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CLOUD-BASED TECHNOLOGY SOLUTION FOR REMOTE WORK AND LEARNING

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1. Abstract

The hydrographic industry is undergoing radical changes in mission and technology to bring rise to a new global hydrospatial movement supporting the blue economy. Teledyne CARIS and Ocean Floor Geophysics, with academic and research partners, are joining forces to develop new solutions for remote survey operations, processing, and mapping with the strategic hydrospatial contribution of H2i. As part of this collaboration, CARIS desktop applications are being integrated into CARIS Cloud Technology to support access to software through web services allowing companies to transition processing personnel out of field situations as well as for improving opportunities for remote learning. This redistribution of personnel will provide efficiencies, cost savings, and reduce the human risk in such work, while increasing operational capacity.

2. Introduction

In recent years, and increasingly with the ongoing global pandemic, many Hydrographic Offices (HOs), academic institutions, and private industry have been demanding an accelerated solution for remote production and training. Migration to a remote work scenario is challenging with new security concerns, evolving technology needs and changing workflows. Desktop software does not lend itself well to working remotely, so with this trend of data moving to cloud environments, software must adapt in this dynamic environment with organizational priorities.

Widespread quality internet onshore, the advent of maritime broadband radio, as well as improvements in satellite-based Internet have made it possible for users to have better and more reliable connectivity. The offshore survey industry has begun embracing this new level of connectivity and worked to fully automate onboard processing by removing people from the vessel and supplementing support through

Remote Operations Centers(ROCs) (Fugro, 2021).

Through funding provided by Canada's Ocean Supercluster (OSC) (Canada's Ocean Super Cluster, 2020), Teledyne CARIS, Ocean Floor Geophysics (OFG), the Marine Institute of Memorial University of Newfoundland (MI-MUN), University of New Brunswick (UNB) Ocean Mapping Group (OMG), the "*Centre interdisciplinaire de développement en cartographie des océans"* (CIDCO), and H2i have formed a collaborative partnership to advance availability and adoption of cloud-based software to support this transition to remote work and operations for the mapping sector. MI-MUN, UNB-OMG and CIDCO are three of the eight members of the Canadian Ocean Mapping Research & Education Network (COMREN) (Church, et al., 2020).

***Figure 1**: Project partner logos*

This project will see CARIS migrating its hydrographic processing and production software to the cloud in support of these changing operations. This new cloud-based platform, CARIS Cloud Technologies (CCT), will make advanced computing capabilities accessible to users with the hardware of a typical home computer. OFG shares their experiences through use cases in the following sections demonstrating how remote cloud-based processing has already supplied efficiencies, cost savings, and reduced human risk. A final scenario illustrates how students and professionals can enhance their skills and knowledge with remote virtual training enabled by the CCT platform.

3. Technology Overview

This project focuses on a pivot of CARIS software to the cloud environment, this development will involve two primary facets: the modification of current desktop software to operate within a cloud environment and developing the framework for future technologies leveraging native cloud infrastructure. The existing line of desktop software products are being adapted to work seamlessly in a virtual desktop environment delivered via Software-as-a-Service (SaaS). The second facet will develop new cloud services to underpin the production processes with optimized scalability, capacity, and security for the entire ping to chart workflow. The goal of CCT is to provide users with professional grade tools in an end-to-end cloud workflow requiring only a basic workstation, stable Internet connection, and modern web-browser to use these tools.

Security is a paramount consideration for CCT, and all system and data access will be tightly controlled using the latest cloud service security standards and protocols. User access controls will be intuitive and simple to minimize the chance for operator error. Using the latest encryption and data validation tools, CARIS will provide a simple yet secure way to transmit and manage the data assets such as processed point clouds, Digital Terrain Models (DTMs), and vector features

that are critical to the marine industry. Given the size of the datasets, data transfer protocols are essential to provide efficient and fault-tolerant uploads, while also accounting for lower/ intermittent internet bandwidth scenarios.

Use of remote technologies in production demands high availability of services and related infrastructure to support 24/7 cloud operations. The increased demand for support will also be met with advancements in automated monitoring, problem detection, and agile diagnosis without user input. These automations will be key to a successful user experience, but also require updates to customer support practices and operating hours.

For these solutions to be practical in a remote learning context, a well-developed digital classroom blueprint will also be necessary. By leveraging the expertise of our academic partners, we will develop a robust digital classroom blueprint to ensure the success of users in a variety of learning environments.

Another ongoing initiative that provides a glimpse of what can be achieved using CCT to fluidify traditional workflows is the S-100 Service the Canadian Hydrographic Service (CHS), PRIMAR, Teledyne CARIS and other operational collaborators and users which aims to shorten the turnaround time from survey to bridge (Lauritzen, Cove, & Maltais, 2020).

4. Use Cases

The following use cases highlight hands-on applications of CARIS Cloud Technologies for Ocean Supercluster project partners and the global hydrospatial infrastructure (Hains, 2020; Pang & Oei, 2020; Ponce, 2020; Jonas, 2021).

4.1 Use Case #1 – Remote Offshore Processing

Clients are looking to capitalize on the advances in global communication technology, enabling participation of skilled survey personnel from anywhere on the globe. Cloud-based CARIS software will provide OFG flexibility to scale the team as needed and equip them with near real time data access and the right tools to carry out their tasks.

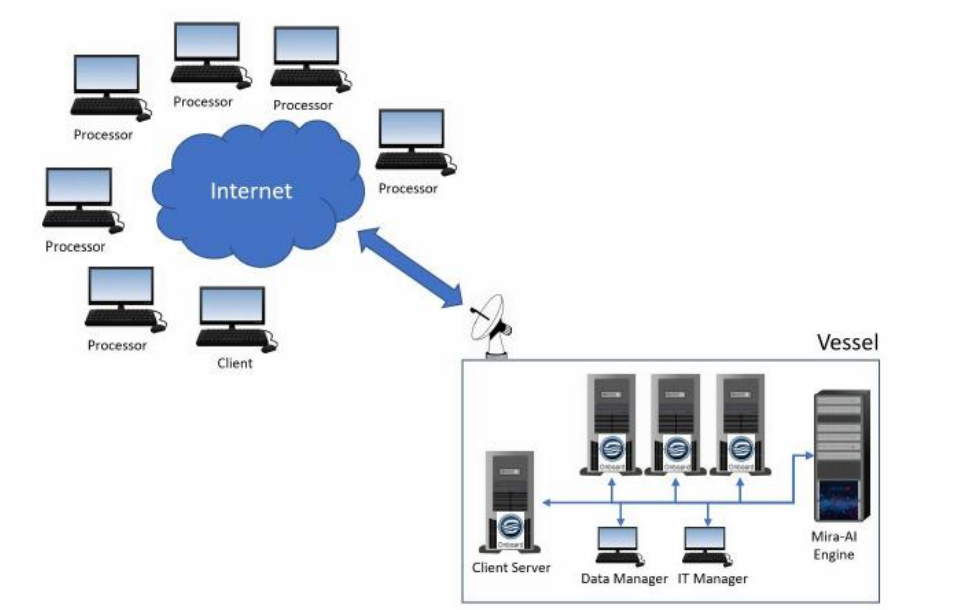

***Figure 2**: System diagram of a remote offshore processing team.*

Moving the processing team from the vessel to shore offers significant advantages for OFG offshore surveys:

- *Lowers Health, Safety & Environment (HSE) risk offshore* – This can be a key metric for large companies when awarding offshore survey contracts.
- *Processing team not constrained by crew changes or visa restrictions* – The make-up of the processing team can change at any time without consideration for work visas or travel time, making it easier to accommodate specialized tasks and unexpected challenges.
- *Smaller offshore crew eases constraints on vessel size* – Vessel selection can often be driven by cabin spaces; reducing the requirements for bunk spaces enables more flexibility with vessel selection. The ability to survey with smaller vessels has several interesting advantages; they can be more environmentally friendly, are typically cheaper to operate, and can access more areas due to decreased draft and increased maneuverability.
- *Risk mitigation due to changing conditions during the pandemic* – Having processors work from home eliminates the need for quarantine and international travel. Rapidly changing travel restrictions currently represents a huge risk to offshore survey projects which need to be planned well in advance of the survey date.
- *Risk mitigation due to more relaxed hardware constraints* – The access to powerful workstations being limited on vessels, moving processing operations to shore increases the reliability of the process and mitigates risks associated with hardware or infrastructure failure. Furthermore, this enables teams to have access to bigger processing resources by several orders of magnitude more than what could efficiently be made available on most hydrographic ships.

The benefits of being able to process offshore survey data using an onshore processing team are easy to imagine but so are the challenges - processing data with an onshore team requires a fast and stable network connection to the vessel, and offshore Internet is notorious for being neither fast nor stable.

Increasing the level of autonomy in the processing workflows is one way of managing the challenges presented by the limitations of offshore satellite Internet. CARIS Onboard, CARIS Mira AI, and CARIS Process Designer allow automated execution of processing workflows and give remote onshore processing teams the ability to monitor the automated processes using the built in CARIS Onboard web-interface. There are two main advantages to this configuration: the data stays on the vessel and does not need to be transmitted back to shore over the slow data link and the automated onboard processes can continue working even during network outages.

This approach has some challenges to ensure that the automated processes stay running and produce a data product with sufficient level of quality and may require a shift in the skillset of the project team onboard the vessel. To ensure a high level of data quality, there should be a senior data manager onboard who can dig deep into data in real-time for troubleshooting and an IT manager to keep all the systems and communication up and running. Complex autonomy will typically be required to manage large data sets with many nested real-time deliverables and time must be allocated to develop and rigorously test the process models prior to the start of any offshore project.

In this new regime of connectedness, data security needs to be considered. Allowing data processors to access the data from shore also makes it vulnerable to hackers and malicious code. Having properly designed IT infrastructure with encryption, firewalls and access restrictions is imperative to keeping the data products safe.

There are often millions of dollars at stake in offshore surveys. High quality tools that are built for purpose are key in the success for offshore operations and remote processing is no exception.

Processing tools that are fit for purpose and have been designed for operation over the Internet lend themselves to secure and robust remote processing systems.

4.2 Use Case #2 – Global Onshore Processing Teams

Video conferencing, working from home, and online collaboration tools are standard in today's workplace. Decentralized data processing teams are a natural extension of modern working practices. In fact, people have been forced into the mode of operation due to the pandemic. For the most part, hastily constructed infrastructure has allowed people to work from home, but it is not optimized. In some cases, it may have even opened projects to vulnerabilities from the Internet.

When given enough time to properly design infrastructure to support a global processing team, the first question is how to share the giant data sets between personnel in the work group. The days of shipping hard drives of data around the world using FedEx are over. Cloud-based data storage and virtual processing desktops are one way to implement the infrastructure needed to support a globally distributed data processing team. This can be a very attractive choice to small companies as it avoids investment in easily outdated high-end hardware and is rapidly scalable to suit a fluctuating workload.

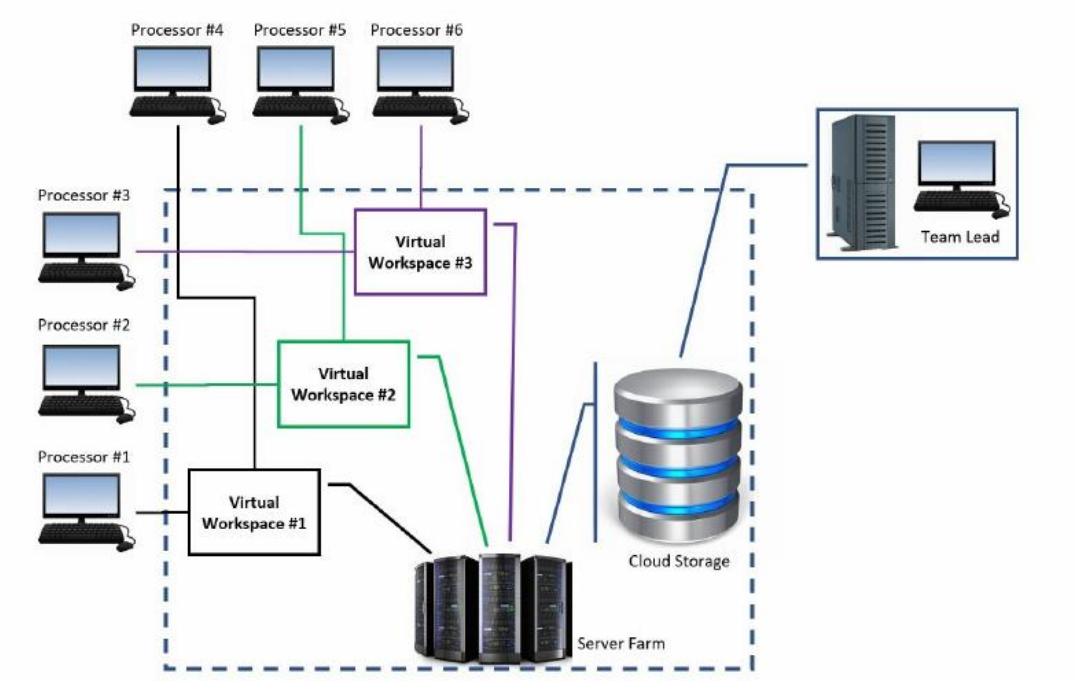

***Figure 3**: System diagram of a global onshore processing team.*

In addition to scalability, this type of infrastructure naturally lends itself to enabling a globally distributed workforce and shared workspaces. One interesting advantage to a well-organized global workforce is enabling the use of software resources 24 hours a day by people in distant time zones crewing opposite shifts in their natural working hours. It also provides additional tools to let a company choose the best team for a job, not just the team that is closest.

Working with widely distributed teams requires diligent communication and project management but using well designed cloud-based tools makes it much easier.

4.3 Use Case #3 – Remote Training

Traditional hands-on training courses can often be logistically challenging and difficult to organize. Typically for a hands-on training course, an organization needs to identify an open week in scheduling with low competing work obligations, and no holiday leave plans. An organization may even need to fly in team members from various locations. Add to the difficulty, the need to identify a suitable training space large enough for all students, computer equipment, a trainer, and projector setup to work comfortably. This setup can significantly increase training costs if rental space is needed and has added challenges in the current pandemic where grouping everyone together can prove impossible.

Remote training reduces some of these requirements but adds their own complexities. Each user still requires a computer capable of running the software and instead of having the instructor provide and assist in installing the software and datasets, the user is required to prepare the computer for training themselves. Depending on the nature of the training taking place, this can be a time consuming and technically complicated task.

Using virtual workspaces, the same software and dataset can be easily deployed to all course participants. This setup eliminates the technology overhead associated with data transfer, software installation, license activation, and hardware upgrades to ensure users are equipped for the training. Additionally, the ideal course trainer can be deployed from anywhere in the world without needing to consider travel time or expense to arrive at the course location.

5. Remote Learning

The Ocean Mapping Group at UNB has provided world-class undergraduate and graduate training and innovative research and development within the Department of Geodesy and Geomatics Engineering since 1991. Over the past 30 years, the training environment has evolved along with the theory and technology, but a substantial shift is currently underway in programmatic and pedagogical views of hydrospatial education. The move to autonomous survey methods and the acceleration and proliferation of cloud infrastructure means that with the right tools, a traditionally heavily hands-on training discipline can now look to broaden its reach with blended and remote instruction. The OSC project and resulting CCT platform will advance meaningful, remote, synchronous, and asynchronous educational programs to accelerate workforce development with state-of-the-art engineering education. Through this OSC project, the Ocean Mapping Group will examine optimizing online training course development using the CCT platform and, partnering with the UNB Canadian Institute for Cybersecurity, look to overcome some of the data handling challenges.

MI-MUN will allow its ocean mapping students, both undergraduate and postgraduate, to experiment with cloud-based software created by Teledyne CARIS. Software integration into both course labs and student-led projects will provide developers with useful feedback to enable iterative product improvement. The practical experiences of students and faculty at MI-MUN will also inform the design of an engaging online education portal by Teledyne CARIS. This e-learning environment should be accommodating of both individuals and organizations in terms of course selection and pricing. It must also offer modular micro-certifications to individual students, allowing them to make progress in several distinct career-building skill paths. Curriculum development will consider the recognized professional skills defined by the International Board on Standards of Competence for Hydrographic Surveyors and Nautical Cartographers (IBSC).

In line with CIDCO's e-learning platform experience, the availability of cloud-based hydrographic data processing technologies enables new ways to support the delivery of education services. As an IHO-certified training center, one of CIDCO's primary use-case is delivering training to multiple locations across the globe in a single cohort, including several developing countries. This poses

several challenges in terms of software licensing, access to hardware and data transfers. These constraints are alleviated by centralized license-management features, access to identical shared hardware backends, and centralized data hosting. Since these features are inherent to modern cloud architectures, cloud service delivery can become a significant driving force in enabling modern capacity-building techniques in the developing world.

6. Conclusion

During the dawn of the United Nations Decade of Oceans Science for Sustainable Development (2021-2030) building on The Nippon Foundation-GEBCO, Seabed 2030 project (Mayer, et al., 2018), ocean mapping and hydrography are in revolution. CARIS Cloud Technology is an example of the innovative tools hydrographic offices, academic institutions and private industry need to meet the challenges of a dynamic and ambitious global blue economy. Support of Canada's Ocean Supercluster slingshots Canadian companies like Teledyne CARIS and Ocean Floor Geophysics ahead as global leaders in this hydrospatial operational race.

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