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Editor: Peter Baumann

OGC® OWS-5 Engineering Report on WCPS (Web Coverage Processing Service)

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Preface

Suggested additions, changes, and comments on this draft report are welcome and encouraged. Such suggestions may be submitted by email message or by making suggested changes in an edited copy of this document.

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1 Introduction

1.1 Scope

This OGC™ document represents the Engineering Report for the WCPS activity within the OWS-5 SWE thread. It summarises tasks and outcomes.

Note that this document describes the current state of implementation; not all of the concepts described in this document are available at the time this document was written.

1.2 Document contributor contact points

All questions regarding this document should be directed to the editor or the contributors:

Name	Organization
Peter Baumann	Jacobs University Bremen, rasdaman GmbH

1.3 Revision history

Date	Release	Editor	Primary clauses modified	Description
2007-dec-07	0.0.1	pb	created	
2008-mar-06	1.0.0	pb	Final version	
2008-mar-07	1.0.1	Pb	Intro language description all	Switched on change tracking Corrected syntax typo Improved wording, formatting
2008-07	0.9.0	C Reed	Various	Ready for posting as a DP
2008-08-01	1.0.0	P.Baumann	Various	Adjusted editorial items

1.4 Forward

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2 References

The following documents are referenced in this document. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the normative document referred to applies.

OGC 06-035, *Web Coverage Processing Service (WCPS) Implementation Specification 0.0.4*

OGC 07-157r1, *Web Coverage Processing Service (WCPS) Implementation Specification 1.0.0*

OGC 07-157r1, *Web Coverage Processing Service (WCPS) Implementation Specification 1.0.0*

OGC 07-067r3, *Web Coverage Service (WPS) Implementation Specification 1.1.1 (Corrigendum)*

3 Terms and definitions

For the purposes of this report, the definitions specified in Clause 4 of the OWS Common Implementation Specification [OGC 06-121r3] and in OpenGIS® Abstract Specification Topic 6: Coverages shall apply.

4 Conventions

- none defined here -

5 OWS-5 WCPS overview

5.1.1 Background

WCS forms the basis for retrieval from large-scale multi-dimensional coverages. In essence, its functionality allows for spatial and temporal subsetting, range subsetting, scaling, reprojection, and data format encoding.

While this provides the sine-qua-non basic functionality, numerous requests have reached the WCS.RWG (WCS Revision Working Group) to go beyond this. Among the randomly picked examples are: recombination of range fields; arbitrary slicing to generate hyper-cubes (i.e., coverages of reduced dimension, with a freely chosen subset of the coverage's axes); deriving coverages by processing (such as NDVI, Normalized Difference Vegetation Index, which can be computed by (nir-red)/(nir+red) from near-infrared (nir) and red bands of a hyperspectral satellite image); combining more than one coverage in a request; deriving summary data (like min/max or histograms).

Rather than randomly adding functionality, the unifying concept of a coverage processing language has been proposed. This adds a new request type, ProcessCoverage, to WCS. Such a request ships an expression of arbitrary complexity to the server that responds with the processing result. A request can make use of one or more input coverages, and the result can consist of one or more coverages.

To make complex WCPS requests human readable, and to remain independent from a particular request encoding, an Abstract Syntax has been defined which lends itself towards XQuery. Due to the formal definition of this language automatic translation is possible, and is available meantime.

Among the advantages of the WCPS language concepts is that it is well suited for automated service orchestration and distributed processing in general, as has been shown by our research (see publication list at [1]).

WCPS has become Best Practice paper with version 0.0.4 (document 06-035) and has been accepted by the WCS.RWG as WCS extension. The current version 1.0.0 has been submitted as document 07-0157r1 to Pending Documents.

Actually the generality of the approach makes WCPS suitable for many applications hitherto not considered (such as geochemistry), and for developing cross-domain applications (such as Earth System science).

Development of WCPS has led to some change requests to WCS, which in turn sometimes have rippled up to change requests against OWS Common; in one case a change request has turned out to have a direction simultaneously followed by ISO currently (see Section 8 below).

5.1.2 Request encoding

WCPS semantics is defined via its Abstract Syntax, which is crafted to be human readable. Encodings are available for KVP / HTTP GET, XML / HTTP POST, XML / SOAP.

The XML Schema relies on WCS (currently: WCS 1.1.1), which it adapts unchanged, but extends it with the new request type *ProcessCoverage*.

The SOAP binding relies on WPS, effectively rendering WCPS to a WPS execute request.

5.1.3 Language overview

The following is a brief overview on the processing language in Abstract Syntax. See the WCPS tutorial at [2] for an introduction to the language. For the mapping, eg, to XML, refer to the WCPS specification document, OGC 07-157r1.

The general request shape is a loop over a list of coverages. Each coverage is inspected in turn. First, it is optionally checked for fulfilling some predicate, and gets selected – i.e., contributes to an element of the result list – only if the predicate evaluates to *true*. Each remaining coverage will be processed, and the result will be appended to the result list. This result list, finally, is returned as the ProcessCoverage response unless an exception was generated. Generally, a processing expression can result in a coverage (e.g., band recombination) or in scalar data (e.g., maximum intensity of a band).

Loops over coverages can be nested to accommodate combination of several coverages (e.g., masking).

For coverage-valued results, these need to be encoded into some data format. Optionally, the result is stored on server side, and only a URL for each result is returned in the response structure.

A host of operations is available for coverage processing, which follow common programming language style. Formally they all can be traced back to only two core operations (coverage constructor and condense operator), so the other functions resemble syntactic sugar (and allow vendors to implement optimized versions).

The expressive power encompasses all analytically expressible, non-recursive operations. This allows to perform the most important task, intelligent data subsetting. Higher level processing, such as analysis by neural networks (which are tightly constrained in the volumes they can process at a time), can be accomplished on client side.

5.1.4 Sample requests

To illustrate the principles we provide some request examples below.

- "ModisScene, TIFF-encoded"

```
for m in ( ModisScene )
      return
       encode( m, "tiff" )
```

- "ModisScene, TIFF-encoded; store server-side, just return URL"

```
for m in ( ModisScene )
      return
       store( encode( m, "tiff" ) )
```

- "False color recombination of ModisScene" (see Figure 1)

```
for m in ( ModisScene )
      return
       encode( { m.nir, m.red, m.green }, "tiff" )
```

- "all areas where the NDVI exceeds 0.6" (see Figure 1)


```
for m in ( ModisScene )
     return
      encode( (m.nir-m.red)/(m.nir+m.red)>0.6, "tiff" )
```

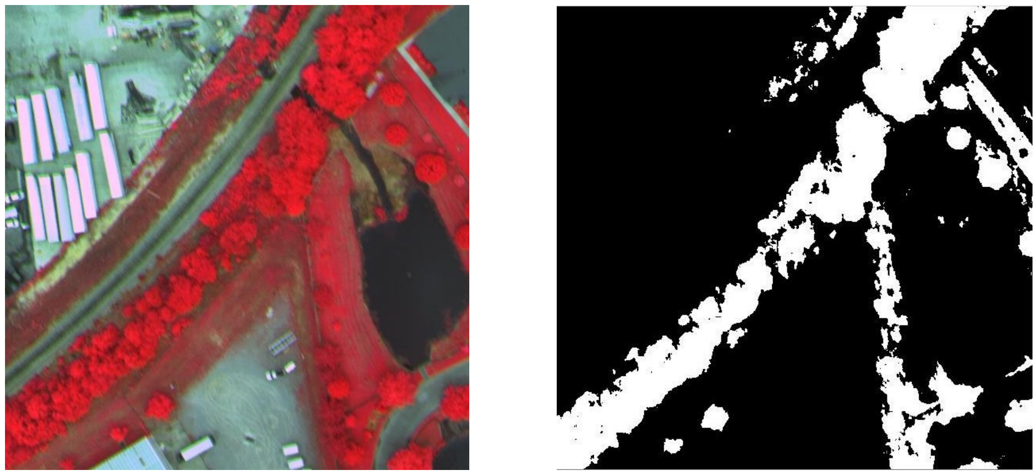

Figure 1 — sample processing results including band combination: false color composition (left) and NDVI thresholding (right)

– "histogram of the red channel, encoded as comma-separated list"

```
for m in ( ModisScene )
     return
      encode( coverage histogram
              over     bucket n(0,255)
              values   count( m.red = n ), "csv" )
```

6 Goals within OWS-5

Goal of the WCPS subtask within the SWE part of OWS-5 is to demonstrate feasibility of the WCPS specification and gain best-practice experience through application to various use cases.

7 Demonstration Scenarios

As this is an unfunded in-kind contribution resources had to be planned carefully. For demonstration, the following use cases have been implemented (see www.earthlook.org/demo):

- sensor timeseries (1D data sets)
- oceanography (2D data sets)
- remote sensing imagery (2D, 3D data sets)

- geophysics (3D data sets)
- climate modeling / prediction (3D, 4D data sets)

7.1 Demo Client and Server Components

7.1.1 Clients

For the purpose of demonstration, several client component have been developed to display coverage results of different dimensions:

- A diagramming client for 1-D coverages; it displays sequences as diagrams.
- A straightforward display mechanism for 2-D results
- A 3-D ortho slicing viewer for 3-D coverage results; it displays 3-D objects through three orthogonal slices which can be moved interactively. Further, zoom, pan, and rotation is possible.
- A WCPS “sandbox”; it allows to type in a WCPS request in Abstract Syntax, submit it to the server, and display the result (currently 2-D imagery only).

All these clients are platform independent, many of them implemented in Java. The website is designed such as to allow access by standard compliant Web browsers (currently tested: Firefox and Opera) as well as MS IE (which, for now, sometimes may convey unanticipated effects).

7.1.2 Server

The service is running Jacobs University’s WCPS reference implementation which consists of the following service stack:

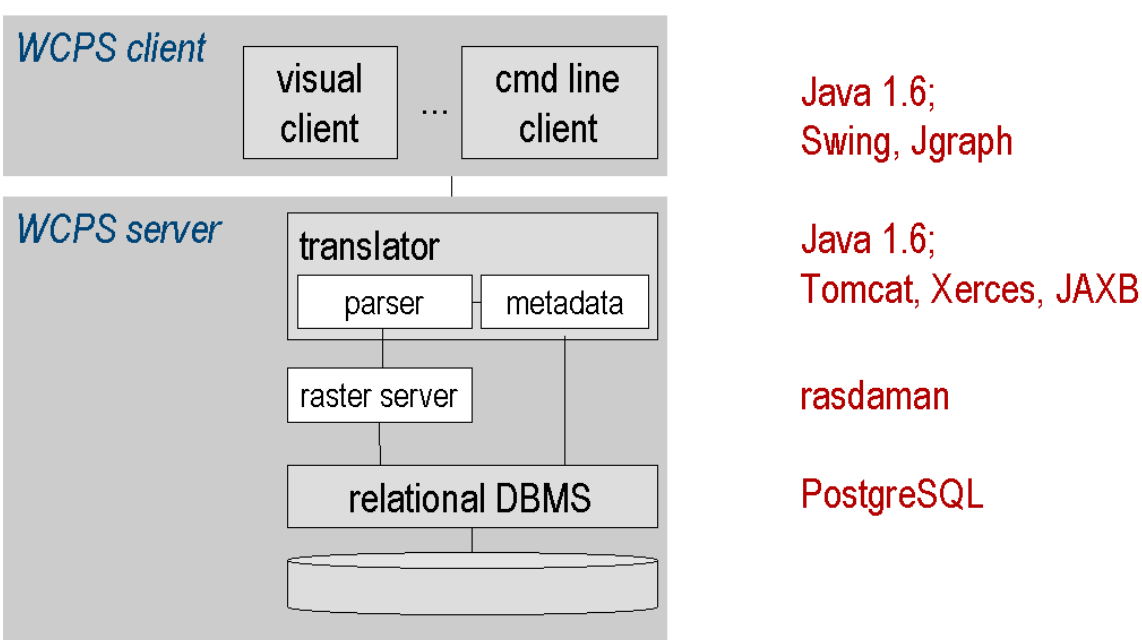

Figure 2 — WCPS reference implementation service stack

7.2 Demo Scope

Scope of this demo is to demonstrate how many different products can be derived from one and the same data source by exploiting the processing capabilities of WCPS. The flexible request language of WPCS allows to provide an array of access methods:

- derived information can be provided as a standard WMS layer via a WMS frontend to WCPS
- standing queries, based on prefabricated requests submitted periodically
- alerters can be implemented by submitting analysis queries which return not a coverage, but a scalar status indicator
- ad-hoc analysis is supported via tasking clients (graphical or textual)

With more data available (in particular: meso-scale weather models), this might be extended into multi-source fire condition forecast and detection. Experts demand an update frequency of 5-15min for risk areas, with automated decision support techniques. WCPS is suited for customizing such applications (in a similar manner like SQL for business applications and Web information systems).

WCPS alerting based on data aggregation is complementary to in-situ sensor observation: while the latter deliver more accurate information, the former allows to monitor any-size areas.

8 Results

It was chosen to provide a demonstration suite for usefulness and power of the technology. Consequently, the result is subdivided into two parts:

- A client setup which allows to invoke WCPS functionality in several use case scenarios, taken from areas as diverse as sensor Web, remote sensing, oceanography, geophysics, and climate modeling.
- A technical overview, including a WCPS tutorial using several clients on different levels (Abstract Syntax textual, Abstract Syntax visual, XML).

8.1 Services

The demonstrator is linked into the EarthLook website, www.earthlook.org.

Within OWS-5, The main achievements within OWS-5 are:

A suite of clients has been established to allow user-friendly, yet flexible access to WCPS functionality for a broad range of users:

- WMS on top of WCPS
- A textual client to type in requests in the high-level Abstract Syntax, or alternatively in XML (aka “WCPS sandbox”)
- A visual client for manual request composition, following a visual programming approach
- A diagramming client to display 1-D coverage results
- A straightforward display mechanism for 2-D results
- A 3-D ortho slicing viewer for 3-D coverage results; it displays 3-D objects through three orthogonal slices which can be moved interactively. Further, zoom, pan, and rotation is possible.

Finally, a WCPS tutorial is online.

8.2 Data

The demonstration is based on the following data sets stored in a rasdaman database (www.rasdaman.com):

- 11 1-D time series
- 2-D seafloor mosaic of the Hakon-Mosby mud volcano, plus bathymetry data
- 2-D airborne image of the Jacobs University campus and surroundings
- 2-D Modis-derived false color image
- several 3-D satellite image time series and derived products (surface temperature; Modis wildfire classification; land/water classification)
- a 4-D climate simulation output (atmospheric temperature, procided by UCAR)

8.3 Documents and further contributions

As part of the OWS-5 activities, the following contributions have been produced:

- Revised WCPS specification document, advancing from version 0.0.4 to version 1.0.0 (OGC 07-157r1)
- WCS Change Request on General Domain, allowing for coverages with any subset of x/y/z/t axes, plus “abstract” axes without spatiotemporal semantics (contribution)

- Discussion contribution to OWS Common Change Request re core/extension model
- Contributions to WCS 1.2
- Classified listing of WCS aspects, to guide core/extension specification writers (internal working document to be integrated into WCS 1.2, no OGC document number)
- Further ongoing ad-hoc discussion of many aspects in the course of the WCS.SWG work

9 Open Issues

- Coordinate system handling is waiting for the General Domain concept to be accepted for WCS, streamlined with ISO 19111-2 (to this end a CR has been proposed already by the newly formed WCS.SWG). Until then, only ImageCRS access is supported.
- The WPS binding needs to be verified in collaboration with the WPS group, possibly leading to a WPS extension.

10 Conclusions

The demonstrator shows feasibility of WCPS for a variety of data structures (1-D time series, 2-D imagery, 3-D image timeseries and geophysics data, 4-D atmospheric data) and application domains (mapping, geophysics, oceanography, remote sensing, climate modeling).

The WCS.SWG group has incorporated WCPS as part of the WCS suite. It is recomm-ended to suggest WCPS 1.0.0 to the TC for voting to become an adopted standard, based on WCS 1.1.2 and, subsequently, 1.2.

Bibliography

[1] http://www.faculty.jacobs-university.de/pbaumann

[2] http://www.earthlook.org

