OCEAN NETWORKS CANADA'S OCEANS 2.0 DIGITAL INFRASTRUCTURE

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Ocean Networks Canada (ONC) is a world-leading organization supporting ocean discovery and technological innovation. ONC is a not-for-profit society that operates and manages innovative cabled observatories on behalf of the University of Victoria, in British Columbia. These observatories supply continuous power and Internet connectivity to various scientific instruments located in coastal, deep-ocean, and Arctic environments. ONC's arrays host hundreds of sensors distributed in, on and above the seabed along with mobile and land-based assets strategically located. The instruments address key scientific and policy issues (subsea earthquakes and tsunamis, ocean acidification, marine biodiversity, etc.) within a wide range of environments. (See Fig. 1).

Fig. 1: Ocean Networks Canada ocean and coastal observing facilities include the VENUS and NEPTUNE systems off British Columbia (see inset), together with a number of community observatories across Canada (including in the Arctic). With over 400 instruments reporting real-time data from the deep ocean to the coast, ONC's Oceans 2.0 data management system makes big data and products available to scientists, governments, municipalities and first nations.

ONC has built Oceans 2.0, the digital infrastructure that manages vast amounts of complex data streams. Oceans 2.0 is unique in that it supports the continuously increasing volume (currently at 500 terabytes), the variety of data types (dozens of instrument types and over 5000 individual sensors), the data structures that enable rapid access and delivery of analytically-derived alerts, the consistency of data through an instrument management system with robust and rich metadata, as well as automatic and manual QA/QC.

Ocean Networks Canada's Oceans 2.0 sensor network data management can also host and distribute data for 3rd parties, and has features for attribution and access restrictions. Some of its unique data access features include a distributed, live video annotation (SeaScribe) and a video search capability (SeaTube); tools for viewing and searching a hydrophone data archive; tools for the continuous browsing of complex time series data, etc. It also includes an integrated suite of observatory management tools to monitoring and control the infrastructure (electrical, communication and data flow control — see Fig. 2).

Fig. 2: ONC's Oceans 2.0 system offers integrated monitoring and control tools for managing power, data flow and communication with the "Device Console" tool. The navigation follows the tree structure of the network topology. The same interface allows operators control over any part of the infrastructure regardless of where it is located.

Oceans 2.0 is solidly founded on a Service Oriented Architecture based on a core Enterprise

Service Bus. This provides a high performance platform based on a modular, loosely-coupled component architecture, and allows for the simplified addition of the constituent modules on an as needed basis.

With this architectural foundation, Oceans 2.0 provides a simplified, well-defined, event-driven and "pluggable" system which can be scaled as the organization's requirements change. (See Fig. 3). The Oceans 2.0 components include: The *Enterprise Service Bus,* which is the message passing system that allows all parts of Oceans 2.0 to interact and pass information and data. All functional components of Oceans 2.0 use it to asynchronously intercommunicate.

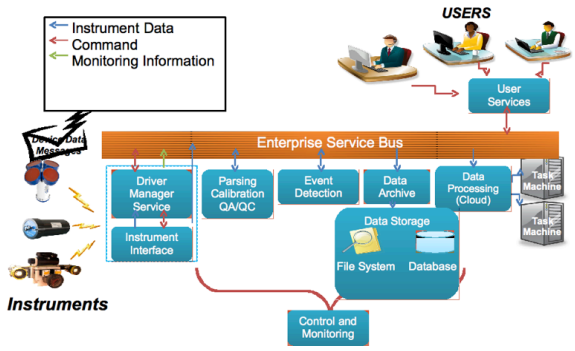

Figure 3. Elements of Oceans 2.0 and their relationship from sensor data generation to the archive and users.

The *Driver Manager Service and Instrument Interface* represent the part of the software that interacts with instruments and their integrated sensors. The software standardizes access to instruments and generalizes their data structures so that they can be used downstream by other software components. Another critically important role of the drivers is their time stamping function that guarantees the same time reference across all the instruments connected to all of the supported networks. Once a raw data record is obtained from an instrument, the driver publishes it to the service bus that subsequently makes it available for other software elements in the system. Oceans 2.0 has drivers for more than 100 different types of instruments from a variety of manufacturers.

Parsing & Calibration, QA/QC is the software module that takes the raw readings from instruments and turns them into meaningful, corrected values, possibly after an optional calibration stage. Moreover, a level 0 automated calibration can be configured to flag sensor values that are out of range.

Event Detection is used to create custom reactions for real-time events. Users can create event definitions using algebraic formulas or other triggers, and associate appropriate reactions if the event occurs. Event Detection currently has several use cases within Oceans 2.0: it is used to perform Quality Assurance and Quality Control (QA/QC) evaluations, and to synchronize acoustic device sampling so as to prevent interference. Another, significantly more advanced event detection system is the ability to detect P-wave from accelerometers, helping with the detection and characterization of earthquakes.

Data Archive takes all data traffic between the instruments and the "surface" side and archives them.

Data Processing indicates the part of the system where data products are generated from the raw data. These include data format conversion, plots and images, etc.

User Services includes a combination of data access and visualization tools, using either a web interactive interface, an application programming interface consisting of standard-abiding web services and a "sandbox" where users upload data processing codes and run them.

Security and resilience. The security of the system against malevolent or accidental access by unexpected parties is provided by isolation of all the key component in secure, private and non-routable networks. The Oceans 2.0 architecture has also been designed around resilience, in particular for the data acquisition component including: fault tolerance in case of network path breakdown, multiple safeguards to minimize data loss in case of unexpected anomalies; and, support of multiple archive centres containing integral data copies.