows and large data sets. Cloud computing systems were deployed at Cornell University, the University at Buffalo, and the University of California, Santa Barbara, and allocations, accounting, and cloud metrics were developed and implemented. Strategic use cases from diverse disciplines demonstrated the potential of using federated clouds to share computing, data, and software resources between institutions and reduce time to science. A rich set of open-source software and cloud usage modalities were supported, including Virtual Machine snapshots of complex software systems, application containers, dynamically-sized and scheduled compute clusters in the cloud, and optimized frameworks for query-based exploration, modeling, and analysis.

The Aristotle project team and use case scientists produced 147 journal publications, conference papers, and presentations (https://federatedcloud.org/about/publications.php) and 28 new technologies and techniques (https://federatedcloud.org/using/technologies.php). New technologies advanced the knowledge and practice of federated cloud computing, public cloud economics, cloud versus supercomputer performance, edge computing, systems for implementing Internet of Things (IoT) applications, automated application deployment, and application containerization and orchestration.

Aristotle research has the potential to impact wind turbine companies interested in harnessing the energy of the atmosphere and converting it into carbon-free electricity, policymakers regulating high-frequency trading, agencies making water resource management decisions, health practitioners treating immune and metabolic diseases, oceanographers restoring nearshore coastal ecosystems, and farmers increasing yield while protecting the environment with real-time soil, water, and atmospheric data. In some cases, implementations of this research are already underway. For example, a low-power, multi-tier IoT deployment developed by the Aristotle team and the agricultural community will monitor the growth of Citrus Under Protective Screening (CUPS) to protect citrus from the Huanglongbing bacteria (citrus greening disease) that devastated Florida and is now threatening California. The Aristotle cloud is the data hosting service.

Aristotle lessons learned and technologies were shared widely at cyberinfrastructure (CI) and scientific

conferences. CI-focused presentations and tutorials were delivered at the OpenStack Summit, Coalition for Academic Scientific Computation meetings, and eScience, High Performance Extreme Computing, Practice and Experience in Advanced Research Computing, and Supercomputing conferences. Science results were published and delivered at the American Association for the Advancement of Science, American Meteorological Society, American Geophysical Union, Systems Engineering for Wind Energy Workshop, the World Economic Forum, and other scientific meetings. Participation in National Science Foundation, Department of Energy, and MITRE and other industry conferences further expanded Aristotle?s reach.

The project also had an impact on education and workforce development. Aristotle hosted 19 National Science Foundation Research Experiences for Undergraduates (REU) students, several of whom went on to achieve PhDs. Graduate and PhD students were heavily engaged in the project which afforded them the opportunity to learn many highly sought workplace skills, including cloud computing, machine learning (ML), data analysis, and data visualization. In addition, Aristotle team expertise in using, maintaining, and scaling campus clouds for academic use led to collaborations that automated and scaled a Math and Statistics Calculus curriculum, Computer Science courses in cloud computing, edge computing, and IoT, and Engineering and Applied Science courses in Programming and Data Science. Aristotle was cost-effective because instructors chose instance types based on class size, and after the semester was over, deleted the instance. Aristotle how-to guides and training videos are publicly available on the Aristotle portal.

Aristotle technologies and cloud computing resources can provide additional value to the CI and research community by supporting new science use cases such as gathering and analyzing remote data from the seabed and atmosphere to study kelp forest dynamics, and analyzing data from ground-based observation networks to study atmospheric cloud formation. The Aristotle team also has the skills and experience to implement emerging technologies such as end-to-end systems for practical and accessible IoT, and federated software development environments for ML and AI. In addition, plans are underway to integrate a regional Jetstream2 cloud with Red Cloud at Cornell to further explore federated cloud computing and make OpenStack enhancements that will benefit the wider community.

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