A WEB-BASED INTEROPERABILITY PLATFORM FOR DETECTION AND TRACKING OF RADIANCE IMAGE STRUCTURES ASSOCIATED WITH BAD WEATHER MONITORING

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Commission VI, WG IV/5

KEY WORDS: Meteorology; Satellites Sensor; Platforms; Web based Standards; Interoperability

ABSTRACT:

This paper designed and implemented a web-based interoperation architecture for integrating diverse sensor data source for weather application using a service-oriented architecture (SOA). In this architecture, the OGC Data Interoperability Technology and Protocols are applied to provide uniform standard access interfaces. Sensor data will be served through standard OGC WCS (Web Coverage Services), satellite-derived winds, model data and in-situ storm reports will be served by Standard WFS (Web Feature Service). The prototype detection and tracing application are decomposed as several independent logical units (Services) and are published as standard WPS (Web Processing Service). By defining WDSL description for these WPS, they can be easily chained and executed through available BEPL Engines. A unified OGC-Compliant Data Access Component is developed to provide standard access to various sources. This paper presents a promising architecture for web based interoperation system.

1. INTRODUCTION

Sensor observation and modelling are increasingly becoming a key element for effective extreme physical events monitoring in a variety of earth science domain. This has generated the extensive need of sharing the sensor data, observations, models, and analysis tools. Sensor webs are distributed, organized systems of sensor, computing and storage nodes, interconnected by a communications fabric that behaves as a single, coherent system. NASA envisions a sensor web as an intelligent and integrated observation network comprised of sensors deployed to vantage points from the Earth subsurface to deep space that provides timely, on-demand data and analysis to users. The observations from sensor webs are used in supporting a variety of decision making contexts.

An important component of sensor web "targeting observing" is the detection of extreme physical events and conditions. In this research, a web-based interoperation architecture of targeting observing for bad weather monitoring was designed and implemented, which enable the acquiring and presentation of satellite and in-situ case study data in a unified way, to run the storms detection algorithms to populate the metadata in physical detection models and support discipline-specific analysis and storms ranking methods.

In detail, this paper designed and implemented the software component comprising the target observing platform for integrating diverse sensor data source for weather application using a service-oriented architecture (SOA). In this platform, the OGC Data Interoperability Technology and Protocols are applied to provide uniform standard access interfaces. Sensor data will be served through standard OGC WCS, satellite-derived winds, model data and in-situ storm reports will be served by Standard WFS. The prototype detection and tracing application are decomposed as several independent logical units (Services) and are published as standard WPS. By

defining WDSL description for these WPS, they can be easily chained and executed through available BEPL Engines. A unified OGC-Compliant Data Access Component is developed to provide standard access to various sources.

This paper will be organized as follows. Firstly an overview of the related works forming the technical base will be given. Basic SOA, OGC standards and their usability in VSW platform will be studied. Then the paper will detail the architecture of this target observing platform and explicate some key technologies of the implementation of the platform. Finally, a storm detection experiment based on this platform and its running results will be presented.

2. CURRENT INTEROPERABILITY TECHNOLOGY

2.1 Service Oriented Architecture

Currently, there are many individual standalone services available over the Internet. However, it is impossible for individual standalone services to meet all service requirements of many users. However, such information requests could be met by dynamically chaining multiple services provided by single and multiple service providers. The service-oriented architecture (SOA) recognizes this and tries to construct a distributed, dynamic, flexible, and re-configurable service system over Internet that can meet many different users' information requirements. It provides the basis for the integration of Web services. There are three key actors in SOA (Figure 1): requestor, provider and broker. The requestor is the user who requires the information services. The provider is the standards-based individual service. The broker is a meta-information repository (e.g., a registry, catalog or clearinghouse). The interactions among these actors involve the operations of publishing, finding and binding. Service composition introduces a new operation into SOA, chaining,

which combines services into a dependent series to accomplish a larger task. SOA is the basis for interoperability and automatic service composition, since services management functions such as registration, discovery, accessing, and execution are well positioned under this structure and these functions are the basic units in the whole automation process.
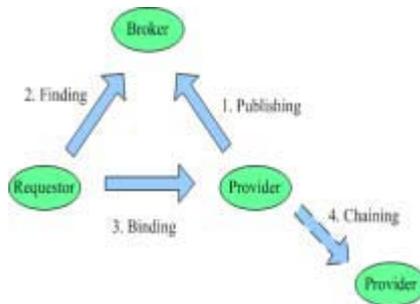

Figure 1 Service Oriented Architecture

2.2 The OGC Data Interoperability protocols

The Open Geospatial Consortium(OGC) has developed a set of web-based interoperability protocols for geo-spatial data access and services through an open, concensus-bases process. The protocols use "Web Service" type of interface, where client and server software interact using HTTP messages. The protocols support HTTP GET with Key-Value paris(KVP) encoding and HTTP POST with XML encoding.

OGC protocols are intended to be discipline-independent and content natural, except for assuming all data are related to a spatial coordinate reference system, including engineering or native data coordinate. Therefore, the protocols can be used for all geo-spatial data.

OGC protocols related to data access include Web Map Services(WMS), Web Feature Services(WFS), Web Coverage Services(WCS) and Catalogue Services for Web(CS/W). OGC protocols related to process access currently only include Web Processing Service (WPS) (Schut and Whiteside, 2005).

WMS,WFS, and WCS are designed for interoperable access to geo-spatial data in the form of map(e.g., JPEG picture), feature type(e.g., point, line, polygon), and grid type data(e.g., space- and airborne image, swath data, digital elevation model), respectively.

The WMS protocols is designed to enable clients to perform multidimensional subset, including spatial, temporal, and parameter dimensions, of gridded, or raster, geo-spatial data. The returned result is a image /map such as a JPEG image which can be directly displayed on a web browser or other commonly used image viewers without the need of using special software. The returned image map is primarily used for display or overlaid with other image/map layers. The protocol allow client to request one image at a time. Therefore, only 2-dimensional slice of data layer can be obtained per request if the original data has multiple layers, e.g., air temperature at a scientific pressure level or height.

The WFS protocol is used for clients to request feature, or vector, type data in which a feature is expressed with a set of data point values and associated spatial coordinate value pairs, sometimes with spatial topological relationship(Vretanos, 2004) for example, a road with certain grade.

The WCS protocols are similar to the WMS protocol in that clients can perform multidimensional (i.e., spatial, temporal, and parameter dimensions) subsetting (Evans,2003). WCS is more flexible that WMS in that it allows clients to retrieve more than one dimensions and slices of data. For example, if a data set in the server side has five dimensions, a client will be able to subset a hyperslab of the data with any number of dimensions. The biggest difference between WCS and WMS, however, is that WCS returns actual data to the client while WMS returns an image. Data returned from a WCS server is not being transformed except for spatial re-sampling/interpolation (clients can also specify no re-sampling and no interpolation if spatial resolution and coordinates are not changed). Therefore WCS is intended to be used by clients for further numerical analysis.

CS/W is designed to provide catalogue services, including both data and service catalogues, for publishing and discovery of data and services. These interoperable protocols are from private industry, academia, andgovernment, both US and international. OGC protocols have framework defining application profiles required to publish and access digital catalogues of metadata for geographic data, services, and related resource information (Nebert and Whiteside, 2004), Using this protocol, OGC clients can search and discover needed data and/or services from the catalogue servers.

According to the definition in (Schut,2005), the Web Processing Service (WPS) provides client access interfaces to pre-programmed calculations and/or computation models that operate on spatially referenced data. The calculation can be as simple as subtracting one
set of spatially referenced numbers from another, or as complicated as a global climate change model.

Most of weather monitoring Earth science data are from satellite remote sensing in the form of imagery or grid. The relevant OGC protocol are the WCS for data access and CSW for data discovery. Currently, significant amount of NASA EOS data can be accessed through the OGC protocols.

CSISS at GMU, as a member of OGC and a participant in those OGC interoperability initiatives, has implemented several OGC-specification compliant Web Services, such as Web Map Server (WMS), Web Coverage Server (WCS), and Catalogue Service - Web (CSW) and so on. We will use the CSISS frame to implement WCS,WFS and CSW services. All these form the technology base for us to implement the interoperability architecture.

3. SCIENCE ALGORITHM AND MODEL FOR BAD WEATHER MONITORING

The current system for detection and tracking of radiance image structure associated with bad weather monitoring is a standalone application. The major modules and workflow are shown in Figure 2. The system was developed in Java and configuration were used in setting the running environment. Core system consists of detection, tracing and ranking modules. Here's a brief description about the three core module's algorithms.

3.1 Detection Algorithm

An effective processing algorithm will be used to identify contours by brightness count intervals in radiometric image data, organize them into hierarchical object collection and rank them in order of their first appearance starting from each end of

dynamic range of the instrument. The current implementation is based on the JAVA language and some features object-oriented software architectures. The method produces linked-lists of contour starting with the maximums and moving through each level below the peak (top) value of the object or feature in the image. Each contour includes parameter such as brightness value, location, area, and linked-lists of minimum locations from line interval operations around the contour. A record is kept of other peaks when contours encircle more that one recording contour points alignment with and orthogonal to the environmental wind vectors at the object 's centres will enable studies of the value of wind as a discriminator for improving skill.

A basic set of parameter are derived for each image and recorded with observation time and other collection metadata. The process is repeated to find and record brightness minimums, the holes in the imagery.

3.2 Tracing Algorithm

Tracking objects involves two dimensional proximity searches between linked-lists locations in time series of brightness images. Software originates from early radar echo tracking concepts, including adjustments the effect size, splits and merges results.

Objects in previous and current images are matched and ranked in accordance with their size and proximity to each other to determine splits and merges. Proximity searches may be complex, irregularly shaped (e.g., elliptical) and aligned with ambient winds or other observations. The threshold search distances are adjusted in accordance with physical limitations of the sensor systems (e.g., resolution, scan frequency). Tracking algorithms disposition each of a list of objects, lost objects, splits and mergers.

The technique expands easily to create hierarchical levels of tracking data that can be used to summarize the dominate feature shapes and wind alignments.

3.3 Event data Assimilation Model and Ranking

The event model will be developed beginning with the object tracking results, and include physical models for object shape events. Data from brightness peaks and valleys (holes) will be correlation to filter out new growth from convection, and identify warm cold couplets. Physical models will include a cloud growth model, an Enhanced-V model, and a cyclonic storm tracking model.
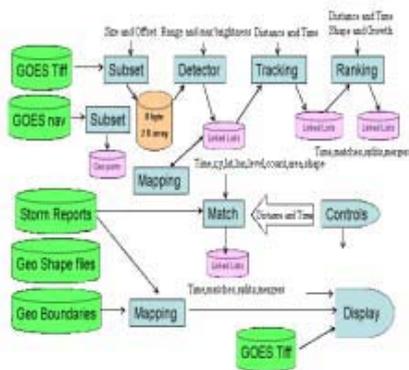

Figure 2. The Modulity Structure of Standalone System

In order to achieve the above goal, an open interoperability architecture are designed as Figure 3 using a service-oriented architecture (SOA). In this platform, the OGC Data Interoperability Technology and Protocols are applied to provide uniform standard access interfaces. Sensor data will be served through standard OGC WCS, satellite-derived winds, model data and insitu storm reports will be served by Standard WFS. The prototype detection and tracing application are decomposed as several independent logical units (Services) and are published as standard WPS. By defining WDSL description for these WPS, they can be easily chained and executed through available BEPL Engines. A unified OGC-Compliant Data Access Component is developed to provide standard access to various sources. Some function and model such as Enhanced Severe Physical Event Tracing application, result visualization can be implemented on the OGC compliant data access component.
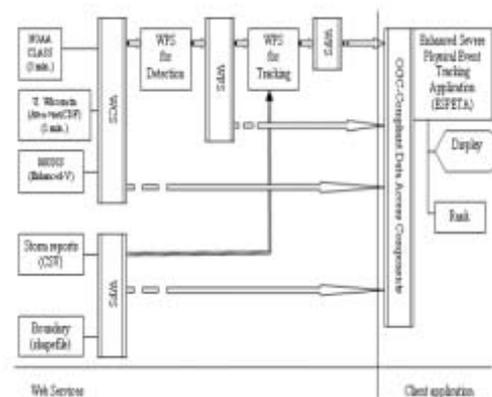

Figure 3. The architecture of Interoperability System

5. THE IMPLEMENTATION OF ARCHITECTURE FOR THE WEB PLATFORM OF BAD WEATHER MONITORING AND EXPERIMENT

The core objectivity of this project is to build an open interoperability sensor platform. In order to achieve this objective, the following technical approaches and implementation strategies are adopted, and the relevant experiments are conducted.

This project is carried out in three phases:
(1) The first phase aims at serving the required GOES data through WCS. Finished tasks includes:
(a) WCS server to serve GOES data, from both NOVA CLASS(5 minute) and University of Wisconsin(1 minute), and MODIS data .
(b) Code modification to LAITS' current WCS to support netCDF swath with GOES projections.
(c) Writing a WCS Access Component, attached to the current severe physical event tracking application.

(2) The Phase II leads to further decomposition of the prototype systems into components and publish these components as standard WPS. These service are chained together through standard interfaces. Tasks for phase II includes:
(a) Refining WCS sever to serve GOES data;
(b) Further decomposition of the severe physical event tracking application into two data module, e.g. detection data module and tracking data module, publishing these components as WPS.
(c) Use WFS-Transaction to serve storm reports and political

boundaries (in shapefile).
(d)Chaining the services using BPELPower to conduct a complex analysis and modeling proceses
(e) Generate and enhance the clients3

(3) The Phases III focus on system debugging and service refinements, experiments with case studies data. This phase the system needs to be adapted after the installation of the servers in place. Debugging and service refinements will be continued. The planned case studies include:
(a) Selected GOES IR rapid scan for detecting the onset of convection.
(b) Selected MODIS rapid scan for detecting the onset of convection.

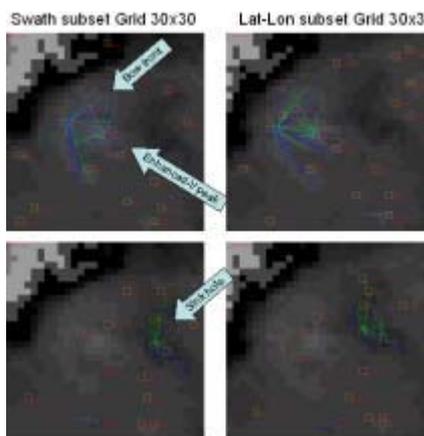Figure 4 shows the MODIS Prototype Contour Detection Results.

Figure 4 MODIS Prototype Contour Detection Results

6. CONCLUSIONS

Because of the limited time, some case experiment such as Enhanced-V detection tests has not finished. However, from the completed experiment, by Comparing the standalone prototype detection and tracing system, it's not hard to find that this web based platform have achieved better properties:

(1) Sharing and Interoperability: researchers can develop and share detection and tracking functions at different location worldwide.
(2) Real-time and Near Real Time data input: to support the live feeding of geospatial image and data.
(3)Uniform access interface: to acquire and present satellite, in-situ case study data and services in a unified way that follow OGC standards and protocols..
(4)Scalable architecture: flexible and easy to add in new sensor image data and process functions.

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ACKNOWLEDGEMENTS