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Towards Semantic Web Services on Large, Multi-Dimensional Coverages

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Observed and simulated data in the Earth Sciences often come as coverages, the general term for space-time varying phenomena as set forth by standardization bodies like the Open GeoSpatial Consortium (OGC) and ISO. Among such data are 1-d time series, 2-D surface data, 3-D surface data time series as well as x/y/z geophysical and oceanographic data, and 4-D metocean simulation results. With increasing dimensionality the data sizes grow exponentially, up to Petabyte object sizes.

Open standards for exploiting coverage archives over the Web are available to a varying extent. The OGC Web Coverage Service (WCS) standard defines basic extraction operations: spatio-temporal and band subsetting, scaling, reprojection, and data format encoding of the result - a simple interoperable interface for coverage access. More processing functionality is available with products like Matlab, Grid-type interfaces, and the OGC Web Processing Service (WPS). However, these often lack properties known as advantageous from databases: declarativeness (describe results rather than the algorithms), safe in evaluation (no request can keep a server busy infinitely), and optimizable (enable the server to rearrange the request so as to produce the same result faster). WPS defines a geo-enabled SOAP interface for remote procedure calls. This allows to webify any program, but does not allow for semantic interoperability: a function is identified only by its function name and parameters while the semantics is encoded in the (only human readable) title and abstract. Hence, another desirable property is missing, namely an explicit semantics which allows for machine-machine communication and reasoning a la Semantic Web.

The OGC Web Coverage Processing Service (WCPS) language, which has been adopted as an international standard by OGC in December 2008, defines a flexible interface for the navigation, extraction, and ad-hoc analysis of large, multi-dimensional raster coverages. It is abstract in that it does not anticipate any particular protocol. One such protocol is given by the OGC Web Coverage Service (WCS) Processing Extension standard which ties WCPS into WCS. Another protocol which makes WCPS an OGC Web Processing Service (WPS) Profile is under preparation. Thereby, WCPS bridges WCS and WPS.

The conceptual model of WCPS relies on the coverage model of WCS, which in turn is based on ISO 19123. WCS currently addresses raster-type coverages where a coverage is seen as a function mapping points from a spatio-temporal extent (its domain) into values of some cell type (its range). A retrievable coverage has an identifier associated, further the CRSs supported and, for each range field (aka band, channel), the interpolation methods applicable.

The WCPS language offers access to one or several such coverages via a functional, side-effect free language. The following example, which derives the NDVI (Normalized Difference Vegetation Index) from given coverages C1, C2, and C3 within the regions identified by the binary mask R, illustrates the language concept:

```
for $c in ( C1, C2, C3 ),
    $r in ( R )
return
    encode( (char) ($c.nir - $c.red) / ($c.nir + $c.red), \"HDF-EOS\" )
```

The result is a list of three HDF-EOS encoded images containing masked NDVI values. Note that the same request can operate on coverages of any dimensionality.

The expressive power of WCPS includes statistics, image, and signal processing up to recursion, to maintain safe evaluation. As both syntax and semantics of any WCPS expression is well known the language is Semantic Web

ready: clients can construct WCPS requests on the fly, servers can optimize such requests (this has been investigated extensively with the rasdaman raster database system) and automatically distribute them for processing in a WCPS-enabled computing cloud.

The WCPS Reference Implementation is being finalized now that the standard is stable; it will be released in open source once ready. Among the future tasks is to extend WCPS to general meshes, in synchronization with the WCS standard.

In this talk WCPS is presented in the context of OGC standardization. The author is co-chair of OGC's WCS Working Group (WG) and Coverages WG.