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Open Geospatial Consortium, Inc.
Date: 2008-07-22
Reference number of this document: OGC 08-073r2
Version: 0.9.0
Category: Engineering ReportEngineering Report
Editor(s): Jessica Cook, Raj Singh

Summary of the

OGC Web Services, Phase 5 (OWS-5)

Interoperability Testbed

22 July 2008

OGC Document **08-073r2**

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Preface

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For more information, contact or George Percivall (percivall@opengeospatial.org) or Raj Singh (rsingh@opengeospatial.org) of the OGC Interoperability Program

Summary of OGC Web Services - 5 (OWS-5)

The Open Geospatial Consortium (OGC) conducts an Interoperability Program (IP) as a global, hands-on and collaborative prototyping program for rapid development of proven candidate specifications for consideration for consensus adoption and public release by the OGC Specification Program. In OGC's interoperability initiatives, international technology developers and providers team together to solve specific geo-processing interoperability problems posed by the initiative's sponsoring organizations. OGC IP initiatives include test beds, pilot projects, interoperability experiments, and interoperability support services – all designed to encourage rapid development, testing, validation and adoption of open, consensus-based standards. The document summarizes the work completed in the OGC Web Services 5.0 initiative.

1 Overview

The OGC Web Services, Phase 5 (OWS-5) Testbed was an initiative of the OGC Interoperability Program (IP). The primary focus of an IP activity is to collaboratively extend and demonstrate OGC's baseline for geospatial interoperability. The execution period forOWS-5 was from July 2007 to April 2008. OWS-5 has the following outcomes:

- **52** Components[1] were implemented and participated in interoperability testing. Components were developed in 4 threads (described in Section 4 below) each extending or refining a portion of the OGC Standards Baseline.

- **20** Engineering Reports (ERs) were written. The OWS-5 ERs were either technical specifications or reports regarding testing and analysis. The OWS-5 ERs have been posted to the OGC Specification Program Pending Documents list for consideration in the consensus process.

- A major demonstration comprised of **13** scenarios that demonstrated use of OWS-5 components. The demonstration was help in conjunction with the OGC Technical Committee meetings during the OGC Interoperability Day in St Louis on March 28, 2008. The demonstrations with a voice-over explaining the content will be released as multi-media products on DVD media and via the web
  - On-line OWS-5 demonstration: http://www.opengeospatial.org/pub/www/ows5/demo.html

- **7** sponsoring organizations defined interoperability requirements for the interoperability threads in OWS-5. The sponsors' requirements were documented in the two Calls for Participation (CFP)documents that were released by the OGC. The CFP is the call for organizations that wished to participate in OWS-5.

- **35** organizations participated in some aspect of OWS-5. Roles for organizations in OWS-5 include sponsors, participants and architects. Additionally, many organizations were observers of OWS-5.

- Major technical achievements of OWS-5 include the following
  - Developed SOAP and WSDL interfaces for four foundation OGC interface standards: WMS, WFS-T, WCS-T, and WPS. This work allowed these services to be integrated into industry standard service chaining tools.

[1] Components are prototype software implementations of one or more OGC or other IT standards required to solve an given interoperability issue as defined by the sponsors of an initiative.

- Demonstrated implementation and integration of IEEE-1451 TIM (Transducer Interface Module), NCAP (Network Capable Application Processor) and STWS (Smart Transducer Web Service) components and refined the integration of IEEE-1451 sensors into SOS framework.
- Developed a BPEL[2] script for a Sensor Web Enablement (SWE) GeoReferencing workflow. This workflow establishes a standardized means to allow the user to interactively access a subset pixels from a coverage service stored in the compressed JPEG2000 and preserve the image relationship with the associated 'sensor' model parameters such that precise geopositioning capabilities can be realized in a dynamic, interactive and networked environment. The OGC specifications used in this scenario include: JPIP enabled WCS-T 1.1, CS/W, WPS, SPS, SAS, and SOS[3].
- Demonstrated workflow supporting EO Wildfire scenario within a SWE framework of a SPS, SOS, WFS, OPS-B (OGC Publish Subscribe-Basic), WPS, and CS/W.
- Demonstrated feasibility of the Web Coverage Processing Service (WCPS) candidate specification by implementing uses cases (sensor time-series, oceanography, remote sensing imagery.
- Service Implementations for WFS-T, WCS-T, WMS and WPS were deployed to demonstrate SOAP and WSDL binding patterns.
- A Conflation workflow process and BPEL script was designed and implemented to demonstrate service chaining and workflow, web processing services, and service interoperability using a variety of OGC service standards.
- Successful design, implementation and testing of data view models to be harvested in a catalog.
- The UML-GML Application Schema (UGAS) tool was enhanced to include: 1) Utilize OCL constraints; 2) Generate schemas based on ISO/TS 19139 encoding rules; and 3) capability to integrate existing XML grammars based on XML attributes.
- Specified how KML could be output from a geospatial database using three existing standards: WMS for the overall information request, WFS Filter for the query, and SLD for styling rules.
- Completed proposal for a new OGC standard for Federated Geo-synchronization that covers necessary functionality.
- Developed an abstract core WFS module and a series of other modules that instantiate web-based data provisioning.
- The Compliance and Interoperability Test and Evaluation (CITE) thread resulted 6 compliance test suites (WCS 1.0 for the TEAM engine, WCS 1.1, WFS 1.1 XLink, CSW 2.0.2 ebRIM/19115 profile, SOS 1.0, and SPS 1.0) and 5 Reference Implementations (WCS 1.1, WFS 1.1 XLink, CSW 2.0.2 ebRIM/19115 profile, SOS 1.0, and SPS 1.0).

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[2] BPEL: Business Process Execution Language – an OASIS standard

[3] WCS-T: Web Coverage Service – Transaction, CS/W: Catalogue Service/Web, WPS: Web Processing Service, SPS: Sensor Planning Service, SAS: Sensor Alert Service, SOS: Sensor Observation Service.

Organizations in OWS-5

1.1 Sponsoring Organizations

OWS-5 was sponsored by the following organizations:

- US National Geospatial-Intelligence Agency (NGA)
- US National Aeronautic and Space Administration (NASA)
- US Geological Survey (USGS)
- Google
- Lockheed Martin – Information Systems and Global Services
- BAE Systems – Network Systems
- Northrop Grumman

1.2 OWS-5 IP Team

The IP Team is an engineering and management team to oversee and coordinate an OGC Interoperability Initiatives. The IP Team facilitates architectural discussions, synopsizes technology threads, and supports the specification editorial process. The IP Team is comprised of OGC staff and representatives from member organizations. The OWS-5 IP Team was as follows:

- Interoperability Program Executive Director: George Percivall, OGC
- Initiative Director: Raj Singh, OGC
- Initiative Manager: Jessica Cook, Lockheed Martin Corporation
- Thread Architects
  - Sensor Web Enablement: Shayne Urbanowski, Lockheed Martin
  - GeoProcessing Workflow: Lew Leinenweber, BAE Systems
  - Agile Geography: Raj Singh, OGC
  - CITE: Jen Marcus, NG-TASC
- Demo Capture: Greg Buehler, OGC; Mark Buehler, OGC

1.3 Complete List of Organizations

The following organizations played one or more roles in OWS-5 as sponsors, participants and/or architects. Additionally there were many organizations that were observers of OWS-5.

1Spatial

Argon

BAE Systems

Compusult

Con Terra

Cubewerx

Ecosystems Associates

ERDAS (Ionic, Leica Geosystems)

FAO

Galdos

GMU

Google

IfGI, GSR

IfGI, Muenster

Interactive Instruments

Intergraph

ITT

Jacobs U Bremen

Lisasoft

Lockheed Martin

Mapufacture

NASA

NGA

NG-TASC

NIST Team 1451

Northrop Grumman

Oracle

PCI Geomatics

Snowflake

Spot Image/ ESA/Spacebel

TOPP

Univ Alabama Huntsville

USGS

Vightel

Wheregroup

2 Schedule

The OWS-5 Testbed Execution Phase was preceded by a Concept Development Phase.

OWS-5 Concept Development Phase:

- Sponsor Meetings February - March 2007
- RFQ development February – May 2007
- Bidders Conference 22 May 2007
- RFQ response period May 2007 – June 2007
- Participant Selection – Phase 1 June 2007
- RFQ Addendum* development September 2007
- RFQ Addendum* response period September 2007
- Participant Selection Phase 2 October 2007

OWS-5 Execution Phase:

- Kickoff Meeting 30 July – 1 August 2007, Oracle, Reston, VA.
- Kickoff Meeting for Addendum Reqts* 13 November 2007, Virtual
- Interim Milestone 16 September 2007
- Interim Delivery 10-14 December 2007
- Final Delivery 18-22 February 2008
- OWS-5 Demonstration 28 March 2008, OGC Interoperability Day, St Louis, MO
- OWS-5 Demo web release 30 April 2008
- Specification Program review of ERs June 2008, TC Meeting, Potsdam

*The RFQ Addendum included the requirements for Federated Geo-synchronization and WFS Core+ Extensions as part of the Agile Geography thread.

After the Kickoff Meeting, design, development and testing of OWS-5 technology components were conducted in a distributed fashion supported by the collaborative development resources of telecoms, a web portal, twiki, web collaboration tools, and e-mail.

Each participant had an agreed to Statement Of Work milestones and deliverables. A limited number of ERs delivery dates were extended as the inputs needed to complete some work items were not available in a timely manner. See the ER table for more information.

3 Development Threads

The development of the OWS-5 initiative was organized around the following 4 threads:

1) Sensor Web Enablement (SWE)
2) Geo Processing Workflow (GPW)
3) Agile Geography
4) Compliance Testing (CITE)

An introduction to these 4 threads is described below, followed by a listing of the components and ERs developed in the thread.

3.1 Sensor Web Enablement (SWE)

The Sensor Web Enablement (SWE) architecture is designed to enable the creation of web-accessible sensor assets through common interfaces and encodings. Sensor assets may include the sensors themselves, observation archives, simulations, and observation processing algorithms. The purpose of the

OGC Sensor Web Enablement framework is to provide interoperability among disparate sensors and models, as well as to serve as an interoperable bridge between sensors, models and simulations, networks, and decision support tools.

SWE enables the creation of integrated sensor networks where all types of sensors, instruments, imaging devices and repositories of sensor data are discoverable, accessible and, where applicable, controllable via Web technologies and standards. In this vision, connections to sensors are layered with Internet and Web protocols and XML schemas are used to publish formal descriptions of the sensor's capabilities, location and interfaces. Web services for serving, brokering and consuming sensor data can then parse and evaluate sensor characteristics and observations based on their published descriptions. Information provided in XML about a sensor's control interface enables automated communication with the sensor system to determine, for example, its state and location, to issue controlling commands to the sensor platform, and to access its stored or real-time data.

OWS-5 focused on integrating the SWE interfaces and encodings into workflows to demonstrate the ability of SWE specifications to support operational needs.

Emphasis for SWE duringOWS-5 was on:

- **IEEE1451 Sensor Integration** - Leveraging results of OWS-4, an emphasis was placed on developing a Smart Transducer Web Services which is a concept associated with achieving interoperability by integrating IEEE1451/NCAP enabled sensors into a larger enterprise system using SOA and SWE.

- **Geo-Referenceable Workflow** - GeoReferenceable imagery is unprocessed imagery that has not been gridded or geolocated. The primary objective of this activity was to establish a standardized means to allow the user to interactively access a subset pixels from a coverage service stored in the compressed domain (JPEG2000) and preserve the image relationship with the associated 'sensor model' parameters such that precise geopositioning capabilities can be realized in a dynamic, interactive, networked environment.

  This effort utilized a JPIP enabled SOS that provides both SensorML and JPIP encoding streaming responses. A transactional WCS (WCS-T) provided an interface that supported the creation of coverages. The primary use case involved having a user request subsets of image data. The workflow then used the functional fit parameters in the metadata to georeference the image segment. The OWS services included in these workflows include: SOS, SPS, WCS-t, WPS, CS/W, SAS

- **NASA EO Wildfire Scenario** - In this scenario image data, provided via a SOS, was processed in a workflow and the result of this processing identified areas over which additional data collection was required. This collection was requested via SPS and the resulting data was accessed via SOS. This scenario addressed the need to make the SWE specifications suitable for consumption by the mass market. The scenario included alternative "push" notification technologies that support a generalized SWE publish/subscribe mechanism.

- **WCPS Scenario -** The goal of the WCPS subtask within the SWE part of OWS-5 was to demonstrate feasibility of the WCPS specification and gain best-practice experience through application to various use cases.

SWE Components	Participant(s)
IEEE-1451 Sensor Integration - SOS	NIST Team 1451
Workflow Scripts	GMU, Vightel
Workflow Engine	GMU, Vightel
SOS	UAH, Spacebel/Spot
SPS for airborne and spaceborne sensors	Vightel, Spacebel/Spot
WPS – EO Algorithm	NGIT
WPS – Coordinate Transformation Service	ERDAS
WCPS	Jacobs University Bremen
WCTS	Spacebel/Spot
WCS 1.1 supporting SOAP/WSDL	PCI Geomatics
WCS-T 1.1 server supporting JPIP	PCI Geomatics, Spacebel/Spot
Mass Market/EO SWE Implementations	Vightel, GMU
CS/W	Compsult,GMU
SAS Georeferenceable	IfGI GSR
Security	Con Terra
SWE Clients	IfGI GSR, Spot, Compusult, NGIT, GMU, ITT, Vightel, GMU

SWE Engineering Reports	Participant	OGC Doc #
Georeferencable Imagery ER (JPIP/SOS/WPS/WCS)	UAH	08-071
Mass Market/EO SWE Interfaces	Vightel	08-058r1/07-138r1
SWE Architecture ER Revision	IfGI GSR	06-021r2
SWE Change Requests – SPS	IfGI GSR	08-020
WCS Subsetting ER	PCI Geomatics	07-169
WPS – EO Algorithm	Northrop Grumman IT	08-058r1
WCS – Extension WCPS	Jacobs University Bremen	08-059
OWS-5 WCPS ER	Jacobs University Bremen	07-166r2
Considerations for WCTS Extension of WPS	ERDAS	08-054

3.2 Geo Processing Workflow (GPW)

The Geo-Processing Workflow (GPW) thread built on work accomplished during several previous OWS Testbed initiatives. Beginning with OWS-2, the Image Handling for Decision Support (IH4DS) thread extended the baseline of OWS service types with image processing services. In OWS-3 the Common Architecture thread continued this work by applying the services developed in OWS-2 to the SWE and GeoDSS environments. In OWS-4, a baseline approach for OWS Workflow using BPEL was established and demonstrated in several scenarios. Several processing services were defined as profiles of the Web Processing Service, e.g., Topology Quality Assessment Service, Model Output Processing Service.

The Geo-Processing Workflow (GPW) thread aimed to develop and demonstrate interoperability among geo-processes through service chaining, workflow and web services, with emphasis on the Web Processing Service (WPS) and SOAP bindings. The results were achieved through valued-added enterprise scenarios that demonstrated the power of interoperability and service-oriented architectures. The OWS-5 GPW thread aimed to integrate and enhance OGC web services specifications drawing on accomplishments of previous initiatives to meet these objectives. UML and GML3.2 application schema development was also part of this thread.

The focus during OWS-5 for GPW was in the following areas:

- SOAP/WSDL Investigations
- Conflation Workflow Process
- Data View Scenario
- GML Application Schema Processing and UGAS Enhancements
- GeoRM License Broker

GPW Service/Component	Participant
WCS-T v1.1 plus SOAP/WSDL	PCI Geomatics
WFS-T v1.2 plus SOAP/WSDL	Ionic
WMS v1.3 plus SOAP/WSDL	Ionic
CSW v2.0.2 (ebRIM profile of ISO 19115)	Ionic
WCS v1.1 - grid coverage DTED	PCI Geomatics
WFS v1.1 - GML 3.2.1 Local MSD	Snowflake
WFS v1.1 – Vertical Obstruction data	Northrop Grumman
WPS V1.0	IfGI
Conflation Service	1Spatial
Topology Quality Assessment Service (TQAS)	1Spatial
BPEL Workflow engine	GMU
BPEL workflow scripts	Northrop Grumman
GeoDRM License Broker	con terra
UML-GML Application Schema tool	Interactive Instruments

GPW Engineering Reports	Participant	OGC Doc #
GeoDRM License Broker Implementation Spec ER	IFGI Muenster	08-076
OWS SOAP/WSDL Common ER	IFGI Muenster	08-009r1
OWS Workflow Architecture ER	NGIT	07-138r1
WPS Conflation ER	NGIT	07-160r1
Data View Architecture ER	Intergraph	07-163r1
GEOINT NAS Schema Processing ER	Interactive Instruments	08-077
Local MSD Data Content Specification ER (renamed)	Interactive Instruments	08-078

3.3 Agile Geography

This thread focused on process integration and 'right-sizing' of services to demonstrate the power of interoperability and service-oriented architectures using OGC Web Services. The following paragraphs summarize the work accomplished in each of the main task areas of the Agile Geography thread of OWS-5.

- **KML Investigations** - The KML investigations work item was designed to study how KML could be better integrated with OGC's existing web services and OGC's standards initiatives in general
- **Federated Geosynchronization** - This part of the thread developed a new service interface for the automated synchronization of geospatial data sets. It builds on the work done in the 2007 Canadian Geospatial Data Infrastructure (CGDI) Pilot, where the need for geo-synchronization to

facilitate the operation of a spatial data infrastructure was identified. That project's scope, however, did not cover the development of a formal open interface for geo-synchronization.

- **WFS Core + Extensions** – The goal of this work was to build upon the specification writing guidance provided by OGC #07-056, Annex to OGC Policy and Procedures — The Specification Model — Structuring an OGC specification to encourage implementation. This document puts forth a way to write specifications based on a core extensions model, and this OWS-5 work applies that model to the Web Feature Services Implementation Specification (WFS).

Agile Geography Service/Components	Participant
Component WMS (FPS) – KML output Service	TOPP
Component WMS (FPS) – KML output Service	Galdos
Component WMS (FPS) – KML Client	TOPP
Component WMS (FPS) – KML Client	LisaSoft
KML Client – static files	Mapufacture
KML Client – static files	WhereGroup
Federated Geo-synchronization Service	Cubewerx
Federated Geo-synchronization Client	TOPP

Agile Geography Engineering Reports	Participant	OGC Doc #
KML / Open Web Services Investigations	TOPP	07-124r2
Component WMS Interface	TOPP	08-064
OWS-5 Federated Geo-synchronization	CubeWerx	08-003
WFS Core + Extensions	Oracle, CubeWerx	08-079

3.4 Compliance Testing (CITE)

The OGC Interoperability Program and the OGC Specification Program have achieved a great deal of momentum as a result of the multiple OGC web service specifications that have recently been published. Key consumers in the geospatial industry are modernizing their enterprises based on the applicability and interoperability of OGC web services. The major geospatial industry consumers require verifiable proof of compliance with OGC specifications in order to reach the desirable outcome of interoperability. Furthermore, as the OGC technology stack has matured, a group of interfaces has emerged that represents a baseline of technology needed to implement a fully interoperable, end-to-end *spatial data infrastructure*. The OWS-5 CITE thread made significant progress towards having a complete suite of compliance tests for this baseline of interfaces. In OWS-5, transitioning the WCS 1.0 compliance tests to the new, open source TEAM Engine will complete this work. The OWS-5 CITE thread resulted in a suite of compliance tests for this baseline of interfaces, which include WCS 1.1, WFS 1.1 XLink, CSW 2.0.2 ebRIM/19115 profile, SOS 1.0, and SPS 1.0. Also included in the requirements are reference implementations of these specifications. A reference implementation is an open source, fully functional implementation of a specification in reference to which other implementations can be evaluated. The OGC provides open source reference implementations to ensure maximum transparency of its specifications for both vendors and customers.

CITE Abstract Test and Executable Test Scripts	Participant
WCS 1.0 scripts for TEAM engine	TASC
WCS 1.1 Compliance test scripts	PCI
WFS 1.1 XLink test scripts	Galdos
CSW 2.0.2 ebRIM/19115 profile Compliance Test	Galdos
SOS 1.0 Compliance Test script	NG
SPS 1.0 Compliance Test script	NG

CITE Reference Implementations	Participant
WCS 1.1 Reference Implementation	TOPP
WFS 1.1 XLink Reference Implementation	TOPP
CSW 2.0.2 ebRIM/19115 profile Reference Implementation	Galdos
SOS 1.0 Reference Implementation	IfGI GSR
SPS 1.0 Reference Implementation	IfGI GSR

CITE Engineering Reports	Participant	OGC Doc #
CITE ER	NG	08-084